Digital Twin Neighborhoods

Forecasting the Value of Health Equity Initiatives

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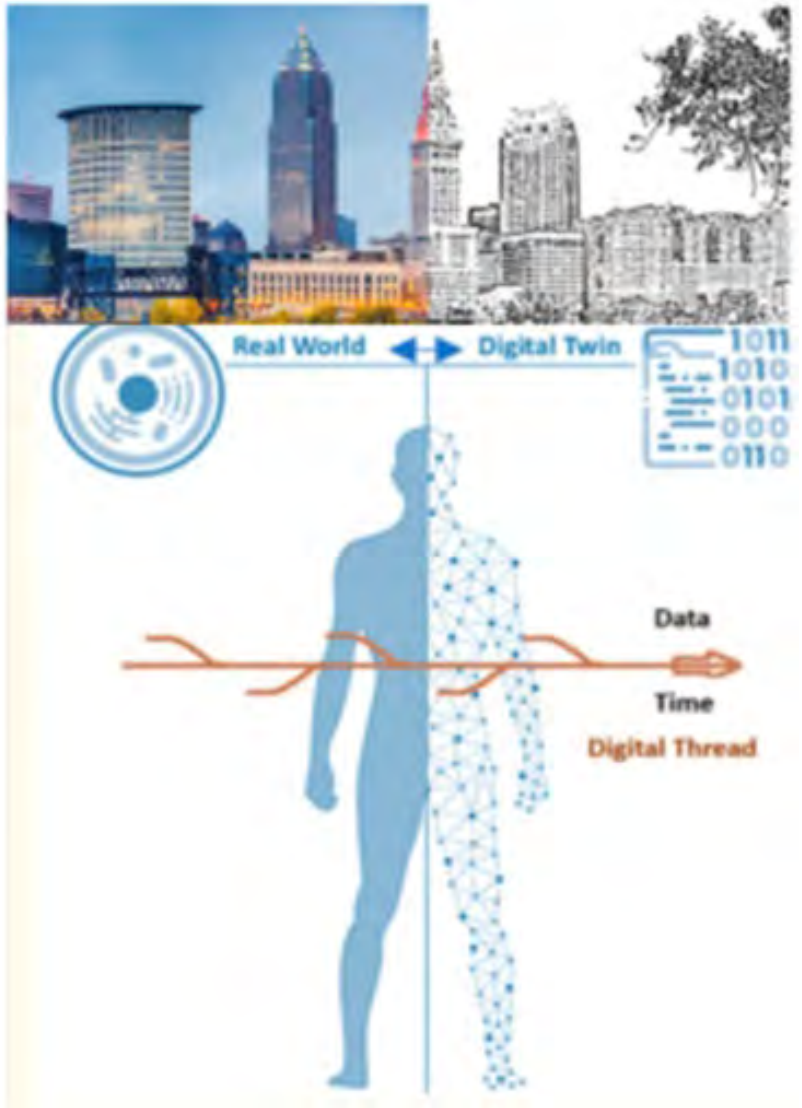

DTN Team

Elizabeth Pfoh
Douglas Gunzler
Kristen Berg
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Jacob Mitchell
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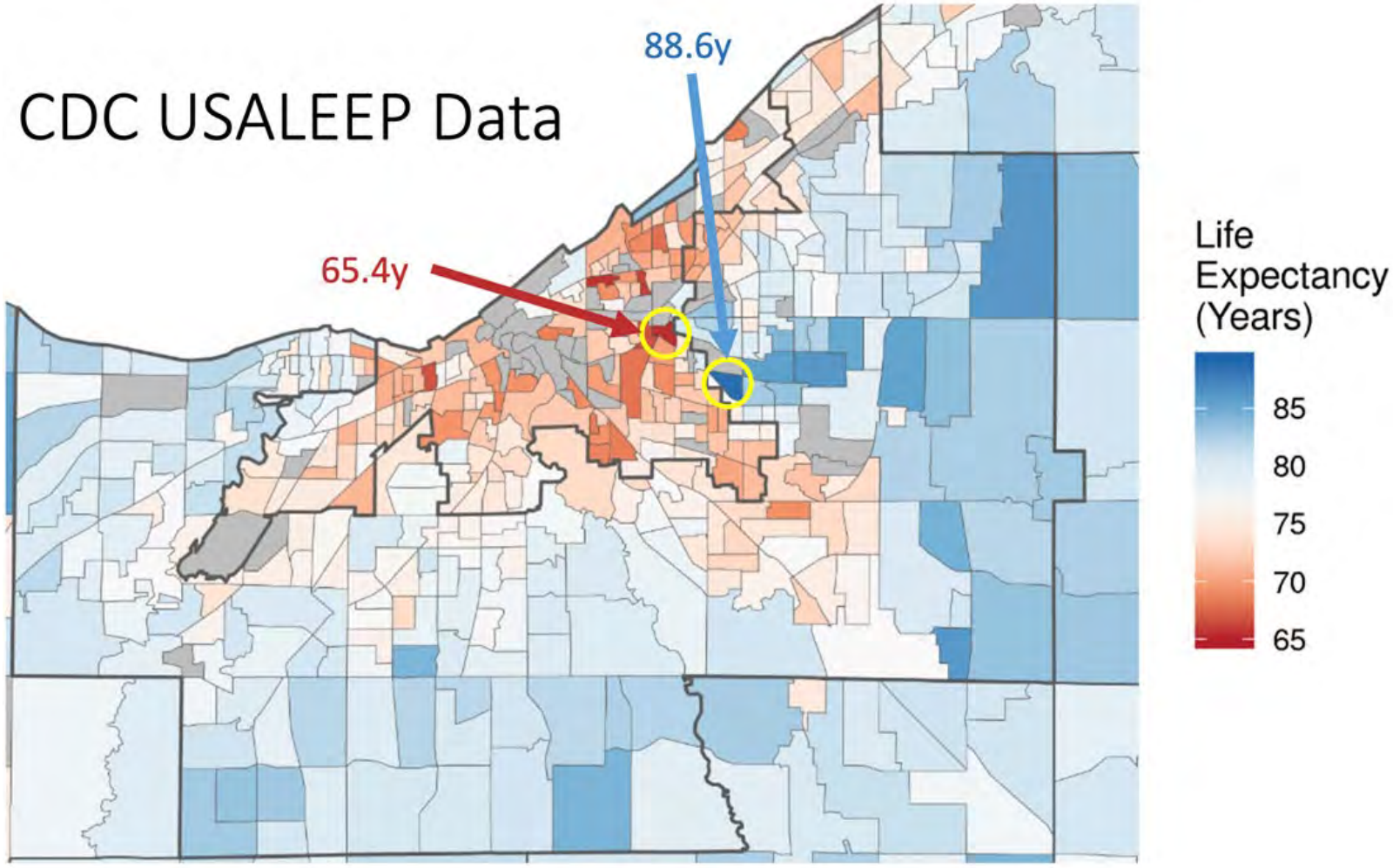
Manpreet Kaur
Morgan Whaley
>80 Community Experts

Overview

- Neighborhood health equity is among the most significant public health challenges ever identified.
- Massive data can be made massively more useful with digital twin and synthetic population approaches.
- We are meeting a critical and growing need for forecasts of health outcomes in neighborhoods that are (1) Valid (2) Equitable (3) Adaptable (4) Hyper-Local.

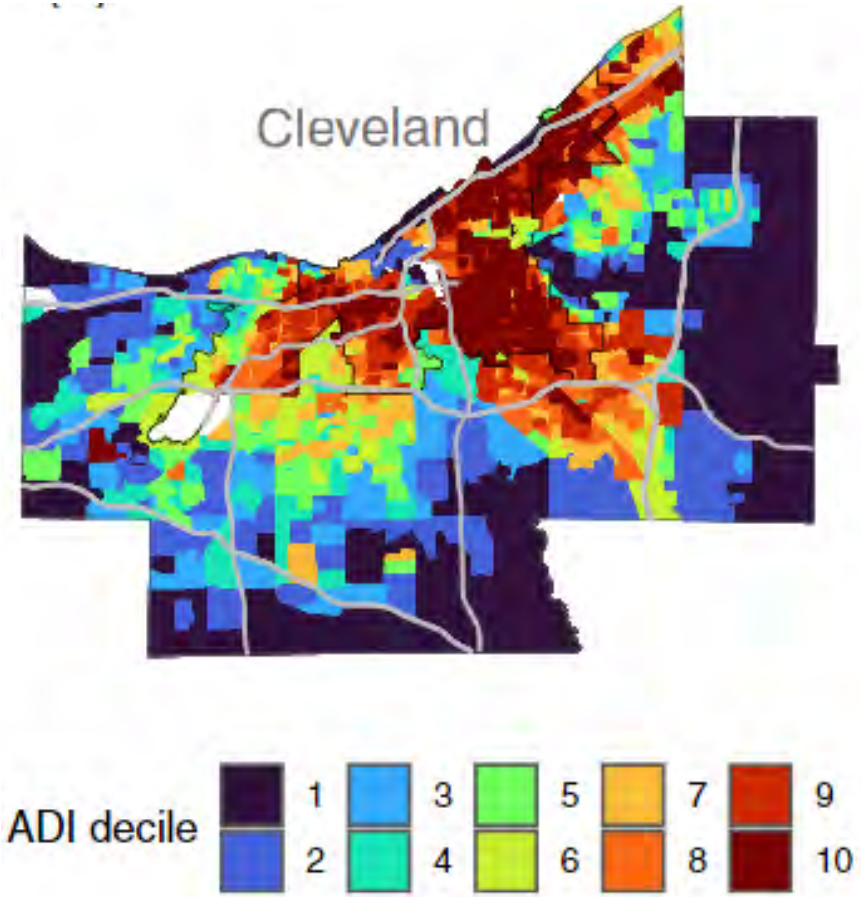
Neighborhoods have critically important influences on health.

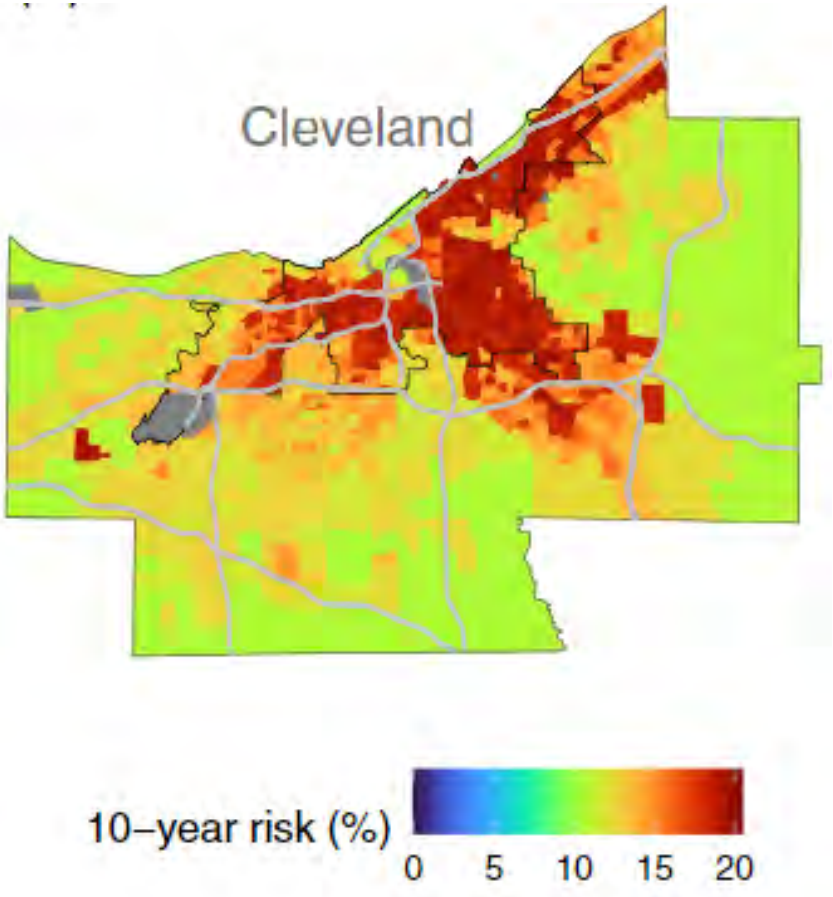
In our region, like much of the United States, there are drastic inequalities in health and life expectancy at the neighborhood level.



