



THE OHIO STATE UNIVERSITY

COLLEGE OF PUBLIC HEALTH

# Public Health + Cyber-Physical Systems: Examples from Pregnancy, Food Insecurity and Opioid Epidemic

Ayaz Hyder, PhD

Assistant Professor,

Division of Environmental Health Sciences, College of Public Health

Affiliated Faculty, Translational Data Analytics Institute

**GLOBAL SIGNIFICANCE, LOCAL IMPACT**



After the Moms2B meeting, I go grocery shopping with Lewis and Johnson. Into the shopping cart go bags of kale, hamburger meat, baby formula, cereal, and dozens of other items to feed the family. At the cashier, Lewis pays with a WIC card, four separate Kroger gift cards she received from Moms2Be, and finally, a \$20 bill. She and Johnson carry eight bags of groceries outside to the corner, where they wait 20 minutes for the bus to come. There are no seats; they stand for the ride home.

**A smart city sounds nice to Lewis. It also sounds far from where she lives.**  
“My thing is, someone should get on the bus and ride with us,” she says, “and see what the struggles of everyday people are.”

— Who Wins When a City Gets Smart? (Laura Bliss, 11/1/17, CityLab)



## What is Public Health?

A government agency that addresses the health of populations.

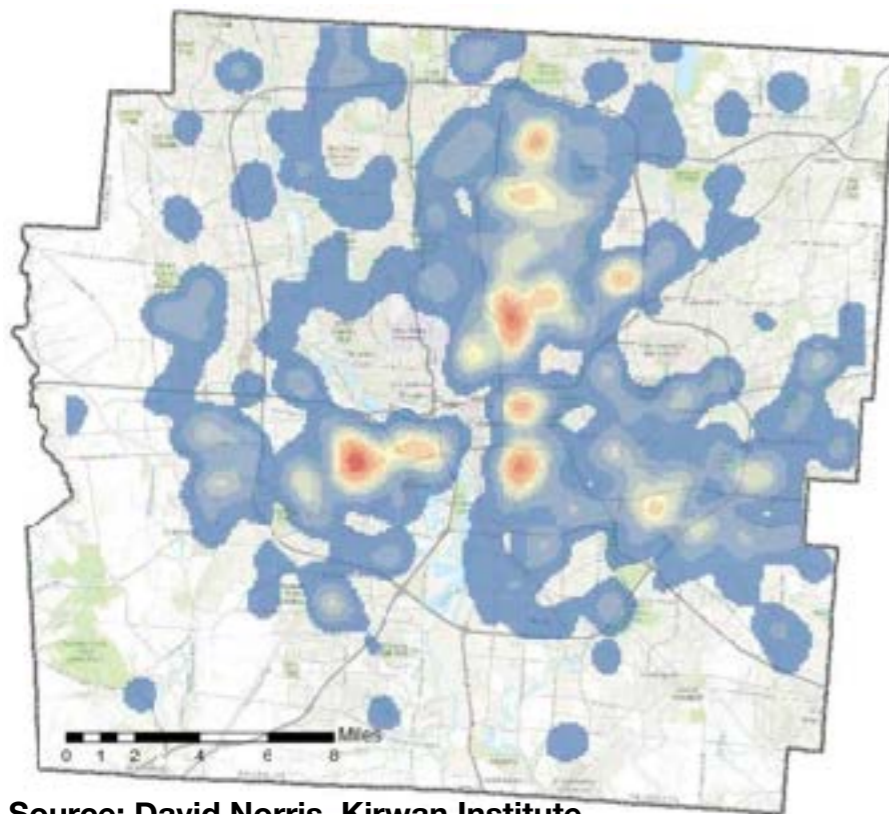
“Public health promotes and protects the health of people and the communities where they live, learn, work and play.” —APHA



# Infant Mortality (IM)

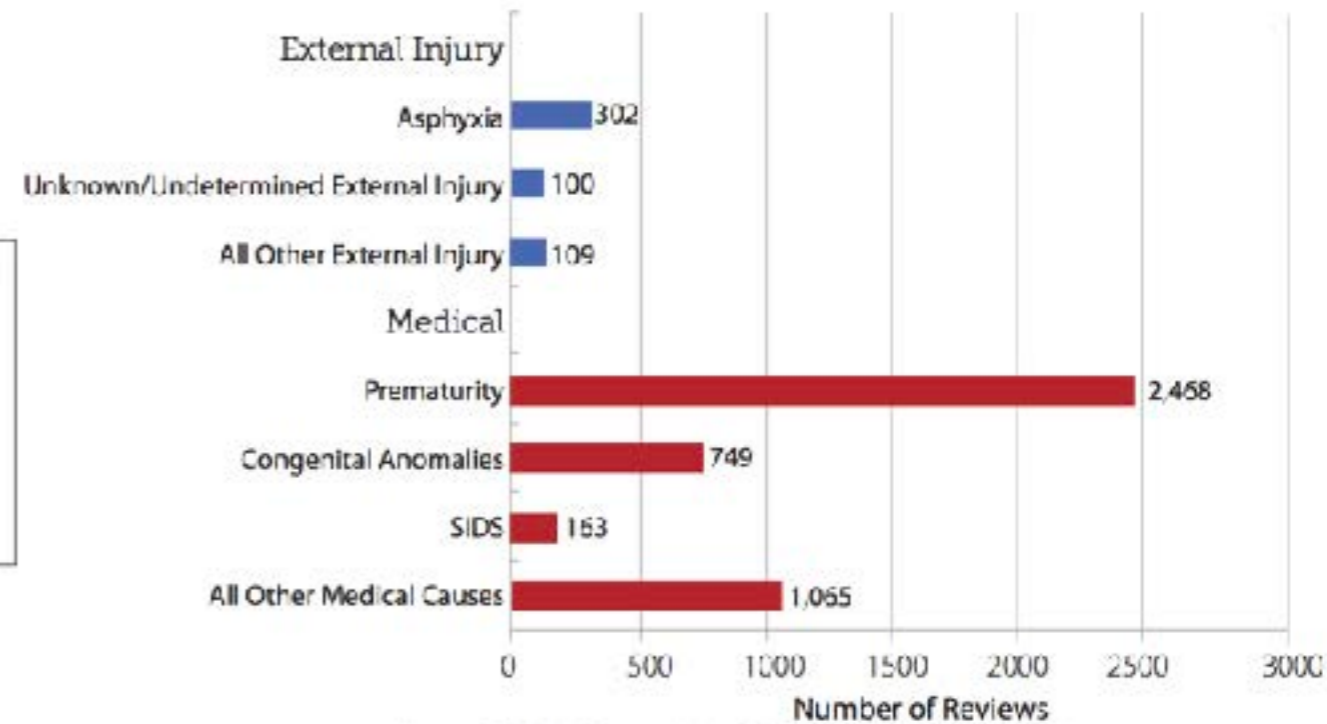
Definition: Infant death before their 1st birthday.

Addressing IM means addressing risk factors preterm birth and taking into account effects of “place”.



