Geographic Information Science and Spatial Analysis in Epidemiology and Public Health Research

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Report Outline

- Introduction
  - Brief history of epidemiology and place
- Uses of spatial analysis and GIS in health
- Conceptual Framework
- Methods
  - Literature review
  - Categorization of abstracts
- Case Studies
  - Exposure, susceptibility, environmental justice, and adaptation
- Results
- Conjectures on future trends
GIS has tremendous promise in health research, policy and practice

Contribution to date evolutionary, not transformative

Spatial epidemiology remains a part of GIS

GIS remains a relatively small but growing part of epidemiology and public health
Interest in Places and Health Dates back to Ancient Greece (Hippocrates 460-377 BC)

On Airs, Waters And Places
Why is spatial analysis used in population health studies? Association of disease with place means:

1. Population living there experiences increased exposure to a risk agent (e.g., air pollution)

2. Population is more susceptible (e.g., elderly, poor)

3. Can also suggest how the population adapts to its environment (Mayer 1983)
Hamilton Steel Mill
Created Distinct Health Geography
1. Pollution Exposure and Asthma Symptoms in Hamilton Canada

Have you had wheezing or whistling in your chest at any time in the last 12 months?
2. Susceptibility Marker: Cluster of Low Income - Getis Statistic

The map illustrates the distribution of z-scores across different regions. The z-scores are color-coded as follows:

- **Dark Red**: Significance
- **Light Red**: 1.1 - 3.28
- **Yellow**: -1.09 - 1.1
- **Green**: -2.56 - -1.09
- **Light Green**: 0 (No Data)

**Regions of Interest**:
- Niagara Escarpment
- Industrial Core
- Hamilton Harbour
- Lake Ontario

**Key Streets and Highways**:
- HWY 403
- HWY 53
- MAIN ST.
- KING ST.
- HWY. 103
- UPPER JAMES ST.

The map indicates a cluster of low income, as highlighted by the dark red areas, which correspond to significant z-scores.
3. Adaptation: Smoking Rates

Legend:
- 0 - 150
- 151 - 300
- 301 - 360
- 361 - 400
- 401 - 450

Map showing smoking rates with areas shaded to represent different rate categories.
GEOGRAPHIES OF RISK IN STUDIES LINKING CHRONIC AIR POLLUTION EXPOSURE TO HEALTH OUTCOMES

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Extended Conceptual Framework for Spatial Analysis in Epidemiology and Public Health

Exposure

Health Risk

Adaptation

Susceptibility
Why GIS in Spatial Health Analysis?

- Seeing the data – important to medically-trained people used to mapping the “body”
- Integration of numerous data
- Interactivity in the analysis
- Ability to use very large data sets: critical when effect sizes are small
- Increased speed of delivery
- Leads to novel questions and more of them
Seeing the Data: Visual Map of the Human Body
Integration: Mortality Around Noxious Site with Met Data

1985-94 Wind Frequency Distribution (Windroses) for Ontario Ministry of Environment 100 m meteorological tower on Woodward Ave. (STP grounds)

at sensor height of 30.5 m (100 ft) (indicative of wind patterns over the lower eastern parts of the city, from the escarpment brow to within a few kilometres of the lakeshore / Hamilton Harbour)

at sensor height of 91.5 m (300 ft) (indicative of wind patterns over the escarpment brow and parts of the upper city in proximity of the escarpment, e.g. TARO site)

2.5 km - radius buffer around the TARO-East landfill site

Mortality Database

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Rapid mapping of outbreaks
All verified outbreaks 2000-2001

Outbreak of Yellow Fever
Côte d’Ivoire, 2001

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Interactive Web Distributed Health GIS and Now Google Maps
Many other traditional GIS and Geography journals featuring health
GIS and Epidemiology Literature Search

Keywords
- GIS and health, epidemiology, community, neighborhood, disease, infectious disease, air pollution, susceptibility, vulnerability, environmental justice, health and deprivation, health and poverty, public health, multilevel models and health, health inequality, health equity
- spatial analysis and health
- remote sensing and health
- Global positioning system and health

PubMed 2004-2008 (n=5,584)
Web of Science 2004-2008 (n=2,920)
Duplicates (n=3,516)
Duplicates (n=669)
Merge (n=4,170)
Duplicates (n=818)
Non-relevant Literature and additional time restriction (2004-2005) (n=3,041)
Title review (n=3,501)
Abstract review (n=460)
Major Exclusions

- Dates restricted to last 3 years to capture innovations
- Eliminated infectious disease articles from foreign countries (in the 1000s)
- Eliminated those with geotechnical risk assessments (landslides, earthquakes, etc)
- Eliminated all pure methods or statistical pieces
- Eliminated any health care access pieces because others are doing this in their papers
Classification Schema

• Based on the susceptibility, exposure, adaptation, risk from earlier conceptual framework

SPATIAL ANALYSIS FOR ENVIRONMENTAL HEALTH RESEARCH: CONCEPTS, METHODS, AND EXAMPLES

Michael Jerrett

1. Visualization – mapping otherwise aspatial data (e.g., mortality rates)

2. Exploration – overlay and cluster analysis (e.g., all areas of high pollution and low income or cancer clusters)

3. Modeling – statistical assessment of association between health outcome
Abstract Classification (so far about 77 of 110 articles classified)

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Trends

- Enormous increase in GIS for epidemiology and public health research
- Increasing complexity of analysis, with multilevel and Bayesian models becoming more common
- Web based distribution growing
- Not much use of GPS or Remote Sensing yet
Case Studies

- **Susceptibility and Risk** - Separate and Unequal: Residential Segregation and Estimated Cancer Risks Associated with Ambient Air Toxics in U.S. Metropolitan Areas, 2006, Morello-Frosch and Jesdale

- **Exposure and Risk** - Spatial Analysis of Air Pollution and Mortality in Los Angeles, 2005, Jerrett et al.

- **Adaptation and Risk** - The Role of Spatial Risk Assessment in the Context of Planning for Adaptation in UK Urban Areas 2007 Handley et al.

- **Susceptibility and Social Conditions** – Still under scoping
Air Pollution and Mortality in Los Angeles

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Rationale

- Airborne particles ≤ 2.5 µm in diameter produced by combustion penetrate deep into the small airways and alveoli.

- Biologically plausible toxic agents that may associate with disease and premature death.

- Recent research from Los Angeles shows intra-urban gradients of PM$_{2.5}$ exposure relate to health risks 2-3 times greater than national studies using between-city exposure gradients.

Societal costs are huge: >$100 billion compliance costs; benefits of PM regulation = 60-70% of monetary value of ALL government regulations.

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From the Los Angeles Times
EPA Panel Advises Agency Chief to Think Again

Study Doubles Estimate of Smog Deaths

USC researchers amassed measurements of lethal particulate matter from hundreds of locations in the L.A. Basin. State may raise its official figures.

By Janet Wilson
Times Staff Writer

March 25, 2006

February 4, 2006
Updated Los Angeles Model: Data and Methods

- American Cancer Society cohort of 23,065 individuals enrolled in 1982 with 5856 deaths by 2000
- Zip code assignment of address (267 zips)
- Pollution surface generated from 23 stations with Land Use Regression method for PM$_{2.5}$ and kriged for 42 stations for ozone
- Control applied for same 44 individual and 8 ecologic confounders in multilevel Cox models
LA Relative Risks Bivariate, Pope et al. 2002 Model, Maximal Control (10 ug/m3 Exposure Contrast)
- Cited by EPA experts as one of the most influential studies on health effects
- Used in health risk assessments
- Cited in Cal EPA and EPA criteria documents
- Reported on widely in media
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