McMaster University

Family Medicine

Geographic Information Systems and Health Research

Watch a recording of the session here

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Michael G. DeGroote SCHOOL OF MEDICINE

Learning Objectives:

Attendees will develop a foundational understanding of:

1. Geographic Information Systems (GIS):
    1. The Origin of Modern GIS
    2. Important GIS concepts
    3. Common GIS Software
2. Applications for health research & science:
    1. Infectious disease epidemiology & outbreak control
    2. Environmental & public health
    3. Health services research
    4. Primary care
3. Resources available to McMaster University personnel

What is a Geographic Information System?

A **Geographic Information System (GIS)** is a computer system used for capturing, storing, manipulating, analyzing and visualizing geographic information and data.

The Origin of Modern GIS

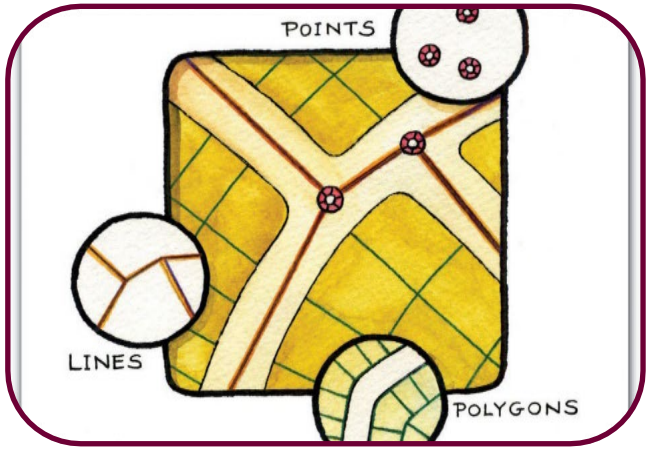
GIS was pioneered by **Dr. Roger Tomlinson** in the 1960s, who was an Assistant Professor at Acadia University.

Dr. Tomlinson developed the first GIS system, the **Canada Geographic Information System**.

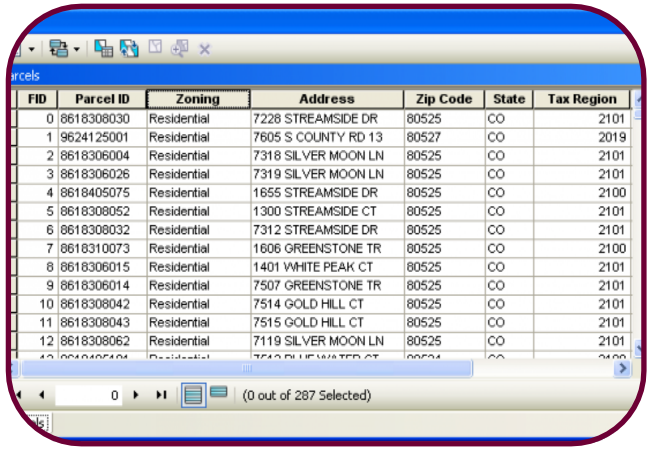
In 1965, the **Harvard Laboratory for Computer Graphics and Spatial Analysis** was established, which lead to the development of **Environmental Systems Research Institute, Inc. (ESRI).**

Important GIS Concepts

There are three types of GIS data:



Spatial

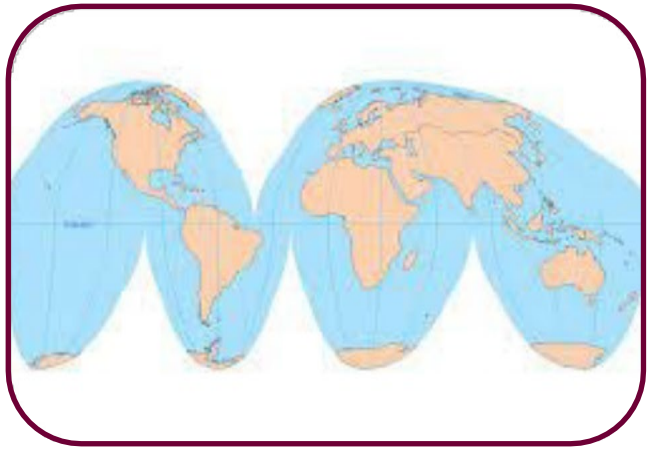


arcels

FID	Parcel ID	Zoning	Address	Zip Code	State	Tax Region
0	8618308030	Residential	7228 STREAMSIDE DR	80525	CO	2101
1	9624125001	Residential	7605 S COUNTY RD 13	80527	CO	2019
2	8618306004	Residential	7318 SILVER MOON LN	80525	CO	2101
3	8618306026	Residential	7319 SILVER MOON LN	80525	CO	2101
4	8618405075	Residential	1655 STREAMSIDE DR	80525	CO	2100
5	8618308052	Residential	1300 STREAMSIDE CT	80525	CO	2101
6	8618308032	Residential	7312 STREAMSIDE DR	80525	CO	2101
7	8618310073	Residential	1606 GREENSTONE TR	80525	CO	2100
8	8618306015	Residential	1401 WHITE PEAK CT	80525	CO	2101
9	8618306014	Residential	7507 GREENSTONE TR	80525	CO	2101
10	8618308042	Residential	7514 GOLD HILL CT	80525	CO	2101
11	8618308043	Residential	7515 GOLD HILL CT	80525	CO	2101
12	8618308062	Residential	7119 SILVER MOON LN	80525	CO	2101

(0 out of 287 Selected)

Attribute



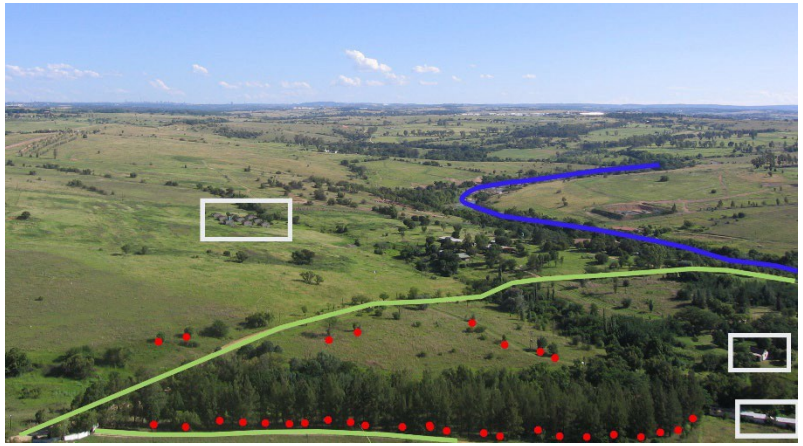
Metadata

Spatial Data

Vector

Point, line or polygon data.