Source: David Norris, Kirwan Institute

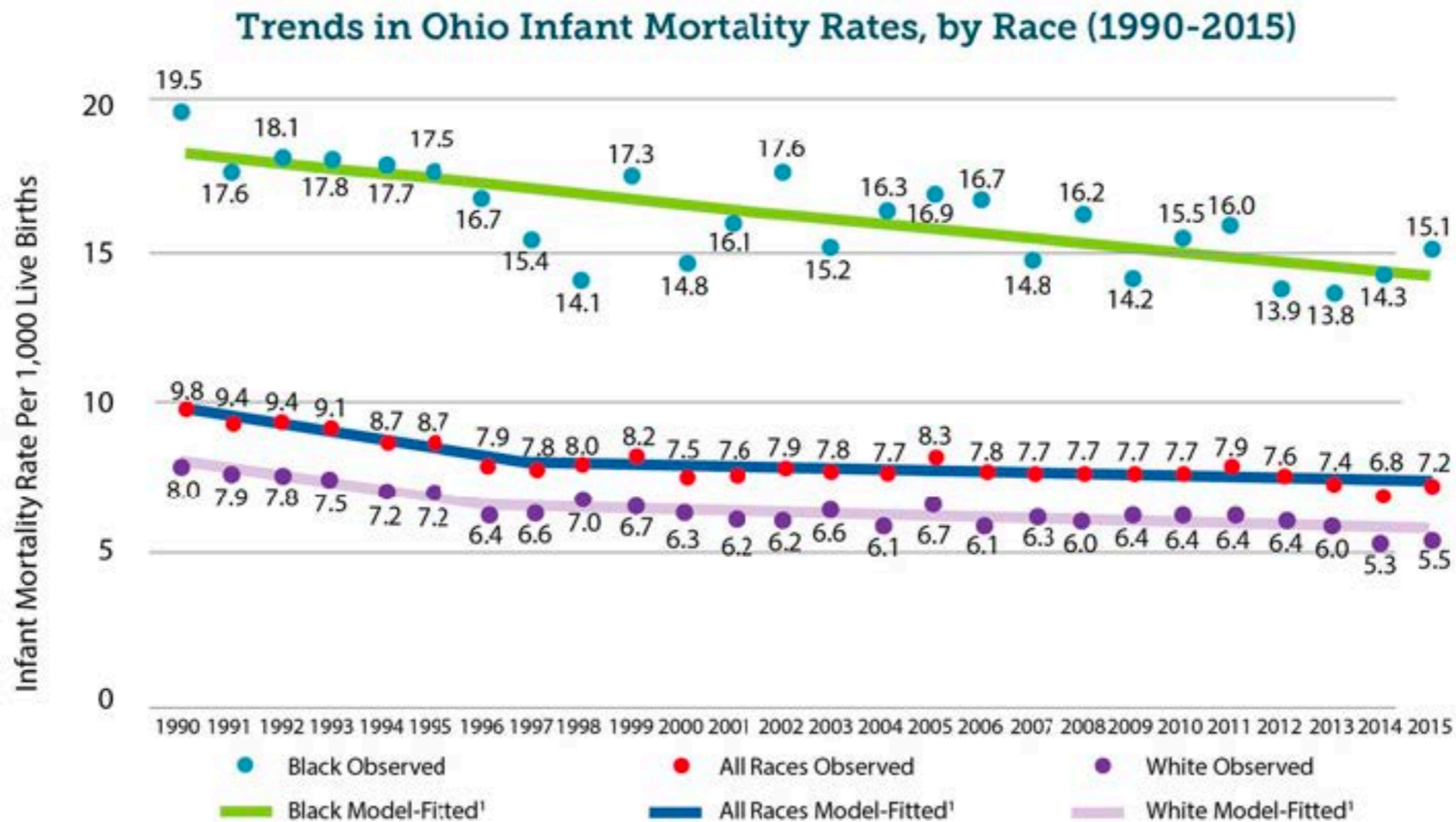
Graph 2 – Reviews of Infant Deaths by Leading Causes of Death, Ohio, 2008-2012



Source: Child Fatality Review 14<sup>th</sup> Annual Report, Ohio Department of Health



# Why do we care about infant mortality?



Source: Ohio Department Of Health, Bureau Of Vital Statistics.

<sup>1</sup>"Model-Fitted" Definition – Joinpoint software models were used to test the statistical significance of changes in trends using a Monte Carlo permutation method. The same methods were used to assess All Races, Black and White Infant Mortality trends. In all cases, the best fitting line for the observed data is presented.



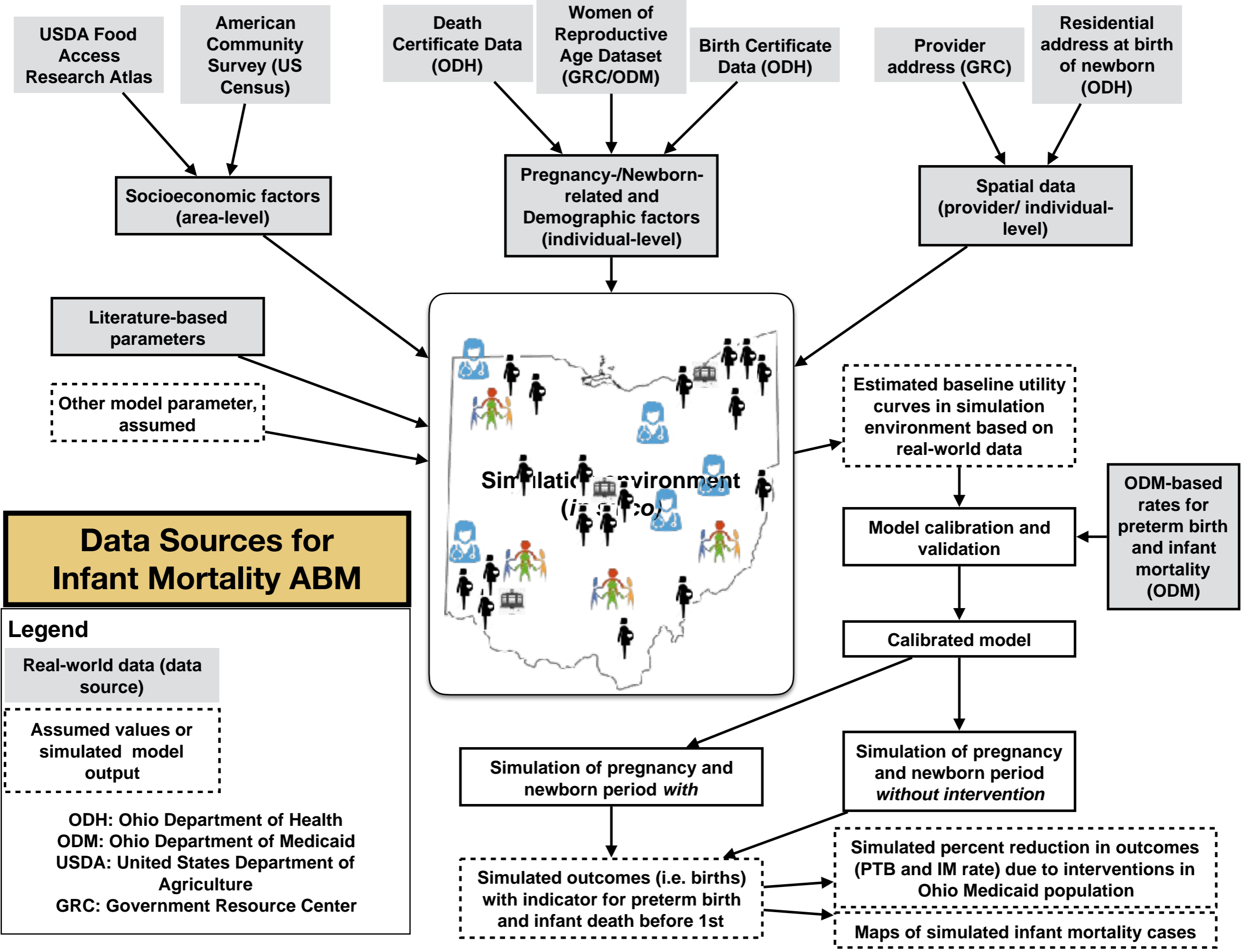
# Agent-Based Model for Infant Mortality in Ohio

- **Background:**

- Ohio ranks 47<sup>th</sup> in IM rate in the US. African-American IM rate is 2x higher than White IM rate.

