An Introduction to Geospatial Analysis for Health Disparities Research

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The Health Geographics Lab: miami.edu/healthgeo
Agenda

Introduction to Geospatial Analysis (me)

Audience Group Activity (you)

Group Discussion (we)
Motivation

The number of tools and data sources for geographic analysis has been exploding.

Most disciplines have re-discovered spatial thinking and spatial analysis (the natural sciences are furthest along).

*Spatial analysis in public health has been mainstream for a while.*
Geospatial Analysis for Public Health Research - 4
UM Communities Using GIS

Civil Engineering
Ecosystem Science & Policy
RSMAS
Master of Public Administration
Sociology and Criminology
Biology’s Coastal Ecology Lab
Office of Civic and Community Engagement
Center for Computational Sciences...
On Airs, Waters, and Places

Whoever wishes to investigate medicine properly, should proceed thus: …consider the seasons of the year, and what effects each of them produces… Then the winds, …such as are peculiar to each locality. We must also consider the qualities of the waters, for as they differ from one another in taste and weight… In the same manner, when one comes into a city, he ought to consider its situation, how it lies as to the winds and the rising of the sun… the waters which the inhabitants use, whether they be marshy and soft, or hard and running from elevated and rocky situations, and deficient in water, or wooded and well watered, and whether it lies in a hollow, confined situation, or is elevated and cold; and the mode in which the inhabitants live, and what are their pursuits…

From these things he must proceed to investigate everything else.

-Hippocrates (c. 400 BC)
Modern Medical Geography

• The emergence of a systematic interest in medical geography can be dated from the first report of the commission on Medical Geography (ecology) of Health and Disease to the International Geographical Union in 1952
  • geographic pathology, medical ecology, medical topography, geographical epidemiology, geomedicine
• More recently: health geography, spatial epidemiology, etc.
Triangle of Human Ecology

Melinda Meade: Medical Geography and Human Ecology, 1977
Fast Forward to Today

Explosive growth in Health Geography due to:

• emerging and reemerging infectious diseases in a globalizing world

• increase in degenerative diseases due to “Westernization” and population aging

• maturity of GIS, leading to increased scientific analysis of spatial patterns of disease and health risks
Epidemiology Defined

“The study of the determinants, **distribution**, and control of disease and other health factors.”
The Holy Grail: The Space-Time Cube
Interest in a Spatial Perspective

Driven by:

a) the ready availability of very different kinds of geo-referenced data

b) the tools to visualize and analyze them:
   – geographic information systems (GIS)
   – spatial analysis
   – spatial statistics
Geographic Information Science
<table>
<thead>
<tr>
<th>State</th>
<th>Teen Birth Rate per 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>41.5</td>
</tr>
<tr>
<td>Alabama</td>
<td>53.0</td>
</tr>
<tr>
<td>Alaska</td>
<td>46.8</td>
</tr>
<tr>
<td>Arizona</td>
<td>56.2</td>
</tr>
<tr>
<td>Arkansas</td>
<td>61.8</td>
</tr>
<tr>
<td>California</td>
<td>38.4</td>
</tr>
<tr>
<td>Colorado</td>
<td>42.5</td>
</tr>
<tr>
<td>Connecticut</td>
<td>22.9</td>
</tr>
<tr>
<td>Delaware</td>
<td>40.4</td>
</tr>
<tr>
<td>District of Columbia</td>
<td>50.9</td>
</tr>
<tr>
<td>Florida</td>
<td>42.8</td>
</tr>
<tr>
<td>Georgia</td>
<td>51.8</td>
</tr>
<tr>
<td>Hawaii</td>
<td>42.1</td>
</tr>
<tr>
<td>Idaho</td>
<td>41.2</td>
</tr>
<tr>
<td>Illinois</td>
<td>38.1</td>
</tr>
<tr>
<td>Indiana</td>
<td>43.7</td>
</tr>
<tr>
<td>Iowa</td>
<td>33.9</td>
</tr>
<tr>
<td>Kansas</td>
<td>45.6</td>
</tr>
<tr>
<td>Kentucky</td>
<td>55.6</td>
</tr>
<tr>
<td>Louisiana</td>
<td>54.1</td>
</tr>
</tbody>
</table>

**summary statistic**

The map shows the teen birth rate per 1,000 for each state, with a color scale indicating different ranges: 19.8 - 32.8, 33.2 - 41.0, 41.2 - 51.8, and 53.0 - 65.7.
What is Spatial Data?

Simply any data with explicit or inherent location

- x-y coordinates
- linked to some areal region
What is Spatial Data?

Geographic (spatial) data have unique features

– location = ID variable
– absolute and relative location
– scale/aggregation
– spatial embeddedness (networks, hierarchies)
– spatial autocorrelation

Ignoring these unique features limits analytical potential and can also introduce problems.
Why Spatial Data?

The ability to analyze, over space and time:

- locations
- quantities
- densities
- changes
- connections
- what’s inside
- what’s nearby
Representations of Geographic Data

Two methods of representing geographic data in digital format:

Vector (features):
- **point**: to record location in a 2-dimensional space
- **lines**: between two points (directions and length)
- **polygons**: closed vectors (area, centroids, and perimeter)

Raster (surfaces):
- use a fixed grid and record information about each element on the grid (satellite images, aerial photos, etc.)
“Everyday” Geographical Objects

Points
households, health clinics, schools, retail outlets, crimes, bus stops, parks, neighborhood institutions and/or community assets, resources and risks...
OR... individuals (or other objects that can move)...

