GIS FOR PUBLIC HEALTH

Bernadette de Leon
Nov. 6, 2019
Do you recognize this map? Yes/No
OVERVIEW

• History and Background
• Uses of GIS and Spatial Analysis
  • “WHO” and How
  • Resources
• Where Are We Headed?
  • The “not too distant” future… Is it already here?
  • Challenges along the way
  • More data sources and tools
Q2: What is the significance of the map in terms of public health? Dr. John Snow mapped (cholera) deaths in London, and the map led to his health intervention of removing the pump handle.

Q3: Do you know the year this was created? 1854
URISA’s 2013 GIS in Public Health Conference
June 17-20, 2013
Hyatt Regency – Miami, Florida

Conference Vision: To provide an open and participatory forum for advancing the effective use of spatial information and geographic information system technologies across the domains of public health, healthcare and community health preparedness.

We are honored to welcome Dr. Estella Geraghty, as our distinguished keynote speaker. She will discuss “Big Data and Public Health”.

Welcome to Miami

The Urban and Regional Information Systems Association (URISA) is pleased to present the 2013 GIS in Public Health Conference in Miami, Florida!

Estella “Este” M. Geraghty, MD, MS, MPH, FACP, GISP
In 1832, Charles Picquet represented the percentage of cholera deaths (per 1,000) in the 48 Paris districts, using a halftone gradient. This map, shows high percentages in districts along the Seine. This map and extensive tabular data appeared in *Rapport sur la marche et les effets du choléra dans Paris et le département de la Seine*.
The 1831 map of cholera published in a Lancet article provides a convenient birth date for the birth of global health as a concept.


© The Author 2014; all rights reserved. Published by Oxford University Press on behalf of the International Epidemiological Association
In 1832, the number of deaths caused by cholera in the years 1833 and 1834 is shown on this map. The area around the City Prison, Castle, and Northernhay is particularly affected. The map also shows the locations of various hospitals and burial grounds.

REFERENCE:
- Shilhay and Lions Hall: where clothes were destroyed
- Station House
- 6.5.6.1, Druggists
- 8.9, Cholera Burying Grounds
- Soup Kitchens
- House for Convalescents
- Guildhall
- Episcopalian School House

DEATHS in 1832
- in 1833
- in 1834

REFERENCE TO PARISHES:
- St. Peter's
- St. Martin's
- St. Paul's
- St. Stephen's
- St. Pancras
- St. Swithin's
- St. Lawrence
- All Hallows
- Nine
- Trinity

The map shows the mortality rates from cholera in various parishes.
Plate from An Inquiry into the Cause of the Prevalence of the Yellow Fever in New-York, by Dr. Valentine Seaman dated March 10, 1797. From Medical Repository, 1 (1800, 2nd edition): 303-323 [Rare Books Collection]

http://libweb5.princeton.edu/visual_materials/maps/web sites/thematic-maps/quantitative/medicine/medicine.html
Background/History (cont.)

• Medical Geography developed over centuries

• 1996 Keith C. Clarke, Sara L. McLafferty, and Barbara J. Tempalski  *On epidemiology and geographic information systems: A review and discussion of future directions*  
https://wwwnc.cdc.gov/eid/article/2/2/96-0202_article

---

**Environmental risk factors for Lyme disease identified with geographic information systems.**

Glass GE¹, Schwartz BS, Morgan JM 3rd, Johnson DT, Noy PM, Israel E.

**Author information**

1 Department of Molecular Microbiology and Immunology, Johns Hopkins University School of Hygiene and Public Health, Baltimore, MD 21205, USA.

**Abstract**

**OBJECTIVES:** A geographic information system was used to identify and locate residential environmental risk factors for Lyme disease.
Background/History (cont.)
GIS & Spatial Analysis Belong *Everywhere* in Public Health

• Medical/Health Geography
• Five Core Public Health Disciplines
  • Epidemiology
  • Environmental Health
  • Social & Behavioral Health
  • Administration
  • Biostatistics

• Public Health and Safety (not a focus here)
  • Previous URISA webinar by Chris Vaughan, FEMA GIO and Response Geospatial Office
  • Also, Andrew Curtis, GIS Health and Hazards Lab at Kent State University, Closing Keynote in 2013: *Health, Disasters and Crime: Working Geospatially at the “Scale” of Intervention*
GIS and Spatial Analysis for Public Health: The “WHO” and How

• Global Health organizations (e.g., WHO.int)
• U.S. Government Agencies and Congress
  • Centers for Disease Control and Prevention
  • EPA, USGS, NOAA, Data.gov, etc.
• State and Local Governments (e.g., www.in.gov/isdh/25154.htm)
• Universities and Research Institutions
• Non-profits (e.g., www.urisa.org/urisahealth, www.statsamerica.org and Healthmap.org)
GIS at the CDC

www.cdc.gov/gis/gis-at-cdc.htm

For questions or more information, please contact the Geography and Geospatial Science Working Group (GeoSWG) Executive Committee at geoswg@cdc.gov.