Neighborhood Disparities in Dementia Risk

Cleveland/Cuyahoga County, OH





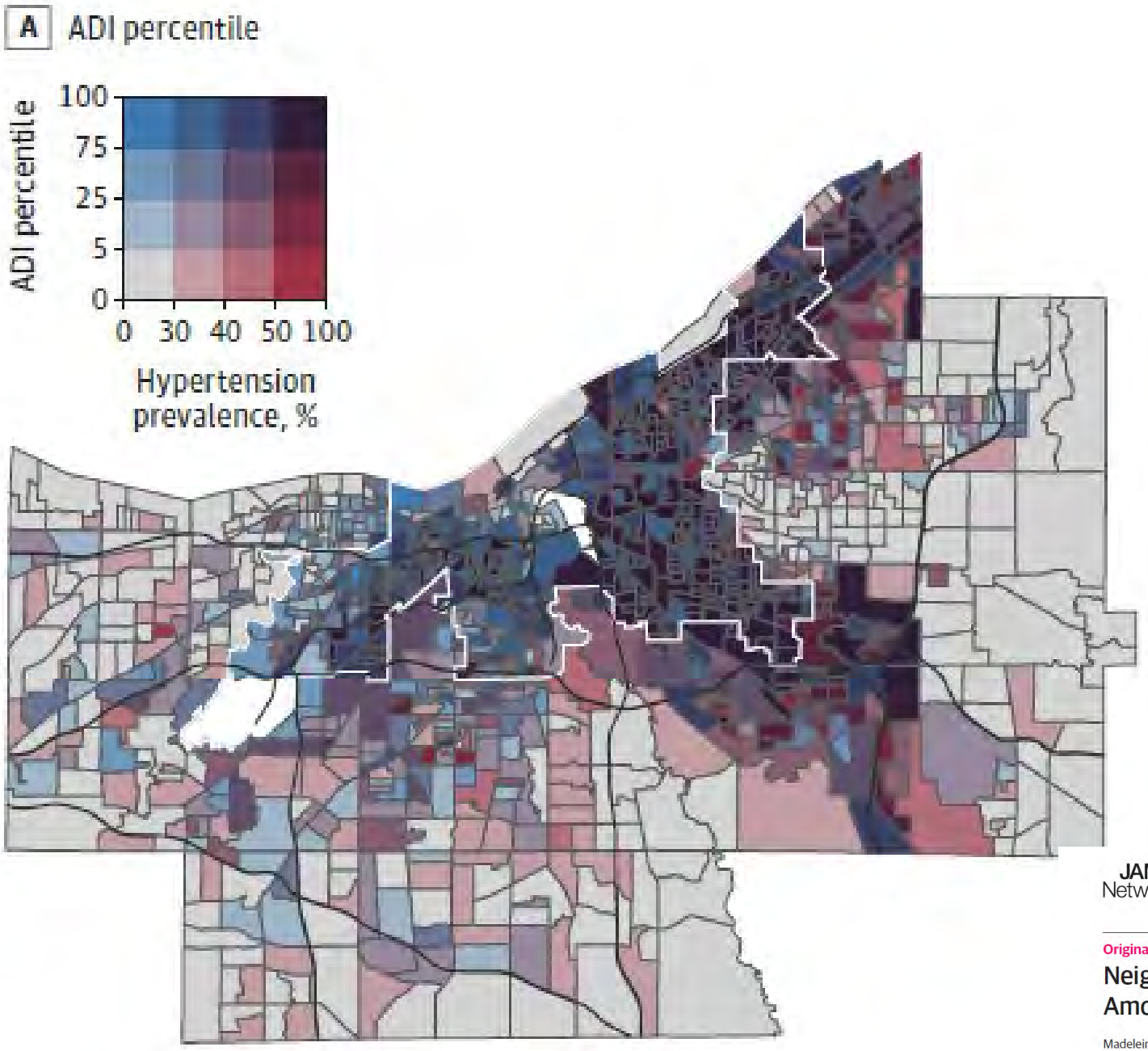
JAMA Network Open

Original Investigation | Equity, Diversity, and Inclusion

Neighborhood-Level Disparities in Hypertension Prevalence and Treatment Among Middle-Aged Adults

Madeleine M. Blazel, BS; Adam T. Perzynski, PhD; Paul R. Gunsalus, MS; Lyla Mourany, MS; Douglas D. Gunzler, MA, PhD; Robert W. Jones, MD; Elizabeth R. Pfoh, MPH, PhD; Jarrod E. Dalton, PhD

- We examined hypertension diagnosis among adults patients aged 35-50 (60,546 MetroHeath and Cleveland Clinic patients).
- Seen at least once in outpatient settings in 2019.
- Patients lived in 1,156 Cuyahoga county block groups



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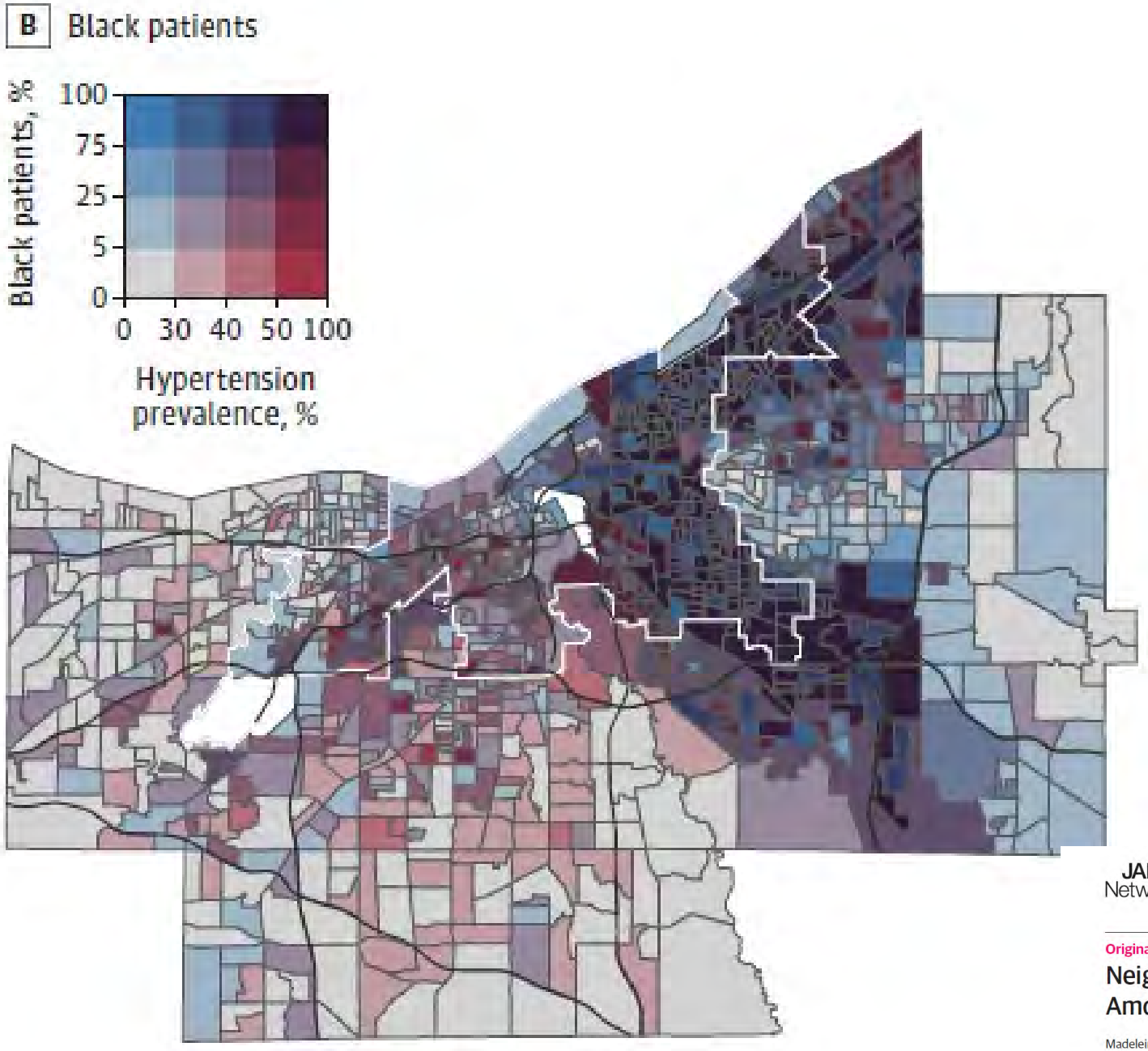

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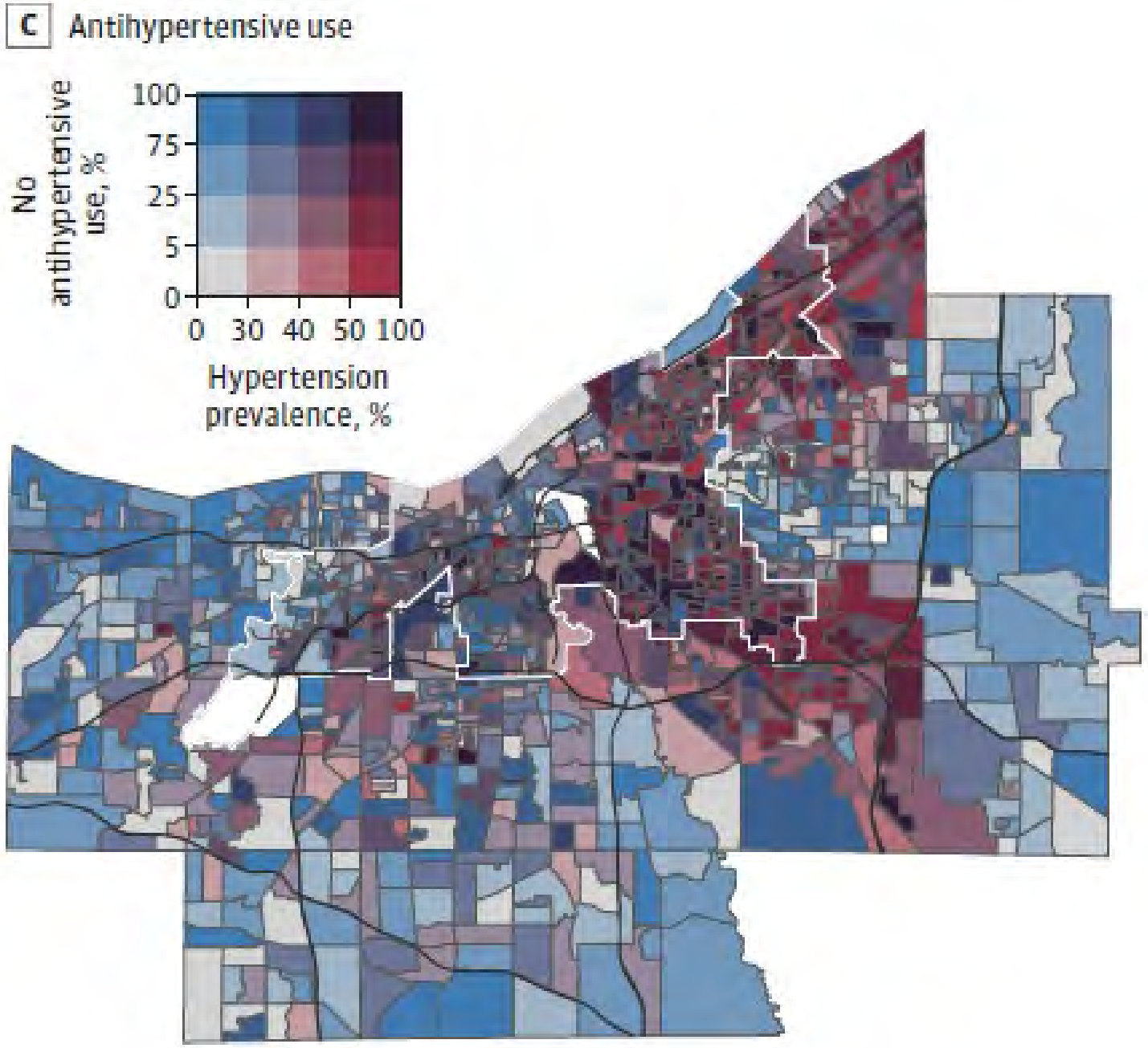

Limited to the 20,863 patients with a hypertension diagnosis.

MA Open

l Investigation | Equity, Diversity, and Inclusion

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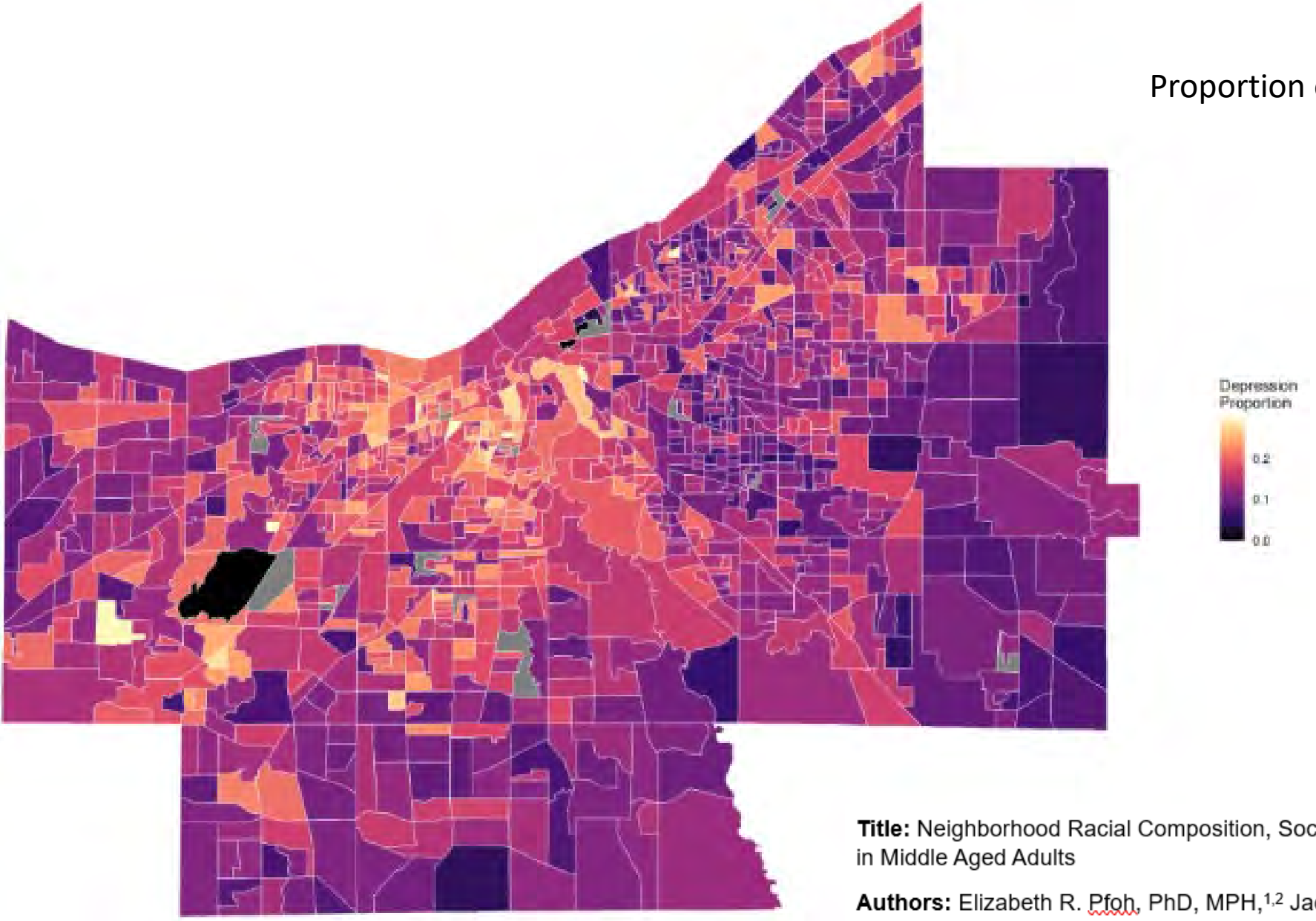
Depression Prevalence

- EHR data on adults 40-55 years in Cuyahoga County, Ohio, who had ≥1 primary care appointment at the Cleveland Clinic Health System or the MetroHealth System between 2010 and 2016.
- Patients categorized as having a diagnosis of depression by ICD-10 codes
- Generated maps and compared by Race/Ethnicity and Socioeconomic Position
- Compared EHR data against the CDC Places Data for the same time period.

