

Geospatial Analytics: Bringing Place to Pediatric Research, QI, and Population Situational Awareness

Molly K. Krager, MD

Zoabe Hafeez, MD

Andrew F. Beck, MD, MPH



Children's Mercy
KANSAS CITY

Children's
MEMORIAL
HERMANN
Hospital



APA
QI
Research Conference

Objectives

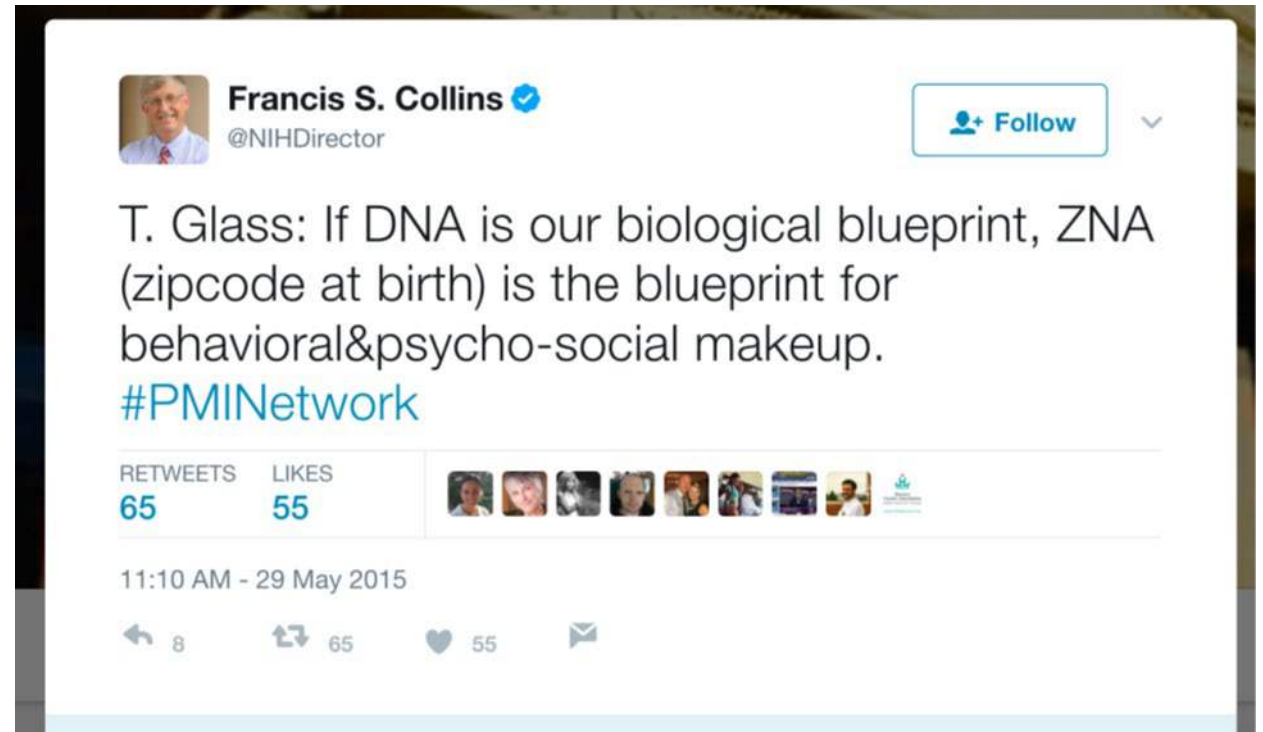
- Introduce geospatial analytics
- Discuss ways to critically appraise geospatial datasets
- Highlight case examples of the use of geospatial analytics and geospatial data for pediatric research and QI
- Leave with knowledge of datasets and tools that can be put into practice at home institutions

Getting started

- Introductions and roles
- In what ways do you currently use geospatial data?
- What tools do you already use that bring knowledge of place into your work?
- What tools do you wish you had that could advance your work further and faster?
- What sorts of future needs do you anticipate where knowledge of place would be relevant?

Geospatial determinants of health

“Conditions in which people are **born, grow, work, live, and age**, and the **wider set of forces and systems** shaping the conditions of daily life. These forces and systems include economic **policies and systems**, development agendas, social norms, social policies and political systems.”



Research Conference

Terminology

- **Geographic information system (GIS)** – an information system that can capture, store, analyze, manage, present data linked to a location
 - Like onion skins, layers that help to answer questions, inform action
- **Geocoding** – the assignment of a code – usually numeric – to a geographic location (e.g., zip code, census tract)
- **Shapefiles** – files describing geometries (e.g., points, lines, polygons)
- **Geomarkers** – objective, contextual or geographic measures that influence or predict the incidence of outcome or disease

Discussion

How can data help us?

Why are data important?

What are potential use cases for
geospatial data?

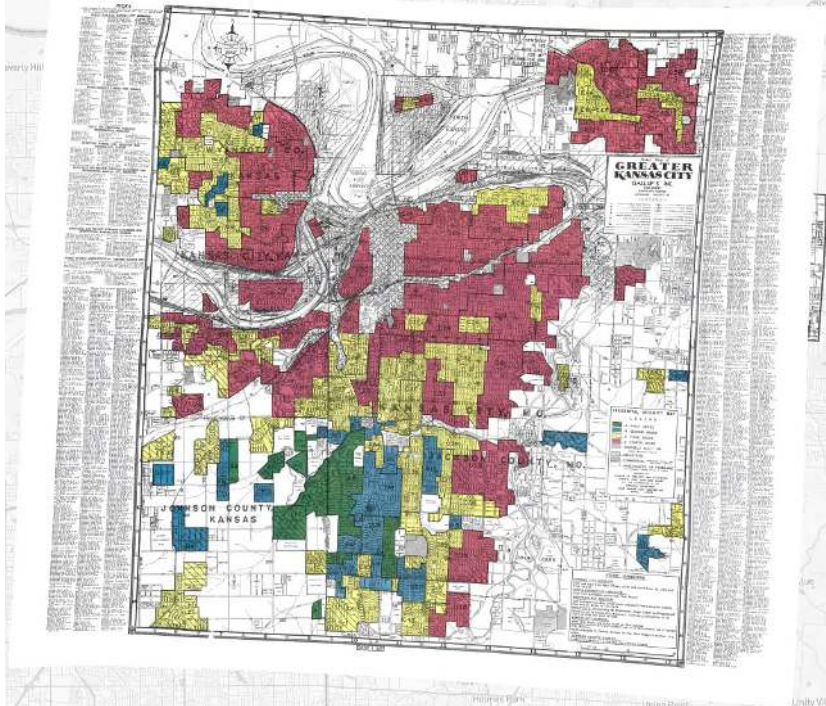
How can geospatial data help us?

- Family stories give a face and heart to needs
- Data expand family stories, inform policy, and drive change
 - Identifying and documenting needs
 - Building partnerships
 - Educating policy-makers/advocacy

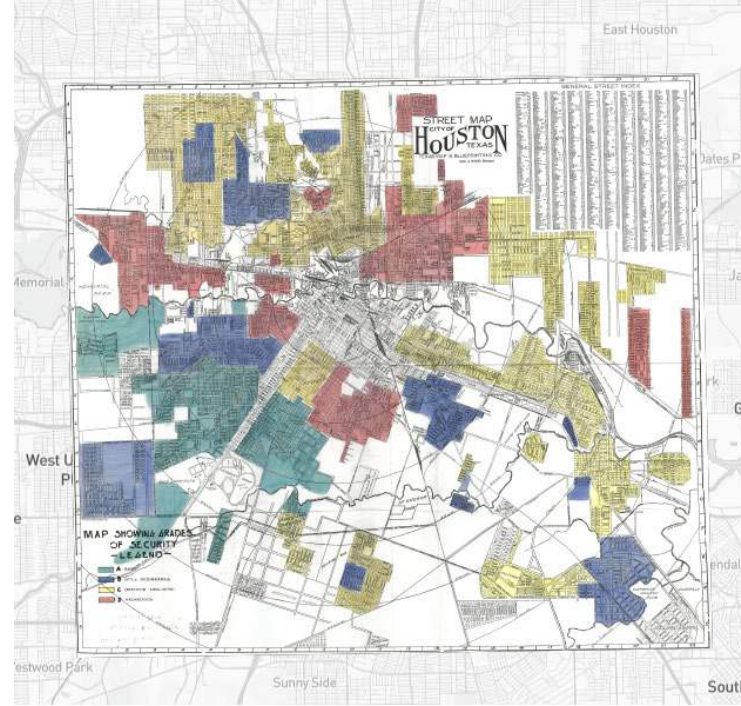
Identifying and documenting needs

- How many people in our community are at risk?
- What do we define as our “community”?
- How many people have what needs?
- How do needs vary across geographies and why?
- How do data support what you hear from the field (providers, families, other partnered agencies)?
- How are needs changing over time?
- What is the **historical context** for a certain place or community?

