

“All Public Health is Local”: The Community Perspective on GIS and Public Health

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Objectives

- To describe the population health paradigm, and demonstrate the utility of GIS as an enabling technology for community-based research within that paradigm
- To explore some of the methodological issues involved in applying GIS to the study of community health
- To set the stage for an exciting and interactive conference
- To keep the audience awake and alert as the opening speaker



House Speaker Tip O'Neill on Politics:

“All politics are local . . .”



Professor Kirby on Health Data

“All health data are local . . .”



Professor Kirby on Spatial Data

“All data are spatial . . .”



Professor Kirby on Health Data

“All health data are political . . .”

. . .with apologies to Dr. Joe Mulinare

The Political Purpose of Infant Mortality Statistics

“The first lesson that you must learn is, when I call for statistics about the rate of infant mortality, what I want is proof that fewer babies died when I was Prime Minister than when anyone else was Prime Minister. That is a political statistic.”

- Winston Churchill

Professor Kirby on Public Health

“All public health is local”

Some Contemporary Archival Research

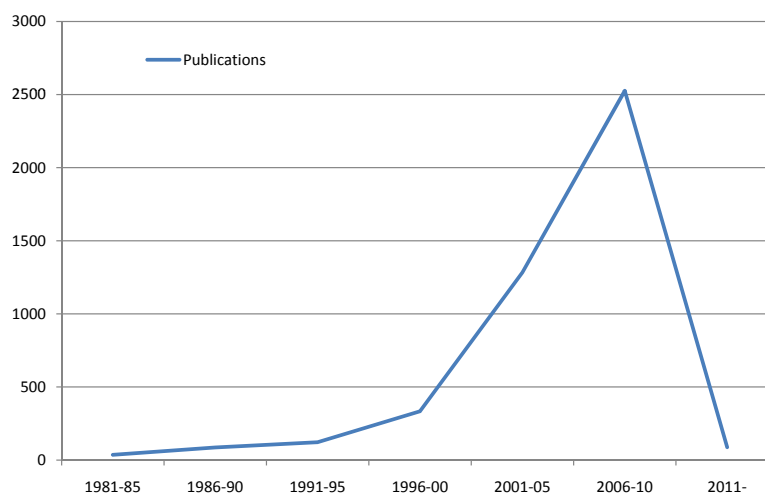
◆ From PubMed (4/15/11) – Citations with:

– GIS	3,138
– Geographic Information Systems	3,775
– Geographic Information System	4,774
– Combined	6,145
– Public Health	4,695,692

◆ Combined and Public Health: 4,395

- English - 4,032; 239 are review papers
- AND Community – 850
- AND (Community or Neighborhood) - 925

PubMed Citations with GIS and Public Health*

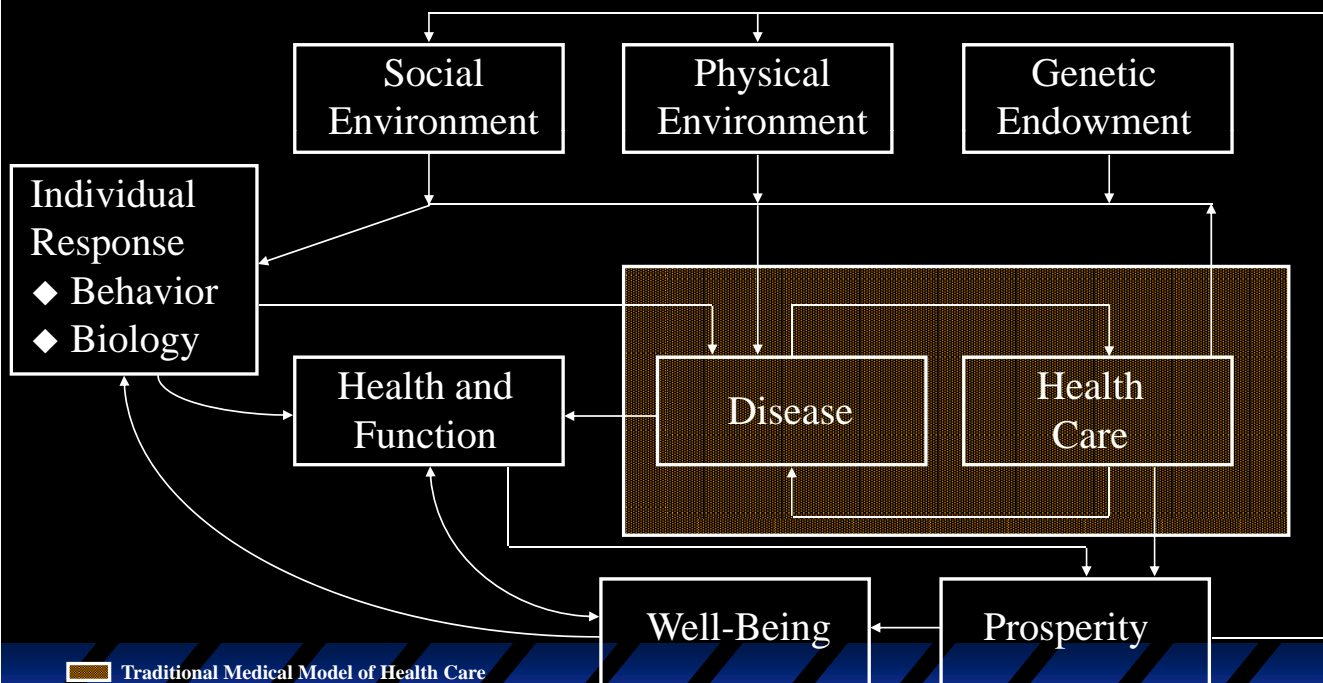


*(GIS OR Geographic Information Systems OR Geographic Information System) AND Public Health
– in any language
Publications for 2011-2015 through 4/15/11 only