Table 1. Demographic, health and neighborhood characteristics of the study population by depression status at the index date (N = 150,715)

	Depression at Index	
	No depression N = 128,923[1]	**Yes depression** N = 21,792[1]
Demographics		
Age	47.1 (42.7, 51.2)	47.2 (42.6, 51.2)
Female	54%	70%
Race and Ethnicity		
Non-Hispanic White	56%	63%
Non-Hispanic Black	31%	25%
Other	7.9%	7.4%
Asian	2.7%	0.7%
Hispanic	1.9%	3.3%
Census Data		
ADI Quintile		
Quintile 1	39,755 (31%)	5,390 (25%)
Quintile 2	19,913 (15%)	3,500 (16%)
Quintile 3	18,021 (14%)	3,351 (15%)
Quintile 4	19,335 (15%)	3,473 (16%)
Quintile 5	31,876 (25%)	6,070 (28%)

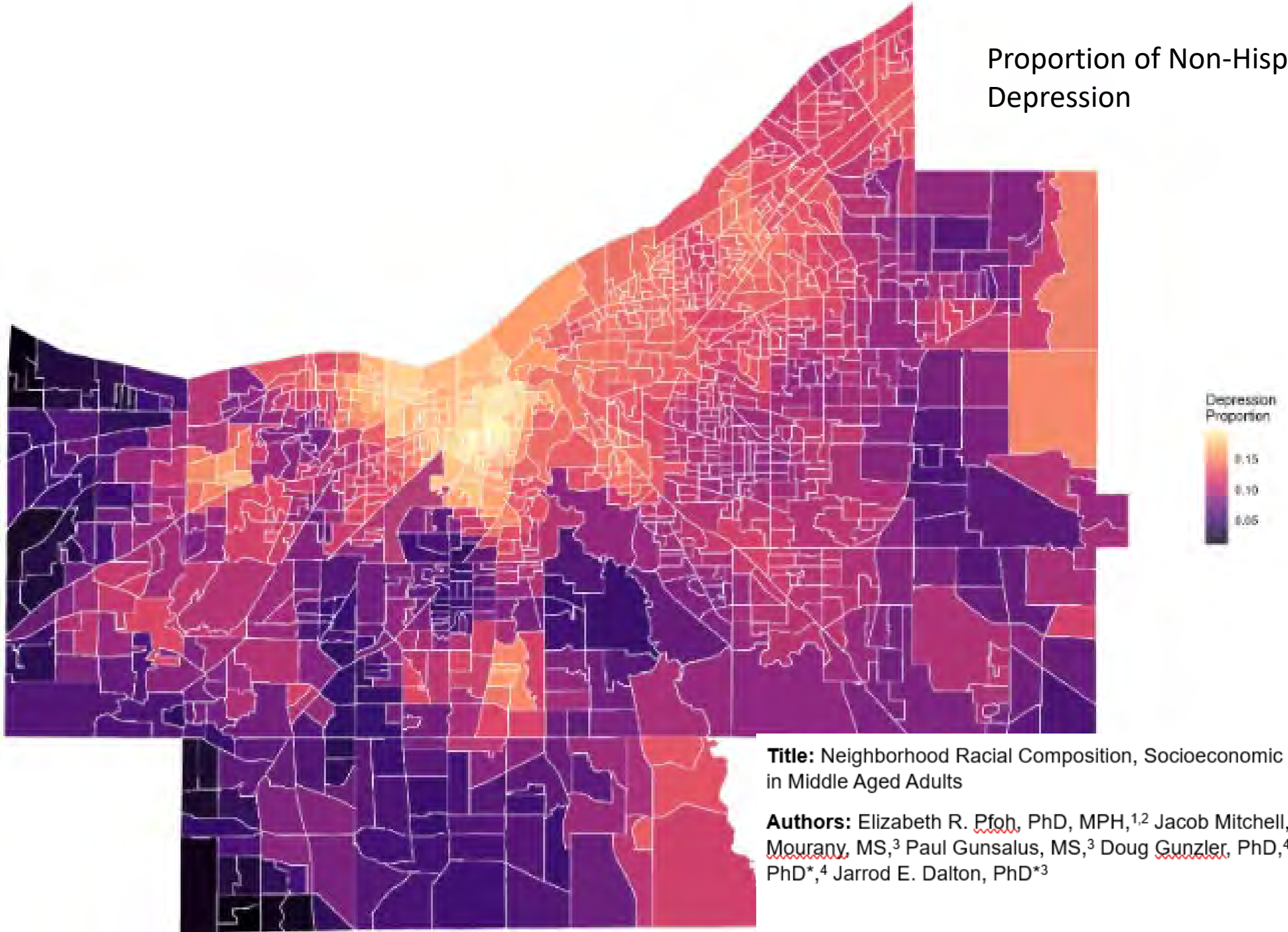


Proportion of Patients with Depression

Title: Neighborhood Racial Composition, Socioeconomic Position and Depression Prevalence in Middle Aged Adults

Authors: Elizabeth R. Pfoh, PhD, MPH,[1,2] Jacob Mitchell, MS,[3] Michael Kenyhercz, PhD,[3] Lyla Mourany, MS,[3] Paul Gunsalus, MS,[3] Doug Gunzler, PhD,[4] Kristen Berg, PhD,[4] Adam Perzynski, PhD*,[4] Jarrod E. Dalton, PhD*[3]

Proportion of Non-Hispanic Black Patients with Depression



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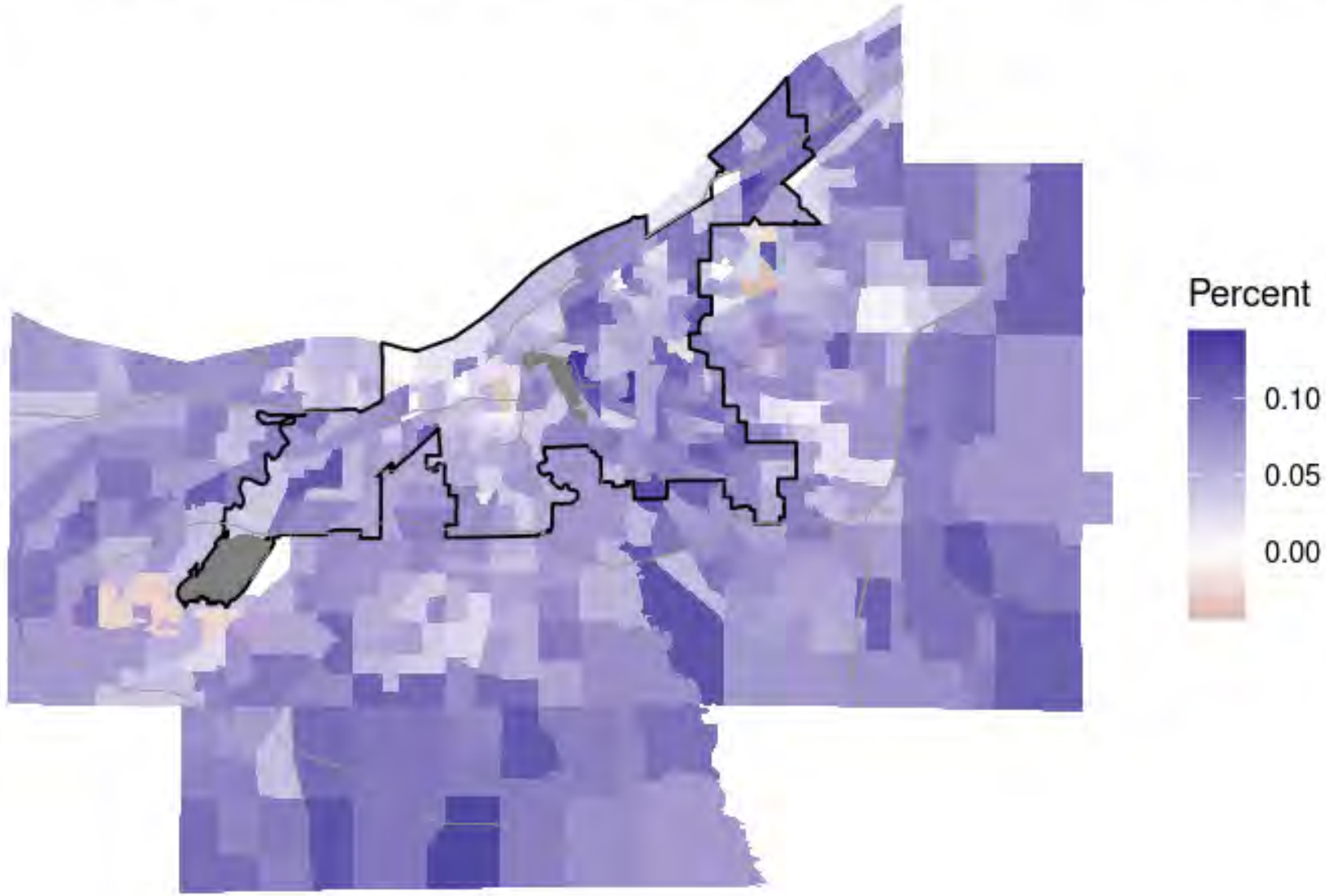
Difference between percent crude prevelence of depression
by CDC and Depression at Index of patients ages 40-55 in Neocare (2013 ADI)



Digital Twin
Neighborhoods have multi-sector value.

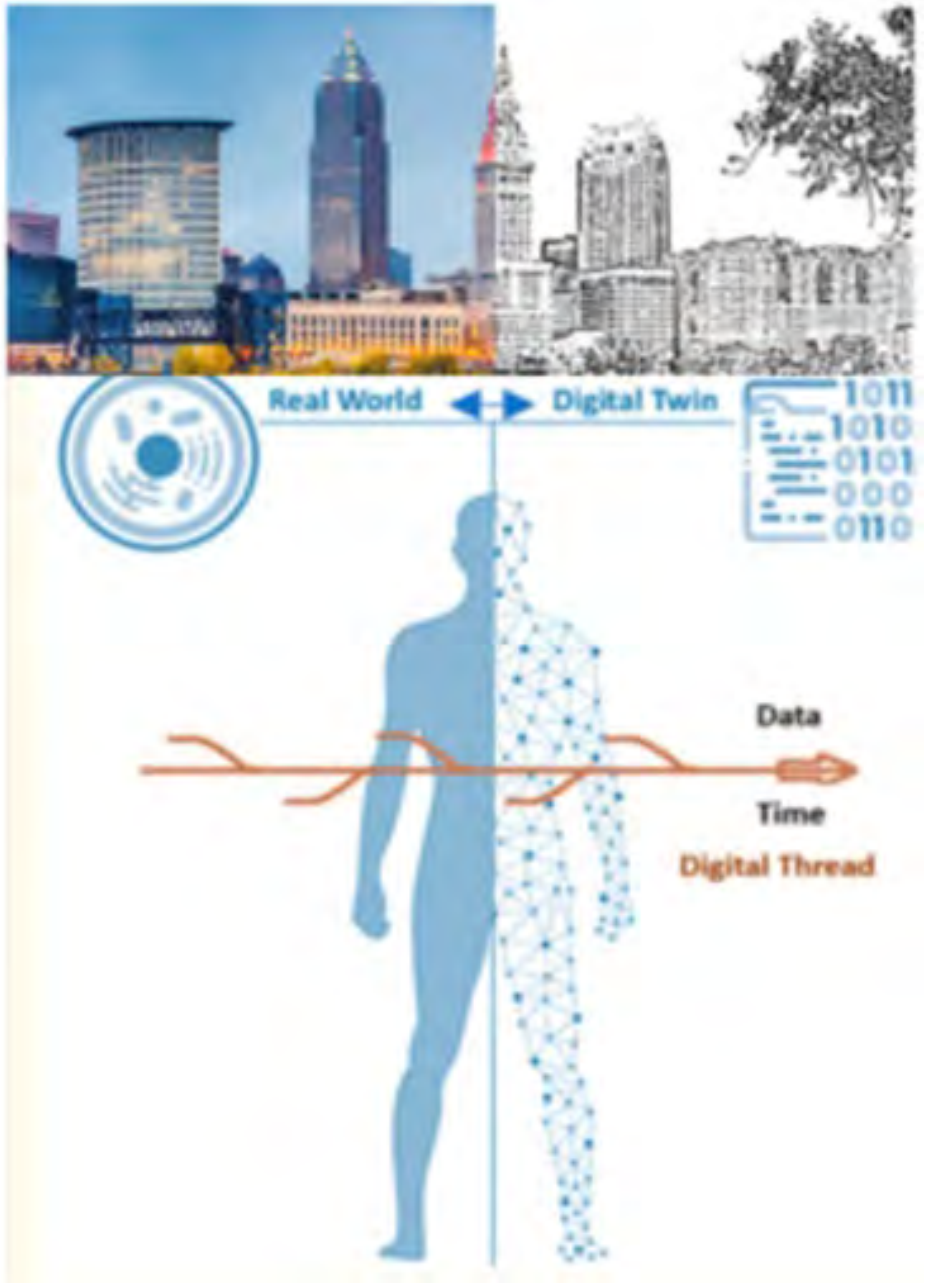
Health care systems and payers

Civic and local non-profit decision makers

State and federal policy making

Hyper-local community value to residents

Our community partners informed us about how we should conduct our work.