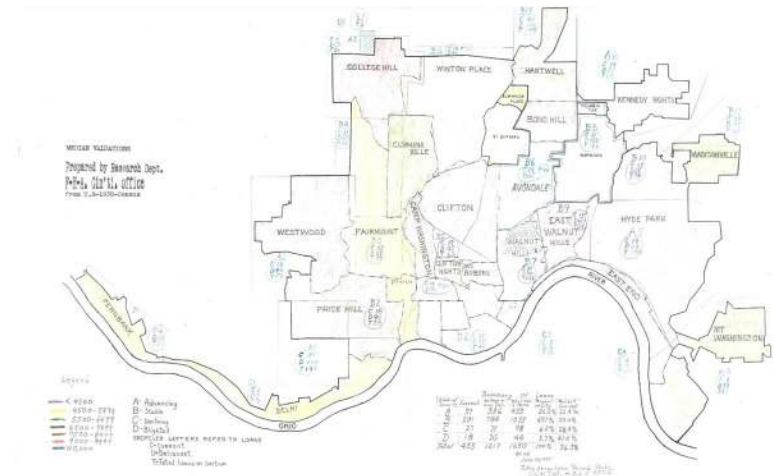
Redlining Maps



Kansas City



Houston



Cincinnati

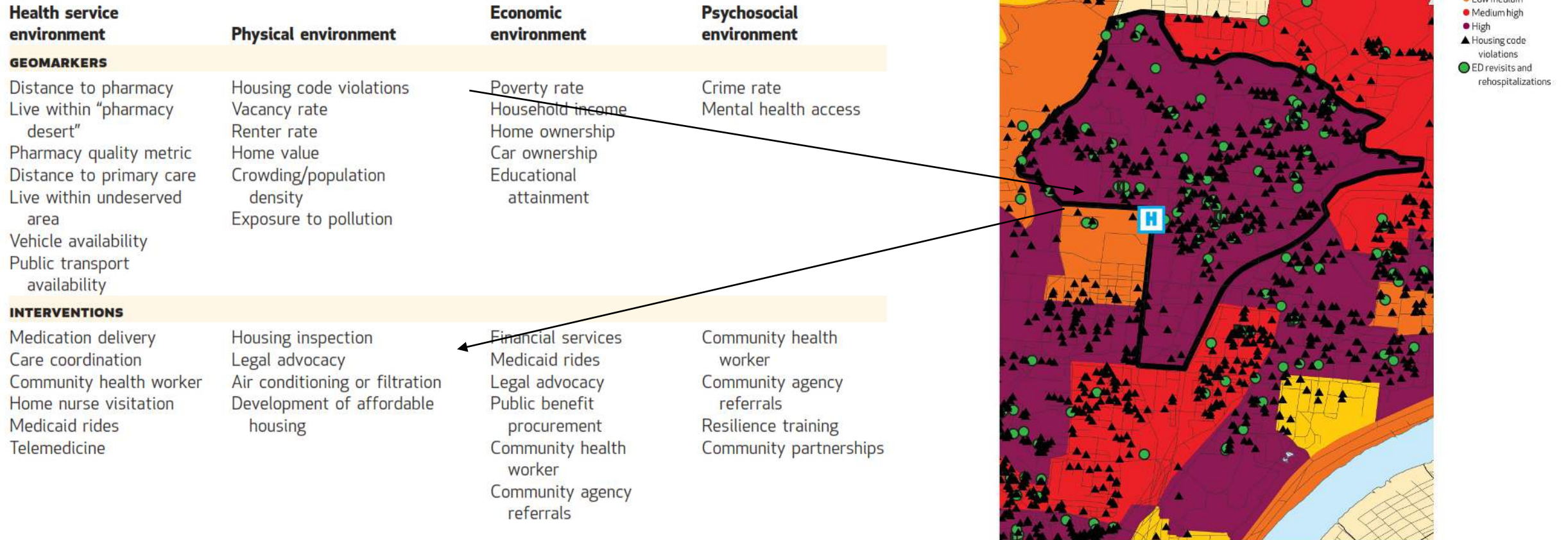


Research Conference

Building partnerships

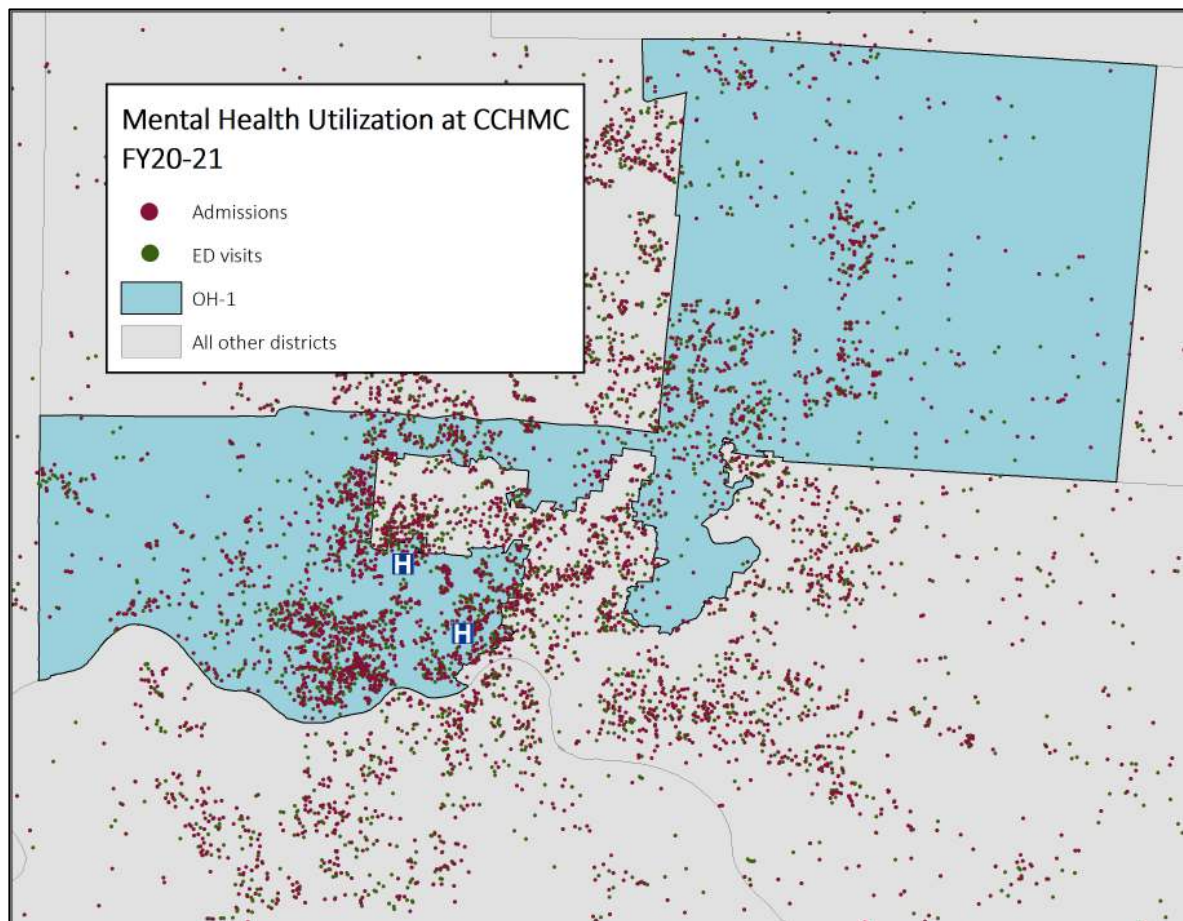
- Who are potential partners?
- What data do we have that they could use?
- What data do they have that we could use?
- How can we share data to support common efforts, improve care?
 - Recognize and act on patterns
 - Complement expertise

Building partnerships



Research Conference

Educating policy-makers

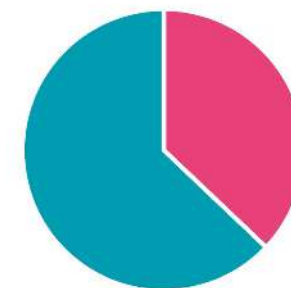


OH1 - Mental Health Admissions
(N=7,058)



- FY20-21 Admissions (Private insurance)
- FY20-21 Admissions (Medicaid)

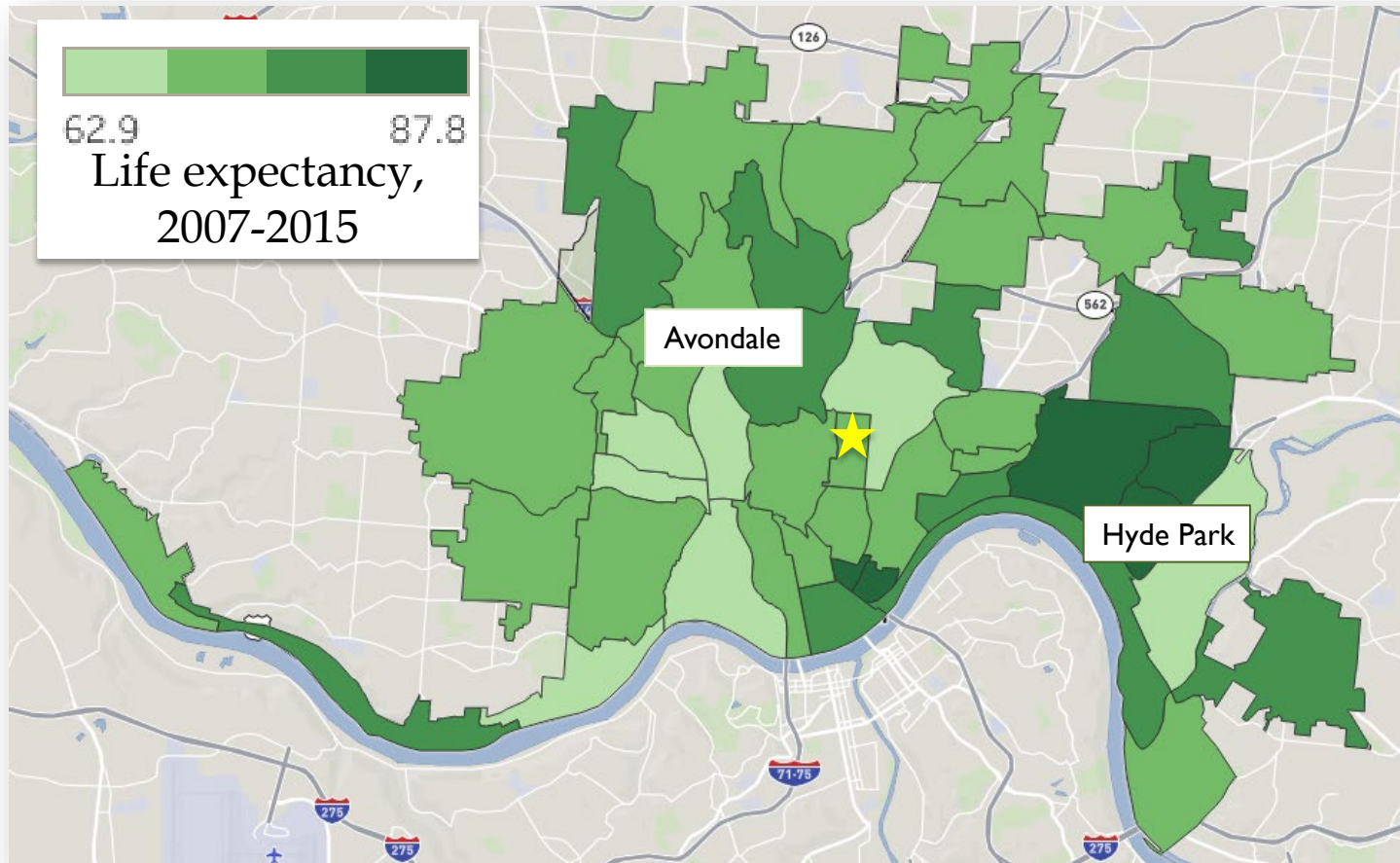
OH1 - Mental Health ED Visits
(N=11,139)



- FY20-21 ED Visits (Private insurance)
- FY20-21 ED Visits (Medicaid)



Advocating for change



Avondale = 68.9 years
Hyde Park = 83.9 years

- 1.5 years per minute drive time
 - 5 years per mile

Check place-based life expectancy in your area now using CDC data

<https://www.cdc.gov/nchs/nvss/usaleep/usaleep.html>

Small group discussion

- **Topic 1:** How can you evaluate the quality of data?
- **Topic 2:** What are different types of data? When and why might you use public datasets?

