



GeoAI: Applications in Health and Healthcare

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Outline



Introduction



GeoSpatial Artificial intelligence



GeoAI Helathcare overview



GeoAI in Public Health



GeoAI in Precision Medicine



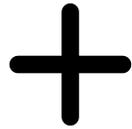
Challenges



Conclusion

Geospatial Artificial Intelligence

Spatial Science 



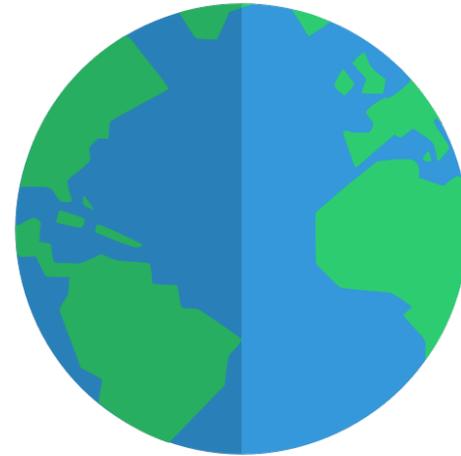
Patterns & Insights 

Artificial Intelligence 

Why do we need GeoAI in Healthcare?

Health is affected by:

- Natural environment
- Built Environment
- Social determinants
- Climate
- Diet



Location affects all these factors!

GeoAI has two major applications in Healthcare

Public Health

Large scale – concerning groups of population, epidemics and factors that influence them.

Coronavirus, Influenza



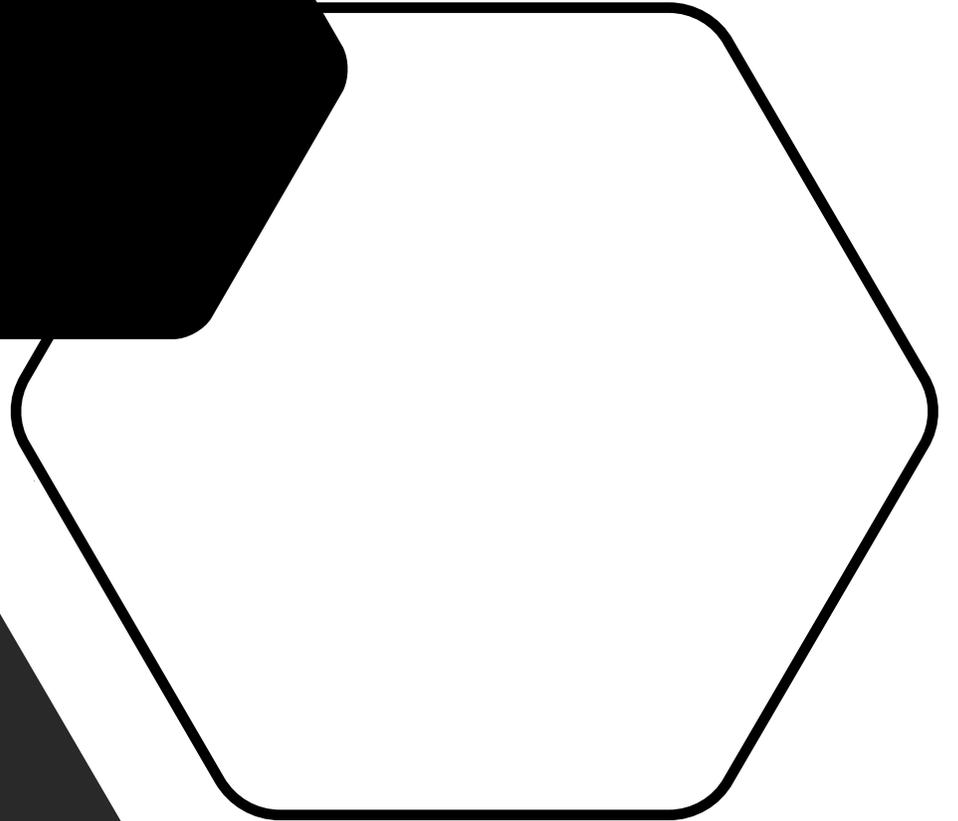
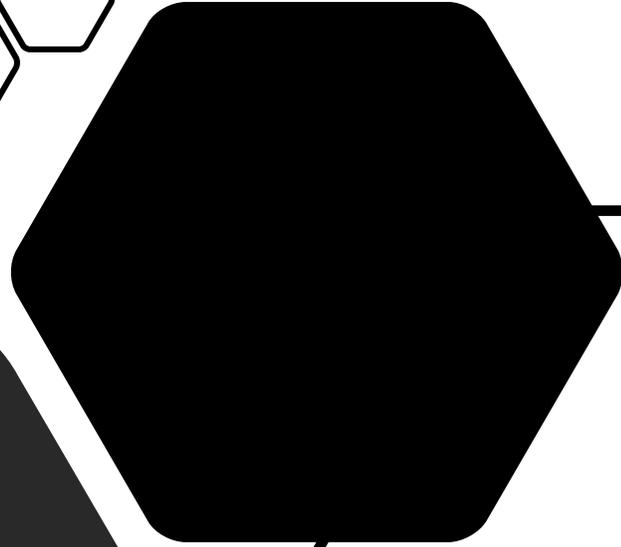
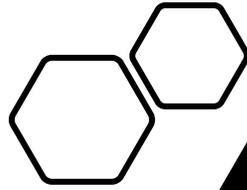
Precision Medicine