Digital Twin Neighborhoods

Platform and Approach to Decision-Making in Population Health

- Integrates state-of-the-science GIS, static and longitudinal modeling technologies with EHRs
- Research funded by $3.14M NIH grant to Cleveland Clinic and MetroHealth
- Builds on 10-year academic collaboration for place-based health disparities

Community Engaged Development

- NIH grant supports iterative design via community engagement studios (45 participants in Year 1)

Privacy-Preserving, Interoperable and Scalable Solution

- Enable fully synthetic analyses and embedded spatial AI resources across health systems
- Develop a flexible digital architecture supporting multisector collaboration for health equity

Approach to Forecasting Impact of Population Health Interventions

- Health systems, payers, public health agencies, and community organizations
- Model effects of operational strategies and policy changes at high resolution

A useful analogy comes from the Auto Industry

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POPULATION HEALTH NEWS

Cleveland Clinic to Leverage Digital Twins for Health Disparity Research

Cleveland Clinic and MetroHealth will use a $3.14 million NIH grant to develop digital twin technology and tackle health disparities.

Source: Getty Images

By Shania Kennedy

February 22, 2023 - The National Institutes of Health (NIH) has **awarded** researchers from Cleveland Clinic and MetroHealth a $3.14 million grant to use digital twins to better understand and address health disparities.

DIGITAL TWIN TECH IS SET TO RESHAPE HEALTHCARE DX

ANALYSIS | BY ERIC WICKLUND | OCTOBER 25, 2023

Health systems are just beginning to develop digital models of everything from organs to people to whole neighborhoods to improve and personalize patient outcomes.

KEY TAKEAWAYS

- **Digital twin technology was developed in the 1960s by NASA to model spacecraft and test out the moon landing; it has only shown up in healthcare in the last decade.**
- **The technology focuses on the creation of a digital model of organs and bodies, to be used to test new treatments, map out complex surgeries, create personalized recommendations for patients, and plot how outside factors affect health outcomes.**
- **Experts say digital models can help health systems identify areas of concern, improve treatments, and plan out recovery times and outcomes.**

A technology first used by NASA to map out space travel is now giving healthcare providers a better look at how to treat patients.

TOPICS
AI
Data Analytics
Diagnosis
Digital Health
Forecasting Models
HIT
Innovation
Physicians
Technology
Treatment

RECOMMENDE
Patients worry abo may be using AI s
Power your Reven Automation and A
Humana used algo 'fraudulent schem Medicare Advanta lawsuit alleges
FDA to review MDMA-assisted therapy, a milestone for

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FEATURES

Can Digital Twin Neighborhoods Help Tackle Health Disparities?

Cleveland Clinic and MetroHealth are building digital twins to better understand how patients' neighborhoods impact their health outcomes.

Source: Getty Images

December 13, 2023 - Addressing health disparities and improving patient outcomes are key to achieving health equity, but tackling these issues requires health systems to understand their population's needs and develop strategies to meet them.

Anchoring to community perspectives is critically important

- Quarterly Community Engagement Studios throughout the Digital Twin Neighborhood project.
- Neighborhood residents and representatives of community-based organization provide input and shape the project drawing on their local community expertise and experiences.
- Our team conducted community engagement studios with 45 community members and more than 30 agency representatives

General Input & Questions	Research Team Response
Maintaining Privacy	• This is a core aim of our funded study. • **Create public facing summaries of how we protect privacy**
Proper use of DTNs to address social determinants of health	• Create limits on what DTNs are used for • Create Terms of Use that clearly detail permitted and recommended ways to use DTN resources.
Impact of accuracy of diagnostic codes in medical records.	• Implement methods from the research literature.
The potential harms or unintended consequences of the findings and visualizations/Limitations of DTN	• Transparency of objectives. • Understand community expectations. • Clarify end-user understanding • Receive community input on visual representations (charts figures etc.) in the DTN resources. • **Maintain community oversight**

Desired data to be included in DTN Software Systems	Research Team Response
Social isolation vs community togetherness	• Ask questions at CES sessions
Power of culture in marginalized neighborhoods	• Include locally relevant community representatives • Discuss social services and resources • Gather resident perspectives
Residents' perceived neighborhood boundaries	• Ask residents at different CES
Spatial Data: parks, gardens, and green space	• Mapping Tools • Local Government Data • City Health Dashboard
Neighborhood resources & structural racism within grocery stores, healthy housing, libraries, and bus depots	• Mapping Tools • Census Data • Connect data to inequitable outcomes • Staying on top of new developments in measuring structural racism
Mental Health	• Studying mental health and the mental health consequences of neighborhoods is a core aim of our study.

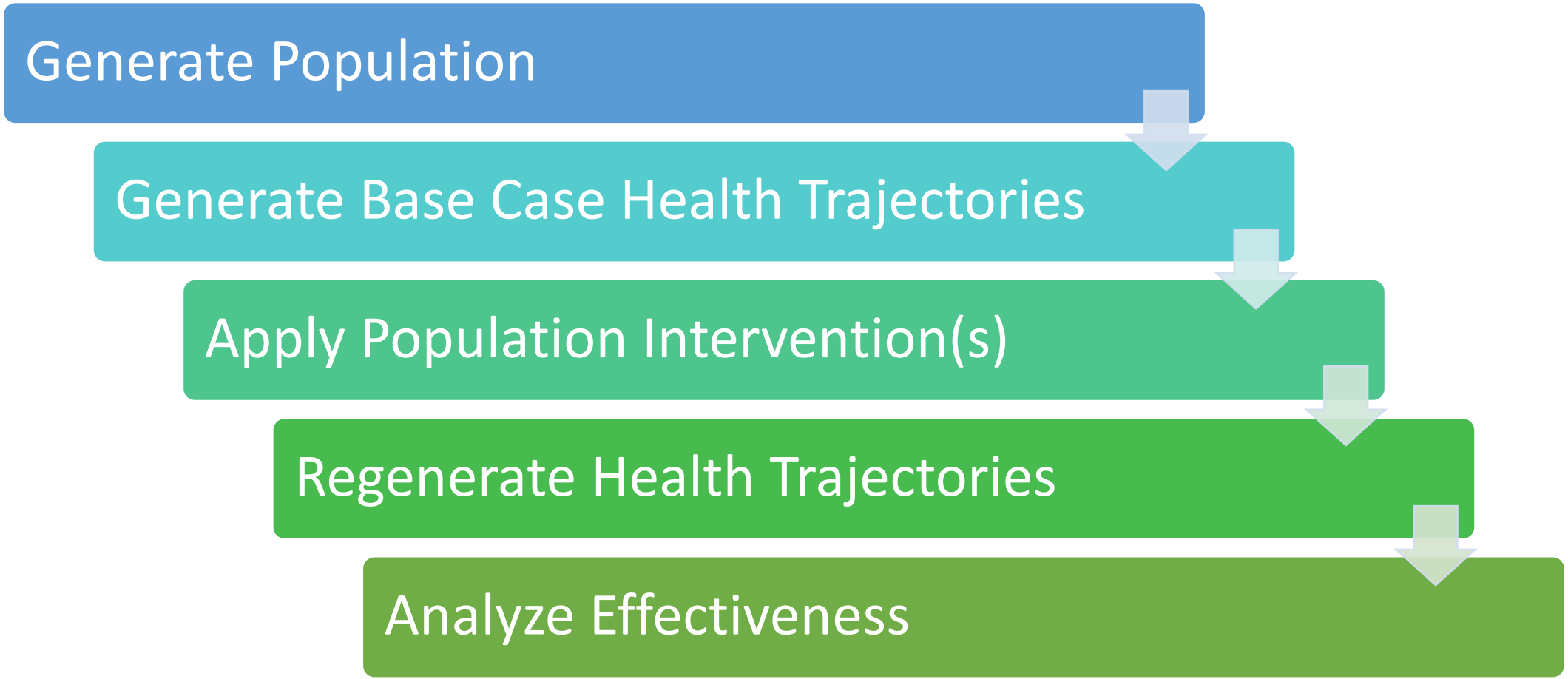
Basically …

- We take all of the electronic health record data on everyone …

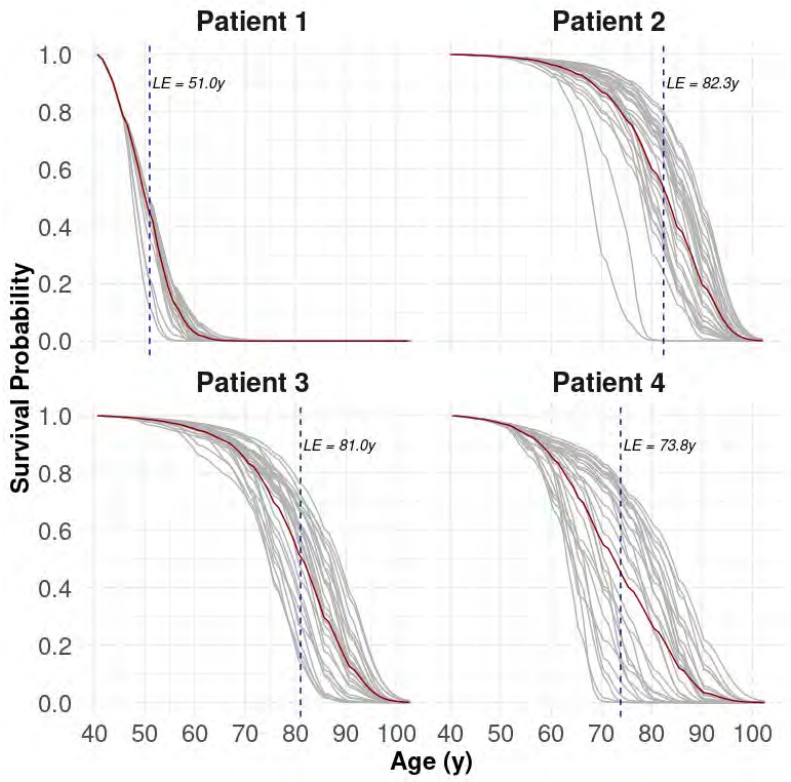
And then

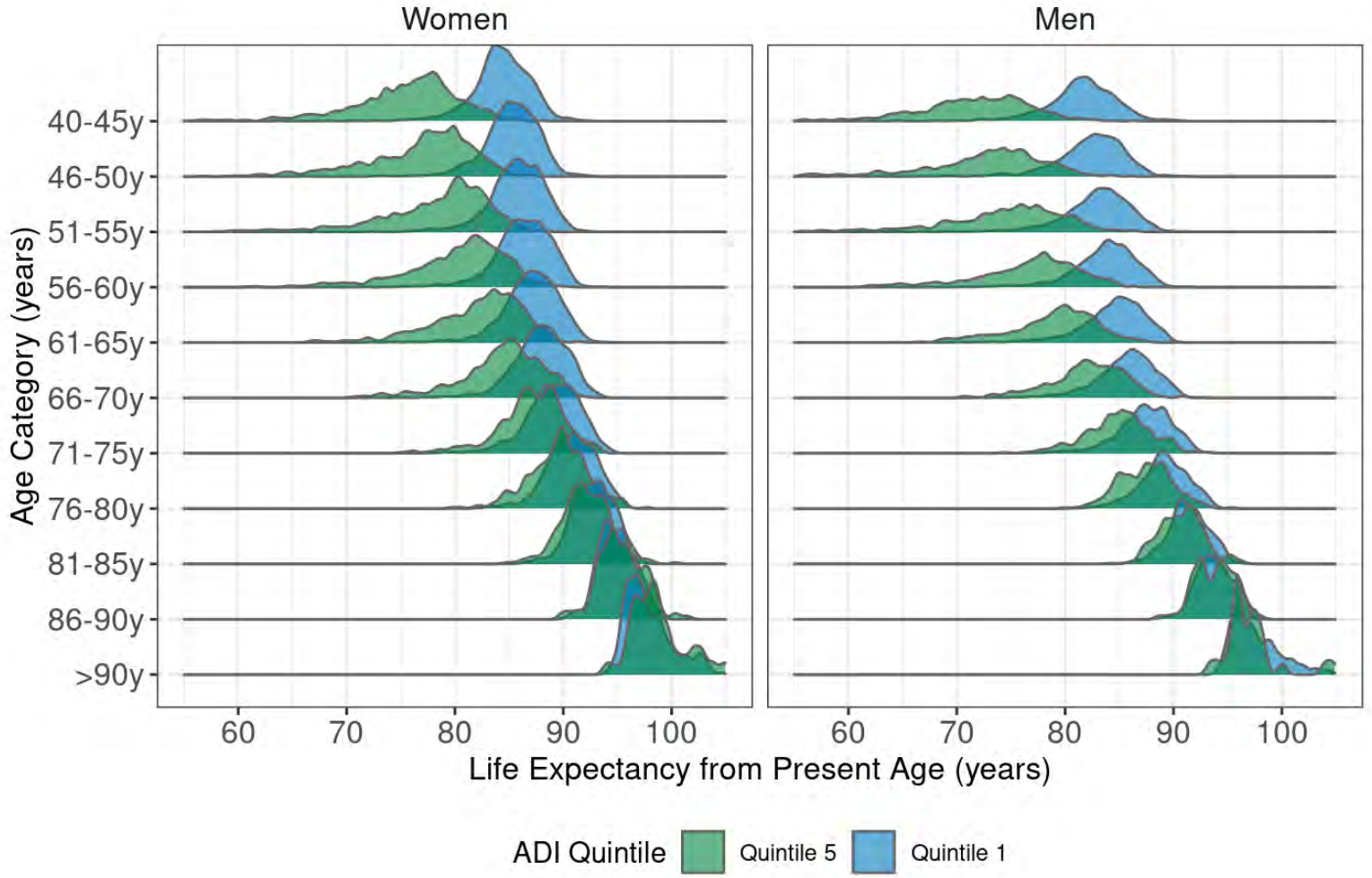
- Pull **Census Data on** demographic variables by neighborhood
- Create **a spatially-designated synthetic population** (of digital twins) based on these demographic distributions
- Pull EHR data for specific disease(s) or health conditions
    - Include neighborhood information and demographics
- Apply a **life course disease and mortality prediction model** to project health data from real patients onto their digital twins ⇩⇩⇩
- Assess fidelity to observed data where you have it

