EMORY UNIVERSITY | Emory Global Diabetes Research Center
Of the Woodruff Health Sciences Center

County estimates of high blood pressure

September 2024

Thomas Hsiao
Department of Biostatistics and Bioinformatics
Rollins School of Public Health
Emory University

Overview

Why is this important?

- Nearly half of adults 18+ have high blood pressure (Source: National Health and Nutrition Examination Survey 2017-March 2020)
- Hypertension increases risk of heart disease and stroke

What is currently available?

- NHANES: 2yr in-person survey with interviews, lab tests, and blood pressure
- BRFSS: annual telephone survey with high rates of non-response
- COSMOS (*outside scope of this analysis*)

Outcome definition: hypertension

High blood pressure (BP) has two levels (as of 2017 defined by AHA):

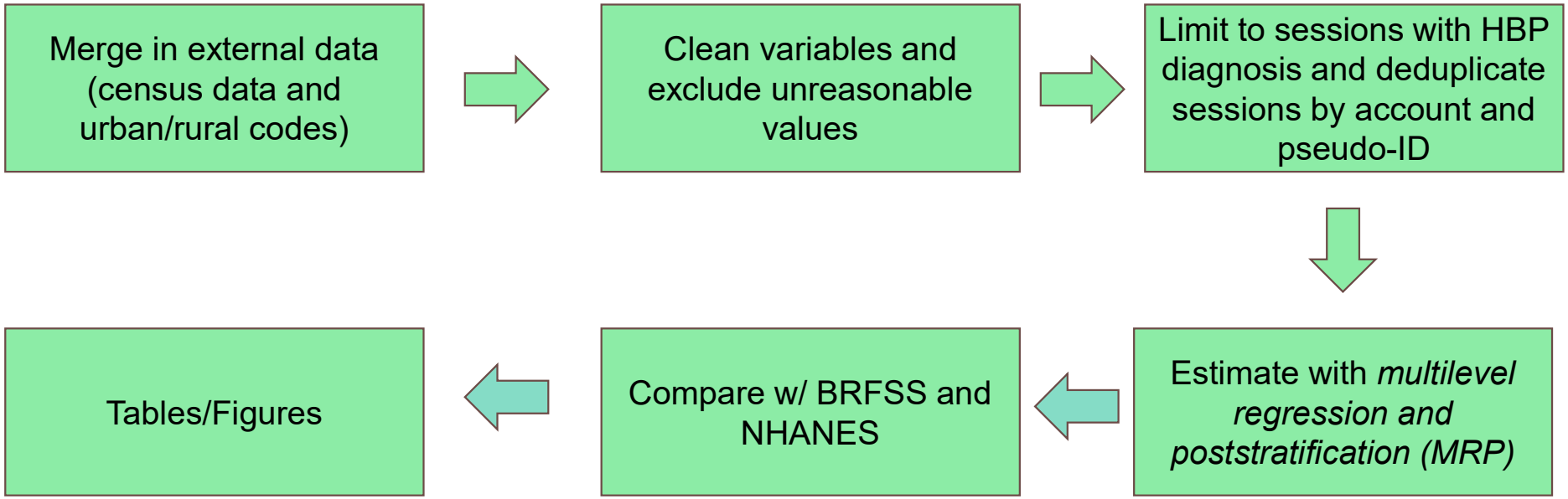
- General: Blood pressure at or above 130/80 mmHg
- Stage 2: Blood pressure at or above 140/90 mmHg

Hypertension care cascade

1. Prevalence: has been diagnosed OR has high BP
2. Awareness: has been diagnosed
3. Treatment: has been diagnosed AND uses medication
4. Controlled: has been diagnosed AND uses medication AND does not have high BP

Goal: county-level estimation of hypertension

Our approach



Why is our approach better than existing ones?