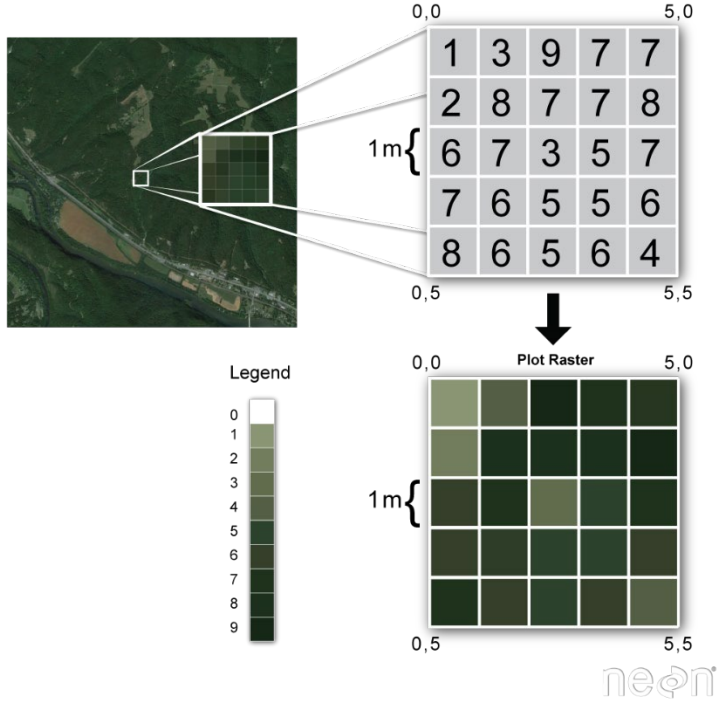
Ex:



Raster

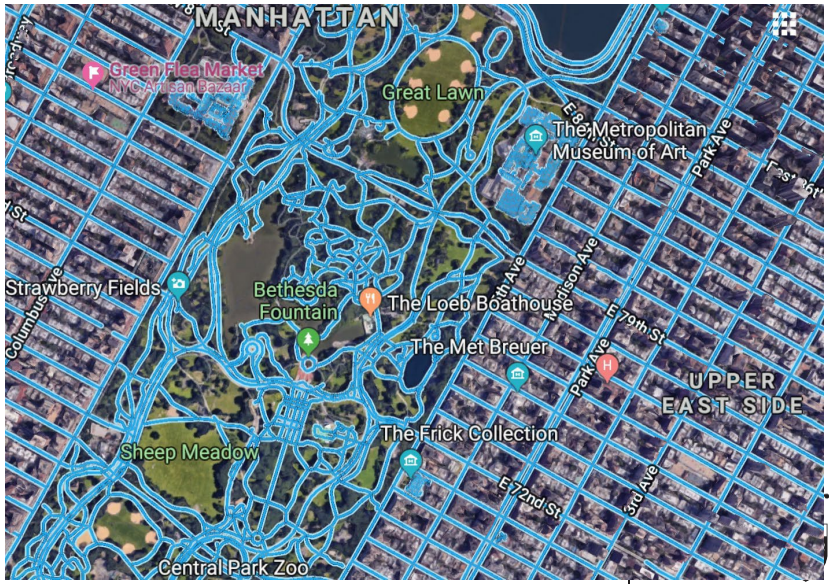
Grid data.

Ex:

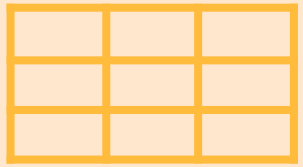


Images*

Pictures such as remote sensing data or scans of maps.
Ex:



Attribute Data & Metadata



Attribute Data are non-spatial characteristics that are connected to spatial data by data tables. Attribute data is vital to any form of spatial analysis.

Example: Vector data identifying postal code zones could be linked to Census Data in table format.

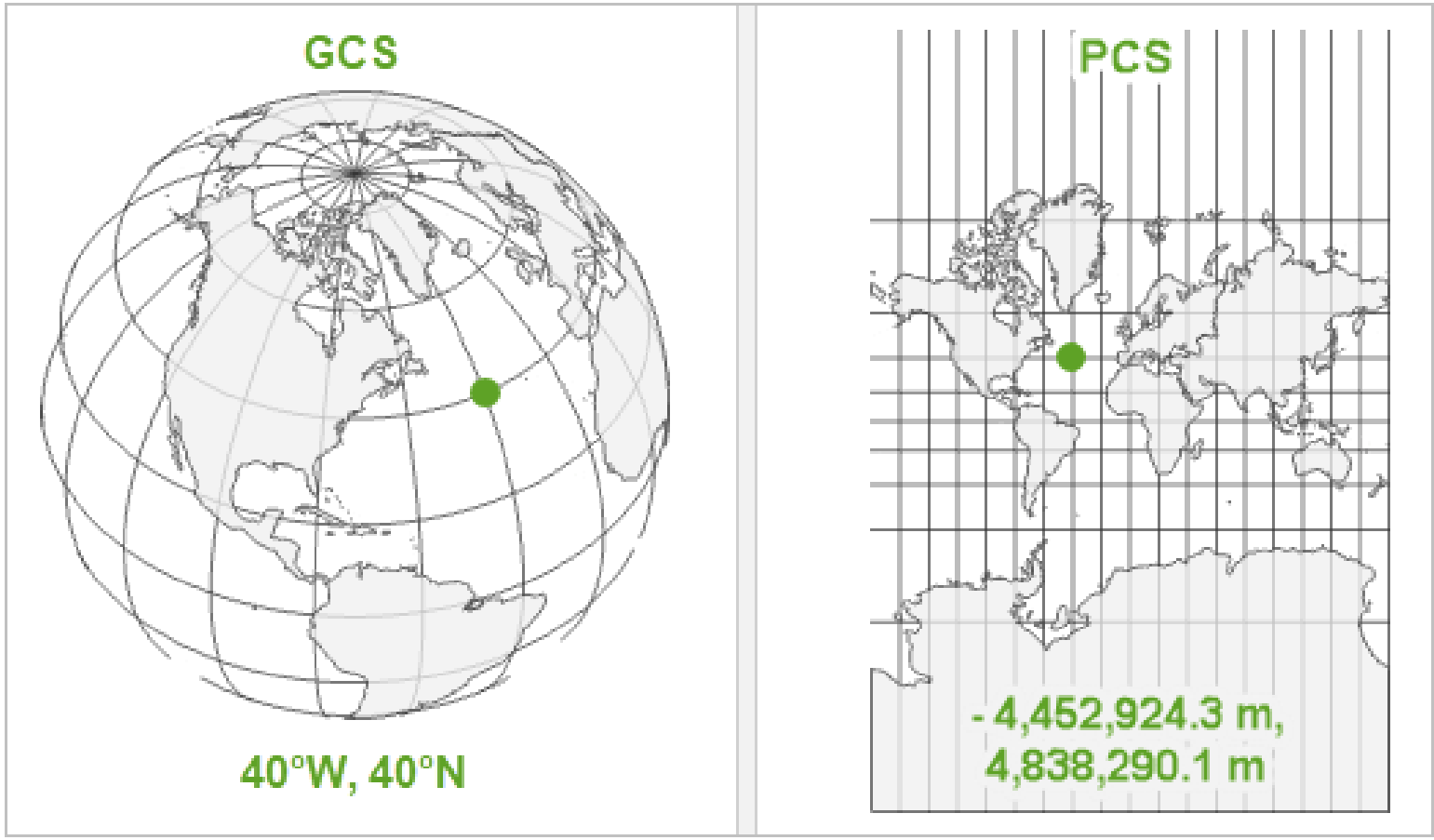
Metadata is vital to GIS. Metadata includes the scale of the data, accuracy, projection types, and data sources. It is important to always disclose the metadata for the data used in your analyses or maps.

Example: Title, Data Type, Source, Author, Modified Date, Thumbnail, and Tags.

What are Geographic Coordinate Systems & Projections?

Geographic Coordinate Systems uses 3-D spherical surfaces to define locations on earth.