General Simulation Procedure



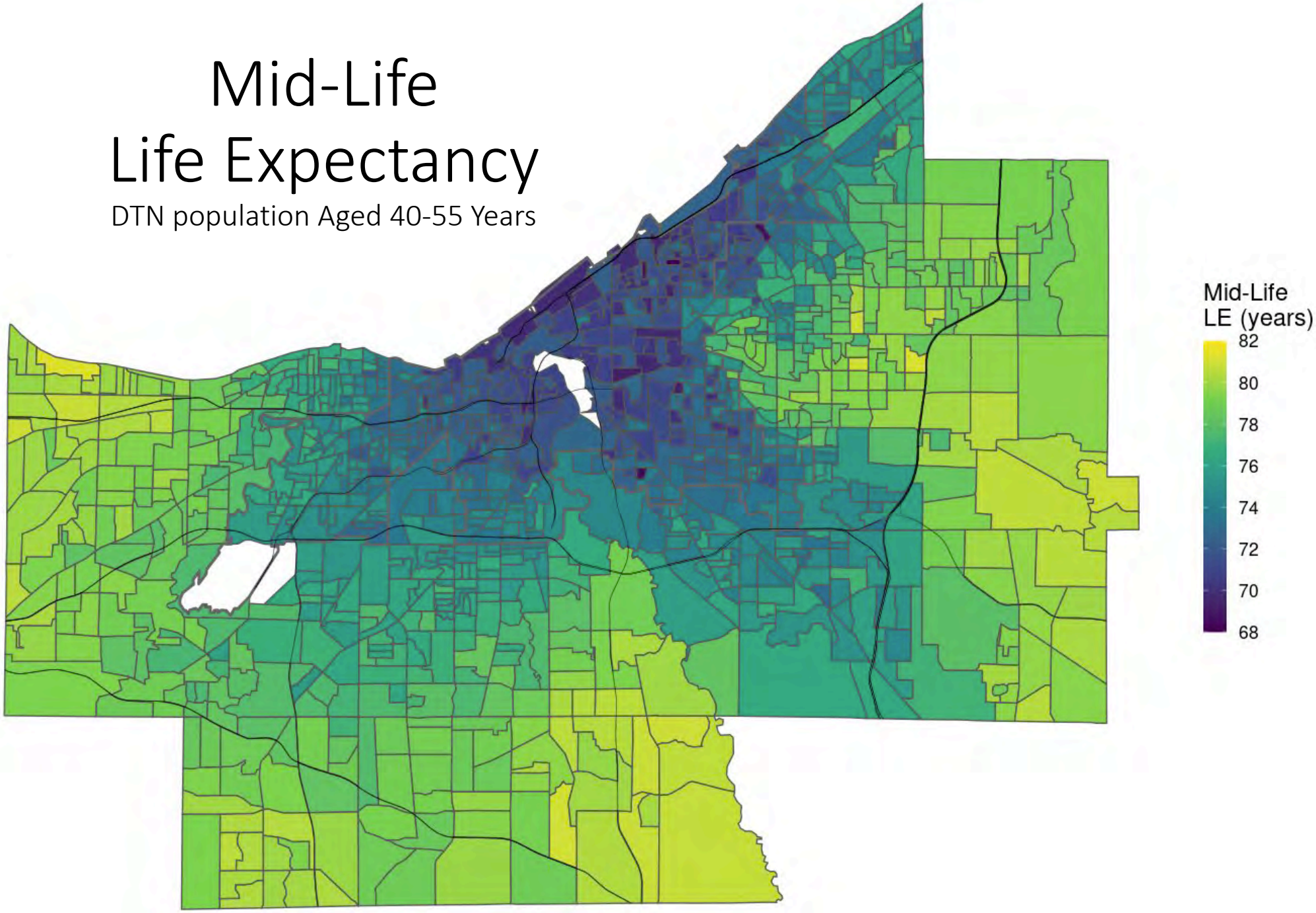
Life-Course Simulation Model Reproduces Population Health Disparities

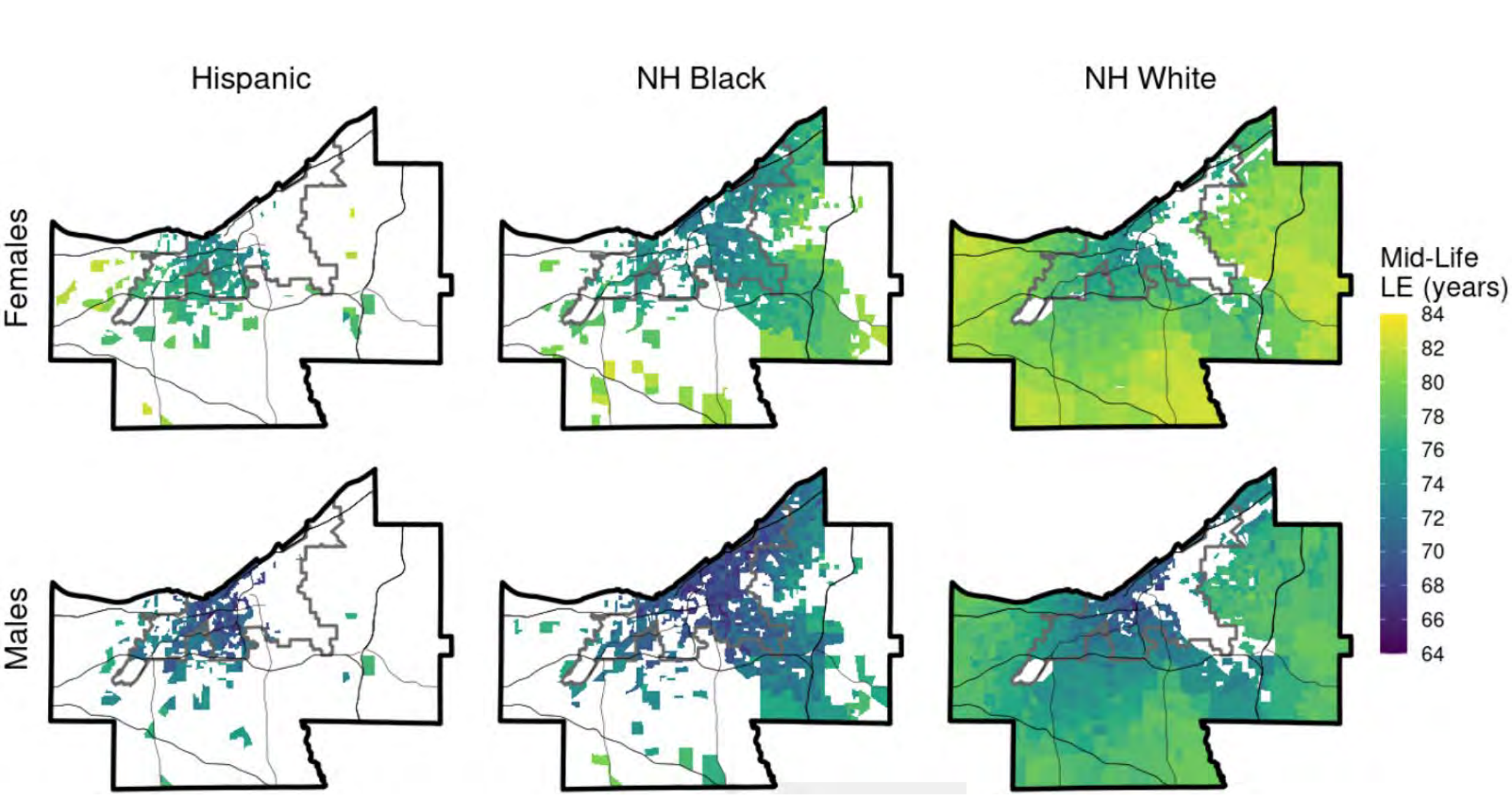




Mid-Life Life Expectancy

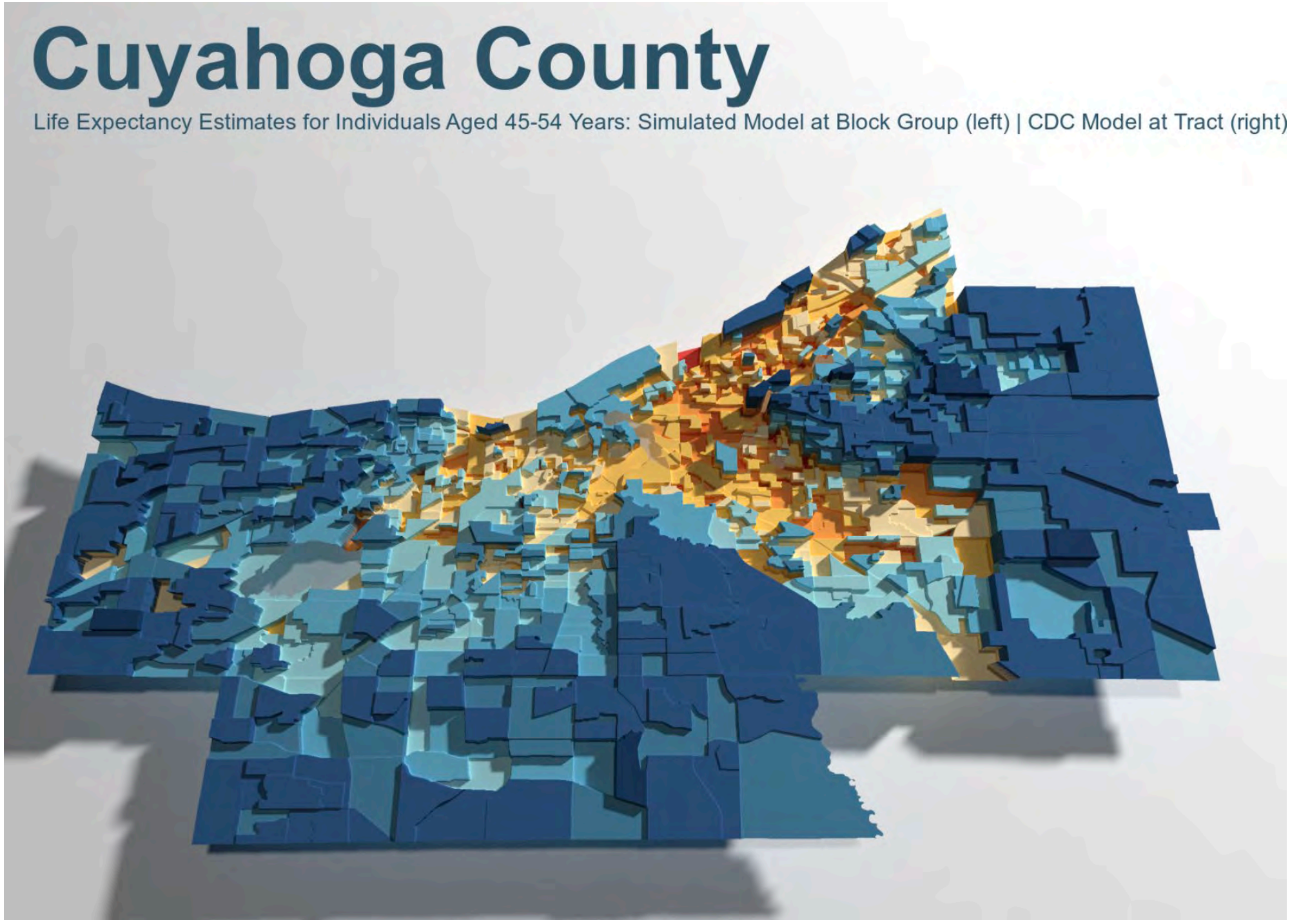
DTN population Aged 40-55 Years




Hispanic
NH Black
NH White
Females
Males
Mid-Life
LE (years)
84
82
80
78
76
74
72
70
68
66
64

Cuyahoga County

Life Expectancy Estimates for Individuals Aged 45-54 Years: Simulated Model at Block Group (left) | CDC Model at Tract (right)