Take 5-10 minutes and be prepared to share!

Choosing a dataset

- Quality
- Fit for your project
 - Availability/cost
 - Level of geography
 - Type of data

Critical evaluation of dataset quality

- Accuracy
- Authority
- Objectivity
- Currency
- Coverage

Evaluation criteria

- Accuracy
 - Is the information reliable and error-free?
 - Is there an editor or someone who verifies/checks the information?

Evaluation criteria

- Authority
 - Is there an author? Is the page signed?
 - Is the author qualified?
 - Who is the sponsor?
 - Is the sponsor of the page reputable?
 - Is there a link to information about the author or sponsor?
 - If the page includes neither a signature nor indicates a sponsor, is there any other way to determine its origin?

Evaluation criteria

- Objectivity
 - Does the information show a minimum of bias?
 - Is the page designed to sway opinion?
 - Is there any advertising on the page?

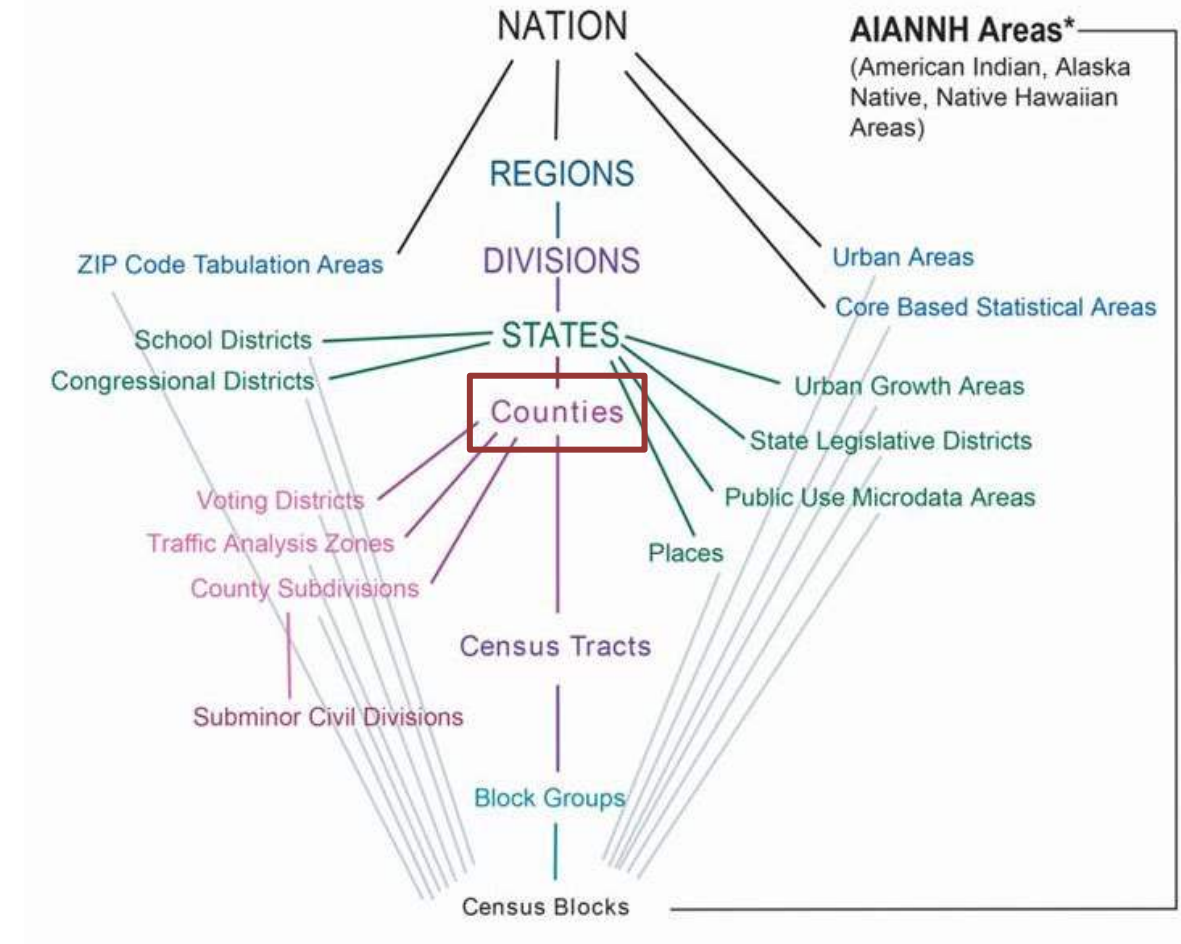
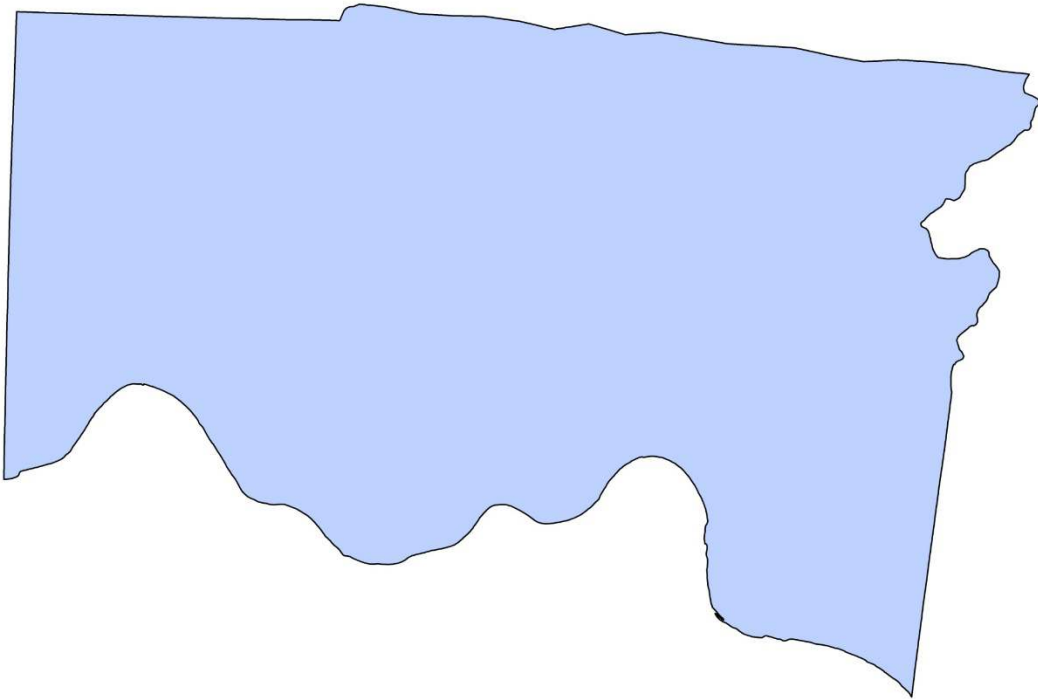
Evaluation criteria

- Currency
 - Is the page dated?
 - If so, when was the last update?
 - How current are the links?
 - Have some links expired or been moved?

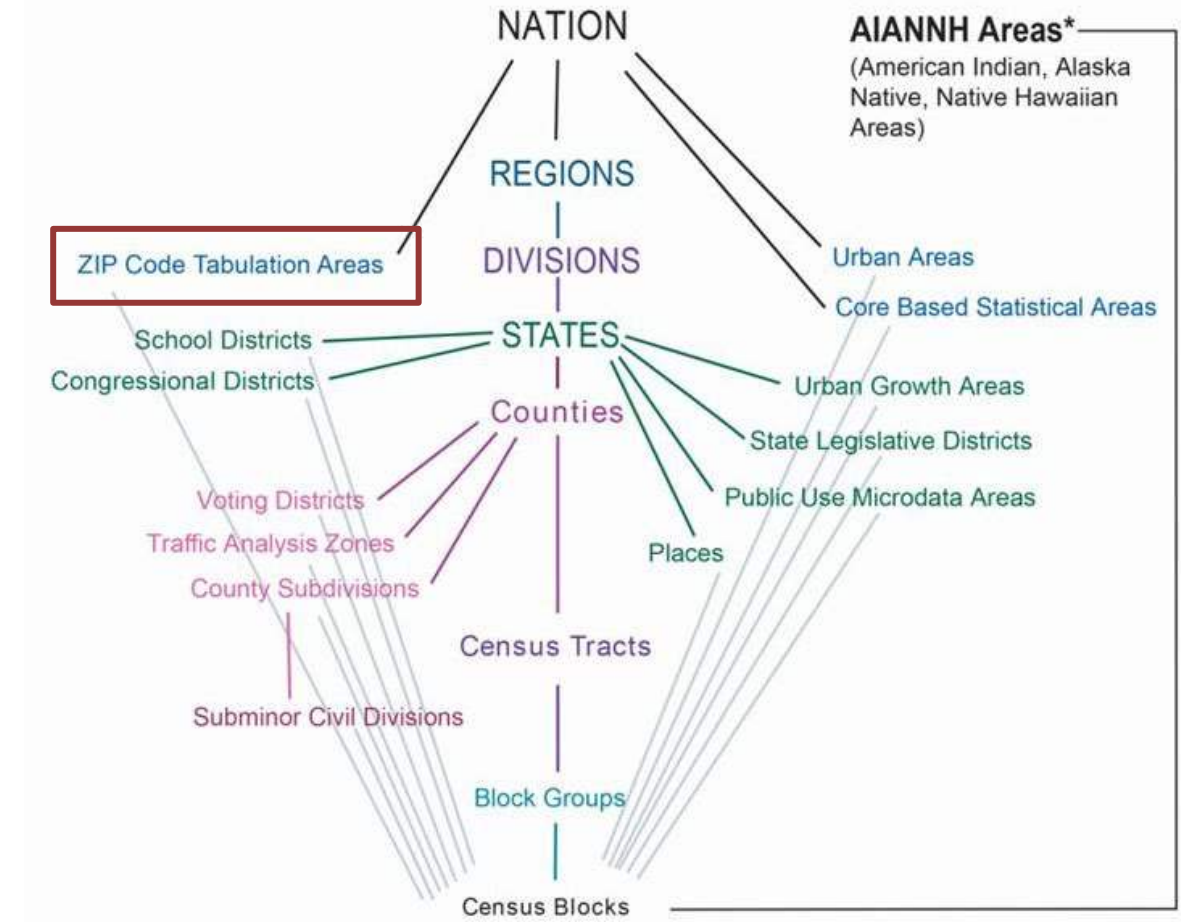
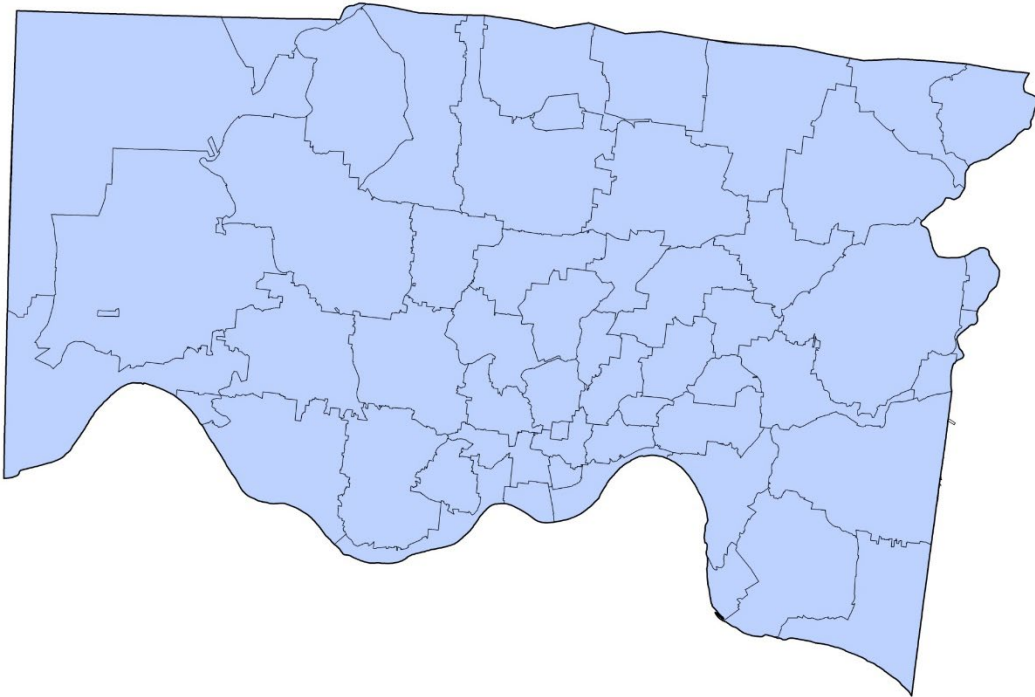
Evaluation criteria