An effort to tailor prevention and treatment strategies through considering individual variability in genetics, environment, and lifestyle.

Allergies, Genetic diseases



Aetiology and Public Health



Aetiology

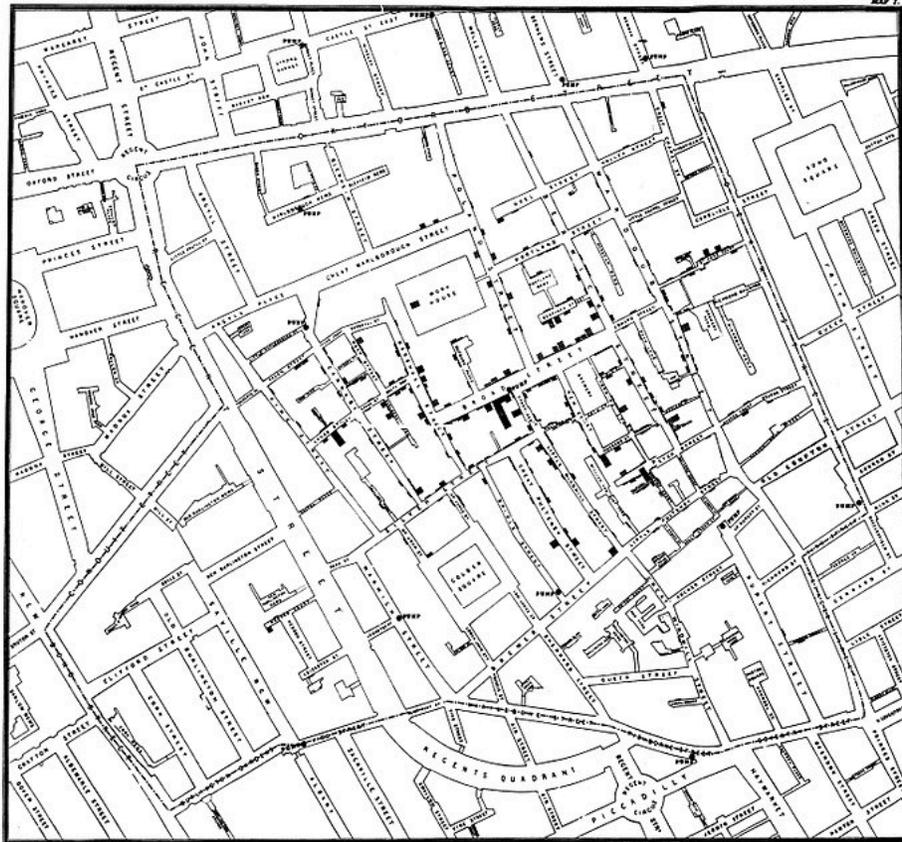
The investigation or attribution of the cause or reason for something.

What do we need?

To investigate epidemics and other health related symptoms of a large population, we need a starting point to conduct research.

GeoAI's Solution – Hypothesis Generation

1854 Broad Street Cholera Outbreak



What did John Snow really conclude from this map?

He was able to **hypothesize** germ theory.

However it was Louis Pasteur and Robert Koch who conducted experiments and demonstrated that diseases are caused by germs.

Hypothesis

A supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.

How did John Snow arrive at this hypothesis?

He analysed spatial features (common water pump locations).

