Geographic-based Research and Applications at the National Cancer Institute

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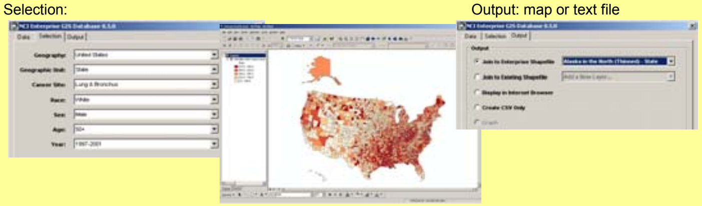
I. GIS database development

A. Enterprise GIS

- Goal: Provide comprehensive, consistent, easily maintained geospatial data for NCI division staff
- Content: Cancer rates and trends; sociodemographic, medical resource, behavioral risk factor data
- System architecture:
  - Visual Basic Form called from a VB .NET dll from within ArcMap
  - This program makes an internet call to a PHP program which retrieves data from Sybase database
  - Resulting text file is written to user's hard drive, joined to shapefile

Selection: Output: map or text file

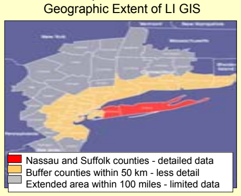


B. Geographic Information System for Breast Cancer Studies on Long Island

A Resource for researchers and the public interested in breast cancer patterns on Long Island

The LI GIS is a geographic information system (GIS) comprising data with statistical and spatial extensions. The LI GIS is designed to study the potential relationships between environmental exposures and breast cancer on Long Island. It also can be used to study other diseases.

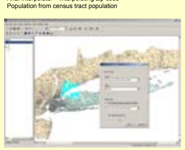
Geographic Extent of LI GIS



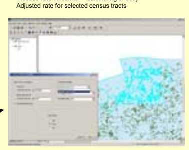
The LI GIS is one of a series of major studies and initiatives within the Long Island Breast Cancer Study Project (LIBCSP), congressionally mandated activities to understand breast cancer incidence rates on Long Island. Researchers can apply to use the entire LI GIS and/or the LI GIS statistical software and spatial extensions. Apply online at ***www.healthgis-li.com***

The LI GIS warehouse contains over 80 datasets covering:
- Topographic;
- Demographic;
- Health outcome, including relative breast cancer incidence; and
- Environmental data for Nassau and Suffolk counties, and to a lesser extent on surrounding counties.

Arial interpolator – interpolating zip code Population from census tract population

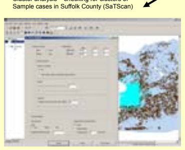


Disease rate calculator – calculating directly-Adjusted rate for selected census tracts

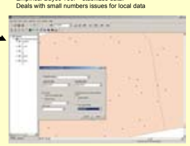


Researcher's toolbox:
A full suite of GIS software and extensions related to study of breast cancer
- ESRI ArcGIS software suite
  - ArcView & ArcInfo
  - Spatial Analysis & 3D Analyst
- **Extensions for epidemiological studies**
  - Case File Formatter
  - Disease Rate Calculator
  - Areal Interpolator
  - Cluster Analysis Tool (using SaTScan)
  - Empiricial Bayes Tool
  - EpiAnalyst
  - S-Plus Spatial Stats
  - Geographic masking
  - SAS
- Oracle 9i
- Online User's Guide
- Additional ArcView extensions and software

Cluster analysis – checking for clusters of Sample cases in Suffolk County (SaTScan)



Empirical Bayes Tool – stabilizes data. Deals with small numbers issues for local data



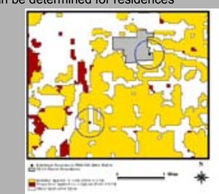
C. Related collaborative research by Surveillance, Epidemiology & End Results (SEER) cancer registries (Rapid Response Surveillance Studies)

- Development of high resolution population distribution data for cancer control
- Assessment of the accuracy of geocoding by geographic scale, impact of errors on cancer rates

II. Spatial data analysis

A. Environmental exposure assessment
B. Statistical modeling
C. Outlier detection for cancer surveillance
D. Cluster identification