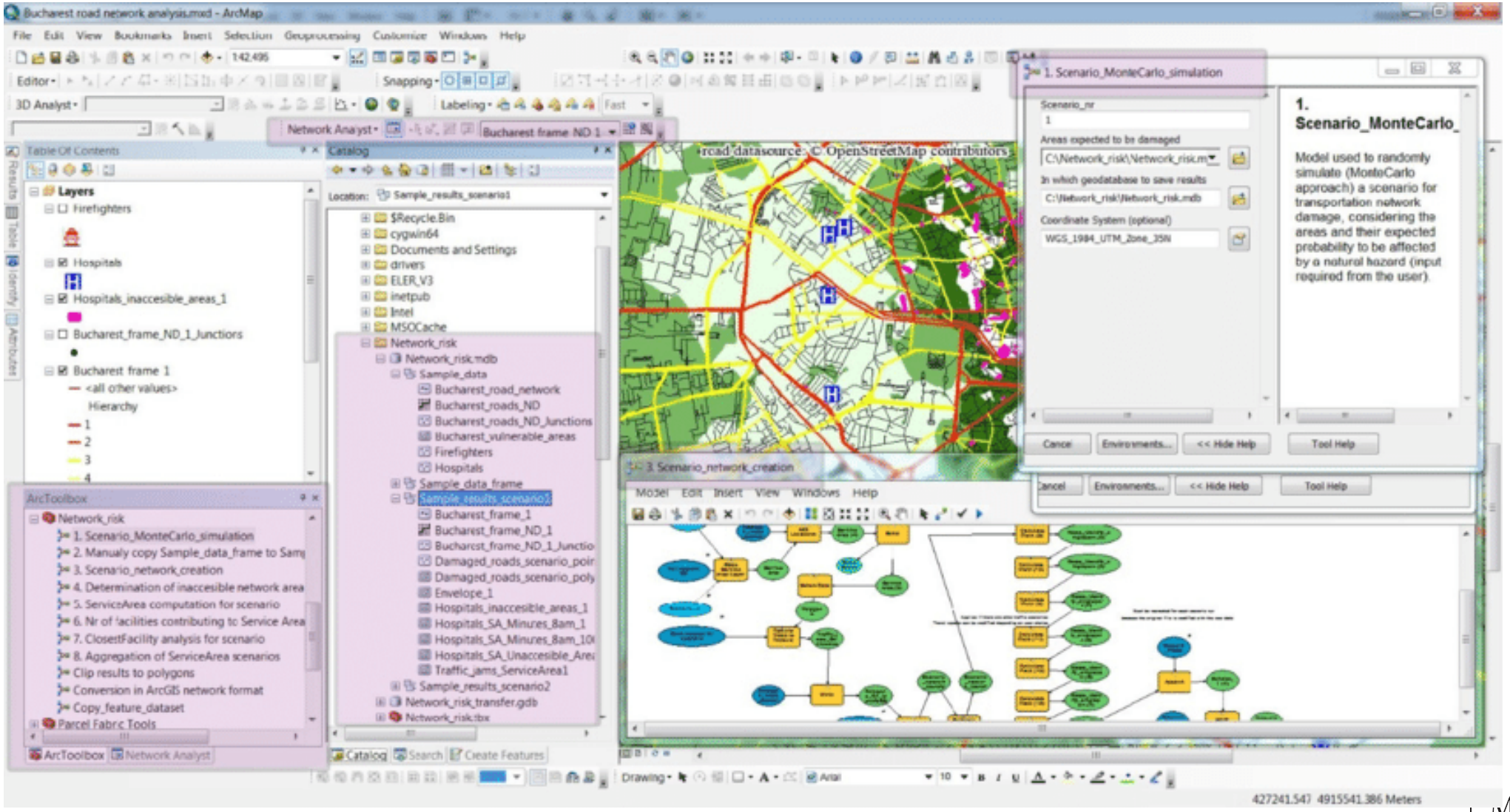
Projections are mathematical transformations to confirm spherical coordinates (such as latitude and longitude) to an XY coordinate system.



Common GIS Software

Software	Operating System	Field of Interest	Language	Free to Public?
ArcGIS	Windows, Linux	Created, visualize, and analyze spatial data.	Python	No
Google Earth	Windows, Linux, MacOS	3D visualization for dynamic graphics and maps.	N/A	Yes
QGIS	Windows, Linux, MacOS	Visualization & analysis (basic and complex).	C++	Yes
S-Plus	Windows, Linux	ArcView (ArcGIS) integration for complex analysis.	S	No
R-Analysis of Spatial Data	Windows, Linux, MacOS	Integration to various GIS environments for basic and complex analysis.	R	Yes

ArcGIS



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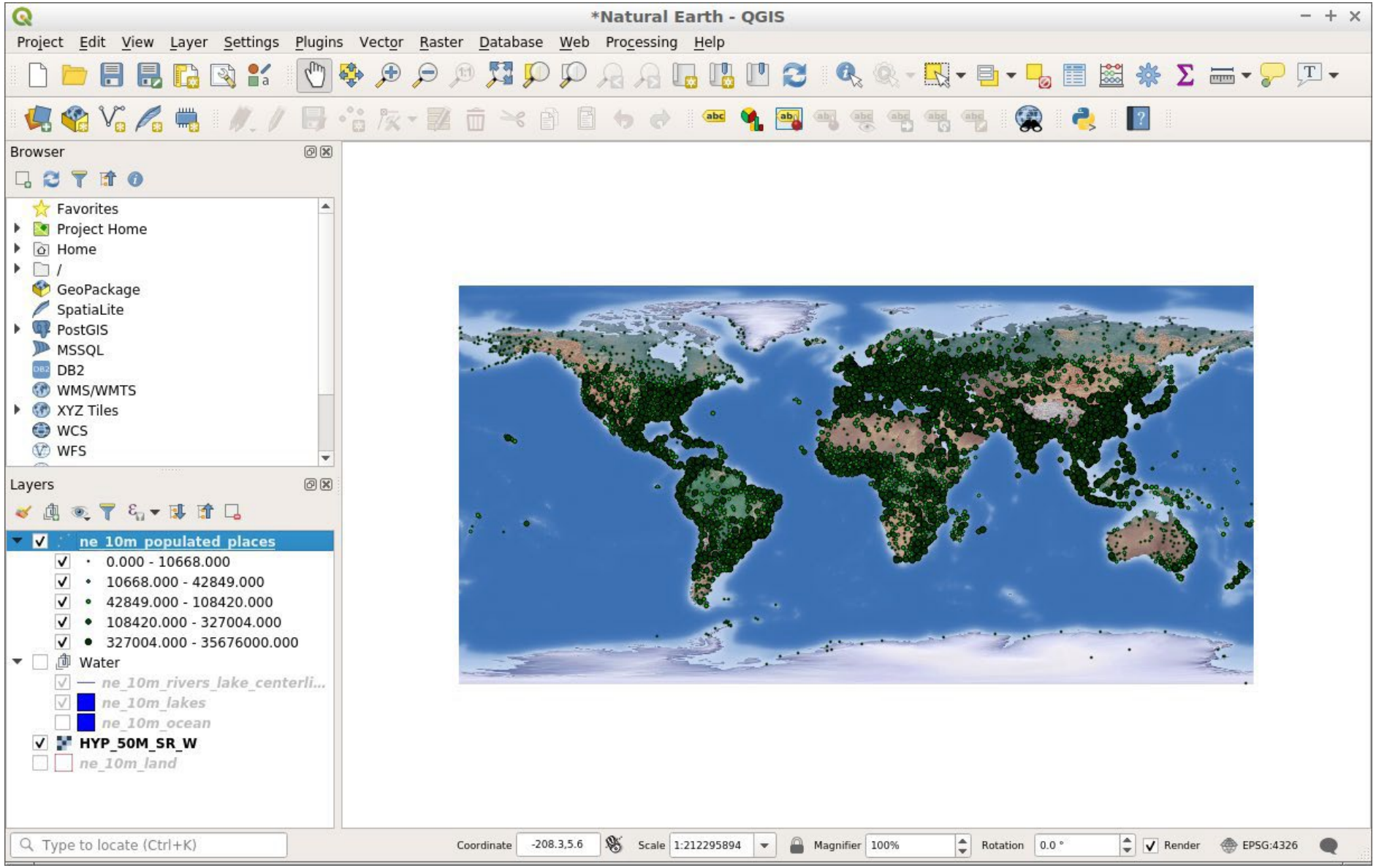
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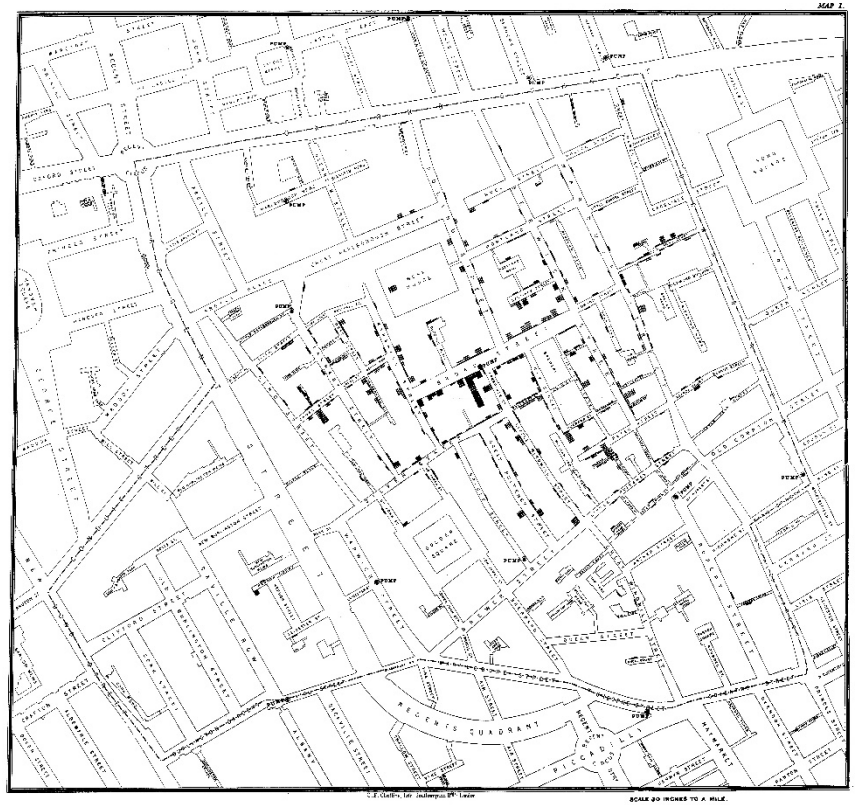
Applications for Health Research & Science