- Coverage
 - What topics are covered?
 - What does this page offer that is not found elsewhere?
 - How in-depth is the material?
 - Geographic coverage – how is place defined?

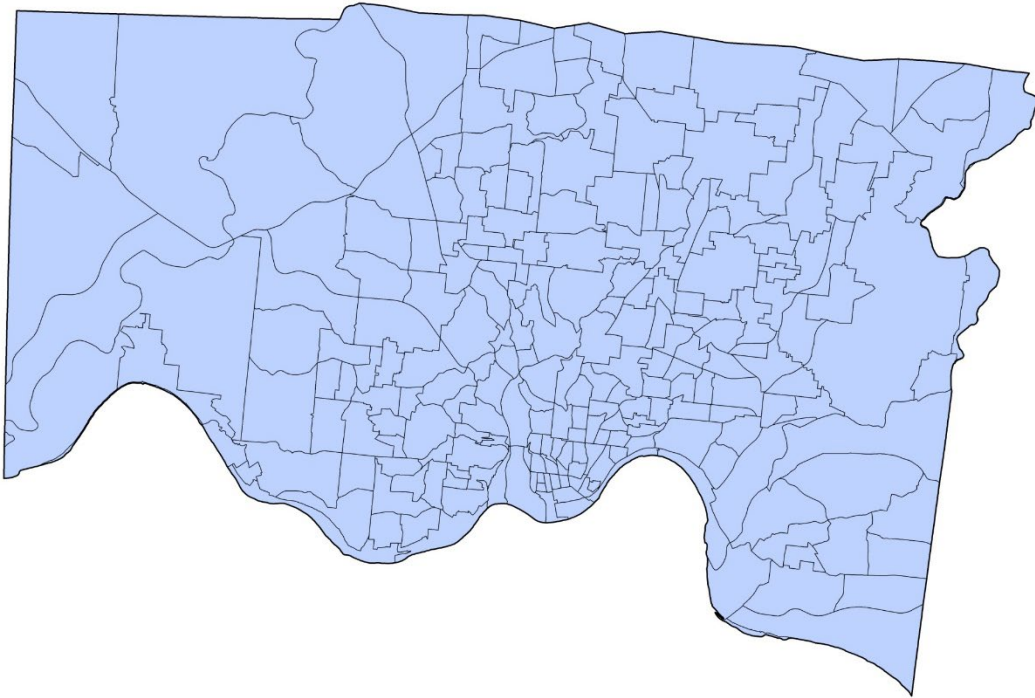
Census geographies



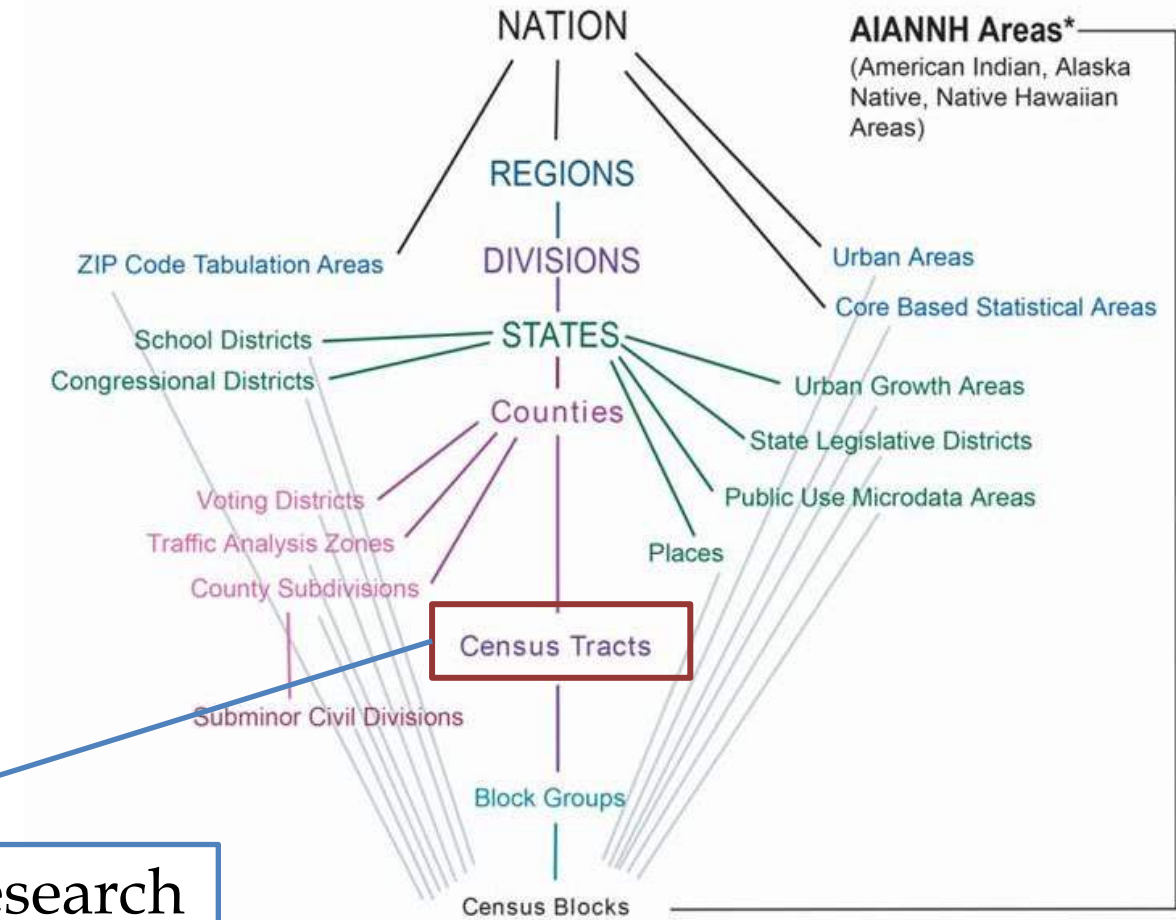
Census geographies



Census geographies

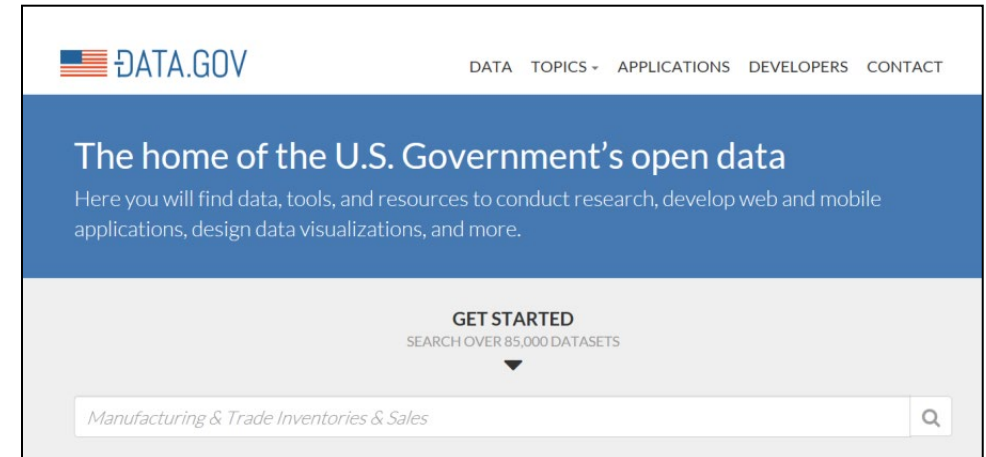


Often used in public health and medical research



National place-based datasets

- National, governmental data sources
 - U.S. Census Bureau – www.data.census.gov
 - U.S. Government data clearinghouse – www.data.gov
 - Centers for Disease Control – www.cdc.gov/brfss and www.cdc.gov/nchs
 - Bureau of Labor Statistics – www.bls.gov
 - Federal Bureau of Investigation – www.fbi.gov