- **Purpose:**

- Reduce disparities in infant mortality rate among Ohio Medicaid recipients (Research)
- Evaluate impact of multiple interventions on infant mortality in Ohio Medicaid recipients (Modeling)

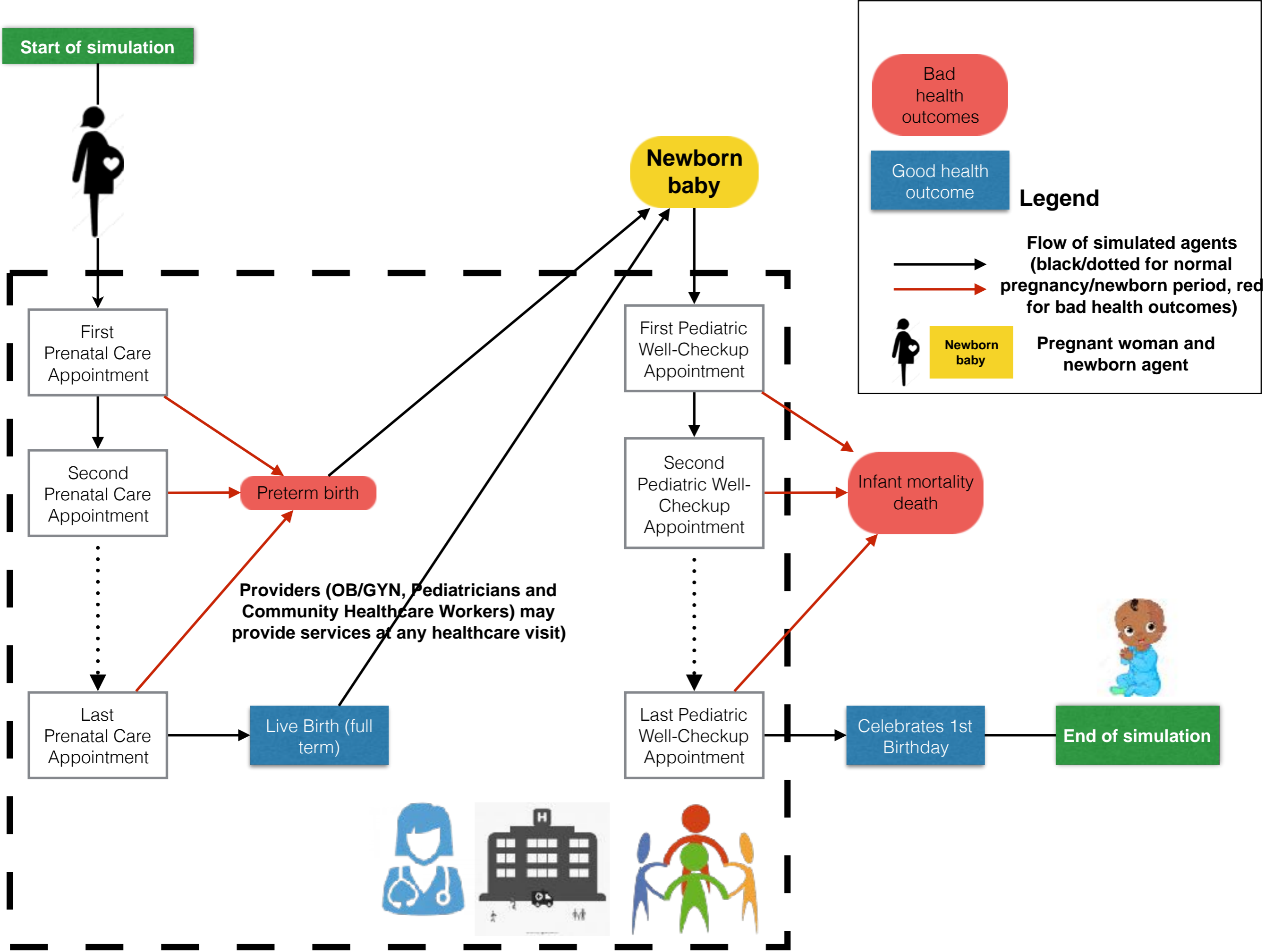


## Data Sources for Infant Mortality ABM

**Legend**

- Real-world data (data source)
- Assumed values or simulated model output

ODH: Ohio Department of Health  
 ODM: Ohio Department of Medicaid  
 USDA: United States Department of Agriculture  
 GRC: Government Resource Center







# Addressing Pregnancy and Infant Mortality via CPS

**Impediments to translation:**

Changing daily needs of pregnant women.

**Supporting infrastructure needs:**

Linking protected health information (PHI) across systems that takes care of HIPAA and data governance/privacy/security issues.

**Stakeholders:**

Pregnant woman, spouse (if any), family and friends (if any), physician(s), midwife, healthcare facility, healthcare insurance company, other children (if any).

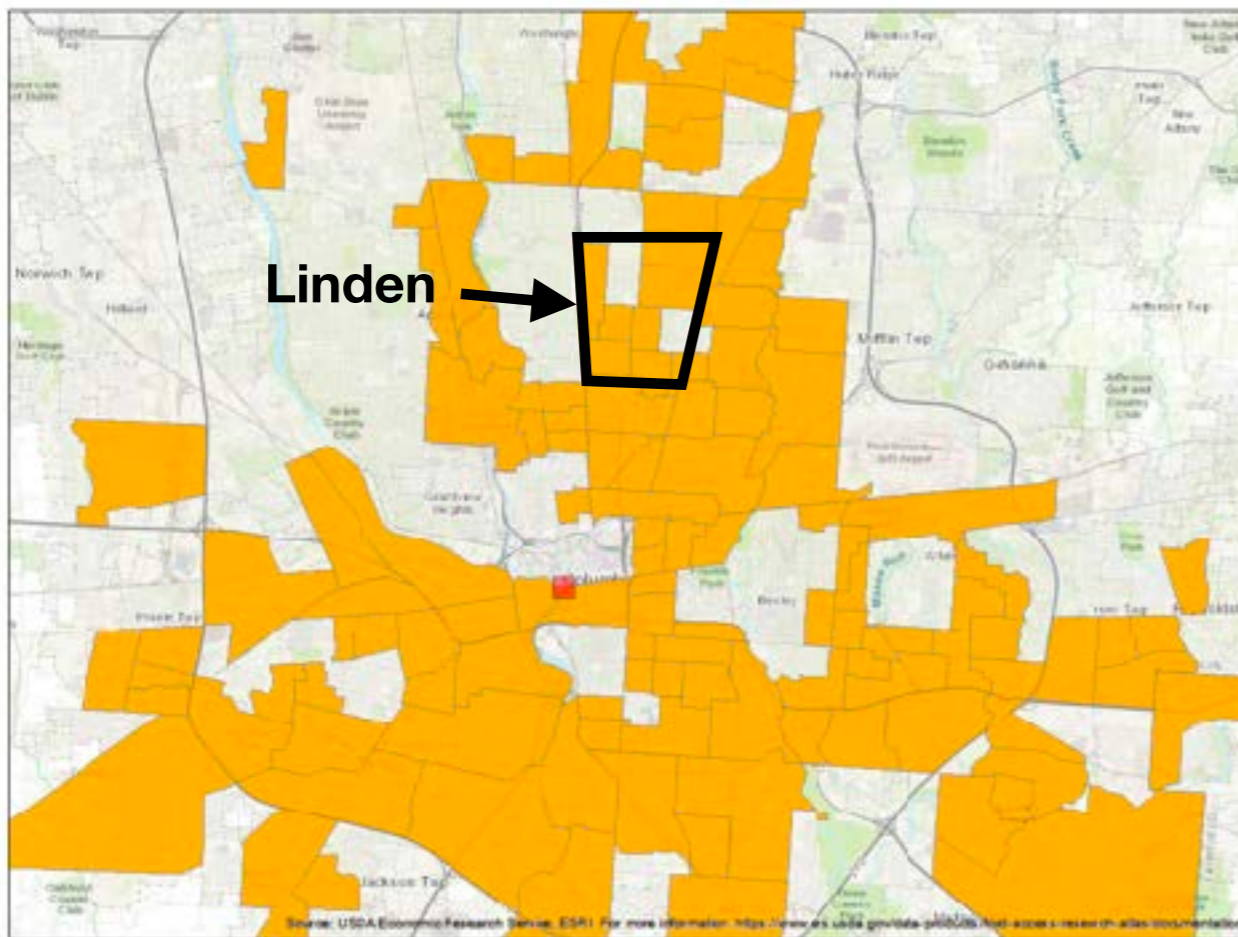
**Engaging stakeholders and infrastructure providers:**

Difficult in hard-to-reach and very low-income communities, healthcare systems not willing to release and link data (e.g., Ohio).