Infectious Disease Epidemiology & Outbreak Control

Before we discuss modern examples…

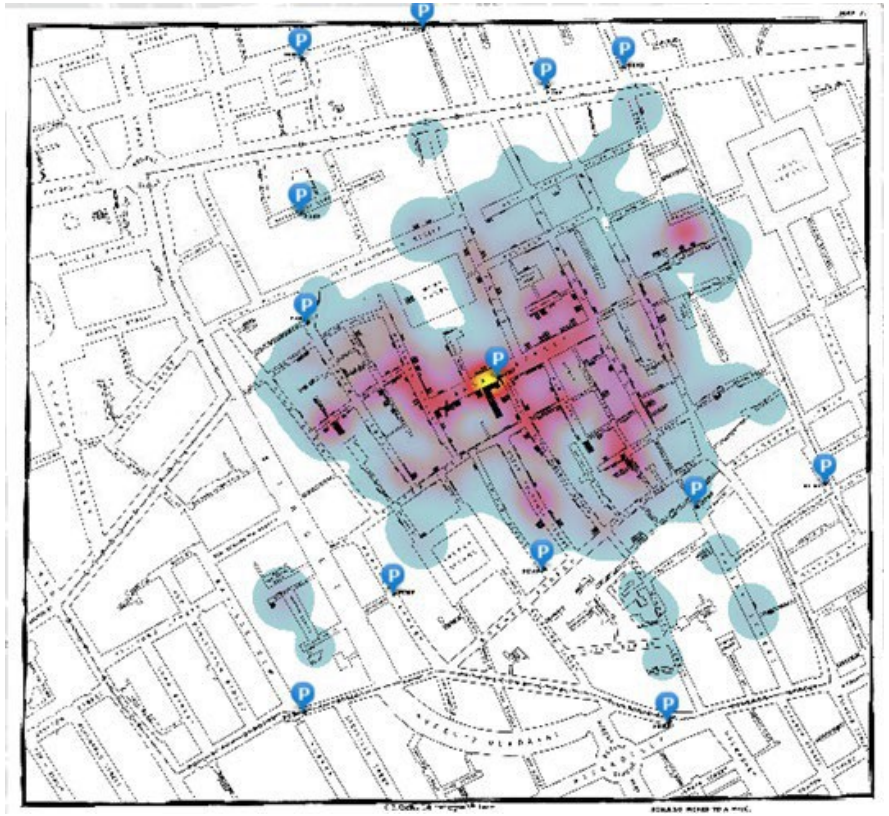


In 1854, London was experiencing a cholera pandemic.

Dr. John Snow identified clusters of cholera cases surrounding the Broad Street public water pump.

Infectious Disease Epidemiology & Outbreak Control

Before we discuss modern examples…



Early use of documenting disease cases through maps.

ArcGIS heat map to demonstrate distribution of cases.

Potential to expand to Hotspot Spatial Analysis.

COVID19 [1]

Guan WJ, Ni ZY, Hu Y, et al. **Clinical Characteristics of Coronavirus Disease 2019 in China**. *N Engl J M. Apr 30 2020;382(18):1708-1720.*