Population Health

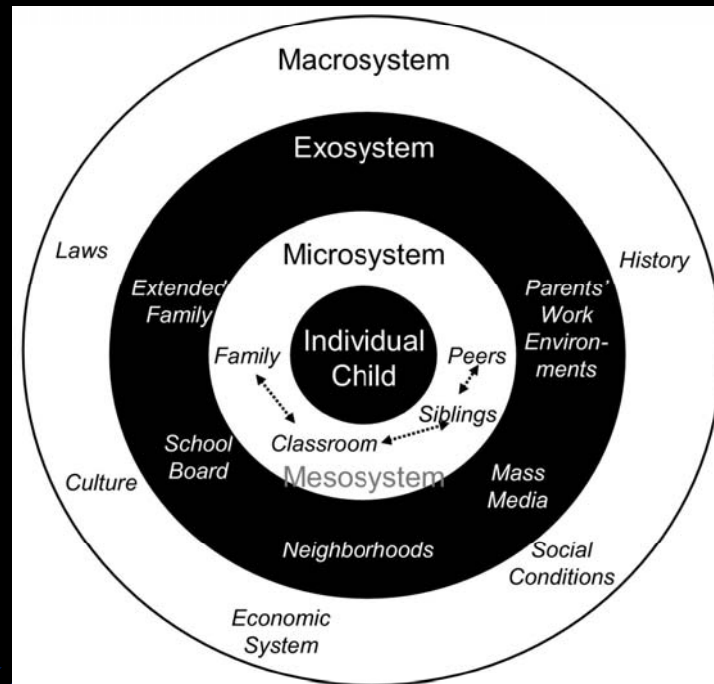
- Population health refers to the health, well-being, and functioning of entire populations.
- In some ways, it is similar to **public health**, but differs
 - in its explicit focus on entire populations
 - in considering a much broader range of inputs and health outcomes
 - in being applicable to populations defined by place of residence, place of employment, membership in an insurance plan, or other clearly defined populations

CONCEPTUAL FRAMEWORK FOR POPULATION HEALTH



Source: modified from Evans RG, Barer ML, Marmor TR, Eds, *Why are some people healthy and others not?*
New York: Aldine de Gruyter, 1994

Socio-ecological Model (after Bronfenbrenner)



Bronfenbrenner's Ecological Model describing the set of nested environmental influences on a child. Eisenmann et al. *BMC Public Health* 2008 8:223 doi:10.1186/1471-2458-8-223

Two Related Perspectives

- Lifecourse Perspective
 - Halfon and Lu (*MCH Journal* 2003)
- The Fetal Origins of Disease
 - a.k.a. the “Barker hypothesis” (publications far too numerous to list)

Both of these theoretical perspectives have antecedents dating at least to the mid-20th C

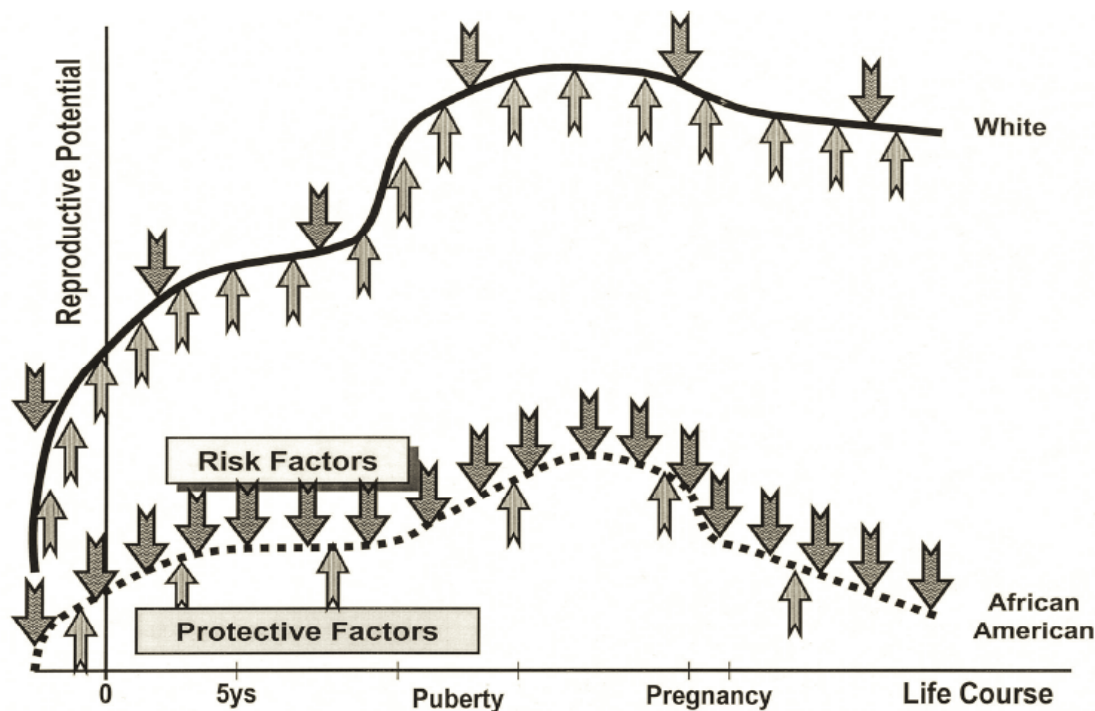


Fig. 1. How differential exposures to risk factors (downward arrows) and protective factors (upward arrows) over the life course affect developmental trajectories and contribute to disparities in birth outcomes. The lower reproductive potential of African American women, relative to White women, results from their cumulative exposure to more risk factors and less protective factors across the life span, particularly during sensitive periods of development.

Source: Halfon and Lu, MCH Journal 2003;7:13-30.