Superimposed the cholera occurrences against the plumbing schematics.

What do you do when there is too much data?

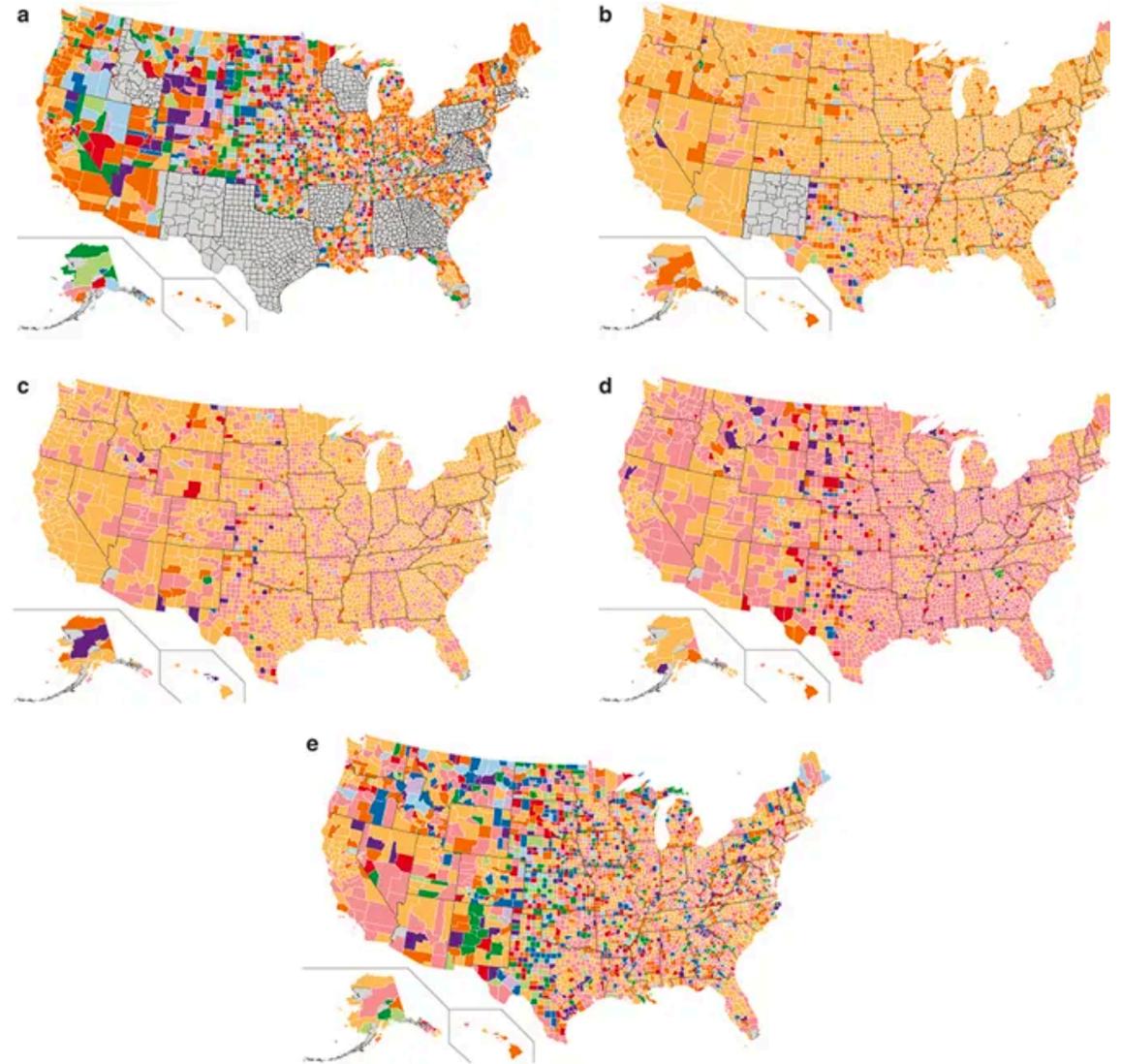
Hypothesis Generation – Public Health

- Use machine learning and AI to generate hypotheses
- Understand epidemics better



Spatial and temporal patterns in preterm birth in the United States

- Suggest that there is a periodicity in preterm births. Which could act as a starting point for researchers to explore the causes and try to prevent them from happening.