Lines
roads and transportation routes, rivers, pathways, social connections, infrastructure...

Areas (Polygons)
census units, ZIP codes, counties, states, provinces, school districts, police precincts, service areas, activity spaces, neighborhoods, watersheds...

Surfaces
weather, topography, land cover, pollution, urban-ness, risk...
“Everyday” Spatial Data Producers

Users have become producers, not just consumers, of spatial data

– Volunteered Geographic Information (VGI)
  • “Old”: Flickr, Foursquare, Google Maps, Historypin, etc.
  • “New”: mobile apps, wearable technologies
– Crowdsourcing (online posts, SMS, tweets...)
– Participatory GIS (PGIS)
  • “empowering the public and communities with GIS”
Classic GIS Applications

Businesses — site location for a new store
Urban planners — map traffic capacity and congestion
Demographers — population growth and decline
Police/firefighters — shortest route to incident
Epidemiologists — spread of disease
Biologists — invasive species or wildlife corridors
Public Health Applications

• Creating public health surveillance databases
• Mapping health data, e.g. spatial clustering of health events
• Risk and spread of infectious diseases
• Landscape ecology of vector-borne diseases
• Access to and location of health services
• Health disparities (geographic, socio-cultural, environmental)
• Ethnography of lived experiences of health care
Disease rates
Service Accessibility
Health Provider Demographics
Global Inequalities in Health

Health Worker Shortage

Map created by Benjamin D. Hennig - www.viewsoftheworld.net

Save the Children

Global Inequalities in Health
Health Worker Surplus

Map created by Benjamin D. Hennig - www.viewsoftheworld.net

Save the Children
A Geo-Environmental Risk Map showing Areas Potential for LF Transmission in Tamil Nadu, Southern India
Beyond the Map... Spatial Statistics

Why spatial statistics?

• Assumption of normality in the central limit theorem: "independent and identically distributed"

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \epsilon \]
Spatial Autocorrelation

The extent to which similar values are near each other; a core principle of spatial analysis.
Primary drinking water sources

Sachet water  Boreholes  Piped water
Local cluster analysis (LISA)

Sachet water

Boreholes

Piped water
Predictors of sachet use

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>β (se)</th>
<th>t-score</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sachet water</td>
<td></td>
<td></td>
<td>0.601</td>
</tr>
<tr>
<td>Constant</td>
<td>0.093 (0.03)</td>
<td>2.994**</td>
<td></td>
</tr>
<tr>
<td>Trash collection service access (%)</td>
<td>0.350 (0.05)</td>
<td>6.704***</td>
<td></td>
</tr>
<tr>
<td>Reside where born (%)</td>
<td>-0.100 (0.05)</td>
<td>-2.200*</td>
<td></td>
</tr>
<tr>
<td>Internet access (%)</td>
<td>0.357 (0.11)</td>
<td>3.245**</td>
<td></td>
</tr>
<tr>
<td>Distance from Accra (km)</td>
<td>-0.0001 (0.00)</td>
<td>-2.636**</td>
<td></td>
</tr>
</tbody>
</table>

* P < .05; ** P < .01; *** P < .001
Geographically Weighted Regression (GWR) coefficients: sachet use

Trash collection (+)  Reside where born (-)  Internet access (+)  Distance to Accra (-)

Coefficient value:
- Low ↔ High
- High
It’s All About Health Disparities
Example: IPV services & race in MDC
Example: IPV service disparities in MDC
Example: IPV service disparities in MDC
Example: IPV service disparities in MDC
Example: GSW in Miami-Dade
So... Why Geospatial Analysis?

• Visualize your data
• Generate and test new hypotheses
• Exploit the unexploited in your data

Gain a fuller understanding of health phenomena

(Oh, and funding agencies love interdisciplinarity)
Audience Group Activity
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Open Source Spatial Tools

• ArcGIS Online and ESRI Virtual Campus
• Google Maps and Google Earth
• SimplyMap
• Quantum GIS
• GRASS
• OpenGeoDa
• SAGA
• ... and many other web map servers, spatial DBMS, and data transformation tools
Resources at UM

• ArcGIS software installed campus-wide

• **GIS Resources at UM Libraries**
  – Budget for data acquisition

• GIS Consultant in Richter Library’s GIS lab

• Center for Computation Science (Ungar bldg)

• Development of a GIS data clearinghouse supported jointly by GEG and UM Libraries

• Health Geographics Lab: [miami.edu/healthgeo](http://miami.edu/healthgeo)
Freely Available Spatial Data

- ESRI’s ArcGIS Online Map and Image Services
- Geocommons
- SimplyMap (via UM subscription)
- National Atlas
- The GIS Data Depot
- DIVA-GIS
- Libre Map Project
- AfricaMap (and other WorldMap projects)
- United Nations Environment Programme
- State and local government offices...
Innovative GIS Applications

- Crime events ([DC homicides](#))
- Economic growth ([Global MetroMonitor](#))
- International migration flows ([Peoplemovin](#))
- Sports analytics ([basketball shooting maps](#))
- Spoken Inuktitut place names ([Arctic Bay Atlas](#))
- The London Blitzkrieg ([Bomb Sight](#))
- Literary landscapes ([Scene Changes](#))
- Historical soundscape of NYC ([Roaring Twenties](#))
- Urban emotion maps ([Christian Nold](#))
- Location-based gaming ([Zombie Apolcalypse](#))
- Virtual tour of Coral Gables ([Coral Gables Virtual History](#))
- Spatially reference historical maps, and more ([HyperCities](#))