## Food insecurity

**Definition:** “is a household-level economic and social condition of limited or uncertain access to adequate food.” –USDA definition



16% (range: 8.7%-20.4%) of Ohio households are food insecure.

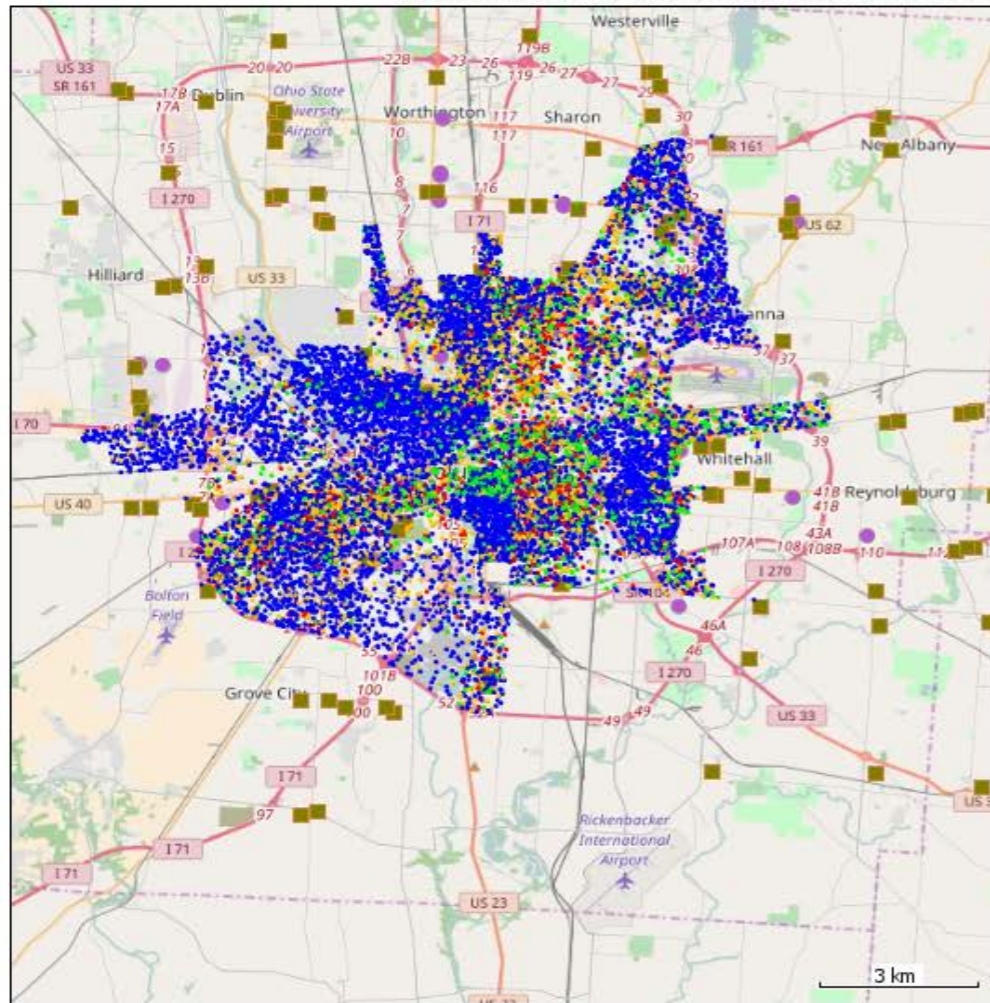
Addressing food insecurity means addressing access, availability and affordability of healthy food.

Food or Rent?  
Eat or Sleep?



### Food Availability Agent-based Model in Columbus, OH

Case 2: Changes in Numbers & Locations of Supermarkets



**Types of Food Stores**

- SMK: Supermarkets Set 2 (n=141)
- CSPM: Convenience Stores & Partial Markets (n=72)

**Types of Households (HH)**

- Enough Resouce & High Car accessible (ERHC)
- Enough Resouce & Low Car accessible (ERLC)
- Lack of Resouce & High Car accessible (LRHC)
- Lack of Resouce & Low Car accessible (LRLC)

#### Scenario Options

**Scenario 1:**  
Changes in Preference to CSPM

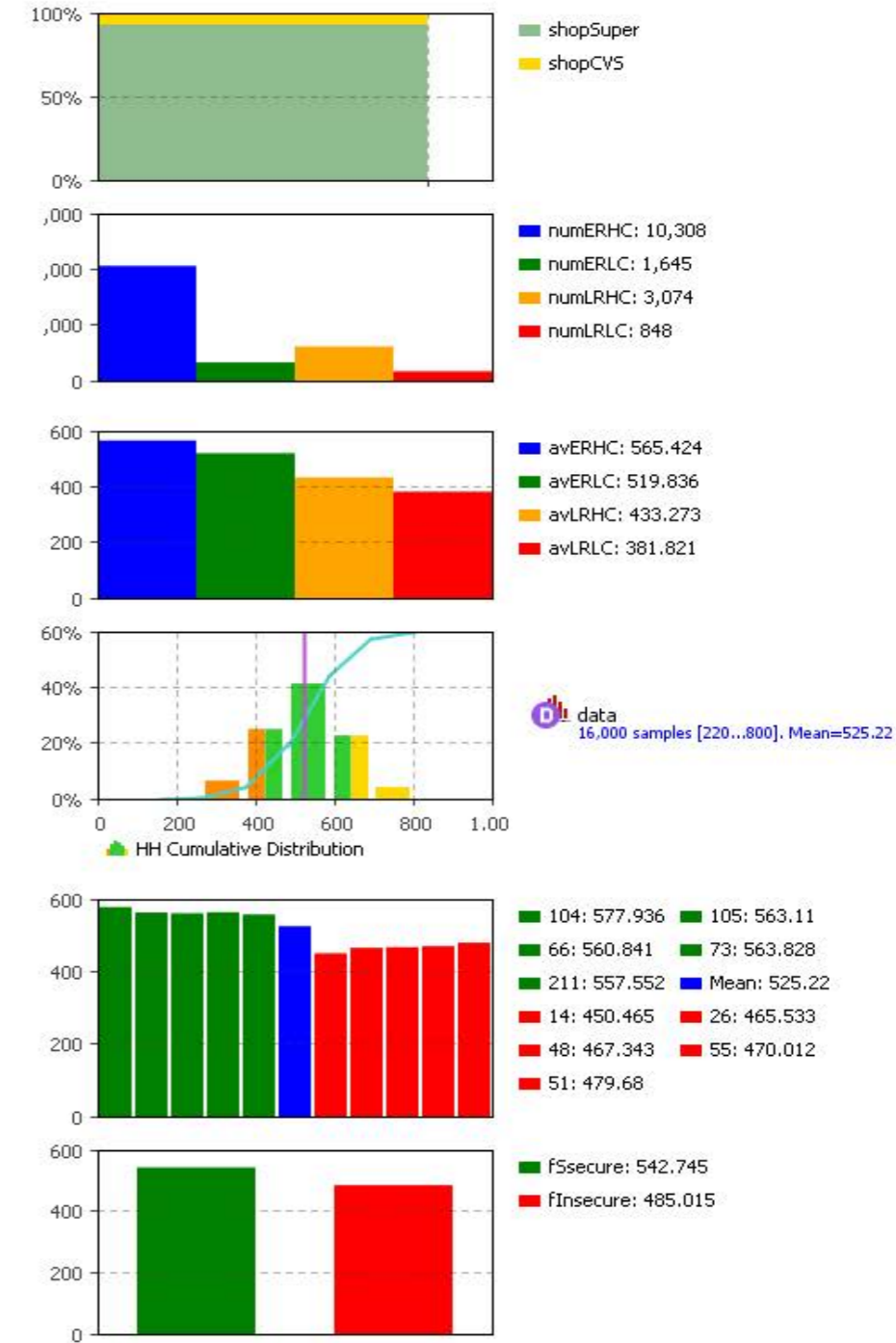
- 1a. All Households Closer to SMK than CSPM (Default: 20%)  
CSPM1a: Min 0, Max 30
- 1b-1e. All Households Closer to CSPM than SMK
  - 1b. ERHC (Default: 24%)  
CSPM1b: Min 0, Max 34
  - 1c. ERLC (Default: 28%)  
CSPM1c: Min 0, Max 38
  - 1d. LRHC (Default: 36%)  
CSPM1d: Min 0, Max 48
  - 1e. LRLC (Default: 40%)  
CSPM1e: Min 0, Max 50