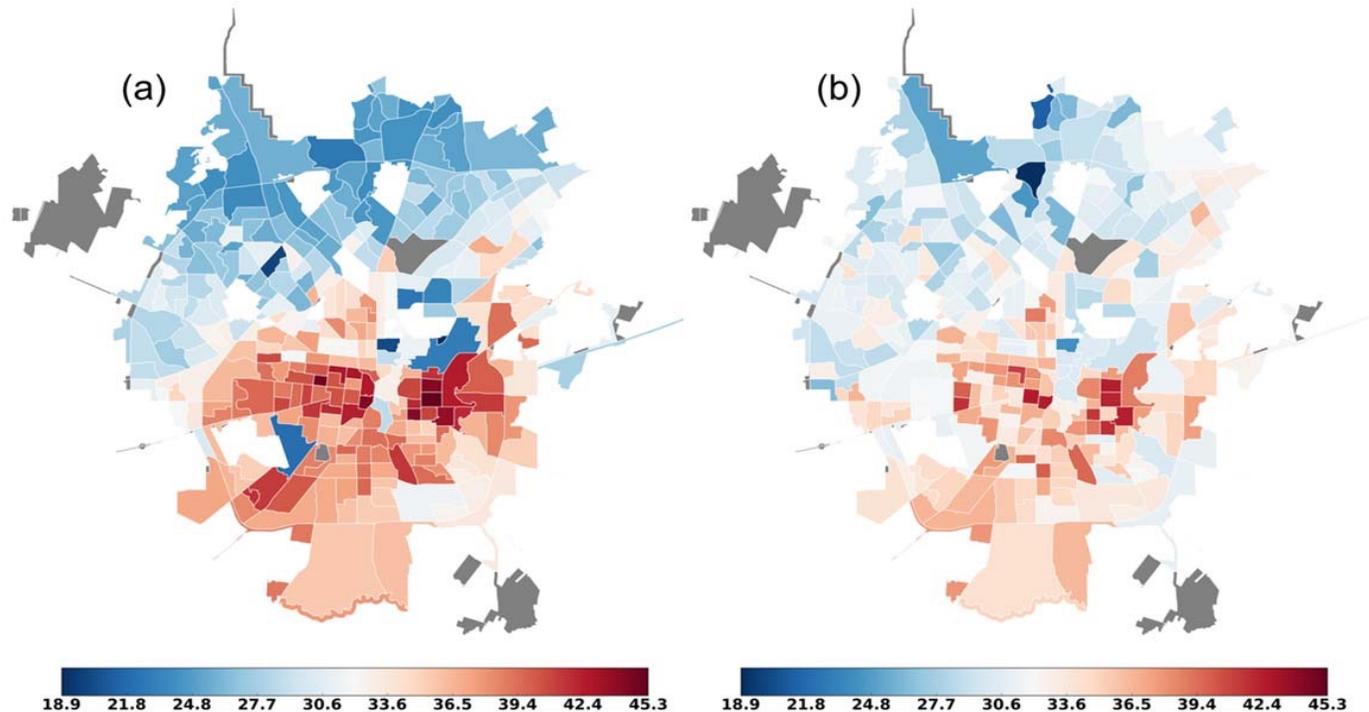


Environmental Epidemiology

- Environmental exposures can be used for exposure assessment in populations.
- In a recent study (2018) CNNs were used on Google Maps Static images and Google places to study in relation to Census tract-level obesity prevalence in the US from Centers for Disease Control and Prevention (CDC) 500 Cities project.

Obesity prevalence

- CNN was trained on images which were tagged with obesity data recorded by the census tract from CDC.



- (a) actual obesity prevalence in San Antonio, Texas
- (b) cross-validated estimates from CNN for obesity prevalence in San Antonio, Texas

How does the model work?



Data:

Satellite images from Google Static Maps API.

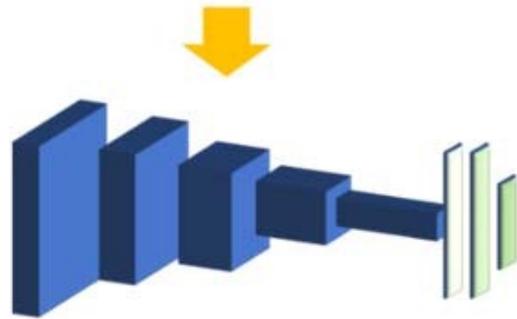
Comprehensive list of places of interest from Google Nearby Search API.