<table>
<thead>
<tr>
<th>Agency for Toxic Substances and Disease Registry (ATSDR)/Centers for Disease Control and Prevention - Geospatial Research, Analysis, and Services Program (GRASP)</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) - Division of Diabetes Translation</td>
<td>+</td>
</tr>
<tr>
<td>National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) - Division for Heart Disease and Stroke Prevention</td>
<td>+</td>
</tr>
<tr>
<td>National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) - Division of Population Health</td>
<td>+</td>
</tr>
<tr>
<td>National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) - Division of Reproductive Health</td>
<td>+</td>
</tr>
<tr>
<td>National Center for Immunization and Respiratory Diseases (NCIRD) - Division of Bacterial Diseases (DBD)</td>
<td>+</td>
</tr>
<tr>
<td>Division of Global Migration and Quarantine</td>
<td>+</td>
</tr>
<tr>
<td>National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP)</td>
<td>+</td>
</tr>
</tbody>
</table>
Six in ten Americans live with at least one chronic disease, like heart disease and stroke, cancer, or diabetes. These and other chronic diseases are the leading causes of death and disability in America, and they are also a leading driver of health care costs.

At CDC, our job is to make it easier for all Americans to make healthy choices so they can enjoy life. We know that most chronic diseases can be prevented by eating well, being physically active, avoiding tobacco and excessive drinking, and getting regular health screenings. CDC's National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) helps people and communities prevent chronic diseases and promotes health and wellness for all.
CDC GIS Resources
www.cdc.gov/gis/resources.htm

Explore GIS Resources

- Map Making Resources
- Geospatial Data Resources
- Online Public Health Maps
- GIS Software & Tools

For questions or more information, please contact the GeoSWG Executive Committee at geoswg@cdc.gov.

Content source: National Center for Chronic Disease Prevention and Health Promotion, Division for Heart Disease and Stroke Prevention
GIS and Public Health at CDC

GIS are computer-based tools used to store, visualize, analyze, and interpret geographic data. These data include anything that can be associated with a location on the globe, or more simply anything that can be mapped. For example, cases of disease, hospitals, roads, waterways, country boundaries, and health catchment areas are all types of spatial data. In a GIS, the data usually include attributes, or descriptive information. For example, you may have a data set of hospitals in the US that can be mapped. The descriptive data also allows you to search and display associated attributes (e.g., number of hospital beds, types of specialized services offered, etc). In terms of analysis, a GIS offers the opportunity to use spatial data to answer questions. For example: where are disease rates higher or lower? how far is it to the nearest healthcare facility? and where can we best locate a new syringe exchange location?

For more information, check out What is GIS?

Learn new GIS techniques & explore training modules
Apps from the CDC

www.cdc.gov/csels/dhis

Division of Health Informatics and Surveillance

Vision
Timely, high-quality data guide public health decisions and actions

Case-based Surveillance  Syndromic Surveillance  CDC WONDER

Learn how NNDSS defends America from health threats and why CDC is modernizing this critical notifiable diseases surveillance system.

NNDSS  NSSP  WONDER

MVPS is software that receives, processes, and provisions data for nationally notifiable diseases based on HL7 standards and new technology.

NBS is an integrated information system that helps local, state, and territorial public health departments manage reportable disease data and send notifiable disease data to CDC.

The PHIN Public Health Directory (PHIN DIR) is a repository of information about organizations and jurisdictions important to public health programs and provides Object Identifiers (OIDs) for use within the public health community.

PHINMS  PHIN VADS  Guides

PHINMS is software that securely sends and receives any message type and facilitates interoperability among public health information systems.

PHIN VADS provides standard vocabularies to CDC and its public health partners in one place as a web-based enterprise vocabulary system.

Access messaging guides on:
- Cancer Reporting
- Immunization
- Mail
- Message Transport
- Network Infrastructure
- Surveillance
Epidemiologic Case Studies

Web-based Case Study

Classroom Case Studies

Instructor’s Guide

Foodborne Disease

Foodborne Disease Case Studies

These Epidemiologic Case Studies are based on historical events and include epidemiologic methods that were practiced at the time. Given the historical nature of this content, the methods that are referenced on this site may be outdated practices in some settings. As some of the practices are still used, they continue to offer educational value.

The foodborne disease case studies available:
- Botulism in Argentina
- Gastroenteritis in Texas
- Multistate Outbreak of Cyclosporiasis
- Multistate Outbreak of E. coli O157:H7
- Salmonella in the Caribbean

Page last reviewed: September 11, 2017
Monitoring health for the SDGs

The 17 Sustainable Development Goals adopted by world leaders in September 2015 set out a vision for a world free of poverty, hunger, disease and want. SDG 3, “Good Health and Well-Being,” calls on countries to ensure healthy lives and promote well-being for all at all ages.