Cuyahoga County

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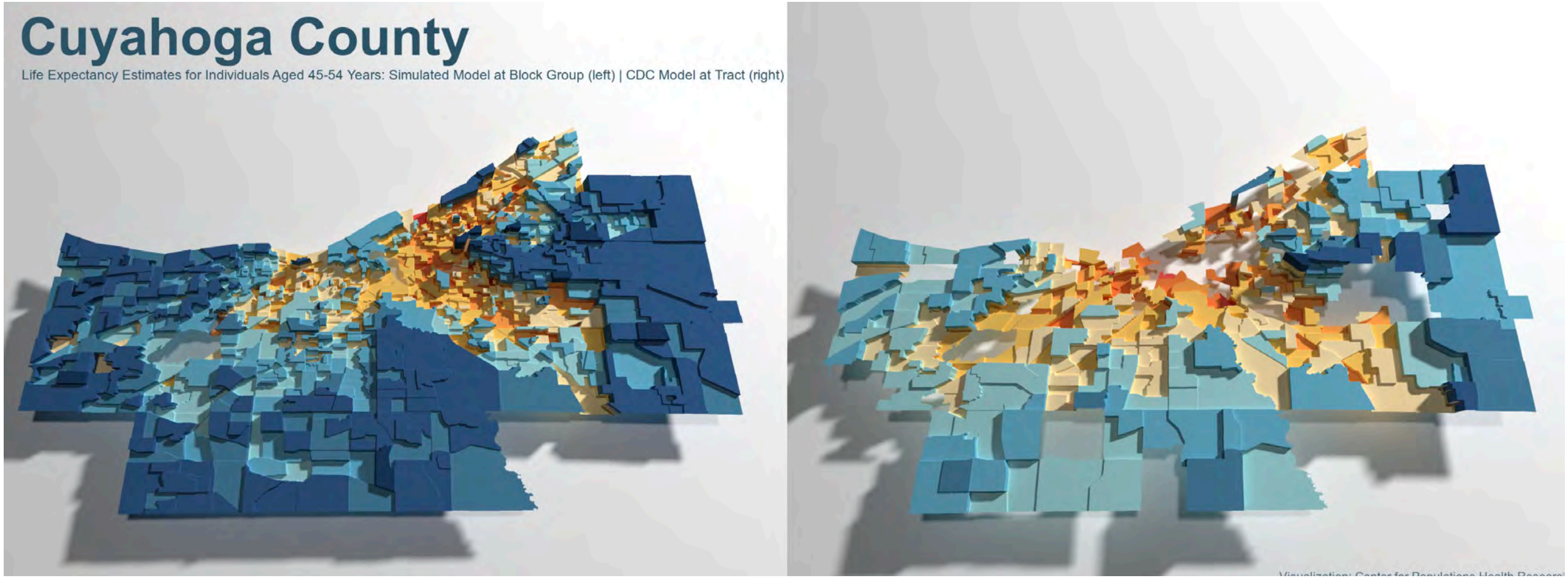
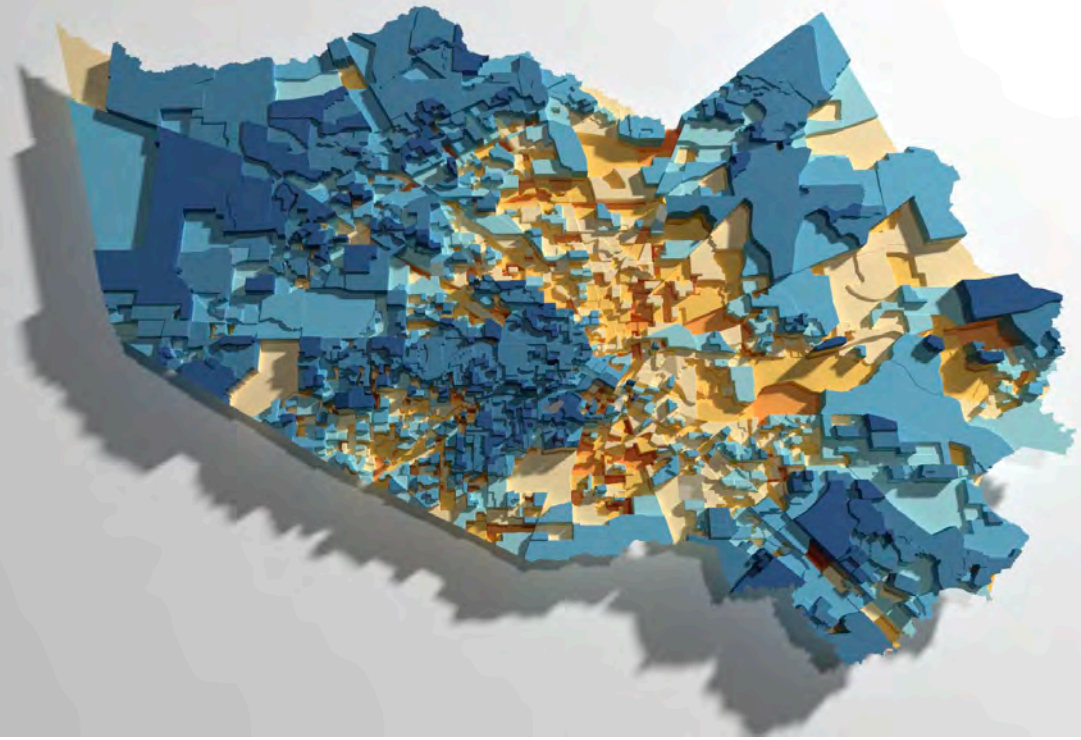
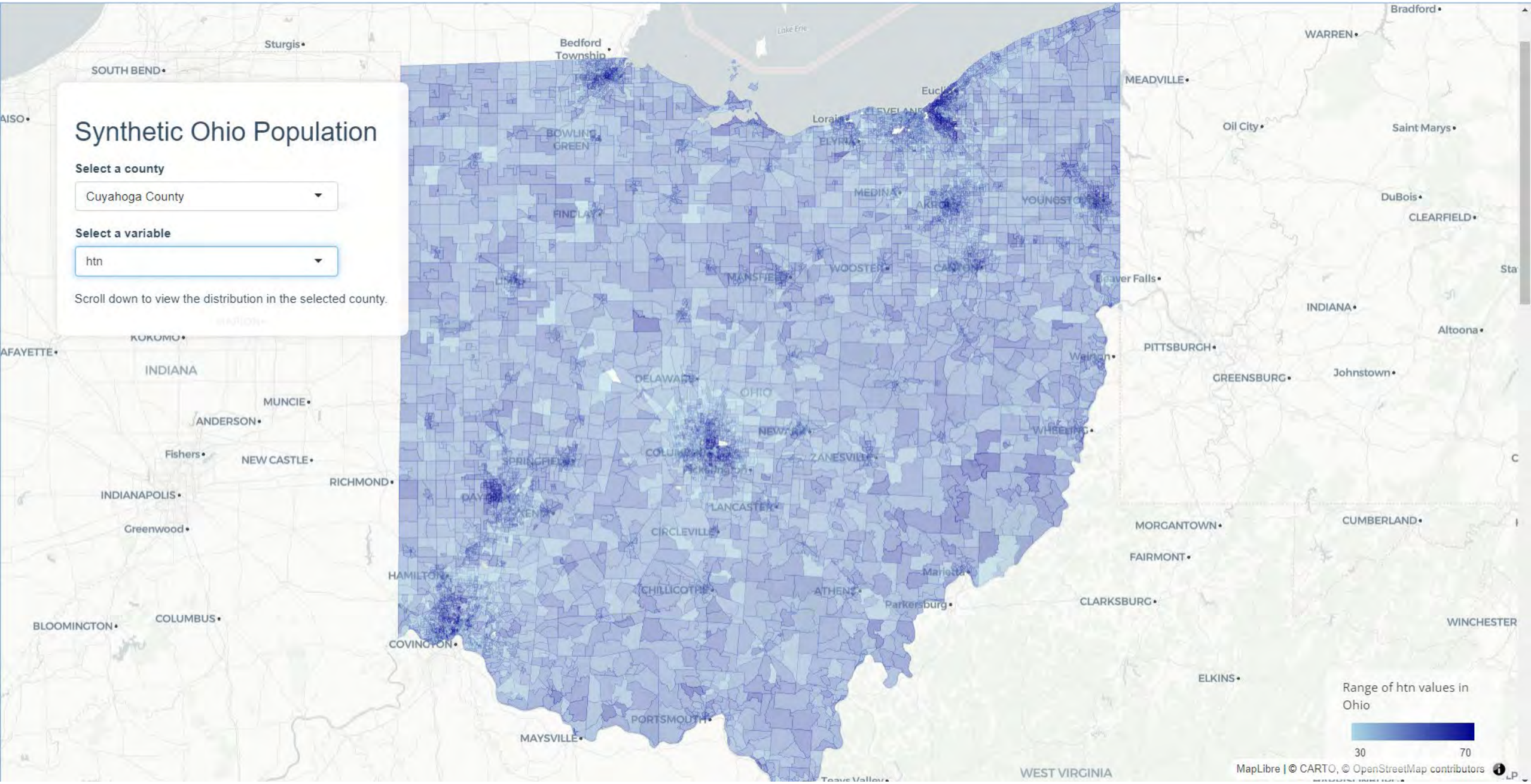


Houston

Life Expectancy Estimates for Individuals Aged 45-54 Years: Simulated Model at Block Group (left) | CDC Model at Tract (right)