National place-based datasets

- National, not-for-profit datasets
 - Robert Wood Johnson Foundation County Health Rankings - www.countyhealthrankings.org/
 - Feeding America Map the Meal Gap - www.feedingamerica.org/hunger-in-america/hunger-studies/map-the-meal-gap.aspx
 - Child Opportunity Index - www.diversitydatakids.org
- Data visualization tools
 - City Health Dashboard - www.cityhealthdashboard.com
 - Health Landscape - www.HealthLandscape.org
 - MySidewalk - www.mysidewalk.com
- Community-level resources and tools for referrals:
 - United Way 211
 - Cap4Kids
 - AAFP Neighborhood Navigator

Multidimensional measures

- Combine multiple contextual factors that have a positive and/or negative effect on health
- Vary widely in number of factors included and level of granularity
- **Benefits:** more nuanced view of social context, provides a common language and tool kit
- **Limitations:** more resources required to build and validate, need to consider whether it provides a unique perspective, easy interpretation

Using data from the US Census

- To get population-based denominators for a certain geographic area
- To get population-based measures of demographics, socioeconomic status, housing, education, etc.
- It's public and easily available
- It's cheap (almost always free)

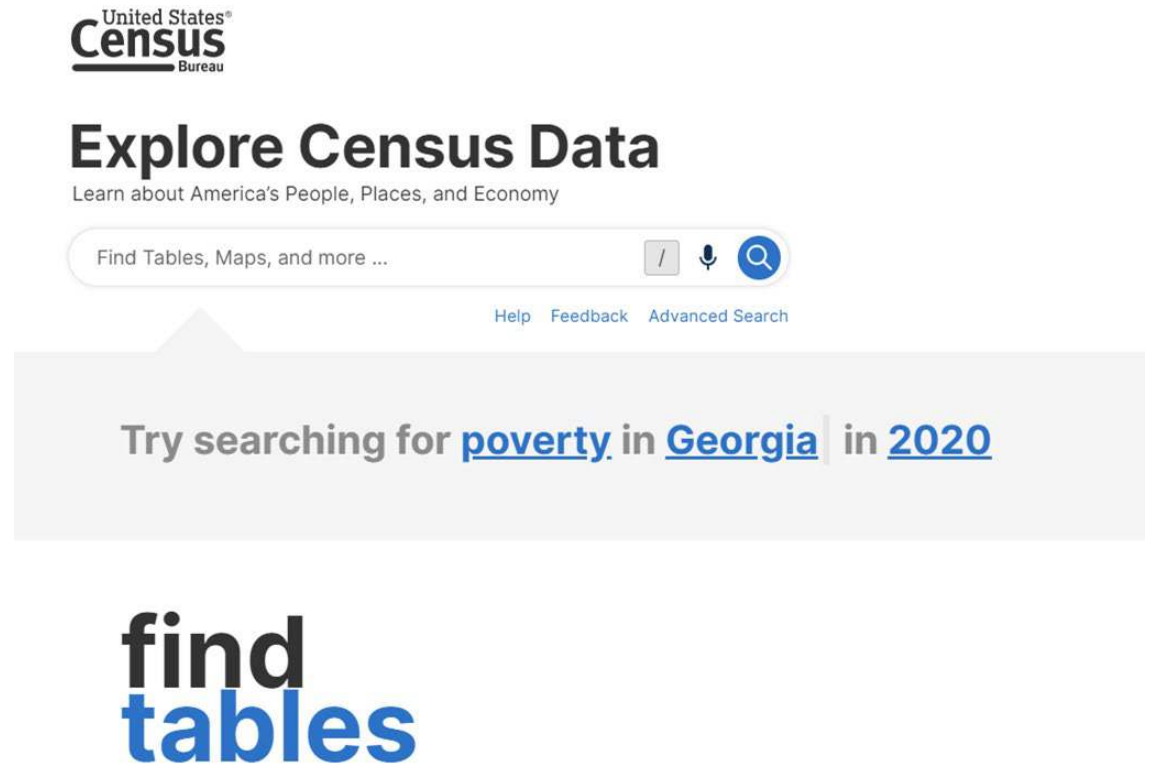
Using data from the US Census

- Decennial census
 - Provides 100% population estimates
 - Includes general demographic and housing data
- American Community Survey
 - Sampled, detailed data (weighted estimates)
 - Single year
 - 3-year compendium
 - 5-year compendium


	1-year estimates	3-year estimates	5-year estimates
65,000 +	X	X	X
20,000+		X	X
< 20,000			X


US Census Demo




- Open: <https://data.census.gov/>
 - Can try both quick search and advanced search
- Try finding the following for the county where you live:
 - Poverty rate
 - Median household income
- What about your county's census tracts?



US Census Demo


 An official website of the United States government [Here's how you know](#)





   Advanced Search


[All](#) [Tables](#) [Maps](#) [Pages](#) [Microdata](#) [Help](#) [FAQ](#) [Feedback](#)


Advanced Search


0 Filters 


 Search for filter

 Codes >

 Geography >


 Surveys >

 Topics >

 Years >

No filter selected

Please select a filter to narrow your search.

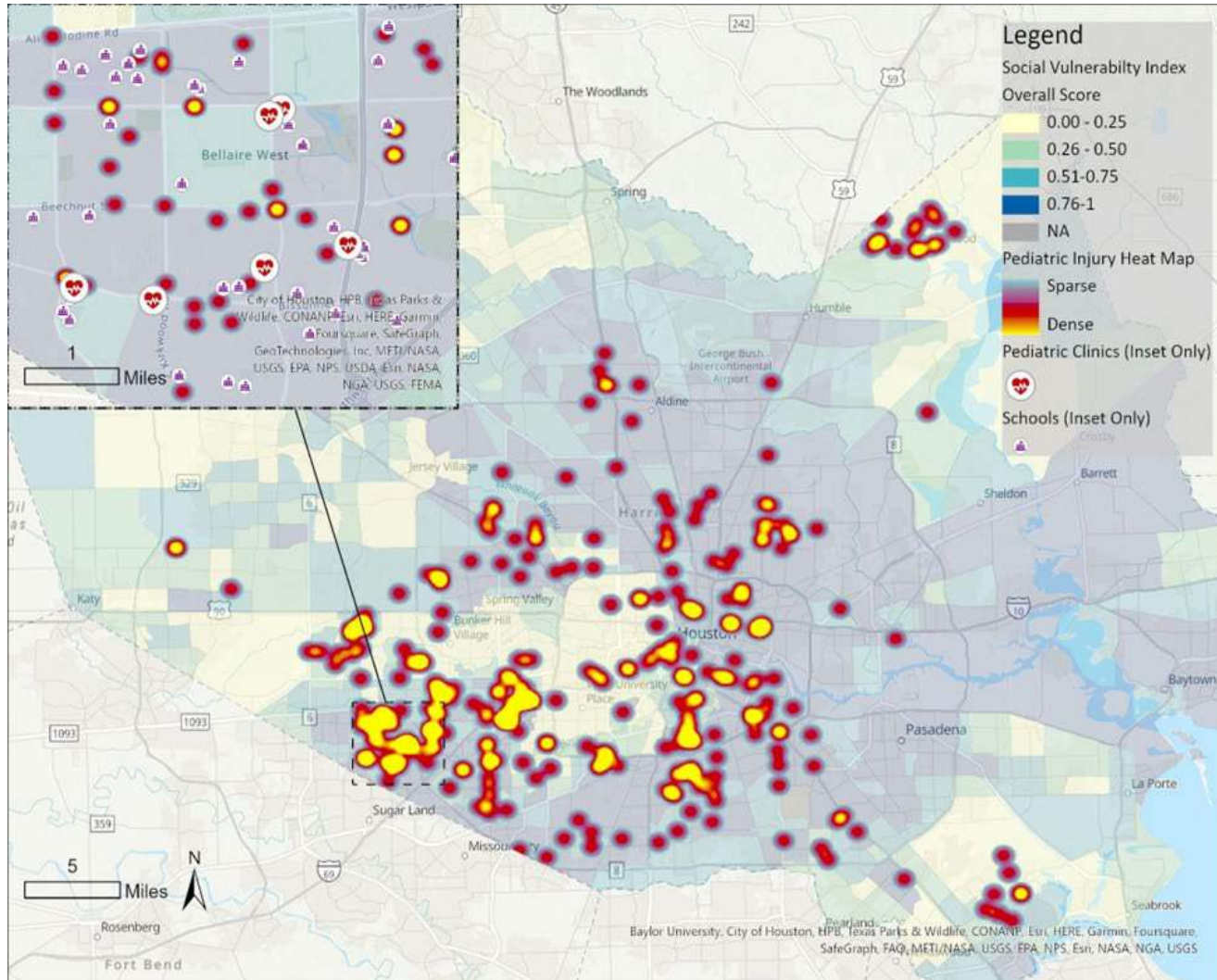


SEARCH

Geospatial data in research/QI

- **Description** – defining spatial variation in health outcomes
- **Analytic** – assessing associations between spatial factors and a range of outcomes (pattern recognition)
 - Place-based data as proxy for individual-level data
 - Place-based data as marker of one's context
- **Prediction** – inform identification of risk or prediction of outcome
- **Adjustment** – for unmeasured or insufficiently measured differences

Child Pedestrian Crash Heat Map



	n	Mean SVI	min	max
Serious Injury	91	0.757	0.034	0.996
Minor Injury	228	0.677	0.002	0.997
Intersection	145	0.663	0.019	0.996
Non-Intersection	161	0.735	0.0043	0.997
All	319	0.700	0.0019	0.997

Analytic approaches to geospatial data

	Overall	Child Opportunity Levels				
		Very Low	Low	Moderate	High	Very High
Asthma	11.8	29.3	15.7	12.3	8.1	5.3
Bronchiolitis	12.5	20.0	14.2	13.3	11.6	9.2
Pneumonia	4.4	5.9	5.0	4.6	4.3	3.7
Cellulitis	3.4	6.2	4.4	3.7	3.1	2.1
Diabetes	2.0	2.8	2.3	2.0	2.0	1.5
Gastroenteritis	4.0	5.3	4.3	4.4	4.0	3.3
Seizure	5.6	7.4	6.7	5.2	5.9	4.4
UTI	2.1	2.9	2.6	2.2	2.0	1.7

The COI 2.0 includes 29 indicators spanning 3 domains (education, health/environment, social/economic) like access to high-quality early childhood education and schools, green space, healthy food, toxin-free environments, and socioeconomic resources.