— View/Download the World Health Statistics 2019 Overview

SDG health and health related targets

3.1 Maternal mortality
3.2 Newborn and child mortality
3.3 Communicable diseases
3.4 Noncommunicable diseases and mental health
3.5 Substance abuse
3.6 Road traffic injuries
3.7 Sexual and reproductive health
3.8 Universal health coverage
Pan American Health Organization

www.paho.org/data
Editorials

New ethical challenges of digital technologies, machine learning and artificial intelligence in public health: a call for papers

Diana Zandi, Andreas Reis, Effy Vayena & Kenneth Goodman
URISA.org Training Resources (www.gisinpublichealth.org)
STATE HEALTH OFFICIALS RENEW WARNING ABOUT SALMONELLA AND “BACKYARD POULTRY”

OLYMPIA — Four more cases of Salmonella illness, including one here in Clallam County, which are all linked to contact with backyard poultry, were reported by health officials this week.

Cases, which also included one each in Island, Stevens, and Spokane counties, raised Washington’s outbreak total to 20 cases so far this year.

As Salmonella infection, children are especially at risk of illness and should be asked to wash their hands and have more frequent hand-to-mouth activities. Salmonella infection begins about one to three days after exposure.
www.statsamerica.org
Other: Kaiser Family Foundation
www.kff.org/statedata
“Not Too Distant” Future of GIS for Public Health

IMAGE: "Artificial Intelligence - BBC Newsnight" by Sandra Rodríguez Chillida is licensed under CC BY-NC-ND 4.0
Artificial Intelligence

“Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions) and self-correction.”

From https://searchenterpriseai.techtarget.com/definition/Al-Artificial-Intelligence
Artificial Intelligence

- Machine Learning (ML)
  - Deep Learning
  - Supervised
  - Unsupervised
  - Reinforcement

- Expert Systems
- Natural Language Processing (NLP)
  - Text Generation
  - Query Answering
  - Machine Translation
  - Classification
  - Content Extraction
- Robotics
- Vison
  - Image Recognition
  - Machine Vision
- Speech
  - Text to Speech
  - Speech to Text

Planning, Scheduling, Optimization

Above graphic modeled after www.researchgate.net/figure/Fields-of-artificial-intelligence-10_fig1_324183626 and definitions at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6199467/
“Not Too Distant” Future of GIS for Public Health: Artificial Intelligence

Digital epidemiology: how big data challenge ethics, society and politics in infectious disease surveillance

Edited by
Tim Eckmanns, Robert Koch Institute, Berlin, Germany
Leon Hempel, Technical University Berlin, Germany
Kate Polin, Robert Koch Institute, Berlin, Germany
Klaus Scheuermann, Berlin, Germany

https://www.biomedcentral.com/collections/DEBD
“Not Too Distant” Future of GIS for Public Health: Artificial Intelligence

<table>
<thead>
<tr>
<th>Potential use of artificial intelligence</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysing patterns of data for almost real-time surveillance and disease detection</td>
<td>Using Google search and phone GPS information to predict restaurants that are causing foodborne illness</td>
</tr>
<tr>
<td>Offering targeted and personalised health advice based on personal risk profile and behavioural patterns</td>
<td>Using machine learning to generate improved cardiovascular disease risk models</td>
</tr>
<tr>
<td>(1) Using machine learning to detect abnormalities in screening tests such as mammography or cervical cytology; (2) machine learning-facilitated automated evidence synthesis</td>
<td>(1) Deep learning algorithms for detecting diabetic retinopathy; (2) the Human Behaviour-Change Project uses machine learning for evidence synthesis and interpretation around behaviour change</td>
</tr>
</tbody>
</table>

From Lancet (https://doi.org/10.1016/S2589-7500(19)30002-0)
Smarterphone apps & image analysis

A cellphone-based microscope for treating river blindness

By Brett Israel, Media relations | NOVEMBER 5, 2017

An adult Loa loa worm.

A smartphone-based microscope technology developed at UC Berkeley has been used to help treat river blindness, a debilitating disease caused by parasitic worms. The technology, called LoaScope, uses video from a smartphone-connected microscope to automatically detect and quantify infection by parasitic worms in a drop of blood.

An app uses a smartphone camera to detect leukocoria, a pale reflection from the back of the eye. It can be an early sign of disease. Here it appears light brown compared the healthy eye.