Data from the United States Centers for Disease Control and Prevention (CDC)



Challenges:

Unavailability of large corpus consisting of millions of labelled images.



Model trained for Domain A

Predictive Model

Feature Maps for Domain B

Transfer of Knowledge

Let classification of objects from the ImageNet dataset be Domain A. The model trained for domain A has learnt how to interpret an image. When the satellite images are fed as input to the model, we receive feature maps that encode this knowledge. These feature maps are used in a regression model to predict obesity values which is domain B.

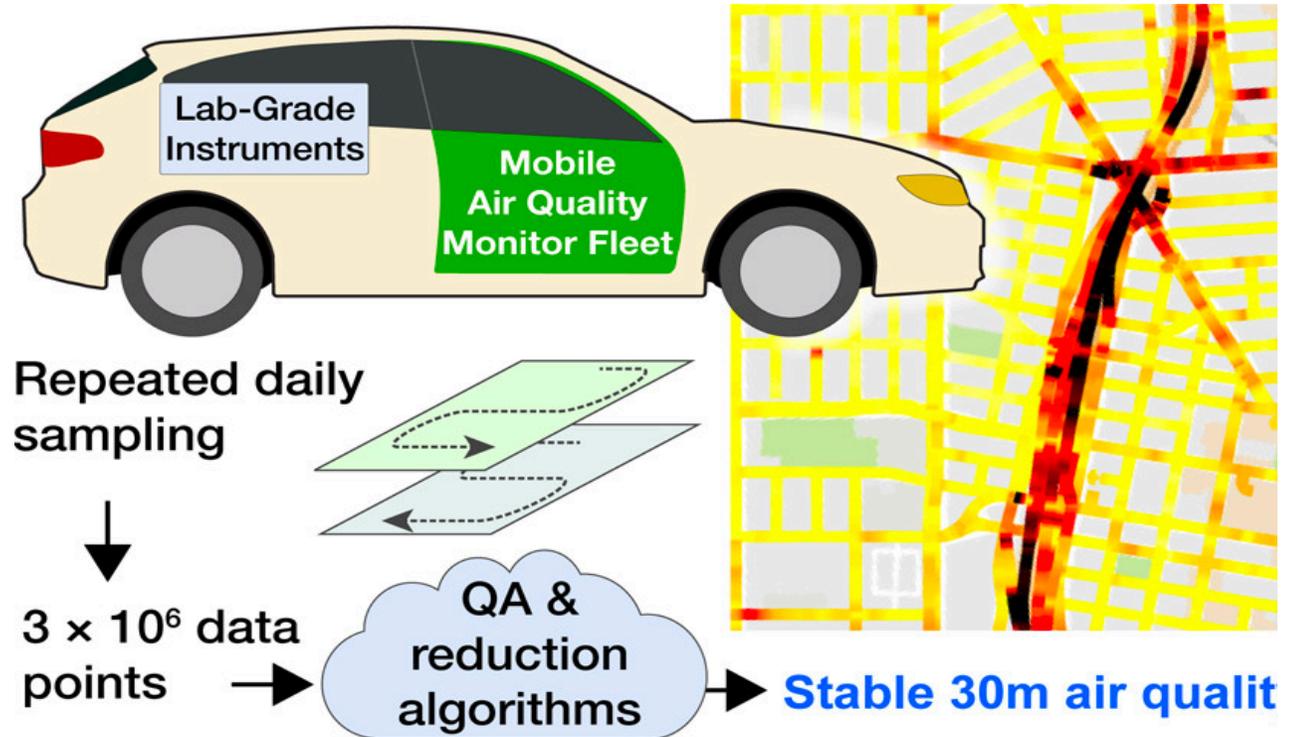


Census tracts containing affluent neighborhoods (close to waterfront, swimming pool in apartment complex), waterfront businesses and downtowns are classified as low obesity areas in Seattle-Tacoma-Bellevue area.