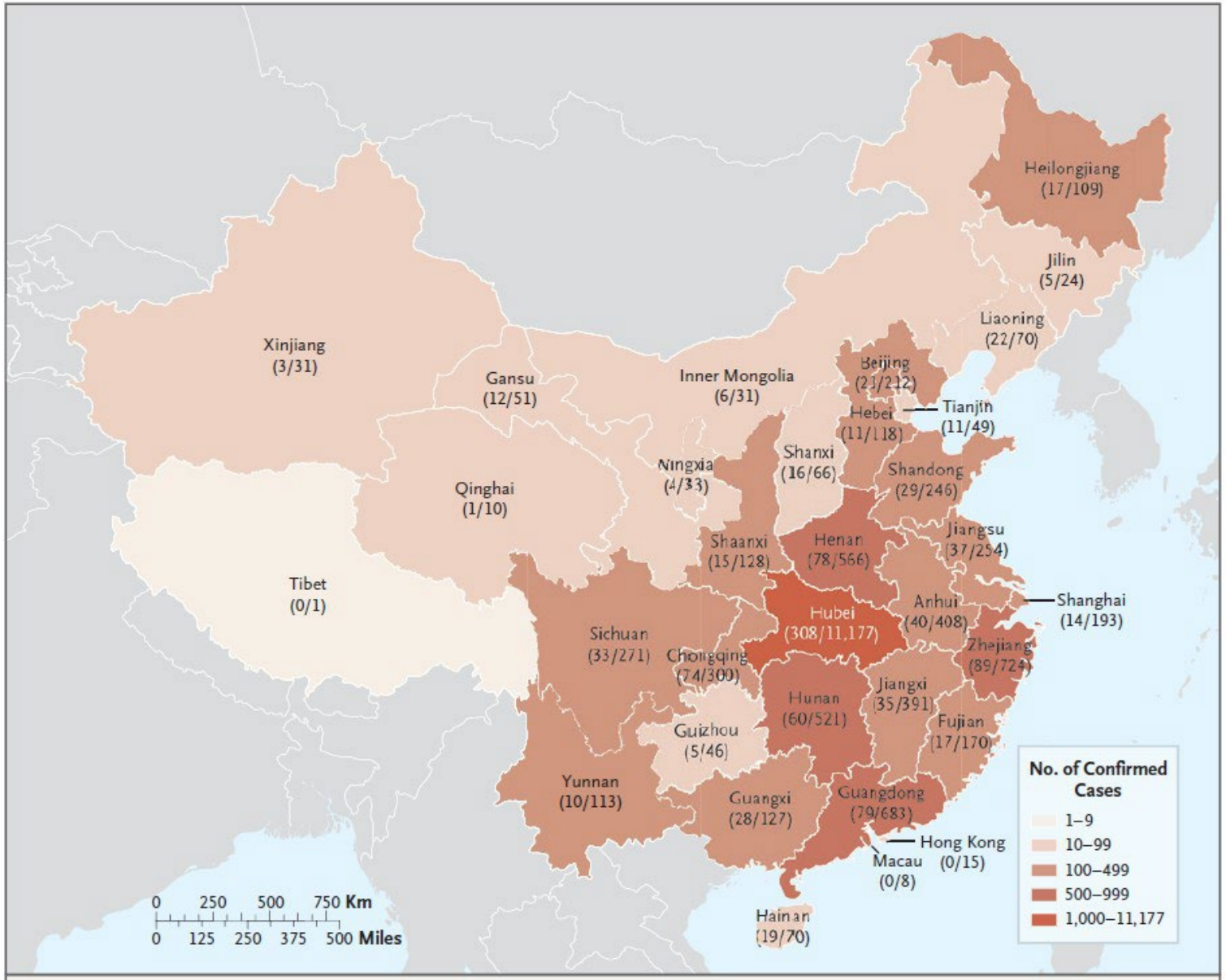


Figure 1. Distribution of Patients with Covid-19 across Mainland China.

Shown are the official statistics of all documented, laboratory-confirmed cases of coronavirus disease 2019 (Covid-19) throughout China, according to the National Health Commission as of February 4, 2020. The numerator denotes the number of patients who were included in the study cohort and the denominator denotes the number of laboratory-confirmed cases for each province, autonomous region, or provincial municipality, as reported by the National Health Commission.

COVID19 [2]

Desjardins MR, Hohl A, Delmelle EM. **Rapid surveillance of COVID-19 in the United States using a prospective space-time scan statistic: Detecting and evaluating emerging clusters.** *Appl Geogr. May 2020;118:102202.*

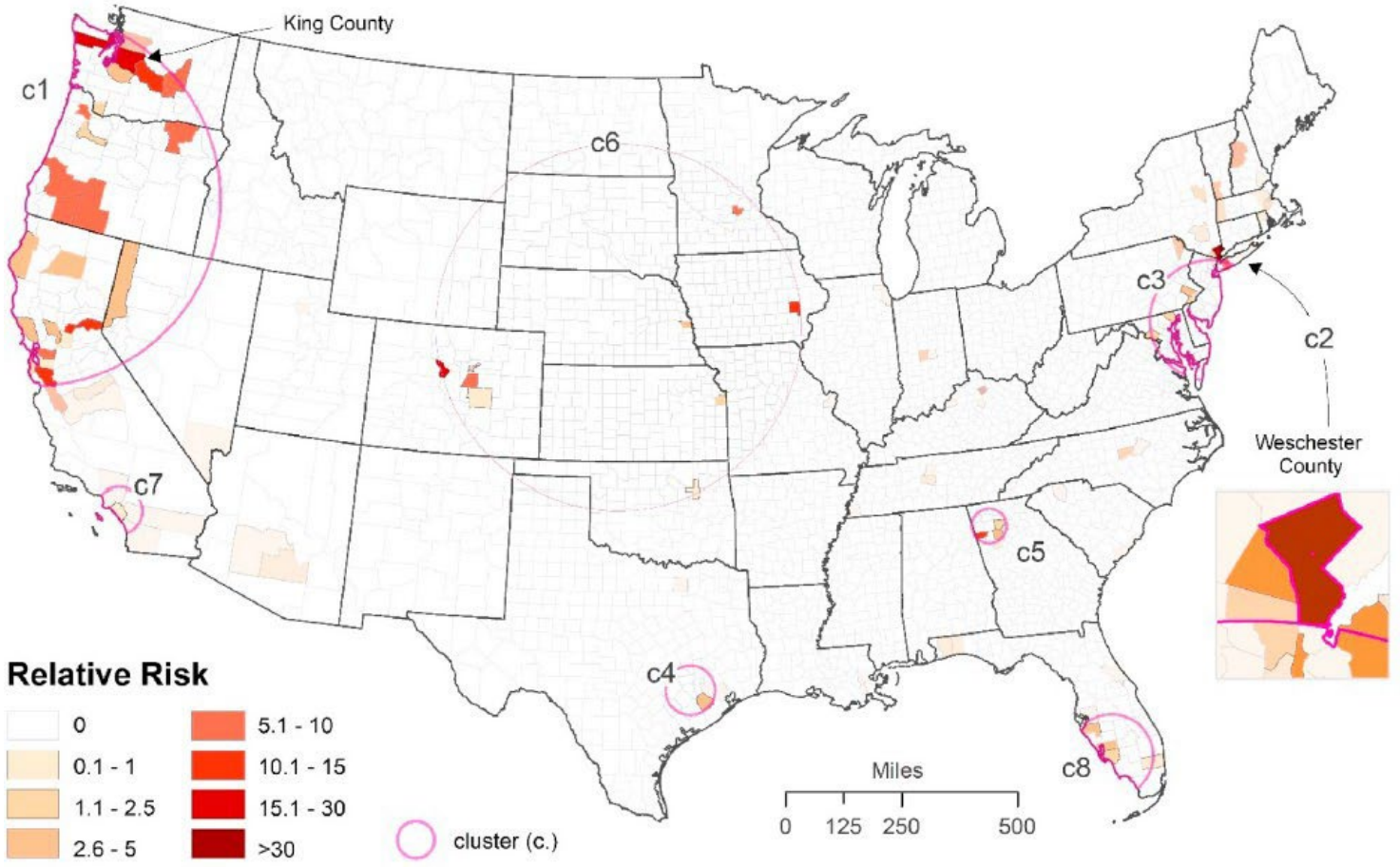


Fig. 2. Spatial distribution of emerging space-time clusters of COVID-19 at the county-level from January 22nd-March 9th, 2020

COVID19 [3]

Barajas-Carrillo VW, Covantes-Rosales CE, Zambrano-Soria M, et al. **SARS-CoV-2 Transmission Risk Model in an Urban Area of Mexico, Based on GIS Analysis and Viral Load.** *Int J Environ Res Public Health. Mar 24 2022;19(7).*