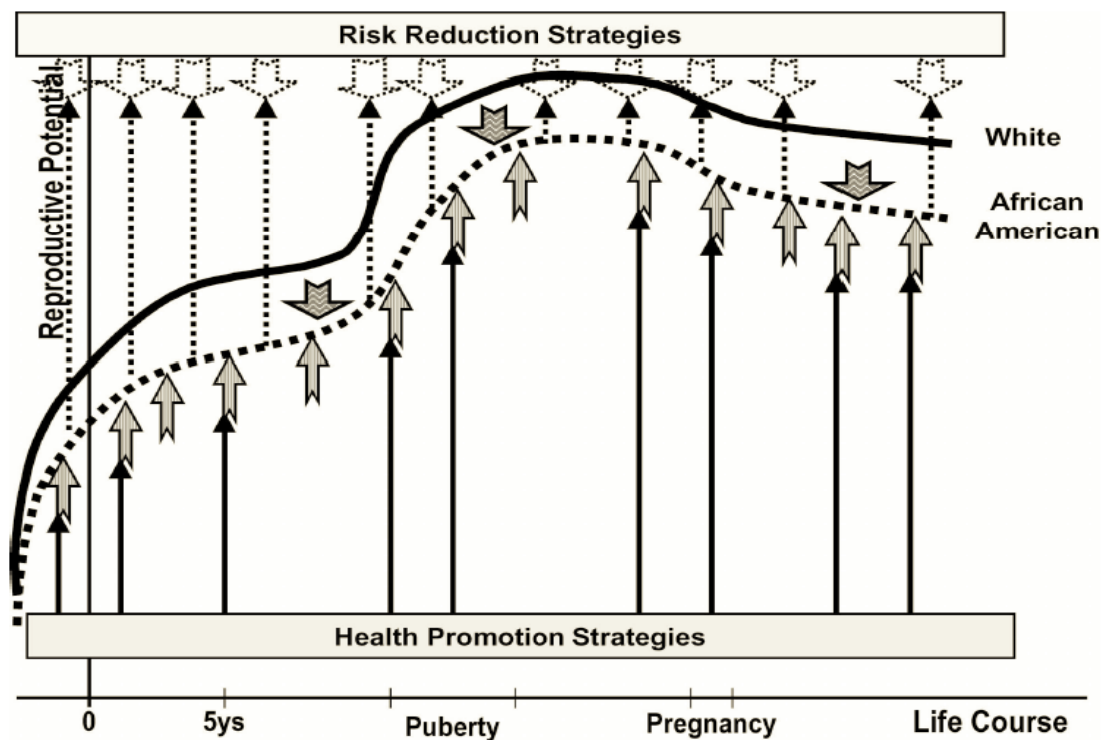


Fig. 2. How interventions throughout the life course, and particularly during sensitive periods of development, such as risk reduction strategies (dashed lines) and health promotion strategies (solid lines), might change developmental trajectories and close the Black-White gap in reproductive potentials.

Source: Halfon and Lu, MCH Journal 2003;7:13-30.

Fetal Origins of Disease

- This theory posits that the in utero experience 'programs' or 'conditions' the fetus for patterns of child growth and development as well as many chronic diseases with adult onset (obesity, metabolic syndrome, diabetes, hypertension, etc.)



Technologies and Methodologies

- Population health informatics
- Lifecourse perspective on perinatal and child health outcomes
- Ecological framework
- Multi-level modeling
- Record linkages within/across domains of public health, health care, education, social services
- GIS as an integrating technology to support within and cross-level analyses

GIS and Population Health Practice

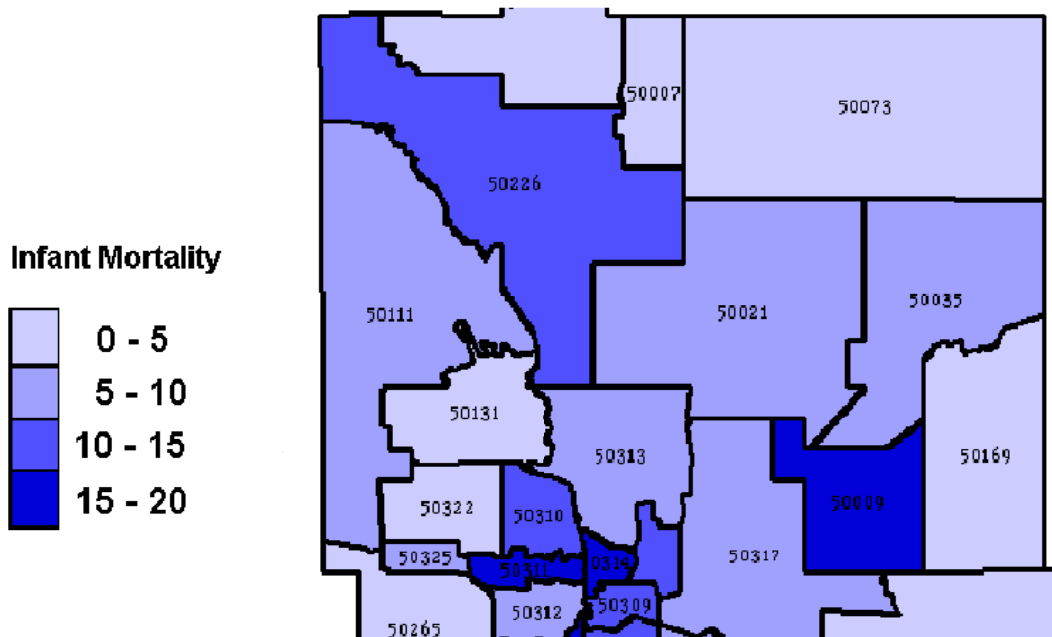
- ◆ Enables integration of spatial data measured at varying scales
- ◆ Enables assessment of spatial pattern and process (space and time)
- ◆ A very useful hypothesis-generating tool – but all good hypotheses have scientific basis
 - Derived from or extending existing theory
 - Physiologic or biological plausibility (often from animal models)
 - Results generalizable and reproducible

The Community Scale Is Where It's At

- ◆ Cities and counties are not homogeneous
- ◆ Studies of areas of neighborhood deprivation, unmet health care need, crime, higher levels of environmental exposure require a finer scale for analysis
- ◆ The definition of 'community' or 'neighborhood' is in the eye of the beholder