**Scenario 2:**  
Changes in USDA Basket Availability

- 2a. Availability Score in Supermarkets (Default: 80-95, Mean 80)  
SupermarketsAvailability: Min 80, Max 100
- 2b. Availability Score in Convenience Stores & Partial Markets (Default: 20-55, Mean 30)  
CVSPMAvailability: Min 20, Max 55

**Scenario 3:**  
Changes in Resource Level

- 3a.  Default (if selected) Vs. All HH ER
- 3b.  If Households <25K Have +1 Income Range



KEUMSEOK PETER KOH, PH.D., AYAZ HYDER, PH.D., AND REBECCA RENO, PH.D., MSW.

Hyder Computational Epidemiology Lab



## Regional Food Systems

- Multiple stakeholders
- Limited connectivity except for supply chains
- Lack of optimization in the food environment (e.g., production to consumption) to improve health outcomes
- Lack of coordination between data-related activities

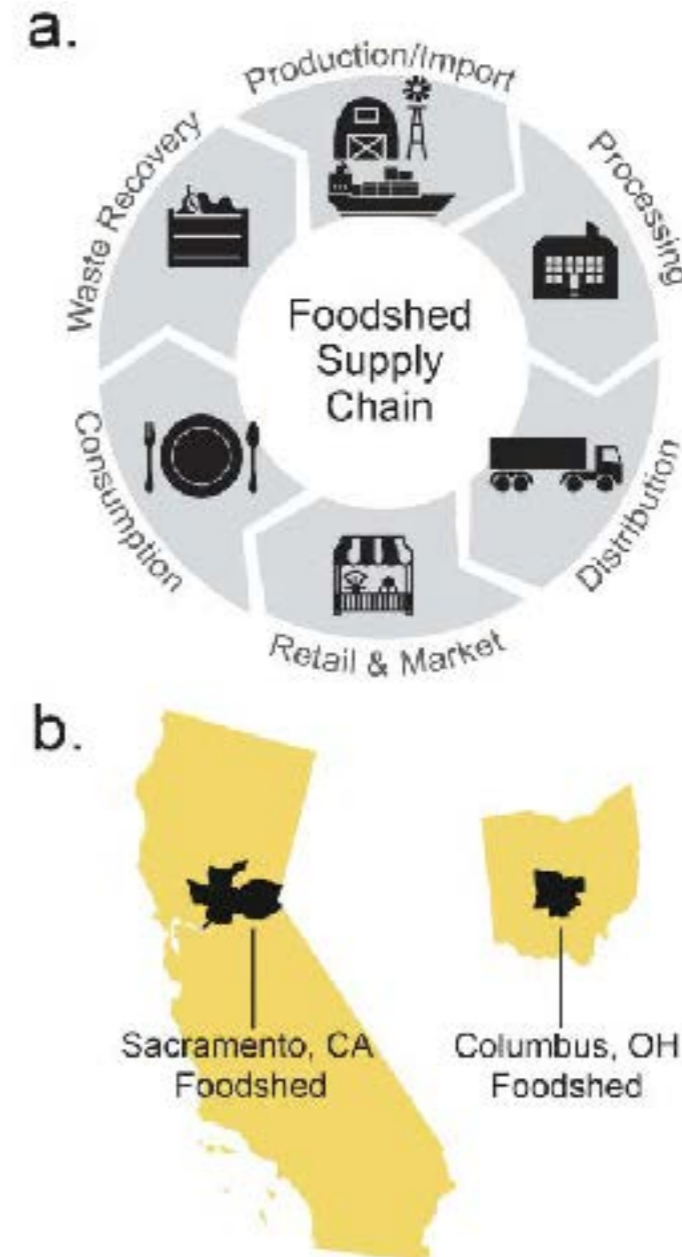
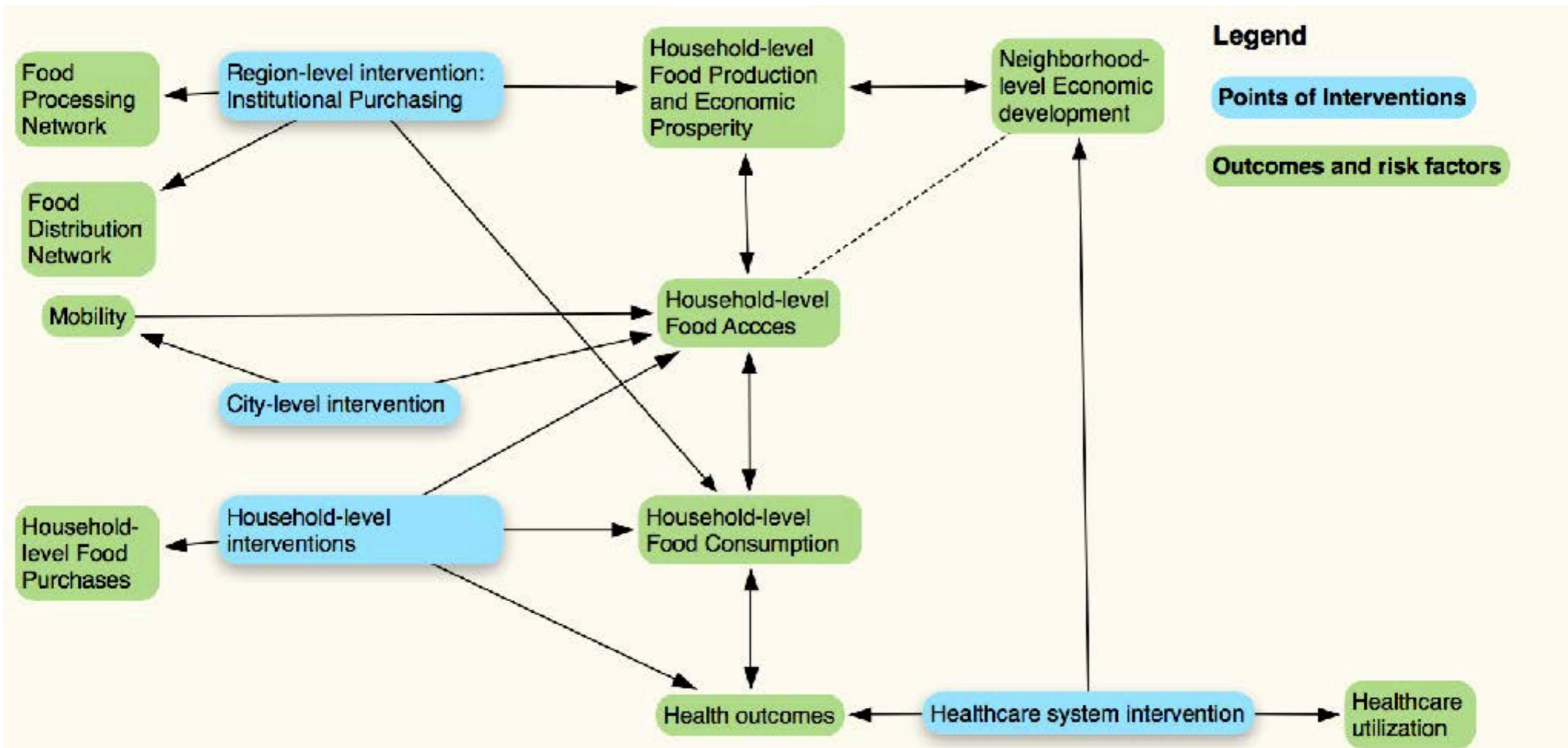