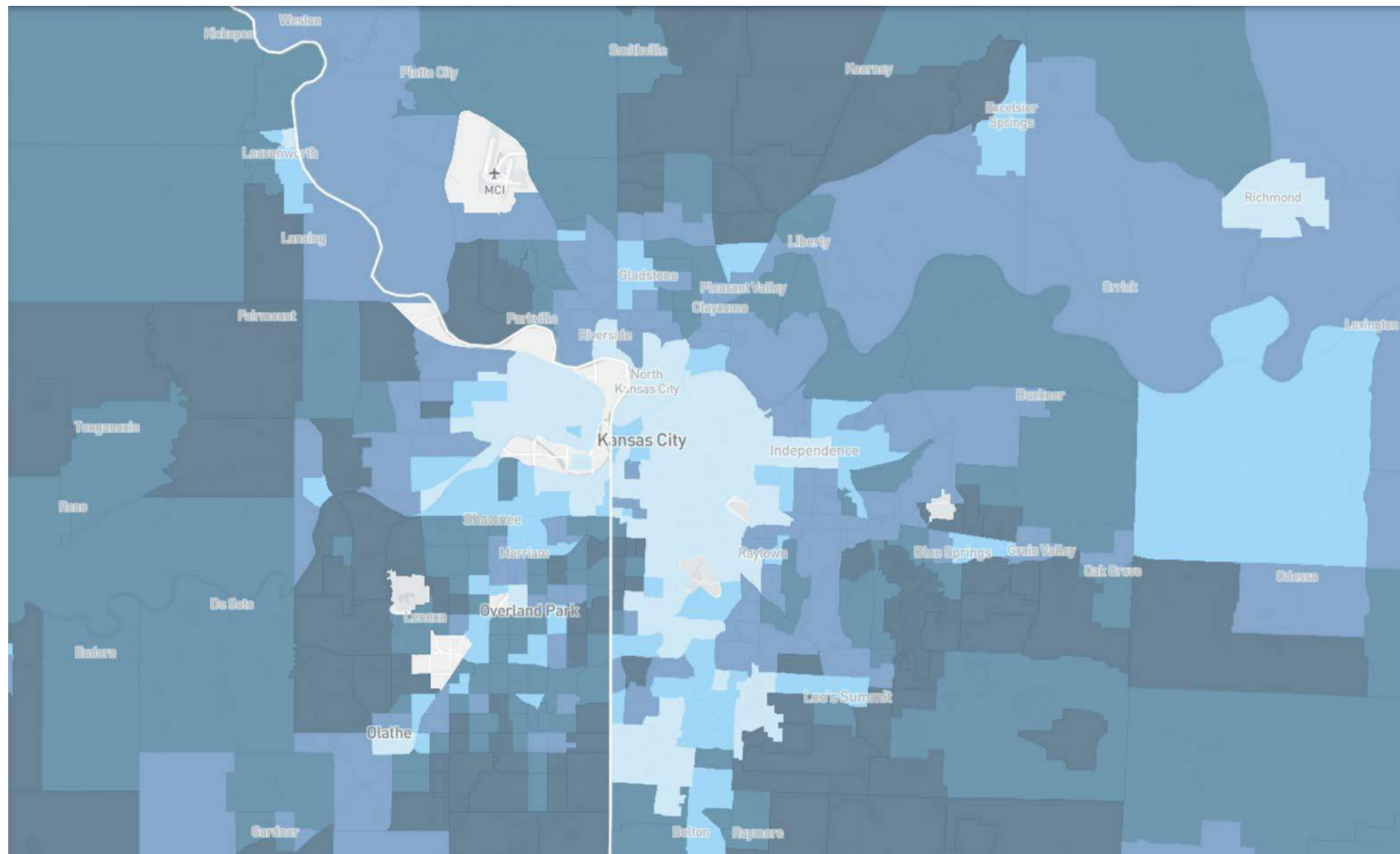
Research Conference

Kansas City, MO- KS Metro Area

COI 2.0 Child Opportunity Levels

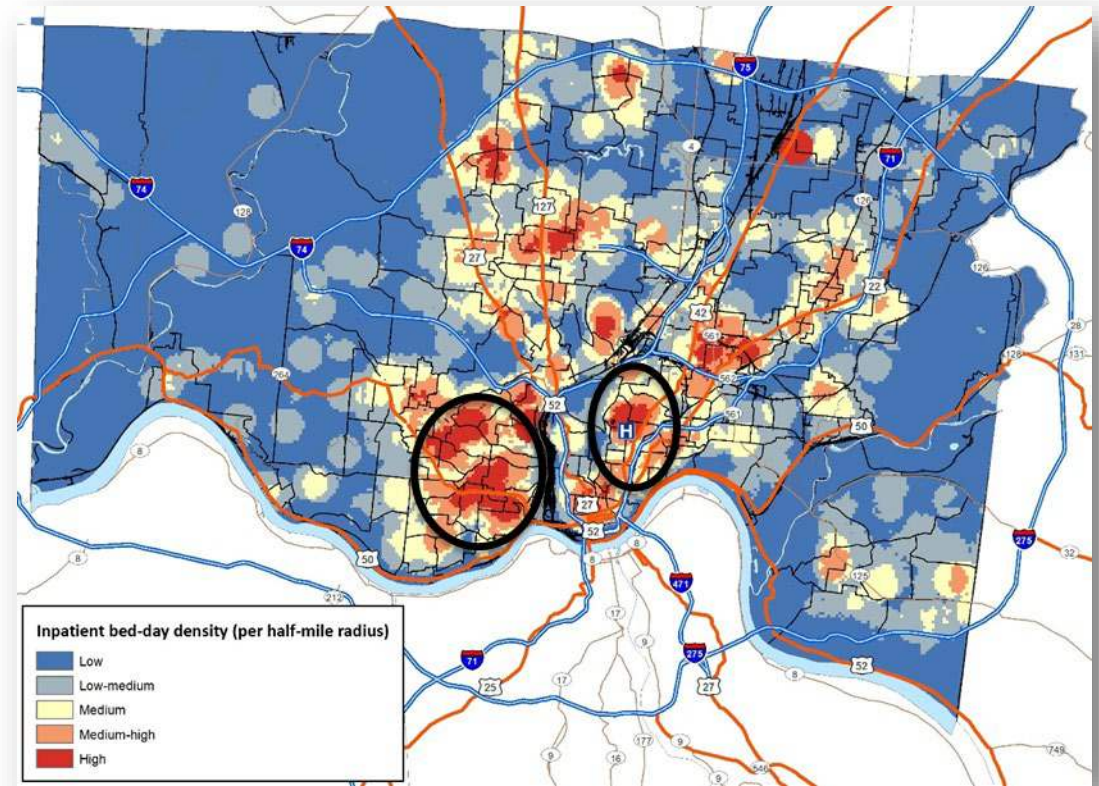
Compared to other
neighborhoods in the
country (nationally
normed)

Source: diversitydatakids.org. Child
Opportunity Index 2.0 Database.



Geospatial data and population health QI

- Disparities in health outcomes rooted in risks related to social determinants
- SMART aim defined in Winter 2015:
To reduce by 10% the child inpatient bed-day (IPBD) rate for two high-morbidity, high-poverty Cincinnati neighborhoods by June 2020
- Baseline: 7/2012 – 6/2015
 - “Hot spots” across conditions, specialties
 - Poverty, old housing stock
 - Partnered schools, health and social service agencies, families



Development of improvement theory

Families are partners in co-creation of improvement strategies

Families receive right care in right place at right time

Families trust they are receiving the right care for them

Clinical decision-making is standardized, but can be adapted to patient and family needs

Families are well-equipped to self-manage acute and chronic disease symptoms

Proactive supports assist families in removing barriers to health

Healthcare system is accountable to population, and able and willing to address disparities in care settings

Families and the community are activated in support of achieving health equity

Child (and family) at center of improvement efforts

Nimble, adaptable, accountable system driving toward equity

Activated partners



Research Conference

Defining measures

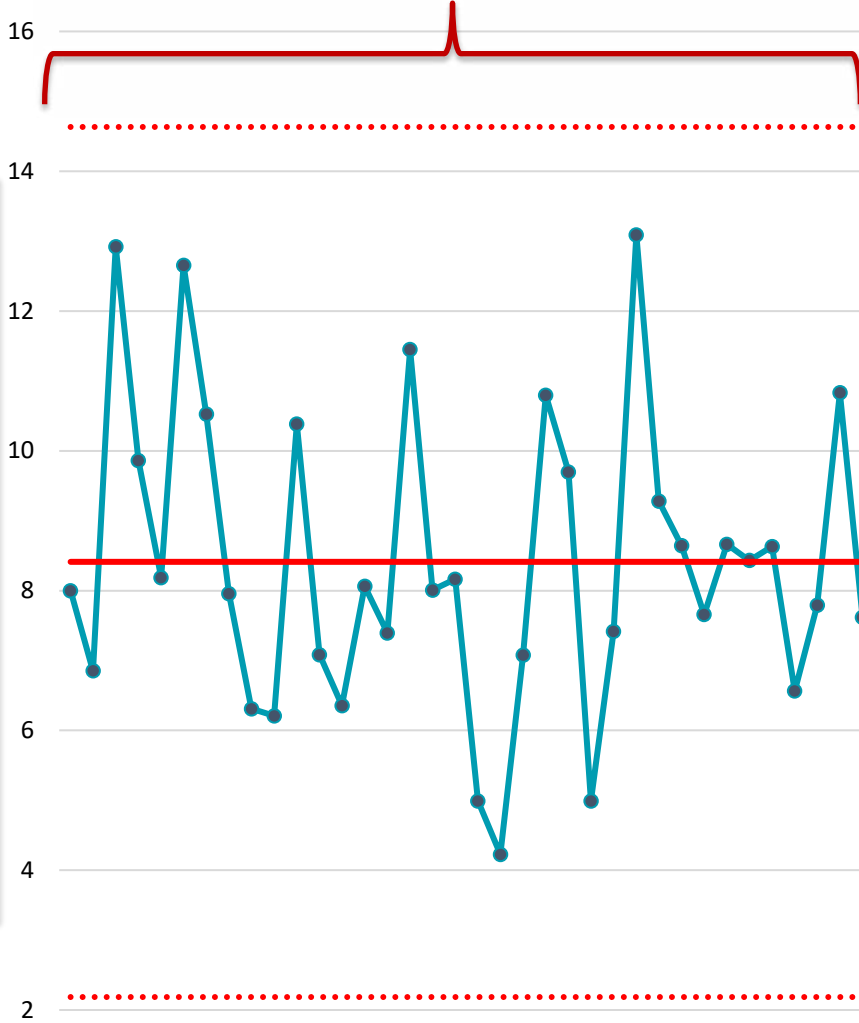
- **Primary outcome:** neighborhood-level IPBD rate

$$\text{IPBD rate} = \frac{\text{\# days children from neighborhood spend hospitalized}}{\text{\# children within neighborhood}}$$