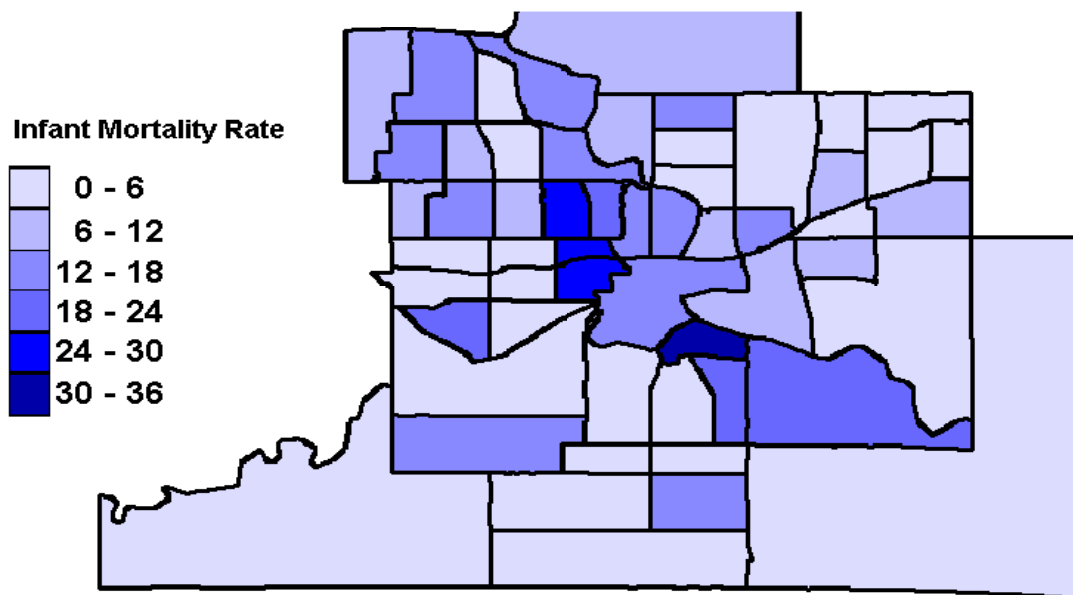
◆ Note – the following slides borrowed from Gerry Rushton

Des Moines, Iowa: Infant Mortality Rate ZipCode Areas, 1989-1993



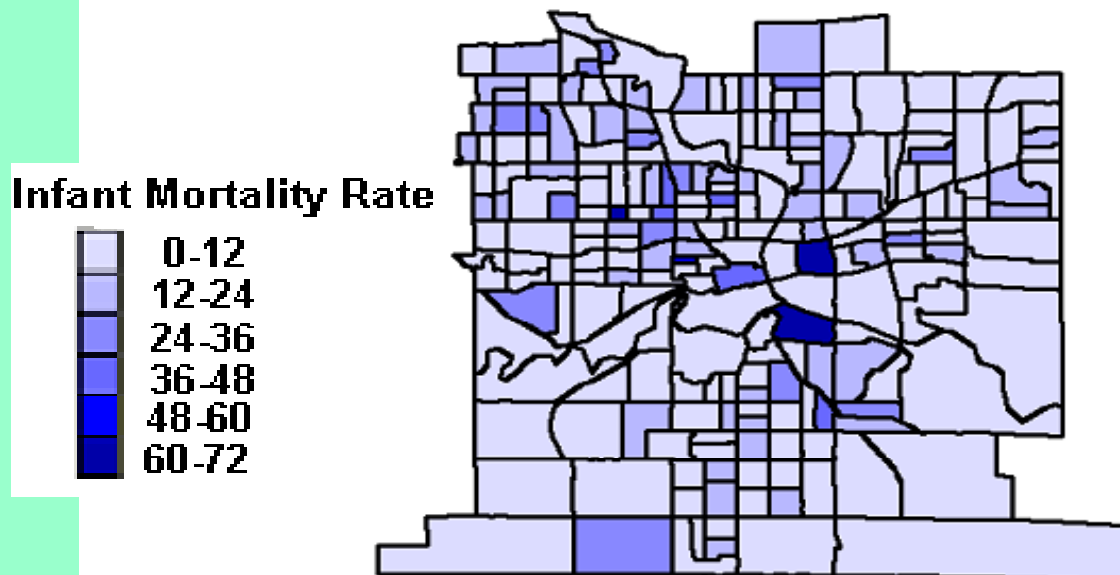
Des Moines, Iowa: Infant Mortality Rate

Census Tracts, 1989-1993



Des Moines, Iowa: Infant Mortality Rate

Census Block Groups, 1989-1993



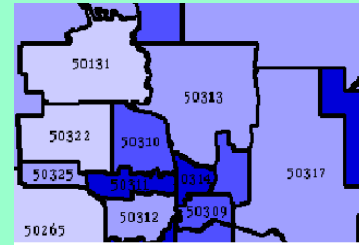
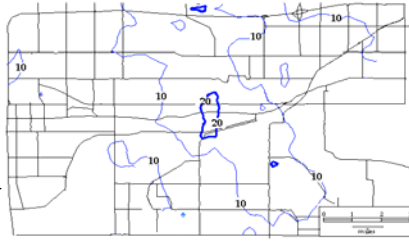
Infant Mortality Rates at Three Different Spatial Scales and Their Approximate Counterparts Using Available Census Administrative Areas

Des Moines, Iowa

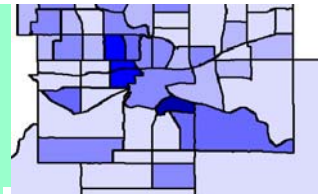
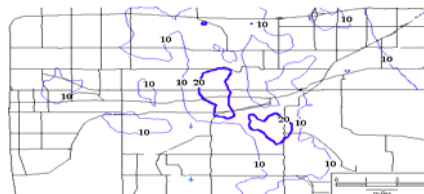
1989 - 1992

Spatial Filters

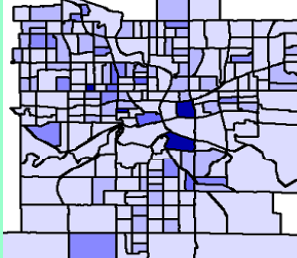
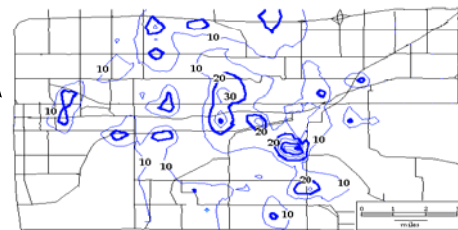
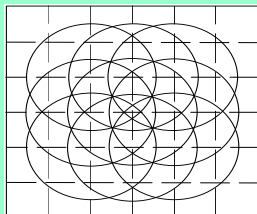
1.2 miles



0.8 miles



0.4 miles



The variability of any disease rate depends on the size of the areas mapped.