Figure 1. “Smart” foodsheds: improving the food supply chain in regional foodsheds. (A) Schematic of the data input points within a regional foodshed supply chain. (B) The two regional foodsheds included in this RCN: Sacramento, CA and Columbus, OH.



# Regional Food Systems





# Addressing Food Insecurity via CPS

Food system is a system that integrates production, processing, and consumption of food within a region.

## **Impediments to translation:**

Don't know societal needs and benefits of linking data across food system.

## **Supporting infrastructure needs:**

Ontologies of food including production, distribution, consumption and food-related health outcomes.

## **Stakeholders:**

Everyone in the food system.

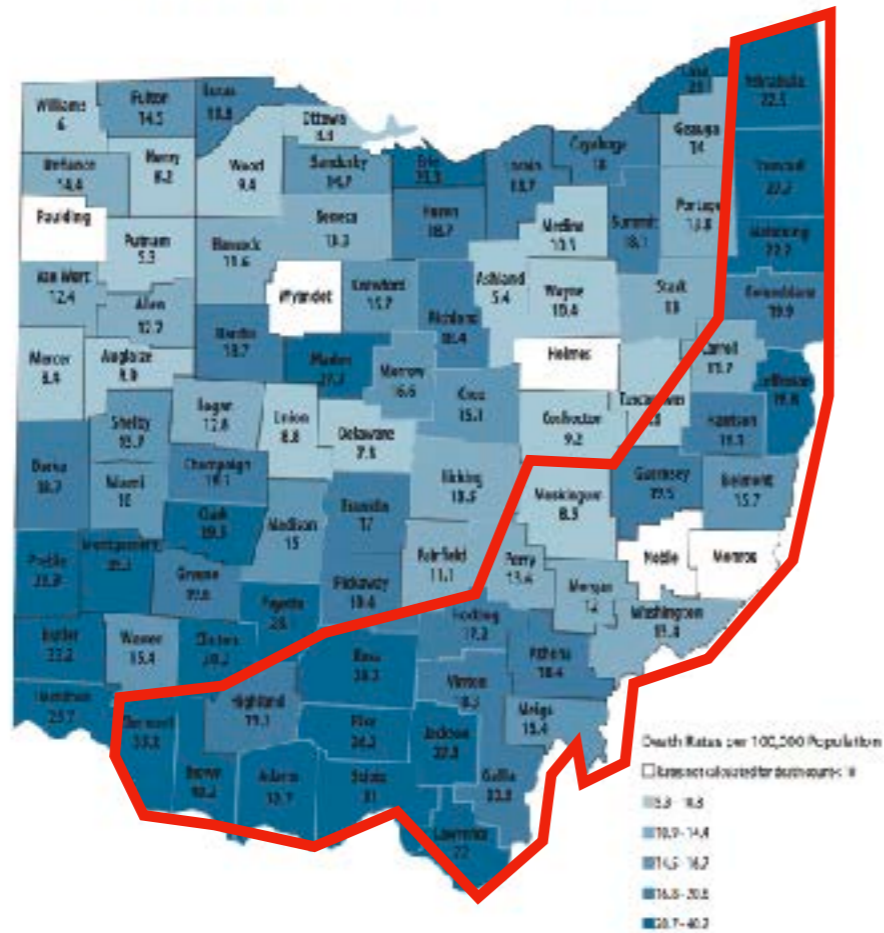
## **Engaging stakeholders and infrastructure providers:**

Must be done throughout the project. Stakeholders help to sharpen the edge and help to test how sharp is the edge.

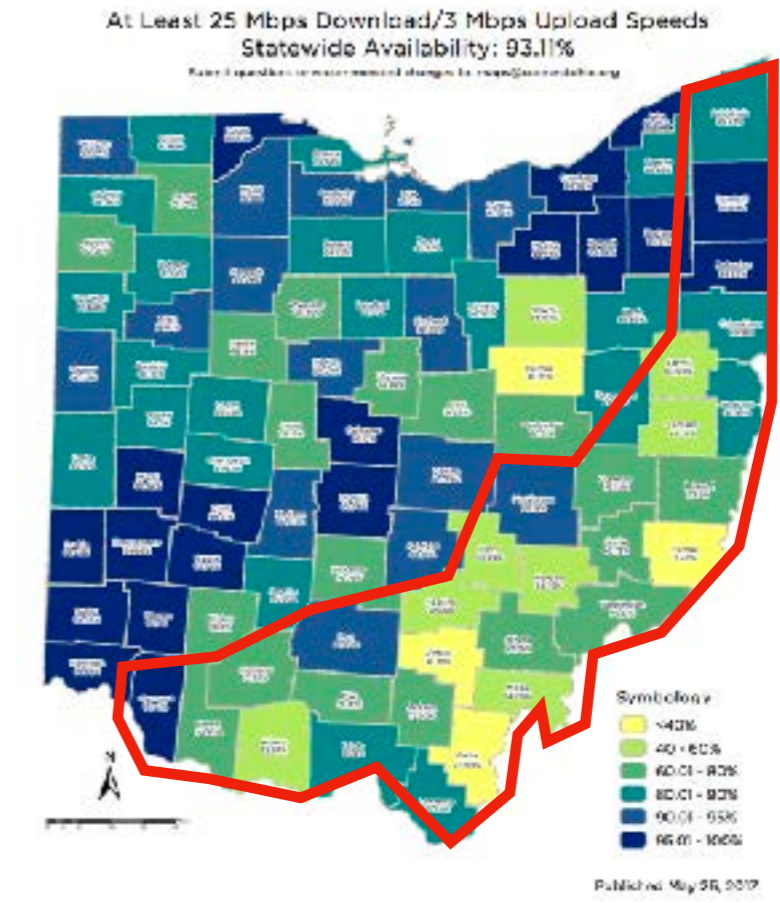




Figure 10. Average Age-Adjusted Unintentional Drug Overdose Death Rate Per 100,000 Population, by County, Ohio Residents, 2010-2015<sup>1</sup>



Broadband Availability in the State of Ohio  
Percentage of Households Served by Terrestrial, Non-Mobile Broadband Service



	Mean overdose rate (per 100,000 population)	Mean proportion of households with broadband coverage (%)		
		3mbps	10mbps	25mbps
Non-Appalachian counties	23.56	99.32	96.28	90.43
Appalachian counties	26.26	94.22	86.29	77.71