Munson et al., Sci. Adv. 2019; 5 eaax 6363
Future of GIS for Public Health: You May Want to Learn about Sensors

<table>
<thead>
<tr>
<th>Data collection</th>
<th>Processing</th>
<th>Analysis and interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Multisensor studies</td>
<td>• Algorithm processing of sensor data</td>
<td>• Life-segment momentary analyses</td>
</tr>
<tr>
<td>• Wearable sensors of:</td>
<td>° Physical activity</td>
<td>° Short-term intensive longitudinal data</td>
</tr>
<tr>
<td>° Location</td>
<td>° Sedentary time</td>
<td>° Dynamic multiplace exposure</td>
</tr>
<tr>
<td>° Behavior</td>
<td>° Body posture</td>
<td>° Spatiotemporally disaggregated outcomes</td>
</tr>
<tr>
<td>° Environmental exposures</td>
<td>° Energy expenditure</td>
<td>° Intraindividual statistical units</td>
</tr>
<tr>
<td>° Health/physiology</td>
<td>° Outdoor time</td>
<td>° Analysis of time sequences</td>
</tr>
<tr>
<td>• Complementation of passive sensor data</td>
<td>° Sleep</td>
<td>° Case-crossover analyses of within-person differences</td>
</tr>
<tr>
<td>° Diaries alignment issues</td>
<td>° Social contacts</td>
<td></td>
</tr>
<tr>
<td>° GPS-based mobility survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>° Ecological momentary assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Geographic momentary assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Geographically explicit ecological momentary assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Algorithm for:</td>
<td>• Environmental exposures</td>
<td>• Analytical biases</td>
</tr>
<tr>
<td>° Place recognition</td>
<td>° Non-area-based measures</td>
<td>° Selection bias (due to nonwear of devices, etc.)</td>
</tr>
<tr>
<td>° Trip recognition</td>
<td>° Area-based variables</td>
<td>° Selective daily mobility bias (confounding)</td>
</tr>
<tr>
<td>° Activity recognition</td>
<td></td>
<td>° Time-varying confounders</td>
</tr>
<tr>
<td>° Transport mode recognition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Personal exposure areas</td>
<td>• Recommendations for just-in-time interventions</td>
<td></td>
</tr>
<tr>
<td>° Activity space variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>° Daily path area (to avoid spatial misclassification)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>° Which buffering radius?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>° Durations of exposure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The “Future” of GIS for Public Health: You May Want to Learn about Sensors

- **Environmental sensors**
  - Humidity
  - Barometer (atmospheric pressure)
  - Altimeter
  - Thermometer (environmental temperature)
  - Ultraviolet
  - Light
  - Air pollutants
  - Noise
  - Electromagnetic fields
  - Number of mobile phones in the vicinity

- **Behavioral sensors**
  - GPS receivers
  - Pedometers
  - Accelerometers
  - Added magnetometer and gyroscope (inertial measurement unit)

- **Cross-cutting tools**
  - Wearable cameras
  - Smartphones
  - Multisensor devices

- **Health and physiology**
  - Body temperature
  - Heart rate
  - Ambulatory blood pressure
  - Respiratory rate
  - Electrodermal activity
  - Blood glucose

The “Future” of GIS for Public Health: You May Want to Learn about... Sensors
The “Future” of GIS for Public Health: You May Want to Learn about... Drones

Press release

Child given world’s first drone-delivered vaccine in Vanuatu - UNICEF

With 1 in 5 children in the remote Pacific island nation not fully immunized, UNICEF partners with the Government on first-ever commercial contract to deliver vaccines by drone

18 December 2018

PORT VILA/ NEW YORK, 18 December 2018 – One month old Joy Nowai today became the world’s first child to be given a vaccine delivered commercially by drone in a remote island in the South Pacific country of Vanuatu.
Some of the Current Challenges

• We often give up privacy for convenience of apps?
• Confidentiality Issues/HIPAA Privacy Rule makes mapping, collecting data & doing spatial analysis challenging. Also, the EU’s General Data Protection Regulation (GDPR).
• Some large data sets that were available in the early 21st century are now less accessible to researchers.
• Though resource-rich countries are well underway in terms of using AI and deploying apps to scale, Wahl, *et al.* warn that health officials and researchers need to attend to ethical & legal issues 
  gh.bmj.com/content/bmjgh/3/4/e000798.full.pdf
• Also, big data is not always clean data. Make certain that you know what you have and the quality of the data.
More data sources & tools…
Please email yours to deleon@iu.edu

- US Government data.gov with:
  - cdc.gov/DataStatistics
  - USDA www.usda.gov/topics/data

- SatScan www.satscan.org
- GeoDa spatial.uchicago.edu/geoda
- U. Arkansas http://uark.libguides.com/gis/gisdata
- Berkley http://guides.lib.berkeley.edu/publichealth/subjects
- Esri livingatlas.arcgis.com & gislounge.com/public-health
- Healthmap healthmap.wordpress.com/resources-2
QUESTIONS?

Bernadette de Leon
deleon@indiana.edu