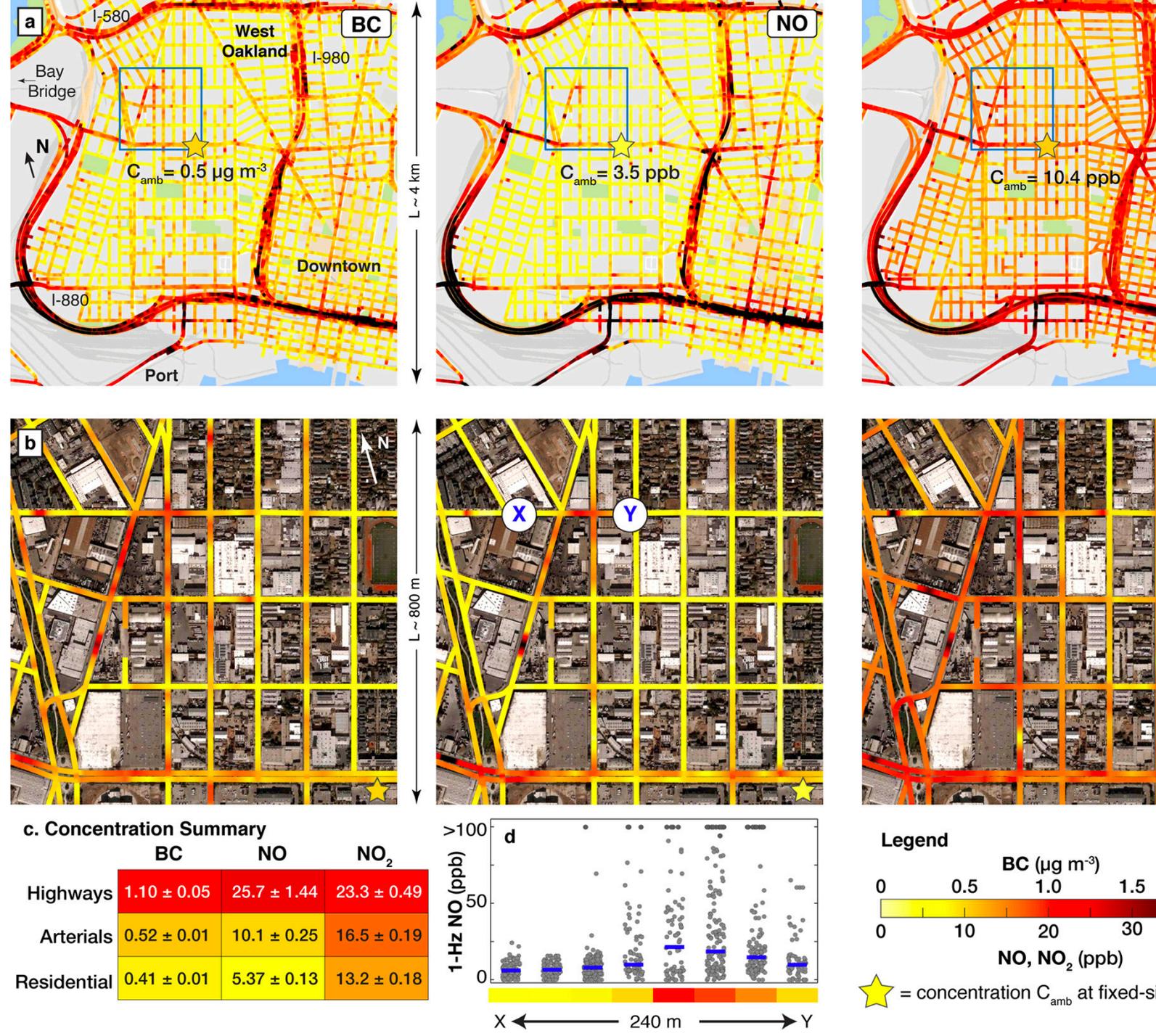
Census tracts with small population density and less urbanized footprint are classified as high obesity areas in Seattle-Tacoma-Bellevue area

Air pollution Exposure modelling

- Neural Networks used to model daily Particulate Matter <2.5 microns in diameter (PM_{2.5}) in US using satellite data.
- Mobile air pollution sensors to provide spatial data.
- Experiment conducted in every street in Oakland, California, US



- NO, NO₂ and black carbon at 30m spatial resolution.
- Results: Higher concentration of pollutants near Highways than the residential areas