Synthetic Ohio Population
Select a county
Cuyahoga County
Select a variable
htn
Scroll down to view the distribution in the selected county.
Range of htn values in Ohio
30
70
MapLibre | © CARTO, © OpenStreetMap contributors
Sturgis
SOUTH BEND
Bedford Township
Lake Erie
WARREN
Bradford
MEADVILLE
Oil City
Saint Marys
DuBois
CLEARFIELD
BOWLING GREEN
FINDLAY
MEDINA
WOOSTER
MANSFIELD
Beaver Falls
INDIANA
Altoona
PITTSBURGH
GREENSBURG
Johnstown
Wayne
DELAWARE
OHIO
WHEELING
ZANESVILLE
LANCASTER
CIRCLEVILLE
MORGANTOWN
CUMBERLAND
FAIRMONT
CHILLICOTHE
ATHENS
Parkersburg
CLARKSBURG
WINCHESTER
ELKINS
PORTSMOUTH
MAYSVILLE
WEST VIRGINIA
INDIANA
MUNCIE
ANDERSON
Fishers
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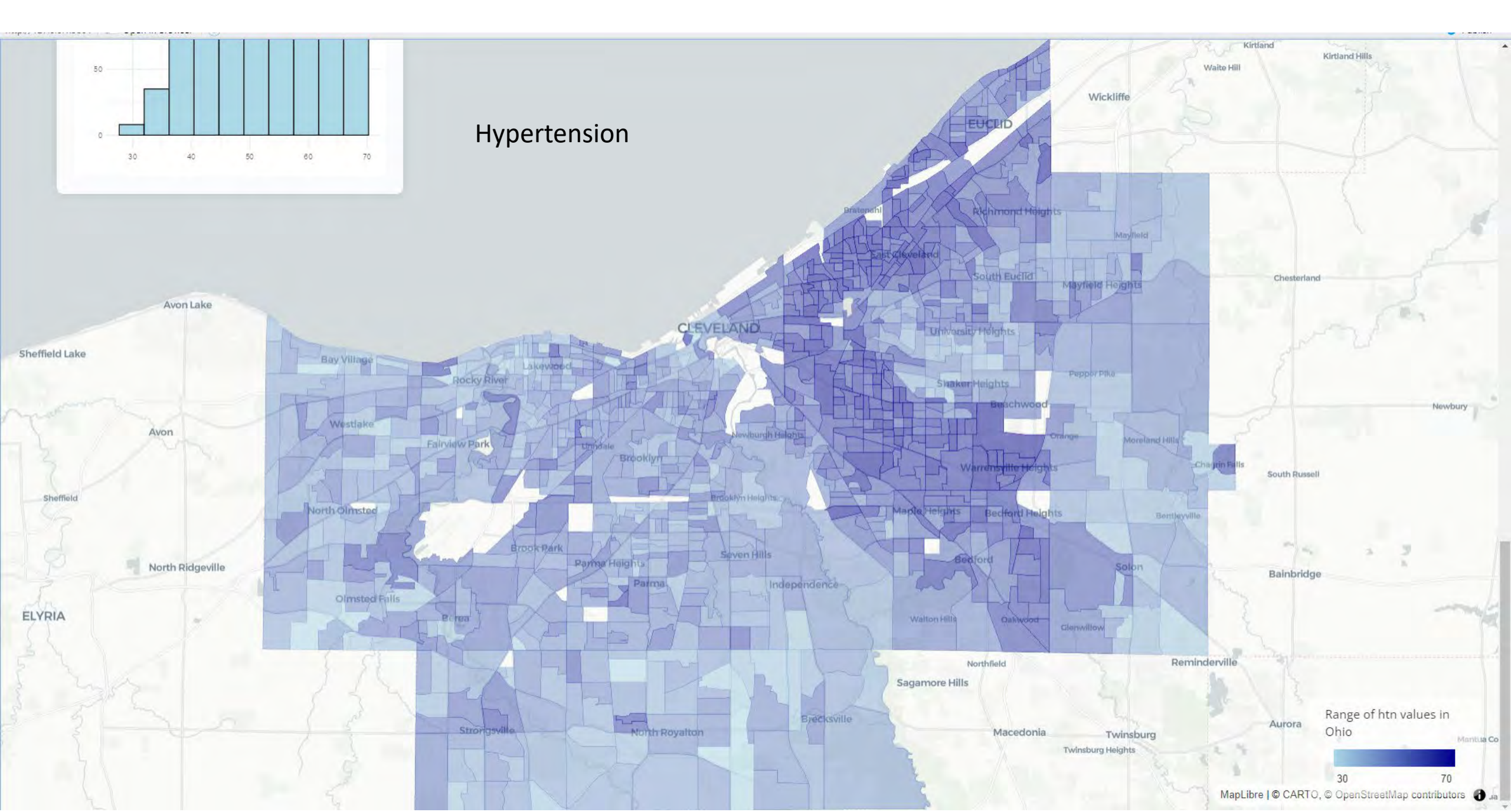
Greenwood
HAMILTON
COLUMBUS
BLOOMINGTON
COVINGTON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Hypertension
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Kirtland Hills
Waite Hill
Wickliffe
EUCLID
Richmond Heights
Mayfield
East Cleveland
South Euclid
Mayfield Heights
Chesterland
Avon Lake
CLEVELAND
University Heights
Sheffield Lake
Bay Village
Lakewood
Rocky River
Pepper Pike
Shaker Heights
Beachwood
Newbury
Westlake
Avon
Fairview Park
Linndale
Brooklyn
Newburgh Heights
Orange
Moreland Hills
Warrensville Heights
South Russell
Sheffield
North Olmsted
Brooklyn Heights
Maple Heights
Bedford Heights
Bentleyville
Brook Park
Seven Hills
Bedford
Solon
North Ridgeville
Parma Heights
Parma
Independence
Bainbridge
Olmsted Falls
ELYRIA
Berea
Walton Hills
Oakwood
Glenwillow
Northfield
Reminderville
Sagamore Hills
Brecksville
Aurora
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North Royalton
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Twinsburg
Twinsburg Heights
Range of htn values in Ohio
30
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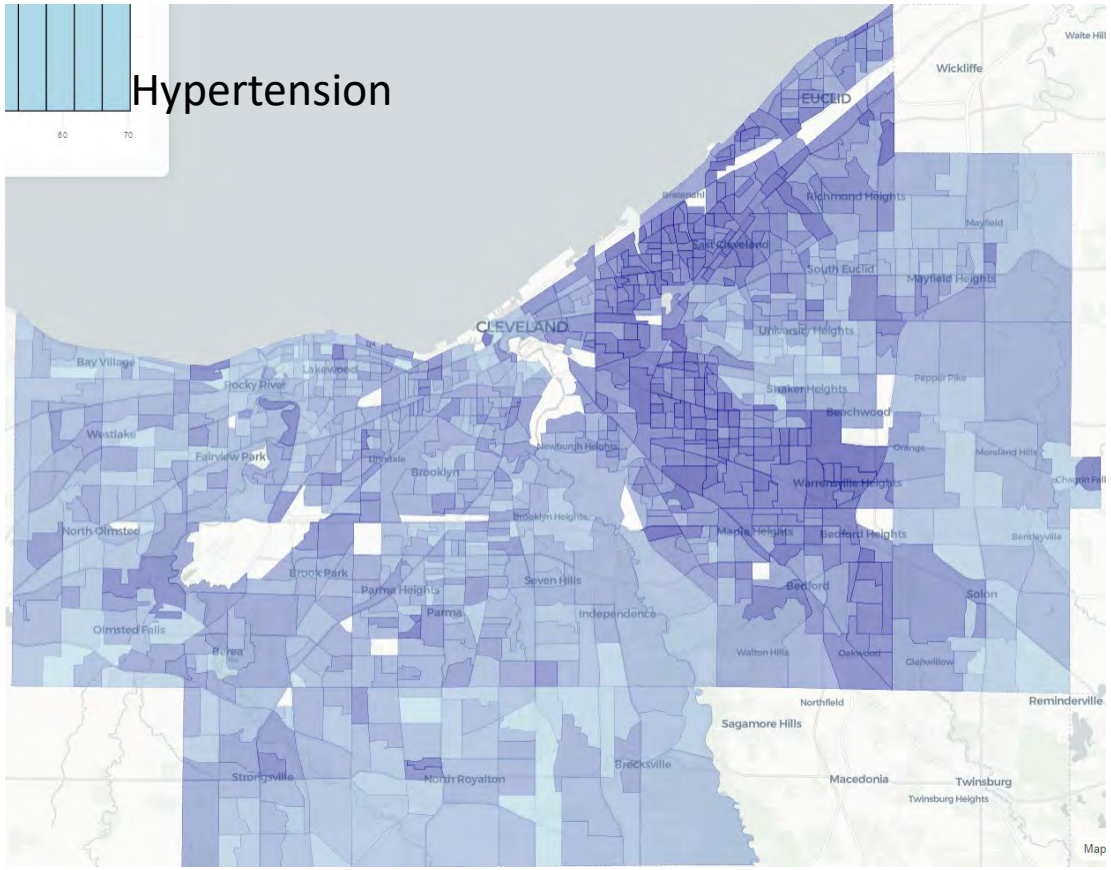
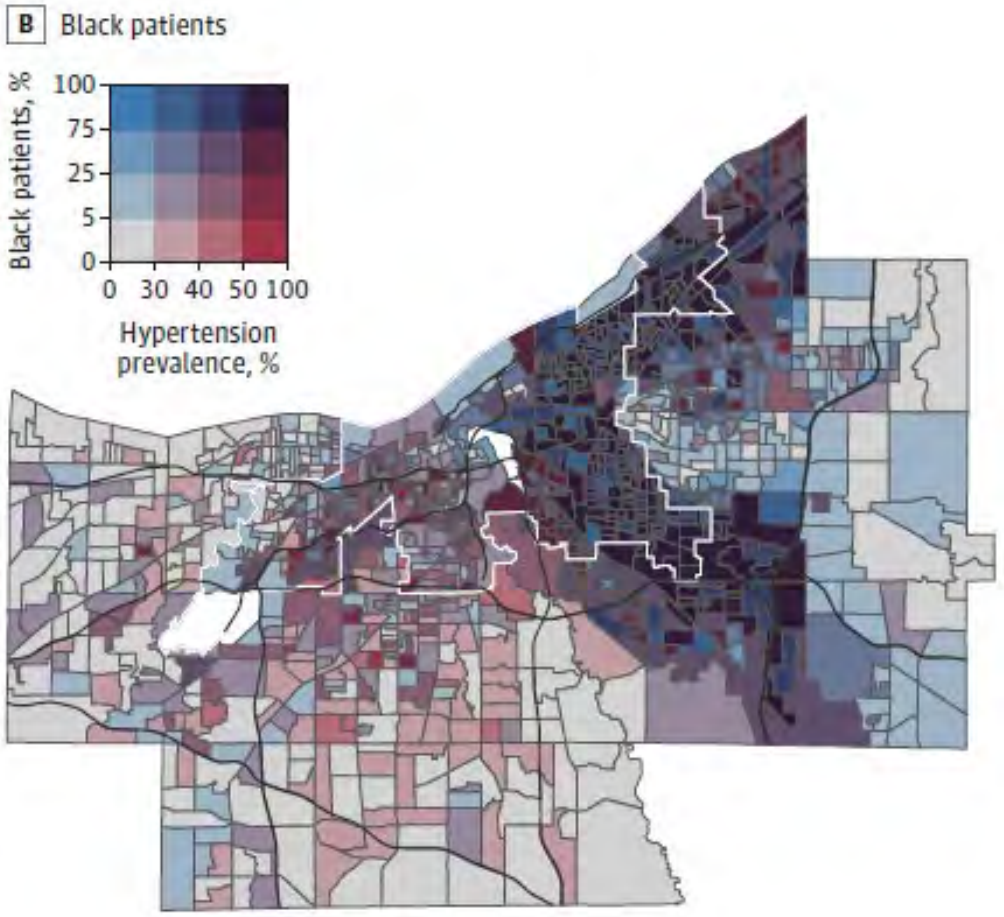
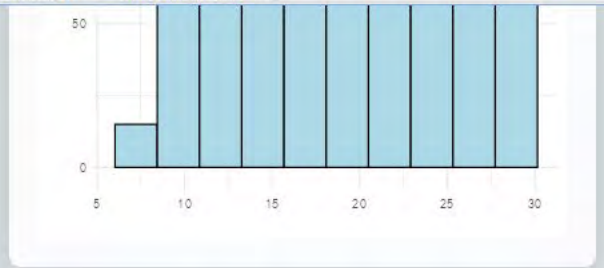


Simulated



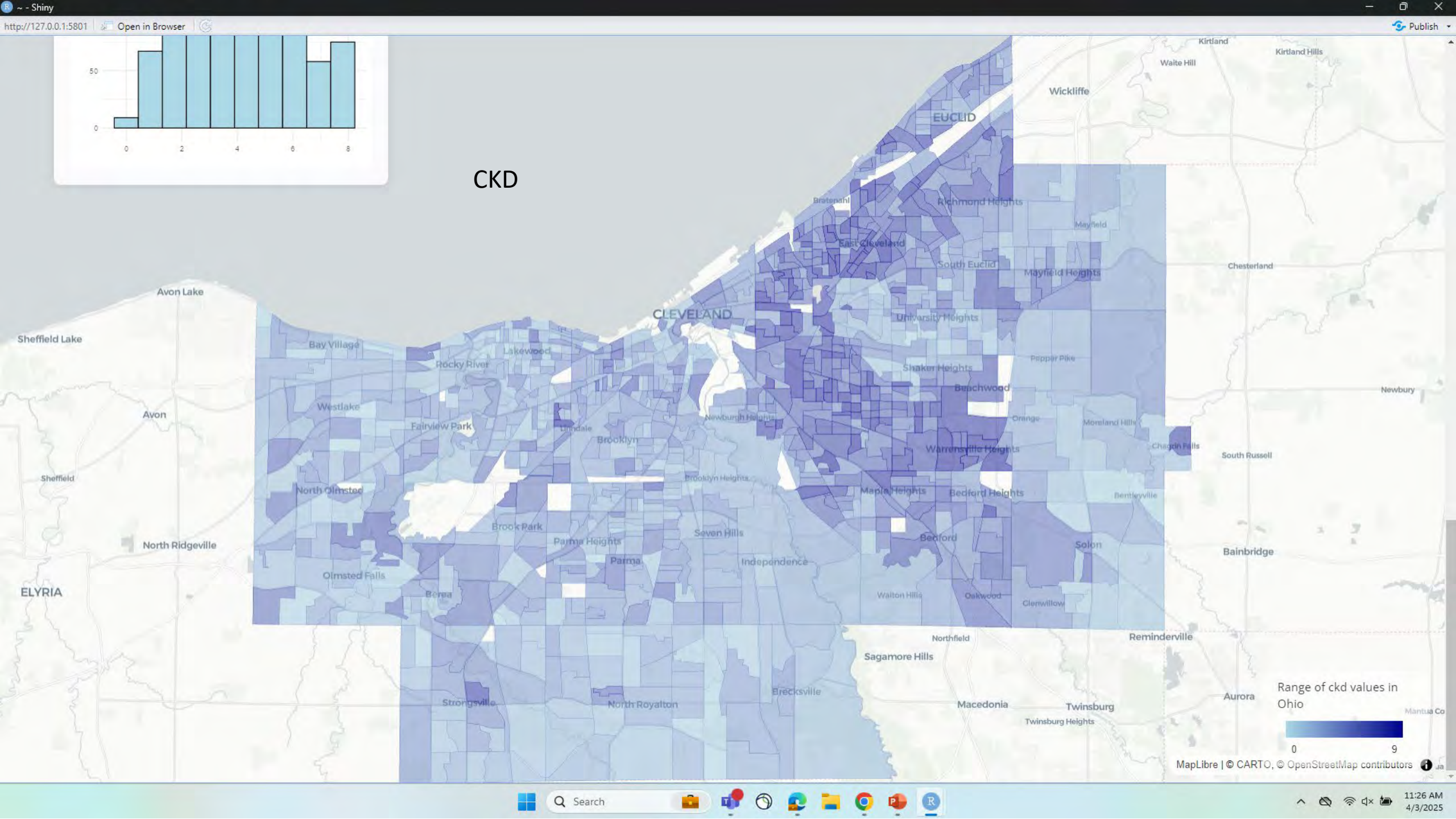
Observed



Type 2 Diabetes

Kirtland
Kirtland Hills
Waite Hill
Wickliffe
EUCLID
Bratenahl
Richmond Heights
Mayfield
East Cleveland
South Euclid
Mayfield Heights
Chesterland
Avon Lake
CLEVELAND
University Heights
Sheffield Lake
Bay Village
Lakewood
Rocky River
Pepper Pike
Shaker Heights
Beachwood
Newbury
Westlake
Avon
Fairview Park
Newburgh Heights
Orange
Moreland Hills
Brooklyn
Warrensville Heights
Chagrin Falls
South Russell
Sheffield
Brooklyn Heights
North Olmsted
Maple Heights
Bedford Heights
Bentleyville
Brook Park
Seven Hills
Bedford
Solon
North Ridgeville
Parma Heights
Parma
Independence
Bainbridge
Olmsted Falls
ELYRIA
Berea
Walton Hills
Oakwood
Glenwillow
Northfield
Reminderville
Sagamore Hills
Brecksville
Aurora
Macedonia
Twinsburg
Twinsburg Heights
Strongsville
North Royalton