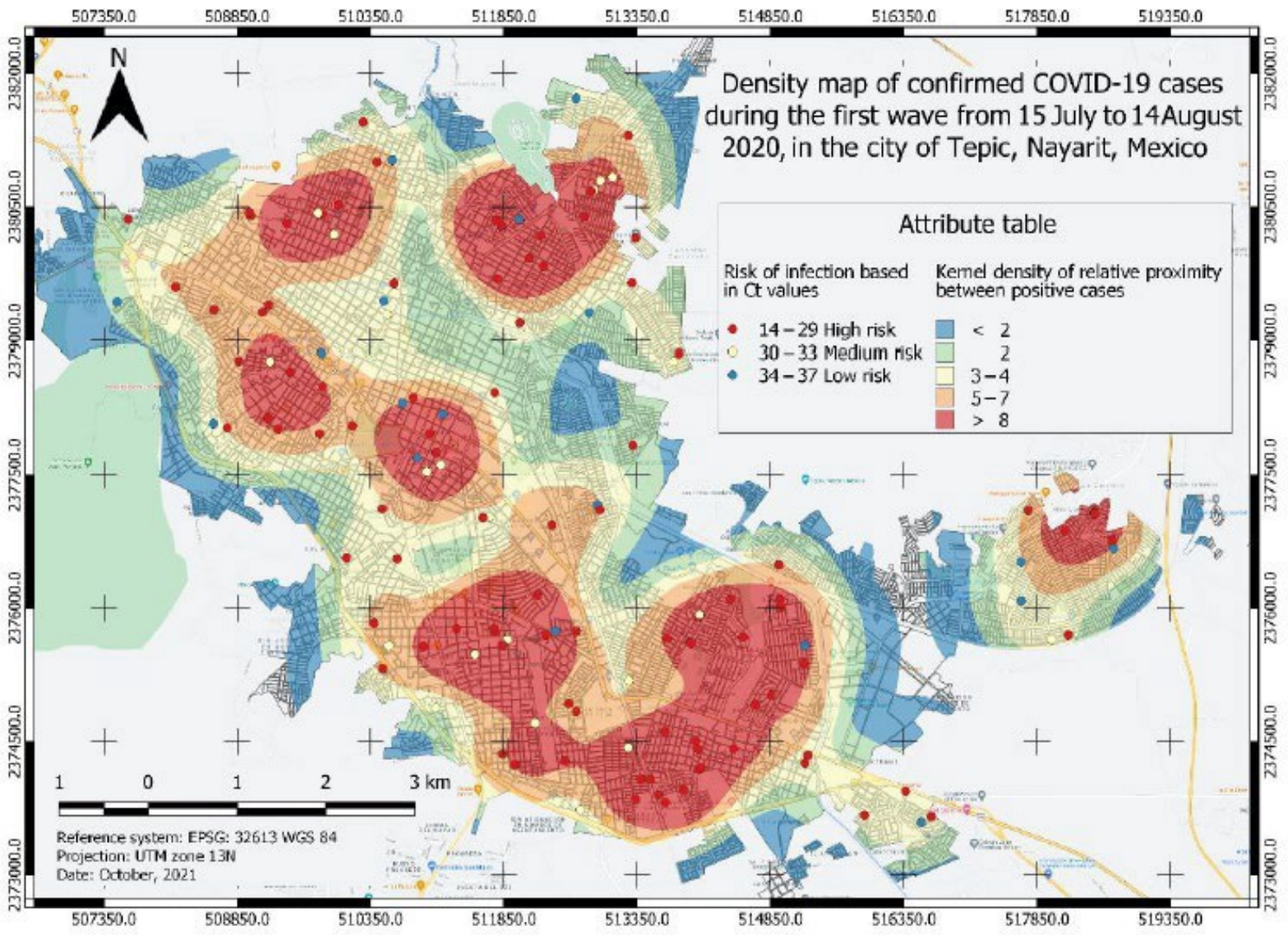
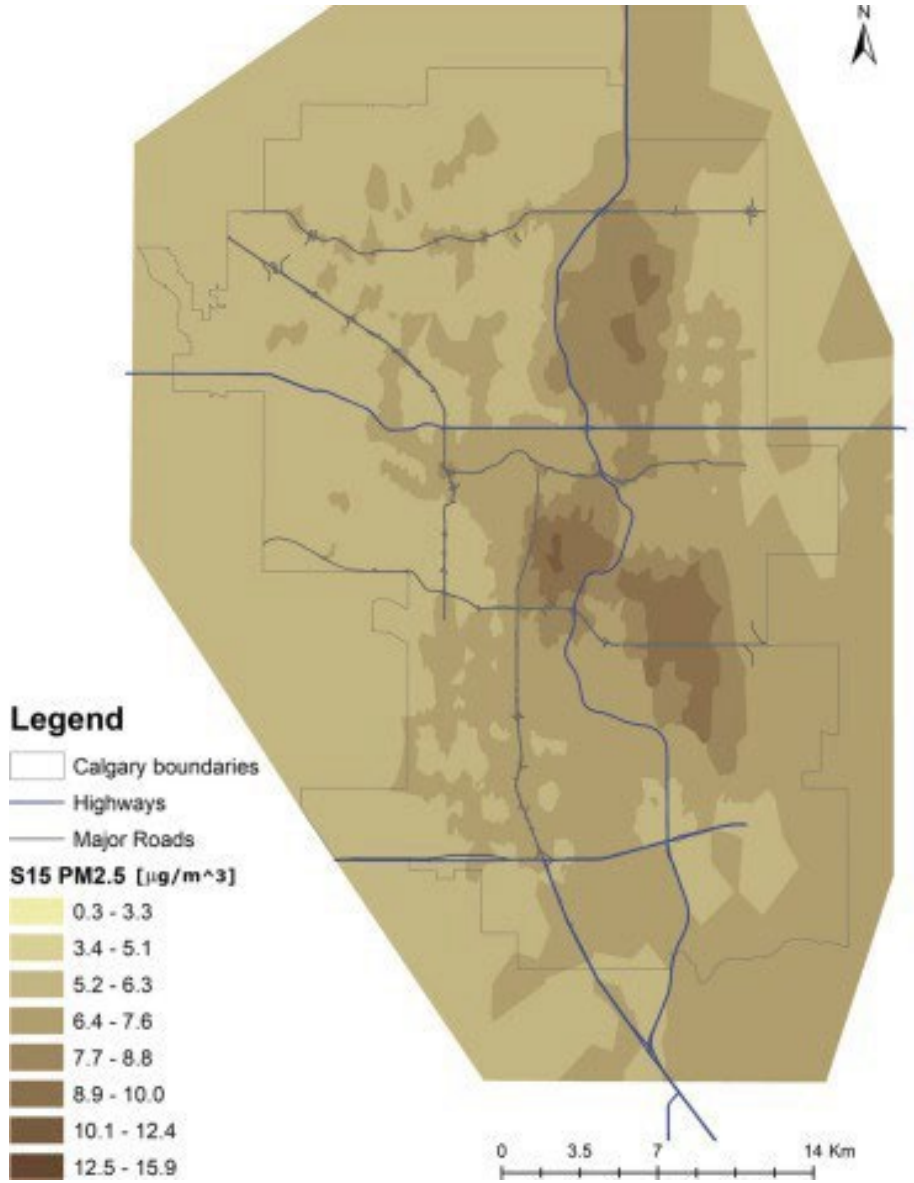
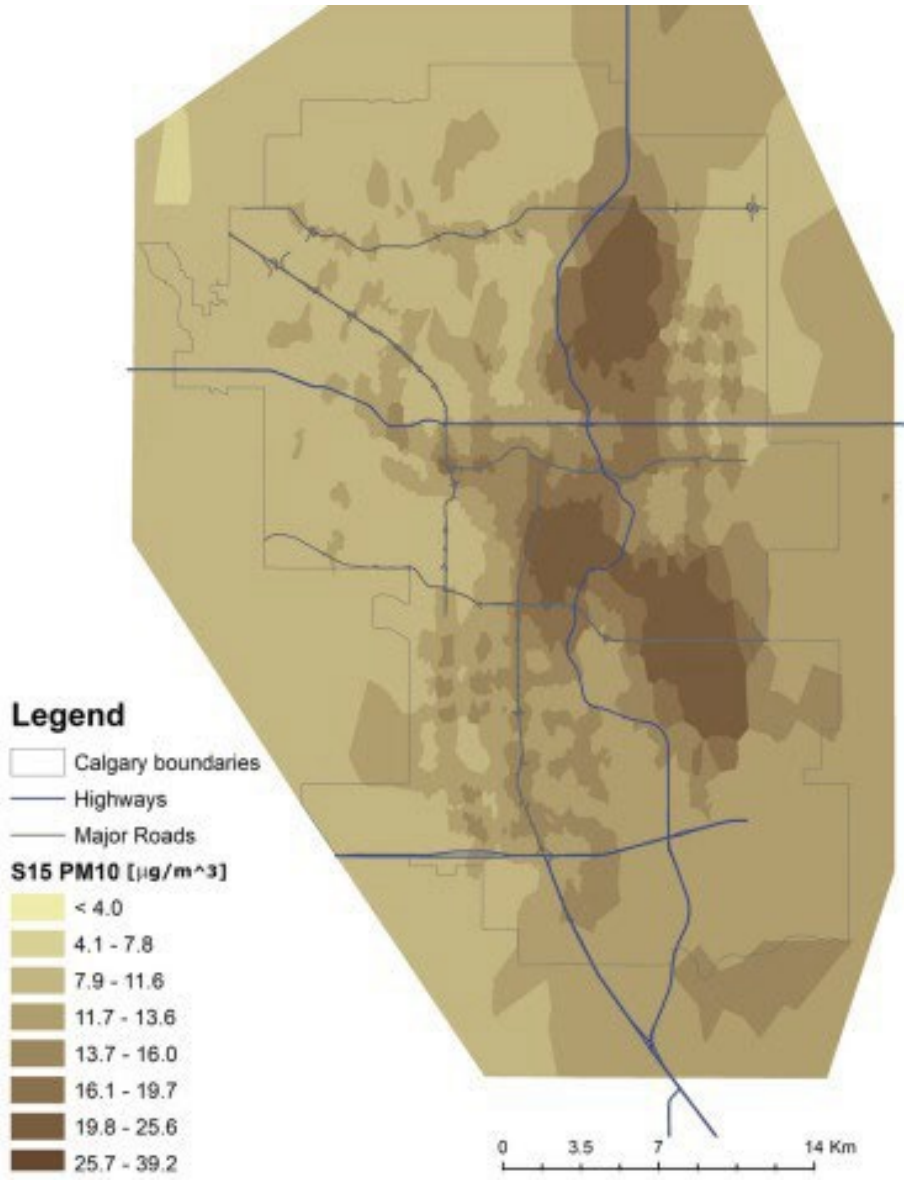