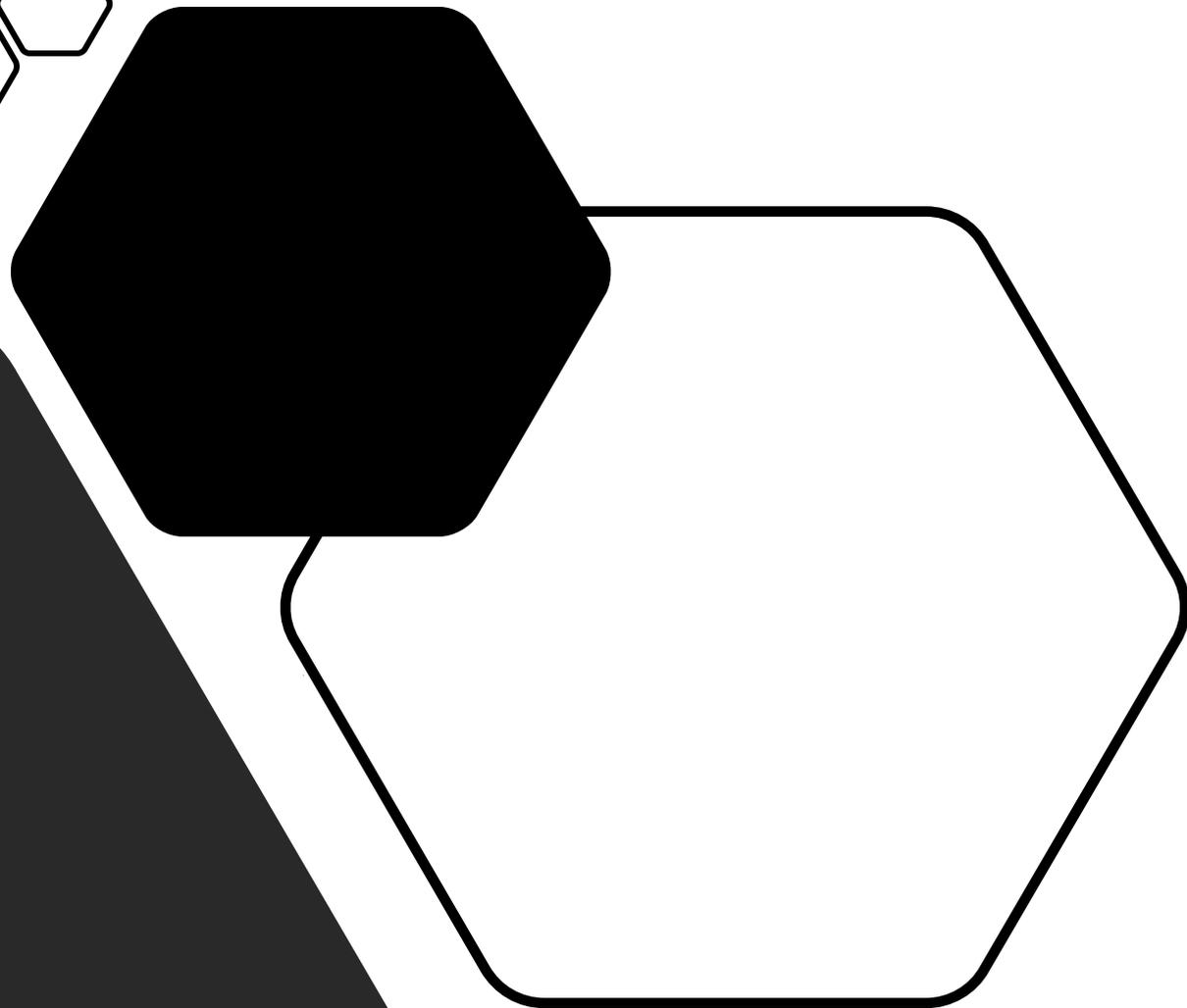
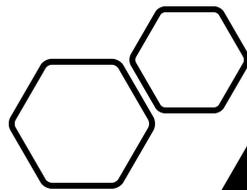
Influenza forecasting model

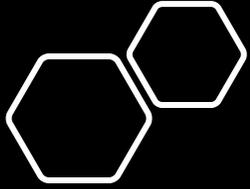
- Applying deep learning methods and incorporation of environmental and spatio-temporal factors to improve the performance of the influenza forecasting models.
- Deep learning recurrent neural networks (RNNs) were used for real-time influenza forecasting at regional and city spatial scales in the US using spatial big data on Google Flu Trends (weekly estimates for different cities) and climate from the National Climatic Data Centre .

Identifying restaurants with poor hygiene

- Machine learning model FINDER to detect foodborne illnesses using anonymous and aggregated Google web search and location data.
- The data collected is used to estimate the fraction of people who visited a particular restaurant and who subsequently searched for terms indicative of food poisoning.
- Alert for restaurant inspection.