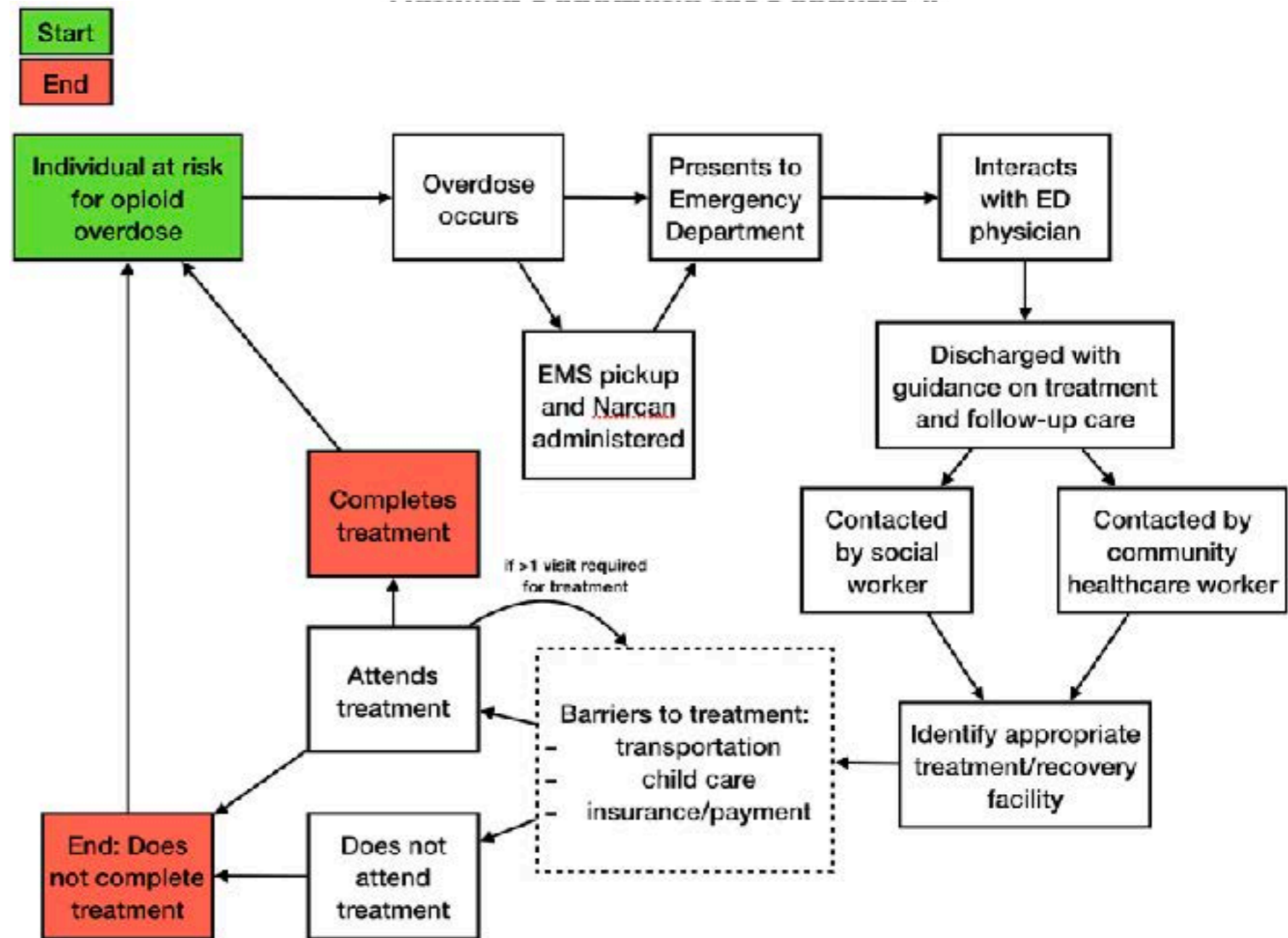
## Example from opioid overdose

-Rural EMS and ED do not provide data

-Follow-up care is complex and social workers do not have all the information

-multiple barriers to treatment

-disparities in data connectivity and access





# Opioid Epidemic in Ohio

## **Impediments to translation:**

Stigma associated with prevention and treatment for opioid misuse, including opioid prescription among vulnerable populations.

## **Supporting infrastructure needs:**

National registry to prescription drug monitoring programs to detect opioid misuse.

## **Stakeholders:**

People prescribed opioids, physicians, parents, children, law enforcement, pharmaceutical companies/distributors, and drug policy makers.

## **Engaging stakeholders and infrastructure providers:**

Need to overcome stigma first, then make a good case for how CPS-enabled solution will help to prevent opioid misuse.



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# **Are you going to ride the bus with me?**

Email me ([hyder.22@osu.edu](mailto:hyder.22@osu.edu)) for bus route to take in your city.

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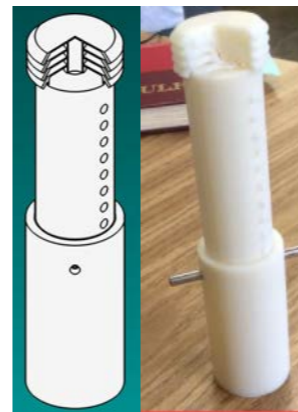
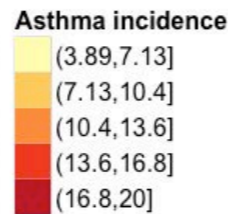
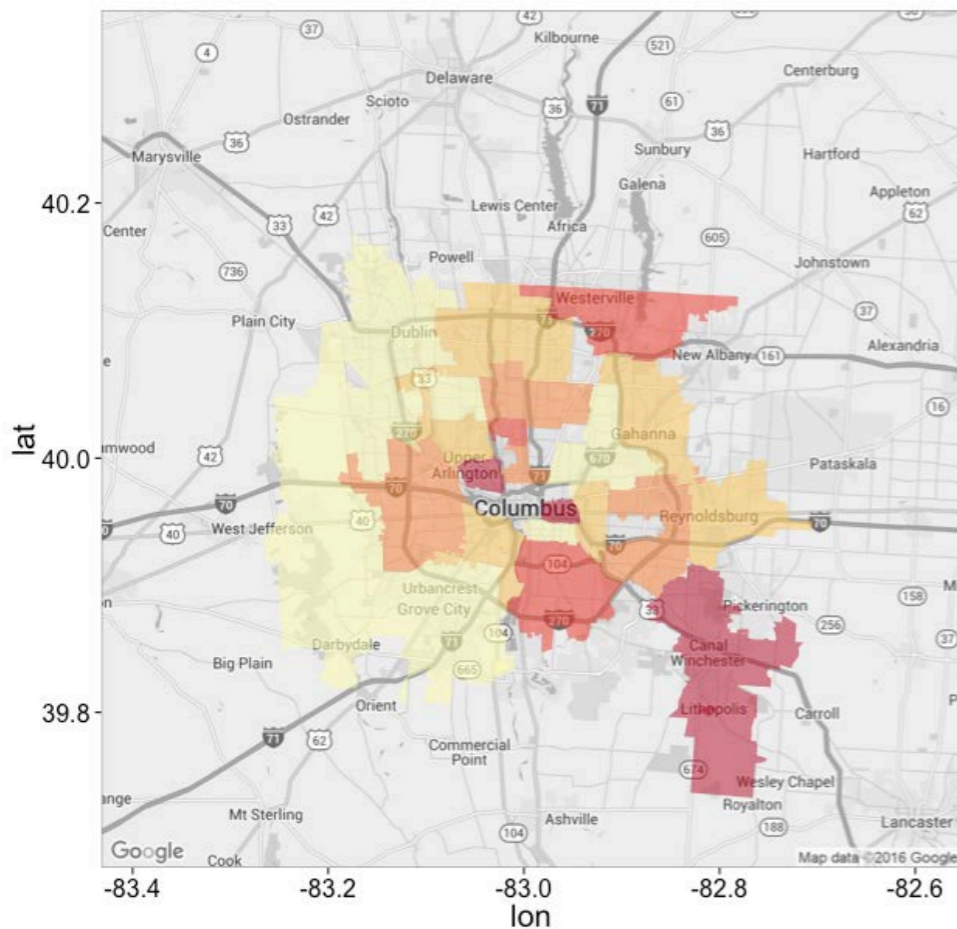
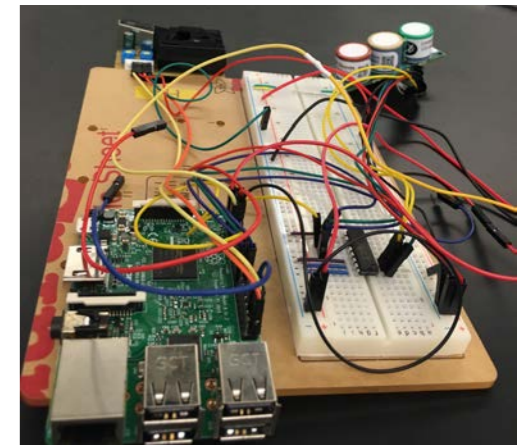