- Per 1,000 children per month
 - Exclusions: hospitalizations for cancer, transplant, complex congenital heart disease, LOS > 14 days, psychiatric conditions
- **Secondary outcome:** hospitalization rate
- Compared “**intervention**” to “**control**” neighborhoods

Avondale & Price Hill IPBD rate (Baseline July 2012-June 2015)

Inpatient bed-day rate per 1000 children



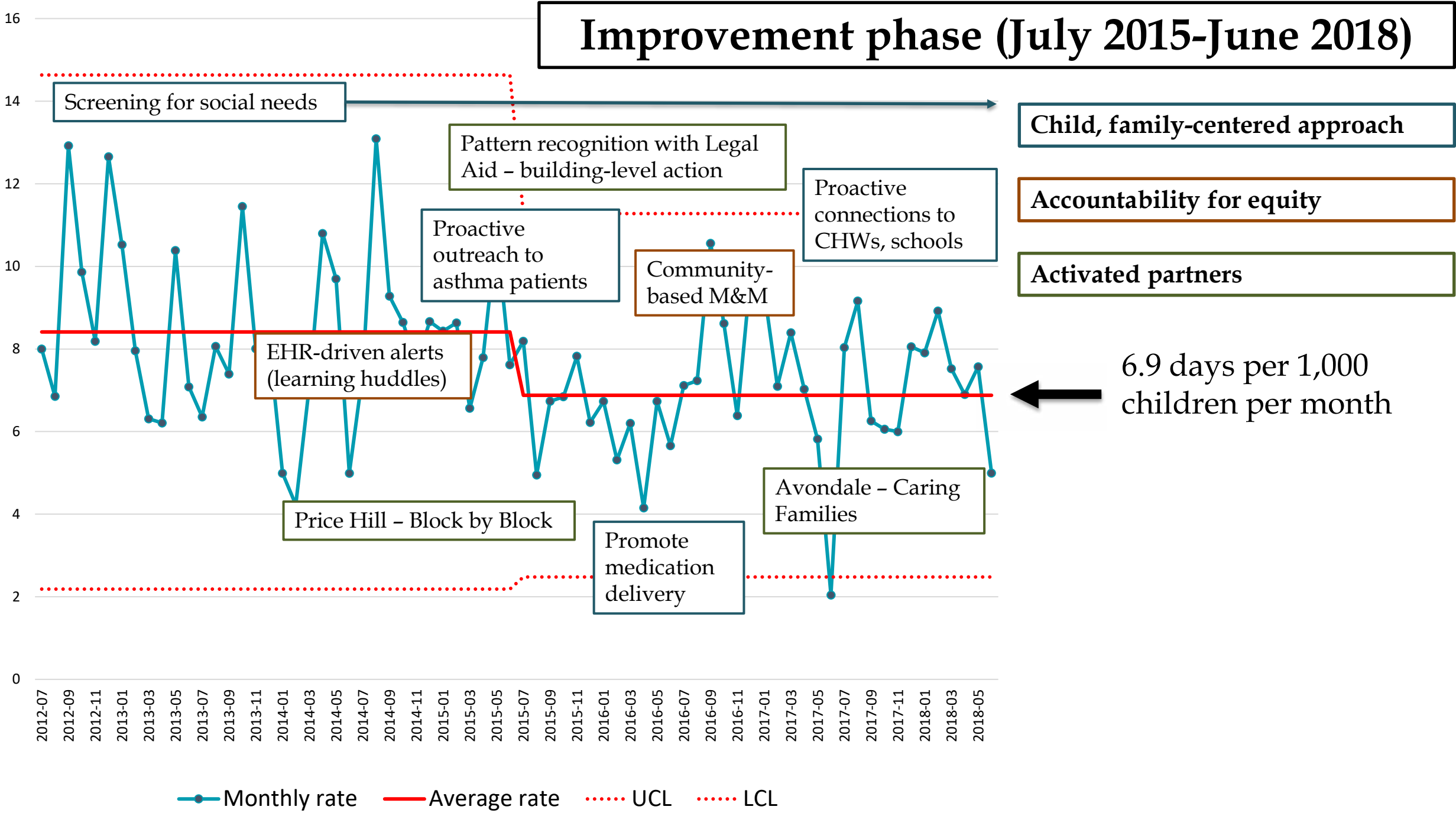
8.4 days per 1,000 children per month
= ~75 days per month, ~900 per year

2012-07 2012-09 2012-11 2013-01 2013-03 2013-05 2013-07 2013-09 2013-11 2014-01 2014-03 2014-05 2014-07 2014-09 2014-11 2015-01 2015-03 2015-05 2015-07 2015-09 2015-11 2016-01 2016-03 2016-05 2016-07 2016-09 2016-11 2017-01 2017-03 2017-05 2017-07 2017-09 2017-11 2018-01 2018-03 2018-05

● Monthly rate — Average rate UCL LCL

Improvement phase (July 2015-June 2018)