A powerful stream of data

	Pursuant	BRFSS	NHANES
Sample size	200-300K (2-yr)	400-500K	5,000
Data collection	Kiosk use	Telephone interviews	In-person interviews, lab tests, physical exam
Finest geographic representation	Kiosk address (no MA)	Census tract (no NJ in ’19, FL ‘21)	Regional (15 counties only)
Cascade level			
***Prevalence*?**	Yes	No	Yes
***Awareness*?**	Yes	Yes	Yes
Treatment?	**No**	Yes	Yes
***Controlled*?**	**No**	No	Yes
Most recent year	2024	2023	2020 (COVID)
Update frequency	Daily	Annual	Every two years
Response Rate	N/A	49.4% (2019)	46.9% (2017-2020)
Processing time	***FAST!***	One year	1-2 years

A flexible statistical model

To predict hypertension prevalence and awareness, we use a logistic mixed effects model to perform *multilevel regression and poststratification (MRP)*

Multilevel: allows us to include predictors at multiple geographic levels (county, state) and estimate hypertension in counties with no data

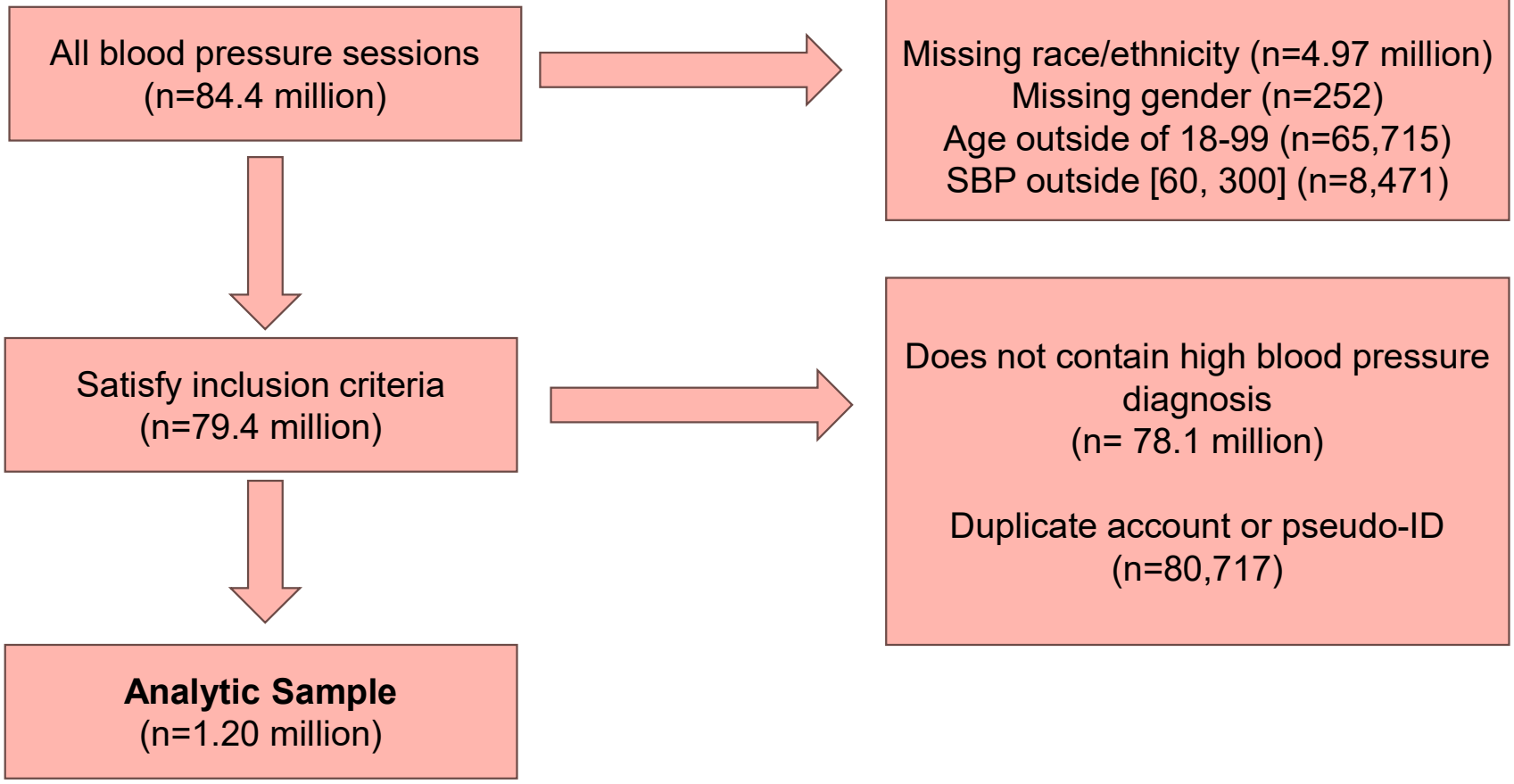
- State-level: Region (Northeast, Midwest, South, West)
- County-level: Urbanicity, unemployment rate (%), percent who didn't graduate high school (%), median household income ($), health insurance coverage (%)

Poststratification: allows us to standardize the Pursuant population to the US demographic profile and estimate hypertension at any geographic level.