# Incorporating Citizen Science Into Real-Time Sensor-Based Estimates Of Traffic-Related Air Pollution Exposure

Ayaz Hyder<sup>1</sup> And Andrew May<sup>2</sup> 1. College Of Public Health, 2. College Of Engineering, OSU

## Rationale

**Objective** Deploy low-cost air quality sensors via citizen scientists to provide reliable air quality data within micro-environments.



**Products** Air quality sensor package connected to Raspberry Pi. We provided materials and students built the sensor package.

## ACKNOWLEDGEMENTS

This project received support from the National Science Foundation under Grant Number 1645226 and was co-funded by the Midwest Big Data Hub.



## Incorporating Citizen Science Into Real-Time Sensor-Based Estimates Of Traffic-Related Air Pollution Exposure

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**Progress** Prototype (left) and small-scale (right) version of housing for sensor package that students developed on their own.

### Lessons learned

- **High school students** very willing to participate in citizen science project when motivated by the use case.
- **High school science teachers** eager to engage with academic researchers.
- **Interest in curriculum development** using the data collected and data visualization web application requires trust building and a long-term commitment.

### Future directions

- Continue engaging with high school teachers.
- Partner with hospitals, libraries and community to expand sensor network.
- Develop user-specific modules for data analytics, data visualization and environmental health education.



## What “may” data-enabled public health look like?

### **Public health department uses data from multiple sources to:**

- make decisions,
- evaluate impacts,
- forecast emerging issues, and
- make data available for education and research via open data platforms.

### **Public health department staff:**

- collect data,
- have capacity to analyze data, and
- have capacity to visualize and interpret data (internal and external).

### **Public health leadership:**

- takes into account limitations of data and use data appropriately to make decisions,
- are forward thinking about collecting data (as necessary), and
- establish partnerships across city departments and community sectors, and
- utilize systems thinking to understand connections between different parts of the public health system using data.



# Opioid Recovery Desert Project

## Objectives:

**Aim 1.** Refine the concept of opioid recovery deserts in an urban setting through a group of experts.

**Aim 2.** Map the location of existing opioid recovery centers in Franklin County and estimate space-time accessibility measures using a time geographic framework that takes into account:

- a. individual-level factors, such as point of origin, mode of transportation, and insurance type, and
- b. center-level characteristics, such as hours of operation, accepted insurance and available treatment options.



# Opioid Recovery Desert Project

## Objectives (continued):

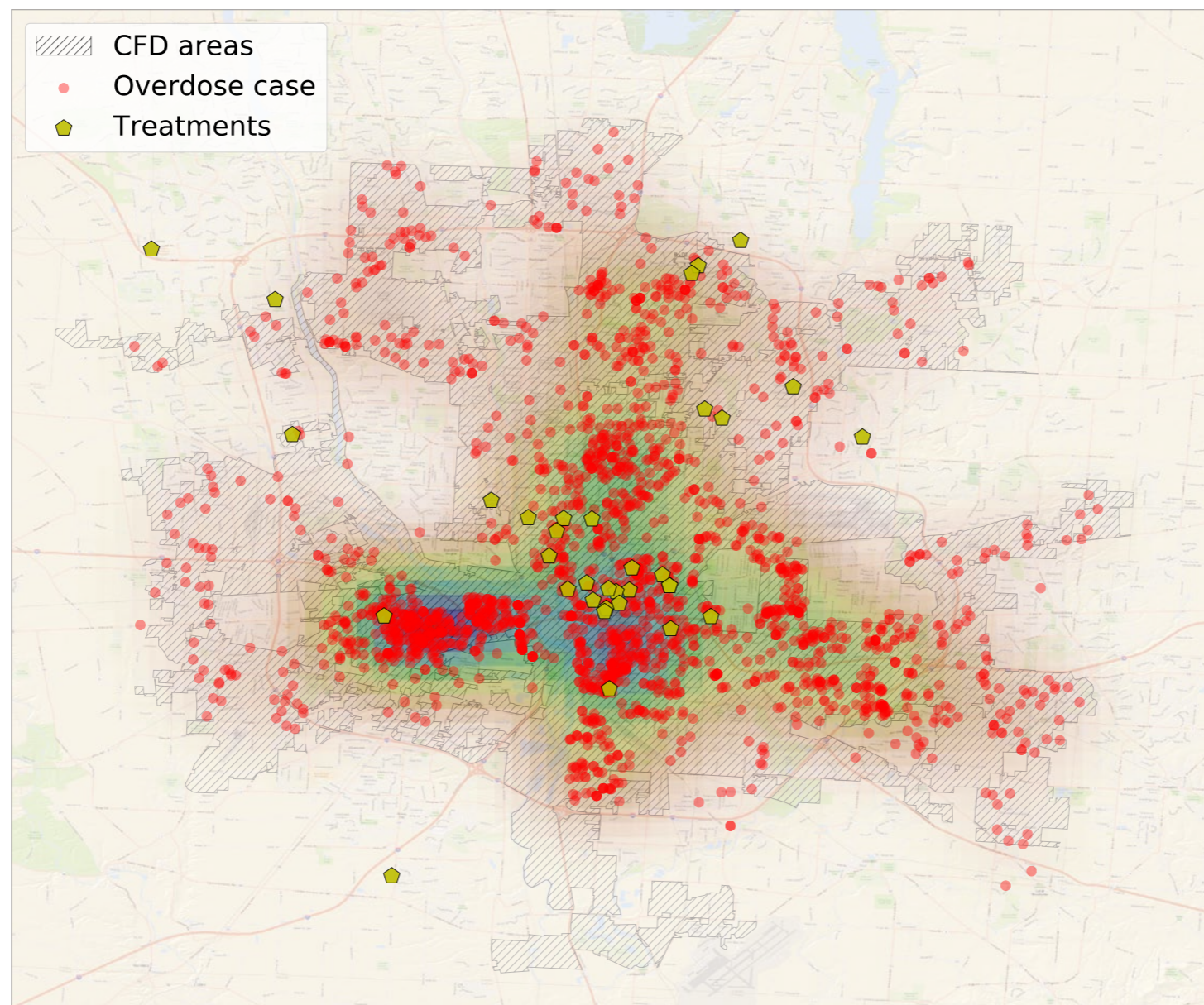
**Aim 3.** Calculate unintentional opioid-related overdose rates (per 1000,000 persons) at the census tract-level in Franklin County using data from Ohio Department of Medicaid and, potentially, Columbus Fire Department and/or Emergency Department records.

**Aim 4.** Identify a census-tract as a recovery deserts if it satisfies two conditions: i) lowest quintile for space-time accessibility measures (Aim #2) and ii) observed unintentional opioid-related overdose rate is significantly higher than the expected rate (Aim #3).





# Opioid Recovery Desert Project



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