- For this example of infant mortality in Des Moines, Iowa, 1989-1992:
 - for zip codes the IMR is from 0 to 20 deaths per thousand
 - for census tracts the rate is from 0 to 36
 - for block groups the rate is from 0 to 72

Modifiable Areal Unit Problem

- ◆ The basic problem is, with point data we potentially get a different answer depending on how we draw the grid
- ◆ There is no solution to MAUP, but the GIS analyst needs to be aware of it, and at least do the analysis several different ways to assure congruence of results

“Don’t Toss It Away!”*

- ◆ When analyzing data measured across areal units, remember that each value (i.e. low birth weight rate) is actually the product of a numerator and a denominator. Together these can estimate the sample variance for each unit.
- ◆ Example:
 - County A: 7 LBW births among 100 total
 - County B: 700 LBW births among 10,000 total
- ◆ Poisson regression permits modeling of outcomes in relation to total events. Logistic regression does not . . .

*Slide title from song by Patti Loveless

Multi-level Methods

- ◆ These methods are well-suited to testing hypotheses within the population health paradigm and/or the socio-ecological model
- ◆ Simply put, the underlying premise is that conditions that pertain at a greater scale can influence the outcome of the individual, controlling for individual effects

Multi-level Methods (continued)

- ◆ Ideally, each level nests neatly within the next level
 - For example, a group of students nest within a classroom, which nests within a school, which nests within a school district, which nests within a state
 - Or, a patient nests within all patients cared for by a physician, which nests within all patients cared for in that hospital

Multi-level Methods (continued)

- ◆ But sometimes we seek to test hypotheses for which the theoretical base is tenuous (or our available measures are weak)
 - Mental health status as a function of public safety – patterns of violent crime at the block group level, nested within the census tract . . .

Other problems with MLM

- ◆ Spatial units and sample size
 - ◆ In a perfect experiment the structure of the data is regular and well-understood
 - ◆ Many MLM analyses in public health rely on existing individual-level data, nested within administrative units with data drawn from other sources
 - ◆ Statistical analysis requires estimable variance at the nested level – so how many observations do we need in each nested area?
- ◆ Spatial surfaces
 - ◆ Just as study subjects may not be independent events, so too each areal unit is part of a larger whole



W. Hamilton

"And it was so typically brilliant of you to have invited an epidemiologist."

What Spatial Data Is Commonly Found in Public Health Records?

- ◆ Vital statistics:
 - Residential address (of mother on birth certificate, of decedent on death certificate)
 - County of residence and occurrence
 - State of residence, state of birth (of mother/father)
 - Induced abortion reports have more limited data
- ◆ Hospital discharge summaries:
 - Typically only ZIP code of residence (occasionally address but not commonly)
- ◆ Claims and other administrative records:
 - Typically billing address (may or may not be residential address)

What Spatial Data Is Commonly Found in Public Health Records?

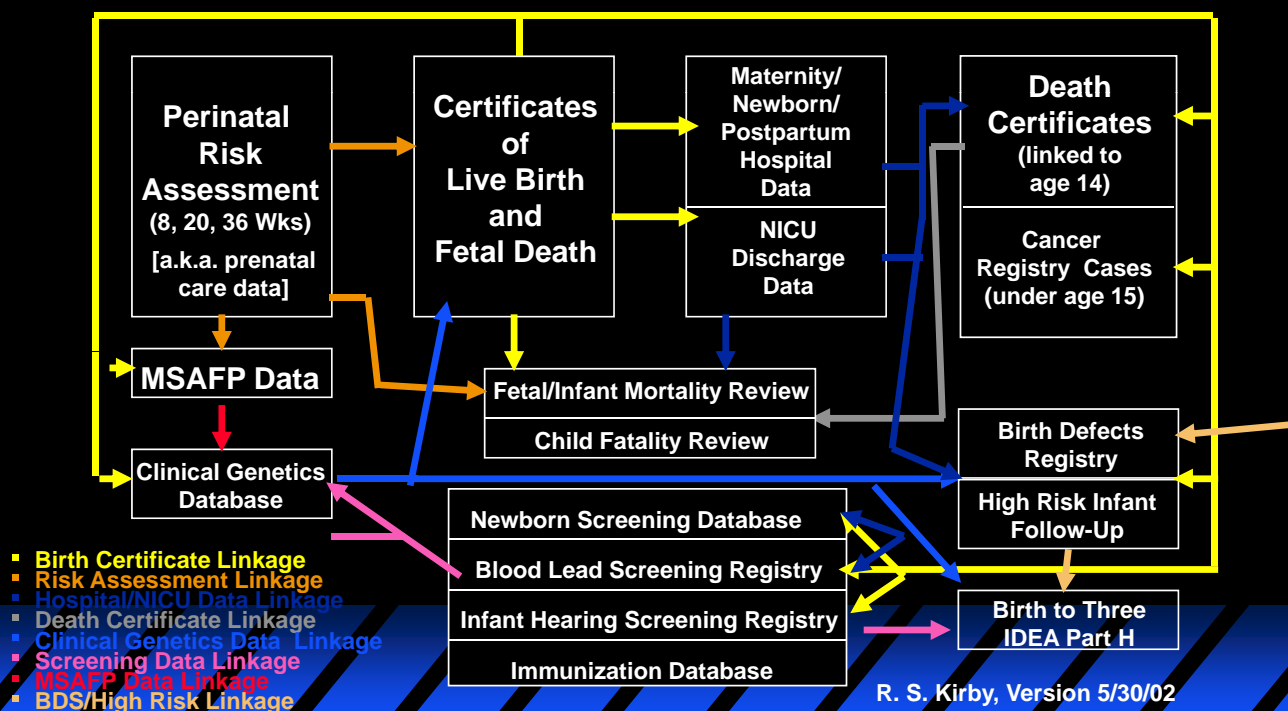
- ◆ Communicable disease reports:
 - Numerous spatial identifiers for place of residence, place of diagnosis, place of infection or onset of symptoms (i.e. Lyme disease)
- ◆ Environmental health data:
 - Many databases for Superfund sites, TRI, etc. Generally identified by specific location and geocoded to a latitude-longitude coordinate
- ◆ Epidemic investigations (shoe leather epidemiology)
 - In the field, collect locations using a hand-held global positioning system (GPS) device