Inpatient bed-day rate per 1000 children



Avondale & Price Hill IPBD rate

Inpatient bed-day rate per 1000 children

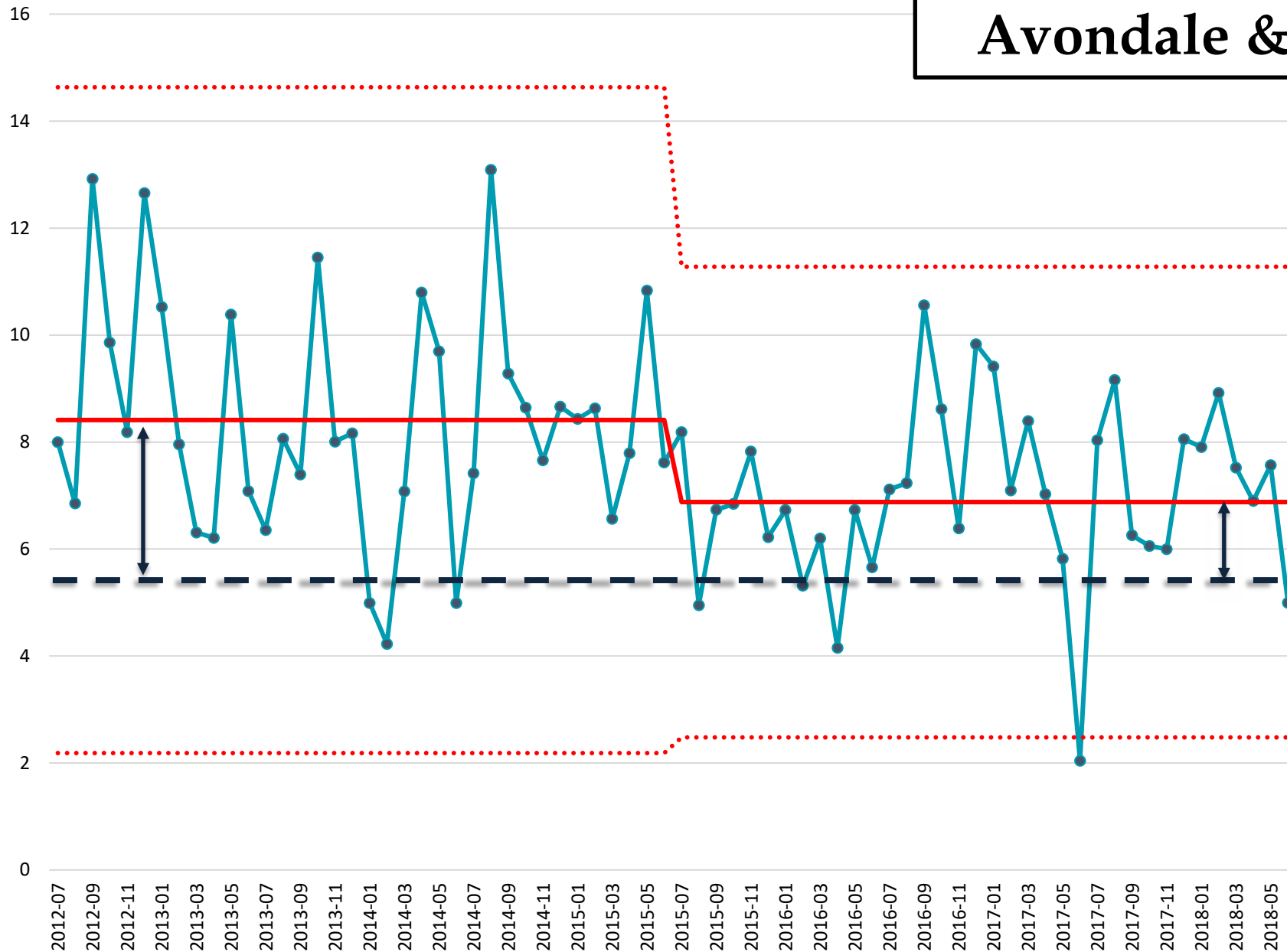
Child, family-centered approach

Accountability for equity

Activated partners

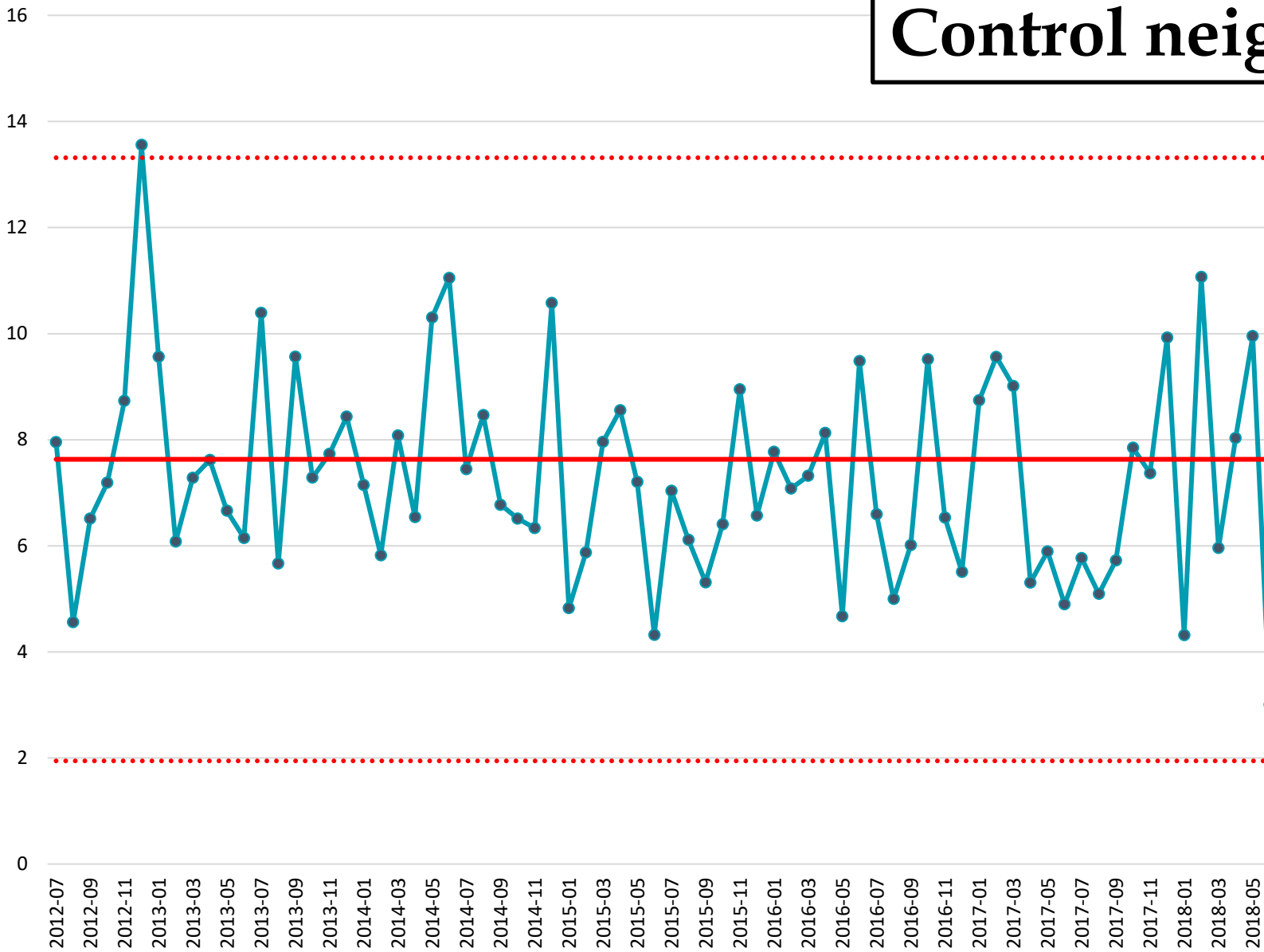
6.9 days per 1,000
children per month
(18% reduction)

Monthly rate Average rate UCL LCL



Control neighborhood IPBD rate

Inpatient bed-day rate per 1000 children



No change in IPBD rate
(or hospitalization rate
from baseline to
intervention phase)



—●— Monthly rate — Average rate UCL LCL

Limitations of geomarkers, analytics

- Database availability
 - Datasets are often static
 - Though possible to vary maps over time
 - Data may be limited in certain locations
- Ethical issues – representing a person's home address
- Ecological fallacy

How might you get started?

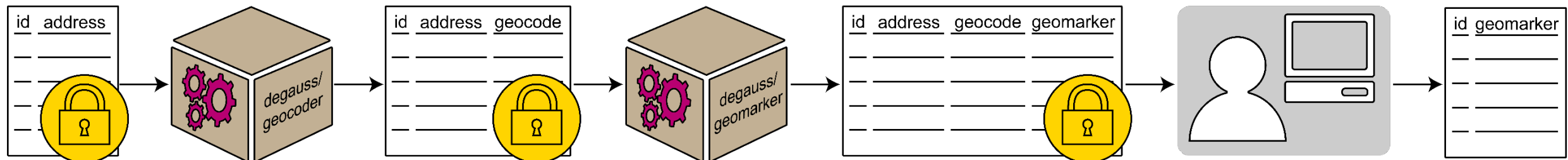
1. Explore how health outcomes vary geographically in your region
2. Use US Census data to gain an understanding of the conditions in which your patients are born, grow, live, work, and age
3. Ask your patients about their understanding of their neighborhood and community, assessing how it does or does not align with your preconceived notions
4. Design a research project that makes use of geospatial data
5. Design a QI project that can be aided by geospatial data

Getting started

- Dive into the literature – start with Prof. Nancy Krieger (<https://www.hsph.harvard.edu/thegeocodingproject/>)
- Play around on Google Maps, explore!
- Explore zip code characteristics for your population using census data
- Software examples
 - Mapping, data linkages – <https://healthlandscape.org/>
 - HIPAA compliant geocoding – <https://degauss.org/>
 - Available geomarkers – <https://github.com/geomarker-io/geomarkers>
 - ArcGIS, QGIS, Geoda, R packages, etc.
- Find partners facile in the method (departments of geography, planning)

Decentralized Geomarker Assessment for Multi-Site Studies

- DeGAUSS is a decentralized method for geocoding and deriving community and individual level environmental characteristics while maintaining the privacy of PHI
- DeGAUSS is executable on a local machine – it does not require extensive computational resources and PHI is never exposed to a third party or the internet



DeGAUSS

- Geocoding
- Capable of linking to:
 - Census geographies (e.g., tract)
 - Census tract-level deprivation index
 - Proximity to major roads
 - Greenspace
 - Daily PM2.5
 - Weather data
 - Drivetime to major pediatric centers
- Uses docker desktop and powershell

Summary and conclusions

- Geospatial data and analytics should not:
 - Be used to stereotype
 - Lead to definitive conclusions that stretch beyond the data
- Geospatial data and analytics can:
 - Add meaningfully to research
 - Inform population health quality improvement
 - Provide important contextual information about patients, populations

@mollykrager @zoabehafeez @afbeckMD
#PAS2023

Geospatial Analytics:
Bringing Place to
Pediatric Research,
QI, and Population
Situational
Awareness



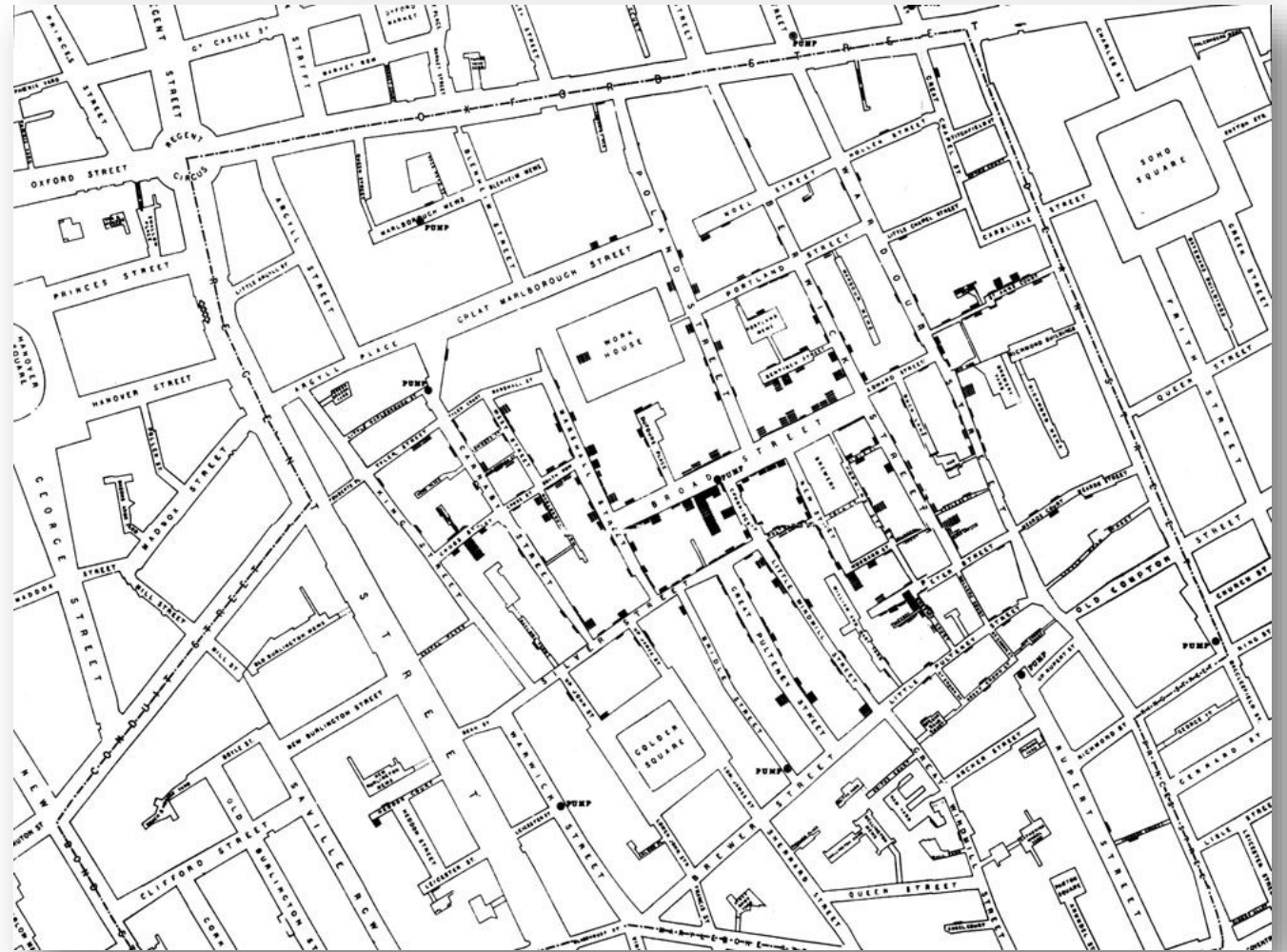
<https://associationresearch.limequery.com/484127?lang=en>

MKKrager@cmh.edu

Zoabe.Hafeez@uth.tmc.edu

Andrew.Beck1@cchmc.org

DISCUSSION



<https://www.nationalgeographic.org/activity/mapping-london-epidemic/>



Children's Mercy
KANSAS CITY

Children's
MEMORIAL
HERMANN
Hospital



APA
QI
Research Conference