Range of t2dm values in Ohio
7
30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CKD
Kirtland
Kirtland Hills
Waite Hill
Wickliffe
EUCLID
Bratenahl
Richmond Heights
Mayfield
East Cleveland
South Euclid
Mayfield Heights
Chesterland
Avon Lake
CLEVELAND
University Heights
Sheffield Lake
Bay Village
Lakewood
Rocky River
Pepper Pike
Shaker Heights
Beachwood
Newbury
Westlake
Avon
Fairview Park
Lindale
Brooklyn
Newburgh Heights
Orange
Moreland Hills
Warrensville Heights
Chagrin Falls
South Russell
Sheffield
North Olmsted
Brooklyn Heights
Maple Heights
Bedford Heights
Bentleyville
Brook Park
Parma Heights
Seven Hills
Bedford
Solon
Bainbridge
North Ridgeville
Parma
Independence
Olmsted Falls
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Berea
Walton Hills
Oakwood
Glenwillow
Northfield
Reminderville
Sagamore Hills
Brecksville
Strongsville
North Royalton
Macedonia
Twinsburg
Twinsburg Heights
Aurora
Range of ckd values in Ohio
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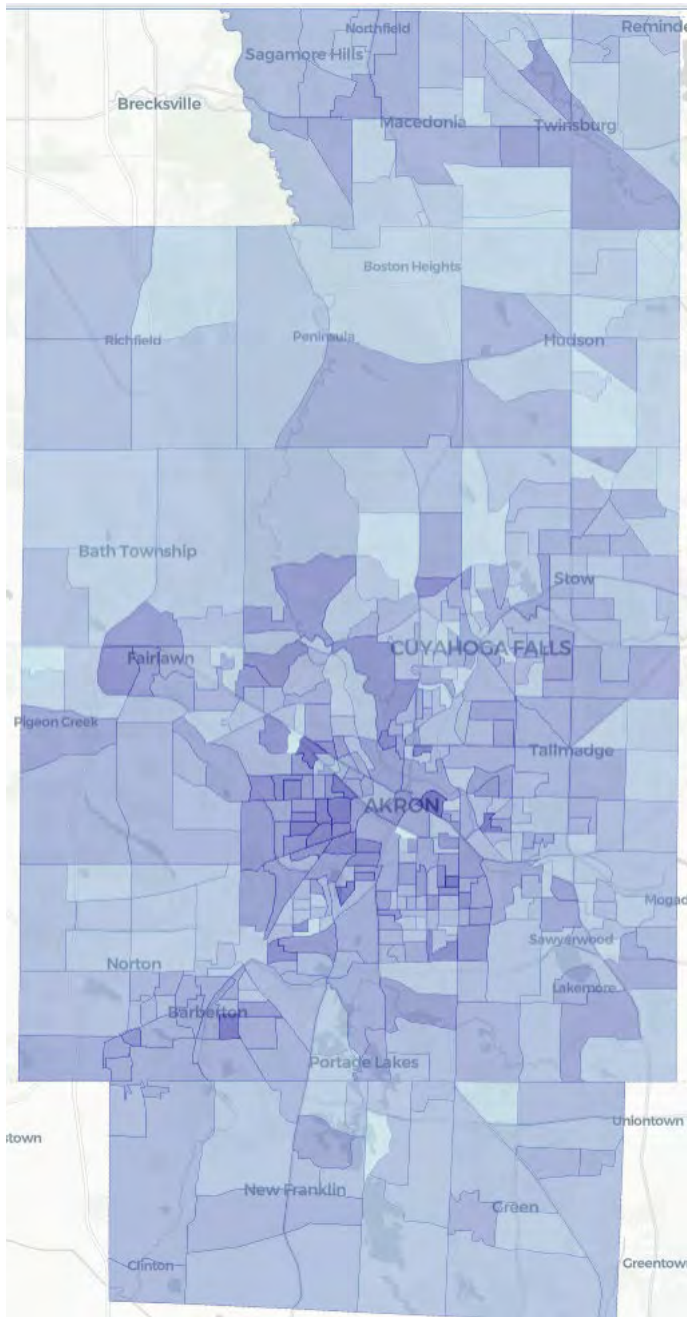
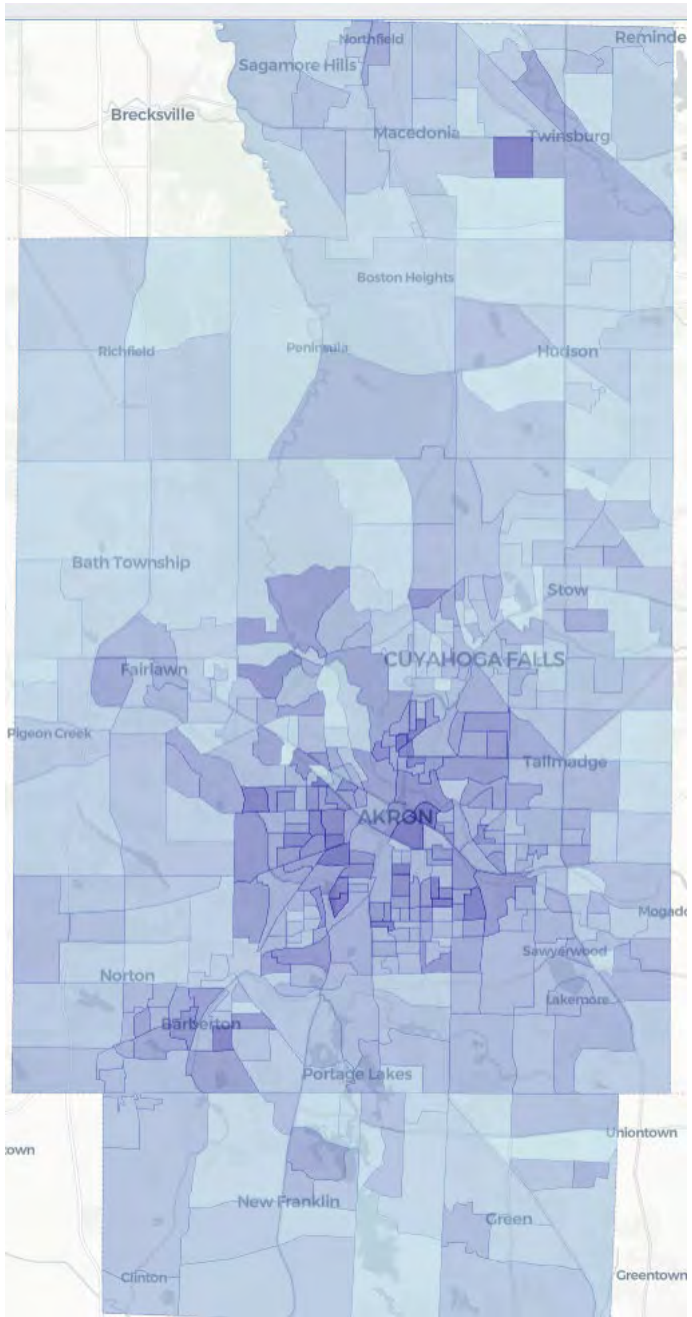
4/3/2025

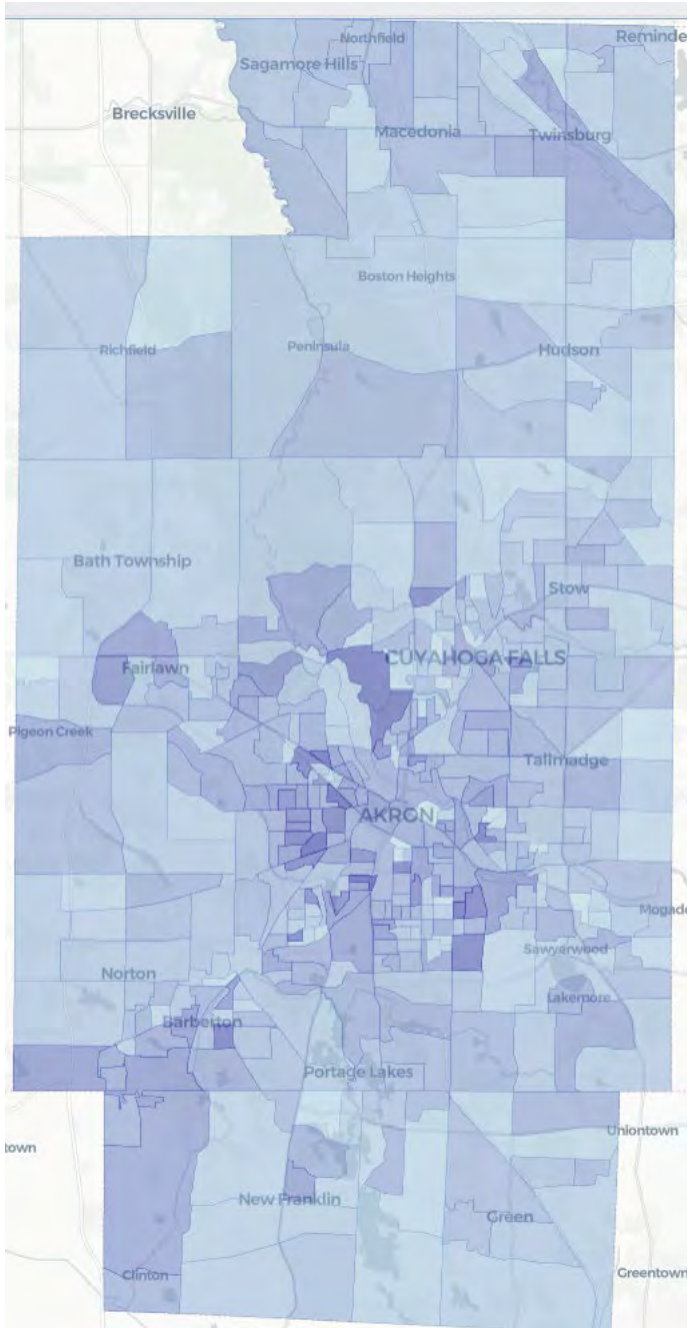
Hypertension



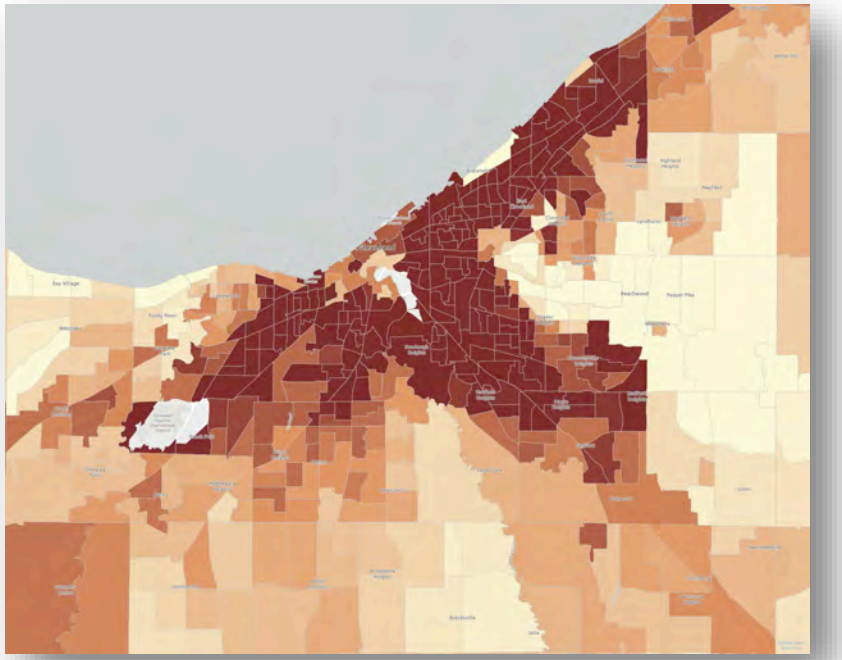
Type 2 Diabetes



CKD



Simulated Impacts of 10% Smoking Reduction



		Simulated Mean (SD) Life Expectancy	
		Under Current Smoking Rates	*Assuming a 10% Reduction*
Females	*ADI Quintile 1*	85.0 (3.5)	85.7 (2.8)
	ADI Quintile 2	82.1 (4.6)	82.9 (4.1)
	ADI Quintile 3	80.7 (5.1)	81.6 (4.6)
	ADI Quintile 4	78.7 (5.7)	79.7 (5.3)
	ADI Quintile 5	76.3 (6.4)	77.4 (6.1)
Males	*ADI Quintile 1*	82.3 (4.1)	83.1 (3.5)
	ADI Quintile 2	78.8 (5.1)	79.7 (4.7)
	ADI Quintile 3	77.4 (5.5)	78.2 (5.2)
	ADI Quintile 4	75.6 (6.0)	76.4 (5.8)
	ADI Quintile 5	72.5 (6.4)	73.4 (6.3)

Health Systems

CONTEXT

Cost Inflation

HCW Shortages

Burnout/Turnover

Negative Margins

Inefficiency

Accountable Care

INNOVATE AND WEATHER THE STORM

VALUE

Value-Based Care

compare population outcomes across diverse neighborhoods
inform efforts to improve health of accountable populations
quality benchmarking

Resource Distribution & Optimization

localized forecasts of care utilization and outcomes
localized impact of capital expansion strategies
staffing allocation

Community Needs Assessment

AI-driven insights to improve equity in access, use and outcomes
catalyze collaborative projects with CDOs & other organizations

Digital Health Transformation

predictive analytics and precision medicine
back-end AI infrastructure and interoperability

Public Health Agencies

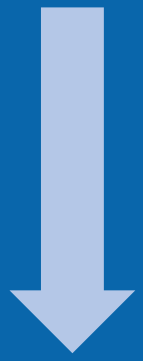
CONTEXT

Budget Constraints

Cost Inflation

Standards & Mandates

Waste, Fraud & Abuse



DO MORE WITH LESS

VALUE

Compliance and Quality

accreditation standards, surveillance mandates, health disparities benchmarks, Healthy People 2030

Resource Distribution

medications, equipment, vaccines

Screening Program Planning

hypertension, breast cancer, colorectal cancer

Community Health Program Planning

opioid recovery services, grant development

Epidemic Monitoring & Forecasting

Disaster Planning

blizzards, hurricanes, earthquakes

Policy & Community Organizations

CONTEXT

Intractable Place-Based Health Disparities

Declining Life Expectancy

Unintended Policy Effects

Fragmented Data

Spiraling Health Care Costs

MAKE U.S. HEALTH CARE WORK FOR EVERYONE

VALUE

Research and Analysis

provide data for development of technical reports
support the identification of policy recommendations

Legislation

data-driven insights to support development

Monitoring and Forecasting

evaluate the impact of policies before/after enactment
conduct natural experiments

Coalition Building

assist in identifying problems in precise neighborhoods
DTN estimates as communication tools

AI Ethics

identify and mitigate risks of applying AI for population health

Thank you!

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