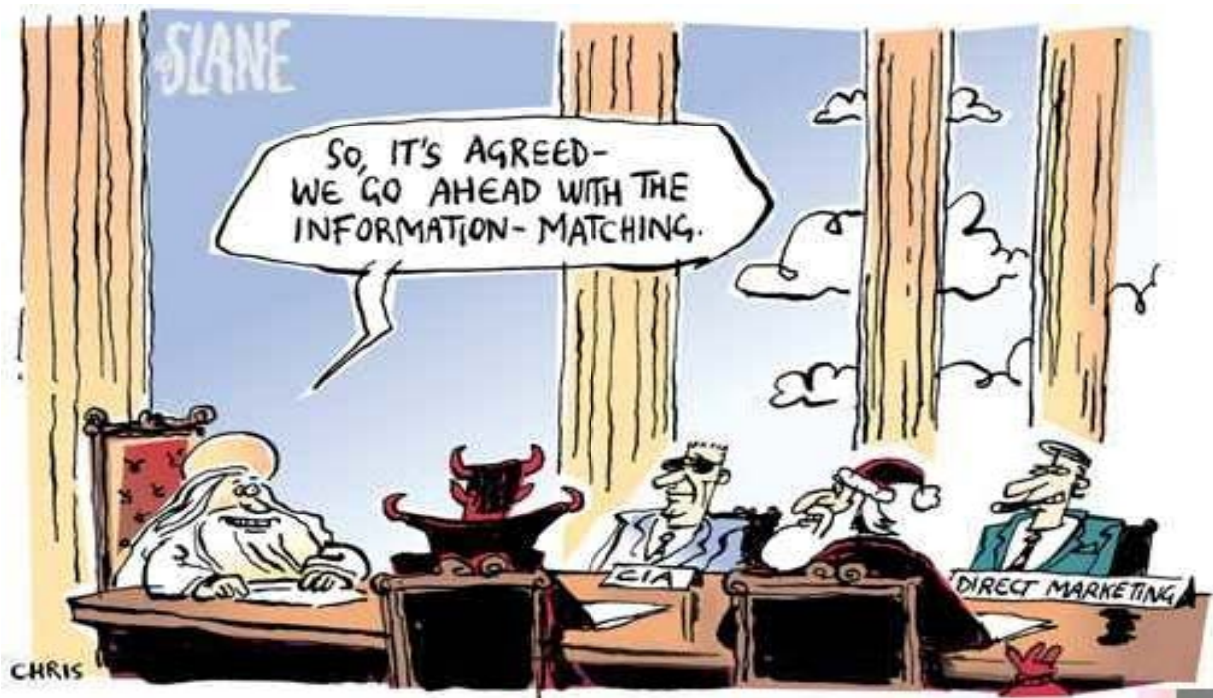
What are Geocodes?

- ◆ Systematic references to specific locations
 - Administrative units are generally numbered for ease of reference and to save space in complex databases.
 - In the U.S. we use Federal Information Processing Standard (FIPS) codes – and it's a good idea to use codes that are based on these standards
 - We also need a way to convert address information into analyzable form. Geocoding is a process whereby specific addresses are matched in an address database and latitude-longitude coordinates for that location are appended to each record. These coordinates can then be mapped.

Public Health Data Sources (with special reference to maternal and child health)

COMPONENTS OF AN IDEAL STATEWIDE PERINATAL DATABASE 1. Linkages relating to the index pregnancy