Example: epidemiologic study of non-Hodgkin's lymphoma (NHL)
- Mapped residences, then assessed proximity of residences to specific crop
- Assigned probabilities of exposure based on available pesticide use data for each crop
- Demonstrated that zones of potential exposure to agricultural pesticides and proximity measures can be determined for residences



A. Environmental exposure assessment

- GIS can provide information about potential environmental exposures that cannot be obtained through traditional epidemiologic methods
- Study in south central Nebraska demonstrated use of satellite imagery to reconstruct historical crop patterns

Ward et al. Env Health Perspectives,2000

Landsat imagery (color infrared display of bands 4,2,1)

+

Farm Service Agency historical aerial photos with crops noted

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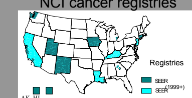
Classified land cover map

B. Statistical modeling

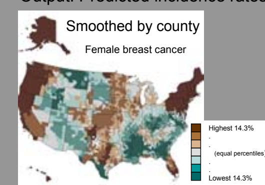
- Cancer incidence prediction project goal: model data from NCI cancer registries (470 counties), predict # cases in all states
- Use hierarchical Poisson regression models to characterize associations between cancer incidence and mortality, sociodemographic, lifestyle factors by county
- These factors explain spatial variation so well that no spatial correlation is needed in the model
- Extensions of original models:
  - Spatio-temporal prediction of cancer rates by state
  - Predicted incidence is used to predict prevalence
  - Predicted incidence is used to calculate % completeness of case ascertainment for each cancer registry

NCI cancer registries



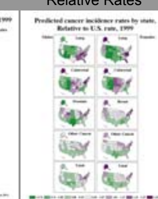
Covariate data available for all counties:
- cancer mortality rates
- sociodemographic factors (income, schooling, etc.)
- medical facilities
- cancer screening utilization
- smoking, obesity, no insurance

Output: Predicted incidence rates



Absolute Rates

Relative Rates

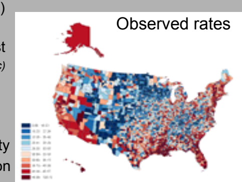


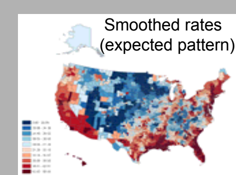
Pickle, Feuer, Edwards. U.S. Predicted Cancer Incidence, 1999: Complete maps by county and state from spatial projection models. NIH Pub No 03-5435, 2003 (available at ***srab.cancer.gov/incidence****)*

C. Outlier detection for cancer surveillance

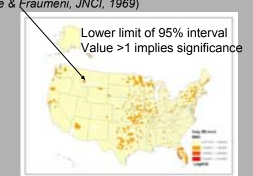
- Can we detect significant outliers (unusual occurrences) of the # of new cancer cases?
- Applied an empirical Bayes data mining algorithm to test data *(DuMouchel & Pregibon, Proc KDD, 2001; Lincoln Technologies, Inc)*
- Method assumes Poisson distribution of # cases, estimates Relative Risk = observed/expected
- Lung cancer mortality, white males, 1950-69
  - Smoothed map provided expected # cases per county
  - Algorithm compared actual # cases to this expectation
  - Found known "hot spot" in MT, site of copper smelter

Lung cancer mortality rates among white males, 1950-69





Most significant outlier is MT county where a copper smelter had polluted air with arsenic (*Lee & Fraumeni, JNCI, 1969*)

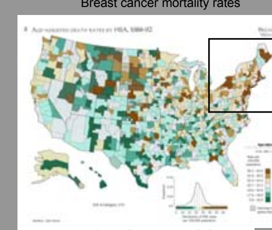


D. Cluster identification

- Are apparent map clusters real or random noise?
- SaTScan software identifies most likely significant cluster over space, time or both
- Algorithm: spatial scan statistic for Poisson or Bernoulli event data, adjusts for population heterogeneity & covariates
- Originally identified circular clusters, new version scans for elliptical clusters, various shapes & angles
- Software: www.satscan.org
- Recently extended to clusters of survival rates

Developed by Martin Kulldorff: Stat in Med, 1995, 1996; Communications in Statistics, 1997; Am J Epidemiology, 1997; Am J Public Health, 1998

Breast cancer mortality rates



Pickle et al., Atlas of United States Mortality, NCHS, 1996

Most likely cluster