Figure 2. Density map of confirmed COVID-19 cases in the first wave from 15 July to 14 August 2020, in the city of Tepic, Nayarit, Mexico. The different areas classified by color indicate the level of risk of probability of contagion of the COVID-19 disease and each point corresponds to a confirmed case categorized by its Ct value.

Environmental Health

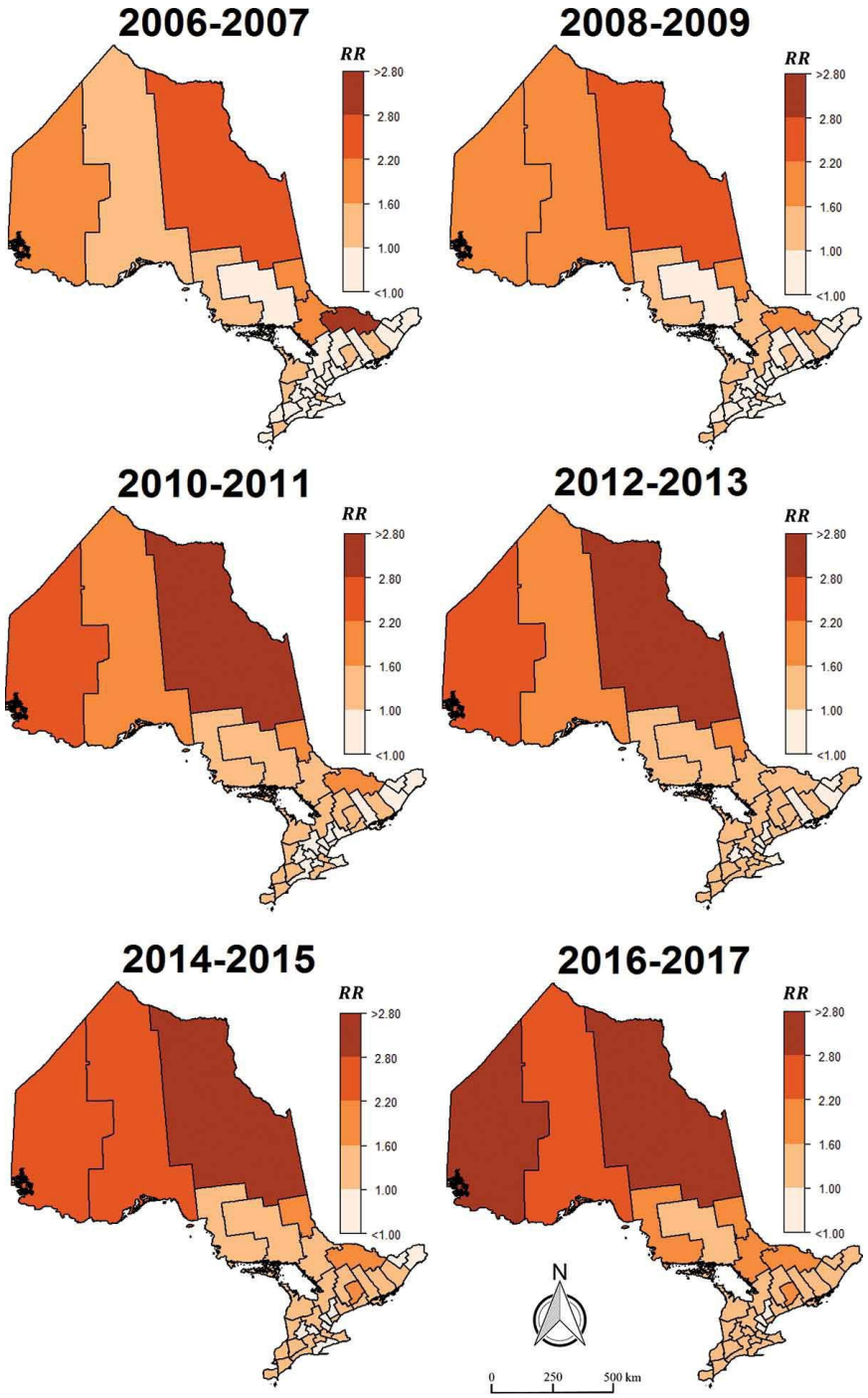
Bertazzon S, Couloigner I, Mirzaei M. **Spatial regression modelling of particulate pollution in Calgary, Canada .** *GeoJournal. 2021;1-17.*





Public Health

Persad, R. **Spatio-temporal analysis of mental illness and the impact of marginalization-based factors: a case study of Ontario, Canada.** *Annals of GIS, (2020); 26(3), 237-250.*