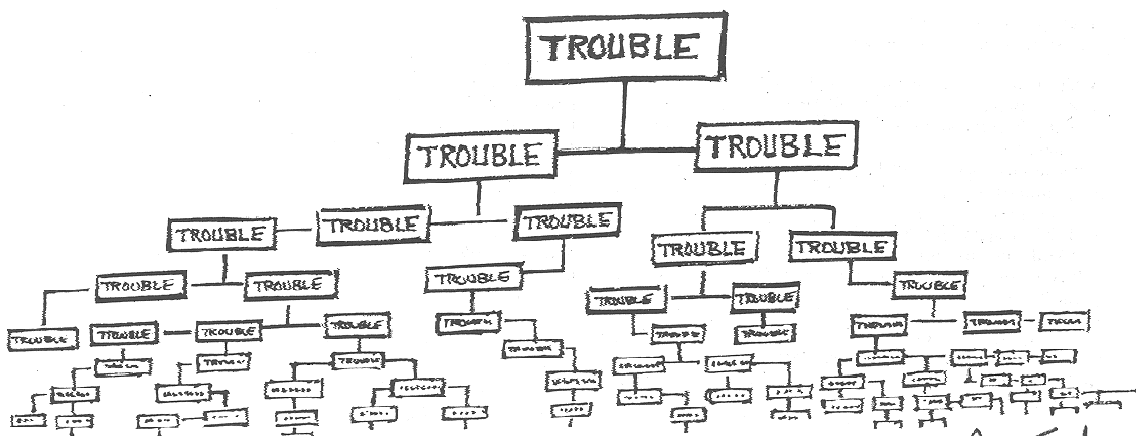
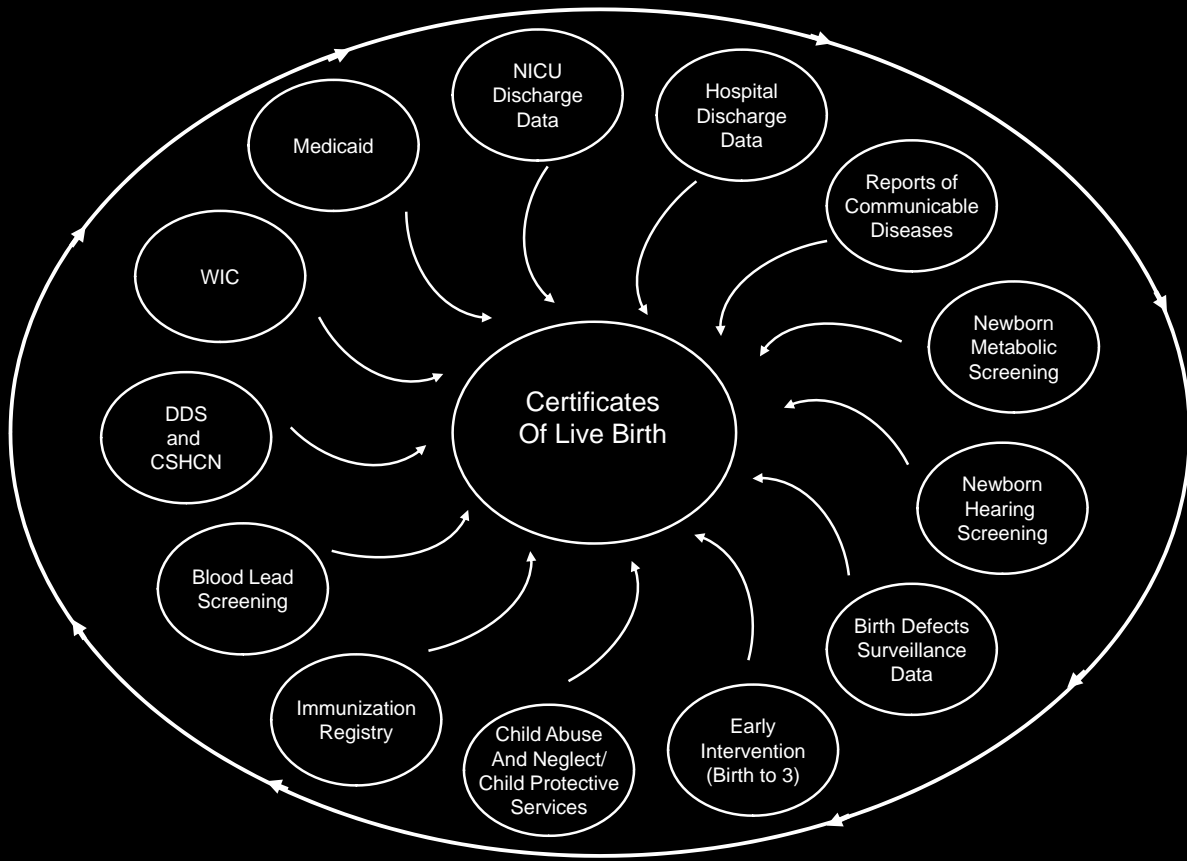




DEFINITIONS

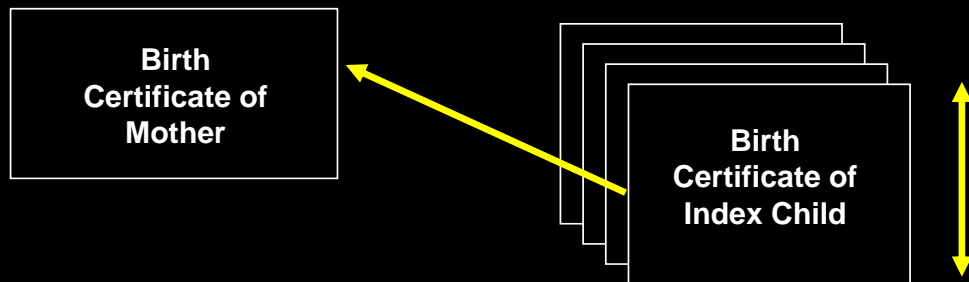
Medicaid (n): archaic Latin term, translating loosely into English as “a system of discontinuous health care services to the poor and disadvantaged.”

Source: Kirby's Eclectic Etymology for the Health Sciences, 22nd Edition. Podunk, IA: Posterior Press, 2001.



Dana Funder

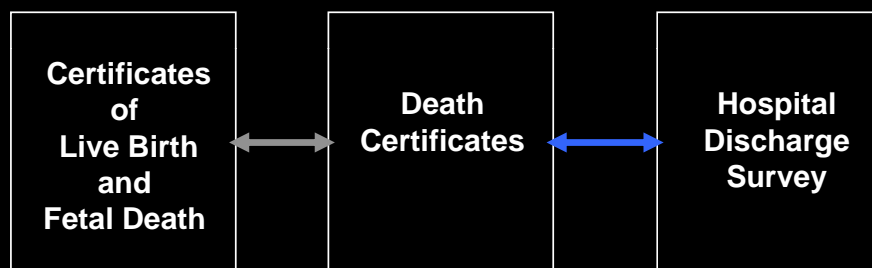
2. Linkages across pregnancies



- a. Sibship studies involving risk factors from a previous pregnancy, or prospective outcomes conditional on the index pregnancy. This can also apply to pedigrees, and to educational records across family members.
- b. Intergenerational effects of pregnancy outcomes.
- c. Linkages within maternal sibships across generations.

R. S. Kirby, Version 4/2/07

3. Linkages between mother and pregnancy



Routine linkage to identify maternal and reproductive deaths among women of child-bearing age (10 - 49), conducted among deaths occurring at 42 or 90 days, or within one year of termination of the index pregnancy. If spontaneous abortion and/or induced termination data are collected with personal identifiers, these events should also be routinely linked with death certificates, as should hospital discharge (in-patient or emergency room) records for deaths occurring to women with ICD-9-CM or CPT-4 codes relating to reproductive health.