Precision Medicine





What is Precision Medicine?

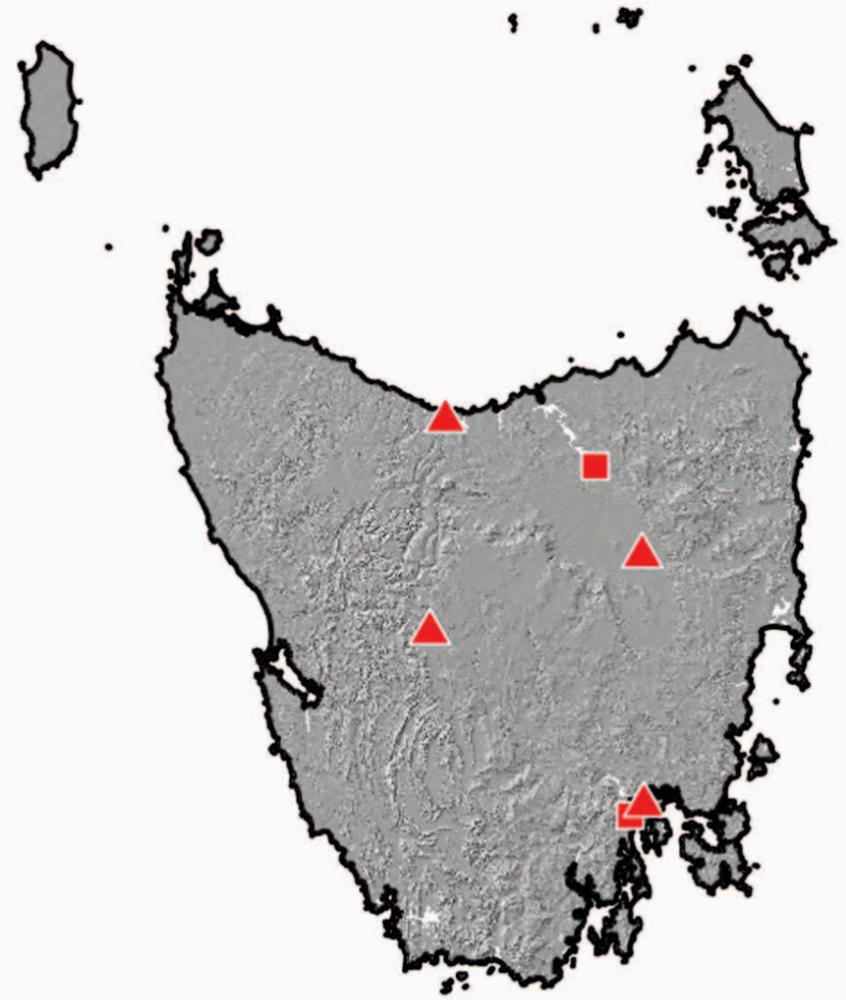
- It involves making decisions based on obtaining as much information about a patient's health as possible.
- Precision medicine is an effort to tailor prevention and treatment strategies through considering individual variability in genetics, environment, and lifestyle.

AirRater Mobile Health Application

- Uses user location data to notify the user of potential allergens
- Suggests medication to deal with symptoms

Pollen Stations

- Daily
- ▲ Weekly



WHAT CAN IT DO FOR YOU?



TRACK YOUR SYMPTOMS

AirRater allows you to track symptoms such as sneezing, itchy eyes or shortness of breath. These symptoms are often the result of exposure to something in the air, like smoke or pollen. Over time, AirRater will build up a picture of when and where you get these symptoms.



MONITOR YOUR ENVIRONMENT

Get up-to-date information about air quality, including smoke, pollen and temperature, everywhere the AirRater app is available. If you want to see these values for other locations, just click that point on the map.



HELP MANAGE YOUR HEALTH

Over time, AirRater will help you work out if you are sensitive to air pollution, pollen or temperature and if certain conditions can trigger your symptoms. Once AirRater has worked out your triggers, it will send you a notification when those conditions are present in your location.

Precision Geomedicine



Our health depends on where we currently live, as well as on where we have lived in the past and for how long in each place.



Primary aim is to identify and find the cause of disease, to enable intervention and ultimately prevention.



Challenges

- Lack of an ethical framework to facilitate handling of patient data, which is confidential.
- Shortage of labelled training data.
- Dependence on domain expertise for training as well as making sense of results of any analysis.



THANK YOU