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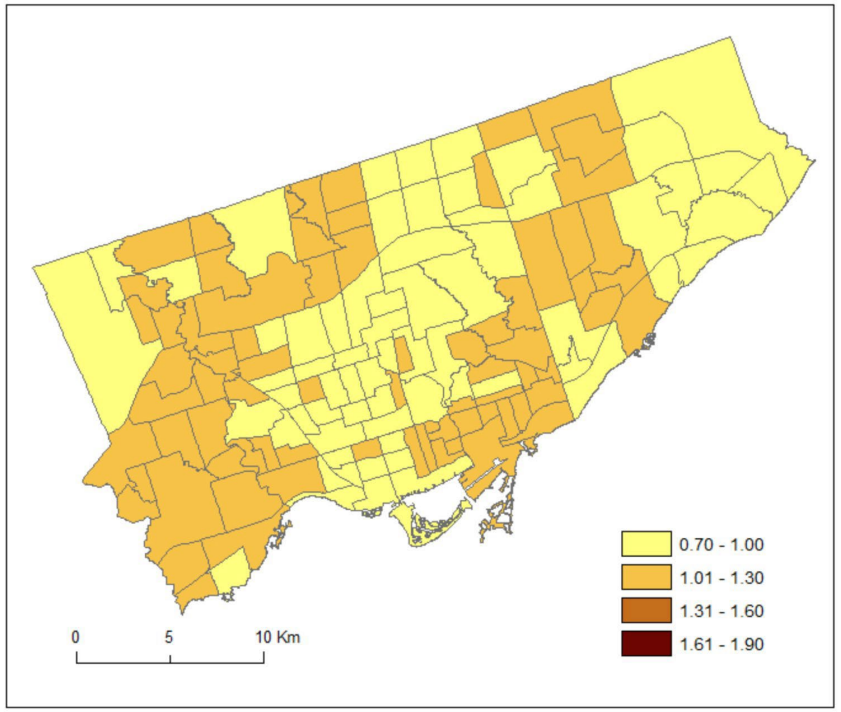
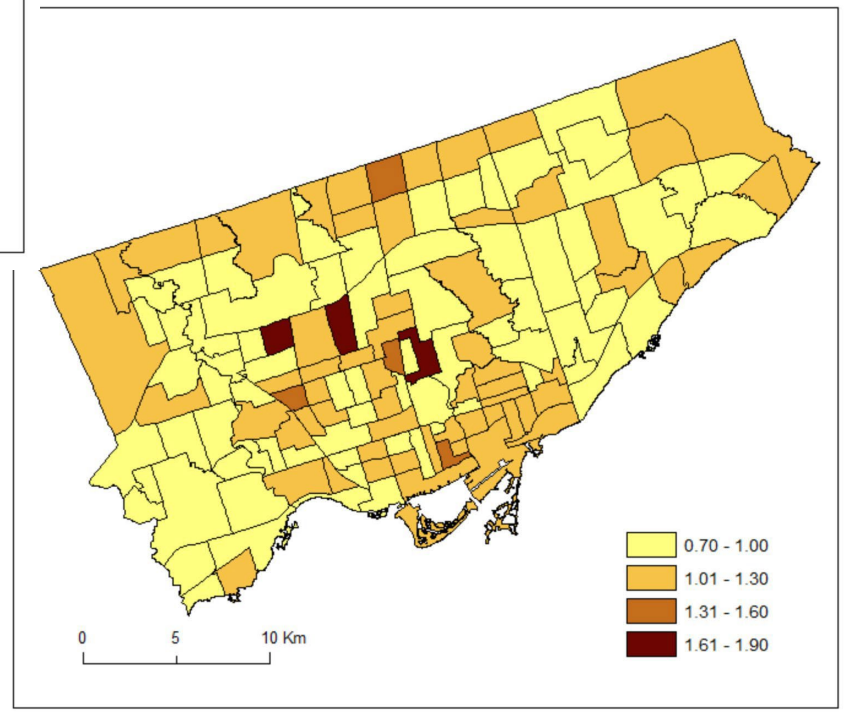
Health Services Research

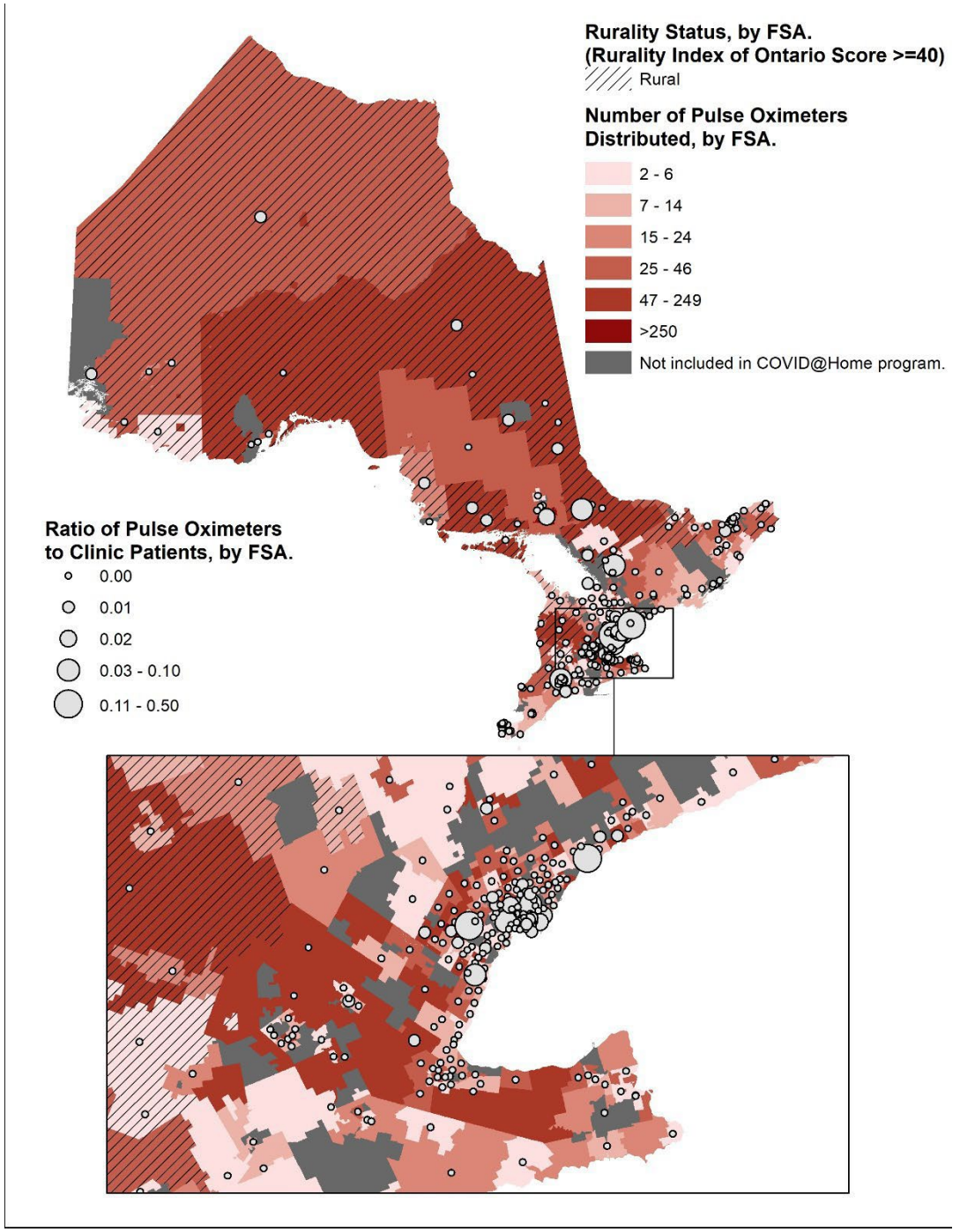
Law J, Perlman C. **Exploring Geographic Variation of Mental Health Risk and Service Utilization of Doctors and Hospitals in Toronto: A Shared Component Spatial Modeling Approach.** *International Journal of Environmental Research and Public Health*. 2018; 15(4):593.





Primary Care

McMaster University Department of Family Medicine. **Evaluation: The Ontario COVID@Home Clinical Pathway for Primary Care of Acute COVID Illness. A report for the Ontario Ministry of Health.** April 29, 2022.



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Resources Available to McMaster University Personnel

McMaster University Library

- Software:
  - ArcGIS Suite (Available to all students, staff and faculty)
    - Please complete the ArcGIS Software Request Form to receive a license.
  - QGIS (Open-Source)
- GIS Workstations:
  - Lloyd Reeds Map Collection
  - Mills, Thode & Inniss Libraries
- Individual & Group Consultation:
  - Class instruction regarding GIS tools, resources can be requested by contacting libgis@mcmaster.ca.

Geospatial Data

Hamilton

Ontario

Ontario GeoHub

Government of Canada

Ontario Data Catalogue

Summary

- GIS is an excellent methodology that is largely underutilized in health research.
- It can be very helpful in exploring various types of health research questions, ranging from infectious disease epidemiology to health services research.
- Excellent resources are available to McMaster University personnel who are interested in exploring how GIS can benefit their work.

Questions?

If you have any additional questions, please reach out to me or to the McMaster University Library at libgis@mcmaster.ca.

Thank you!

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Faculty of Health Sciences

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