R. S. Kirby, Version 8/19/96

COMPONENTS OF AN IDEAL STATEWIDE PERINATAL DATABASE

4. Routine automated geocoding of addresses to latitude-longitude coordinates

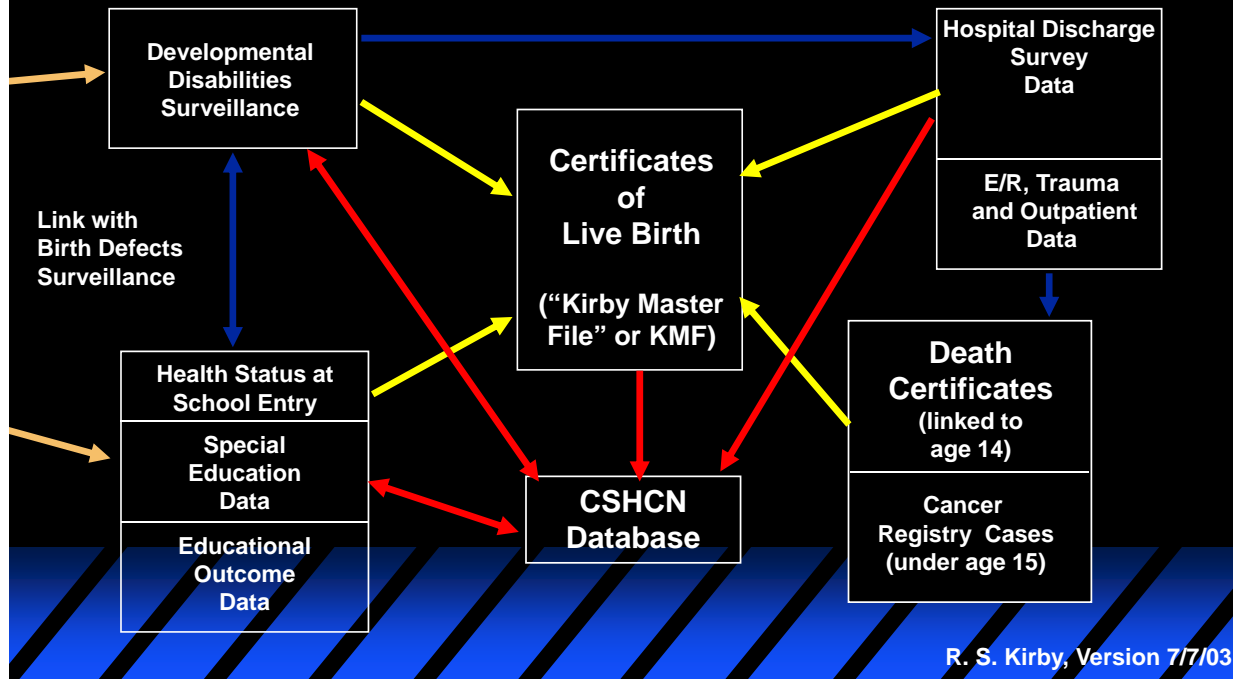
- All vital statistics records should be geocoded by place of residence.
- All health facilities should be geocoded by location.
- For mortality and injury studies, data sufficient to identify the location where the death or injury occurred should be recorded in the documentation, and this location should also be geocoded.
- Routine geocoding is an automated, computer-assisted process; the time required to do it diminishes with the implementation of a prospective system in which address files are continually corrected and updated.

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COMPONENTS OF AN IDEAL STATEWIDE PERINATAL DATABASE

5. Linkages for child health, growth and development



Public Health – Core Functions

- **Assessment**
- **Planning and Policy Development**
- **Assurance**
- **GIS has direct application for each of the core functions, and is most viable at the community scale**



"What I really hate is knowing that I'm doing this exactly the way my mother did it."

THE TEN COMMANDMENTS OF PUBLIC HEALTH GIS

With apologies to Mel Brooks, and thanks for editorial assistance to Elizabeth Kirby and for their insights to the following Internet contributors:

Dabo Brantley, DRH, CDC

Virginia Lee, ASTDR

Dona Schneider, Rutgers University

Russel Rickard, Colorado Department of Health and Environment

Dianne Enright, NC State Department of Health Statistics

Ravi Sharma, University of Pittsburgh

R.S. Kirby, December 2005



**Personally I'm always ready to learn, although
I do not always like being taught.**

-- Sir Winston Churchill

The Ten Commandments of Public Health GIS

Number 10

**Thou shalt not expect thine health
outcomes or disease states to respect
administrative (census block, or tract, ZIP
Code, municipal, mosquito abatement
district, bluegrass music noise control)
boundaries.**

**But without collecting geography in thine
data, thou hast nothing that can be mapped.**



The Ten Commandments of Public Health GIS

Number 9

Thou shalt not unknowingly commit spatial errors.

The Ten Commandments of Public Health GIS

Number 8


Know thy purpose (in creating and using your public health GIS).

Corollary: Thou shalt always be cognizant that the **Scientific Method is not a built-in feature of any GIS software application.**

Number 7


Thou shalt know and understand thine data* prior to bringing it into a GIS.

***Editor's note: this is a more specific example of the recently rediscovered 16th commandment, "Know thy data"**




Number 6

Thou shalt remember that while thine maps are abstractions, the maps reflect the physical environment and are based on data representing actual events that occurred to individual people.




Number 5

Thou shalt protect individual records containing X,Y coordinates as thou wouldst protect records with individual identifiers, as both can reveal confidential information.



Number 4

Thou shalt not clutter thine health data maps with unnecessary layers and map elements (i.e. **chartjunk), nor shalt thou ignore information necessary to interpret the patterns on your map.**



The Ten Commandments of Public Health GIS

Number 4 - addendum

“The real art of cartography is knowing more what to leave out, more than what to put in.”

- John Parsons

The Ten Commandments of Public Health GIS

Number 3

Know thine Metadata.

The Ten Commandments of Public Health GIS

Number 2

Thou shalt not assume that the default settings of thine GIS software will generate useful and meaningful maps.

The Ten Commandments of Public Health GIS

Number 1

Thou shalt show humility to others, and be gracious even unto those who thought it would take weeks to accomplish what thou hast done in a few hours.

Professor Kirby on Change

“The best way to ensure that things never
change is to keep doing the same thing .
..”



Contact Information

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- ◆ More top ten lists can be found at my USF website