- Geographic: county, state, national, urbanicity
- Demographic: age, sex, race/ethnicity

Data

Analytic Sample Selection

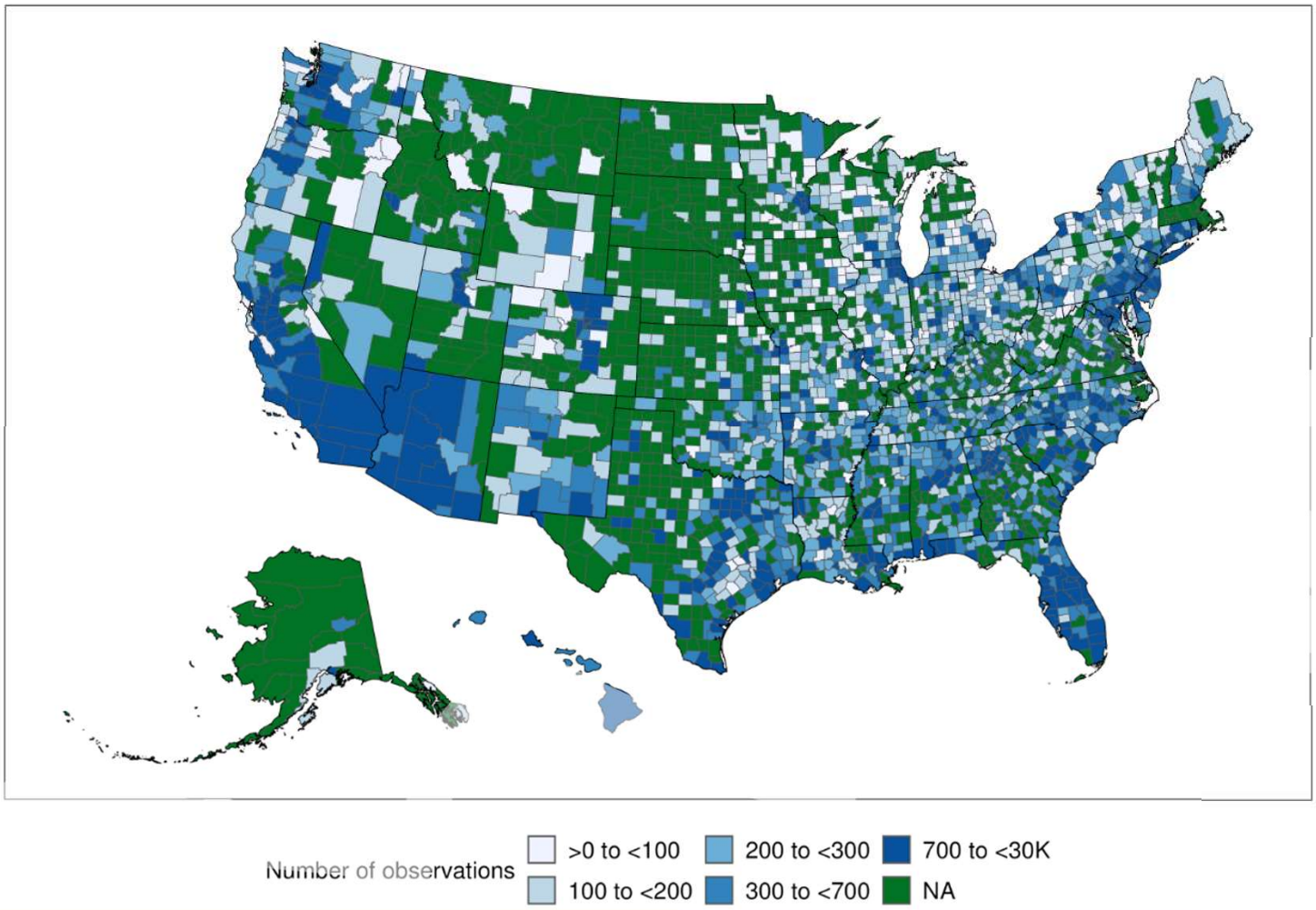


Demographic Comparison

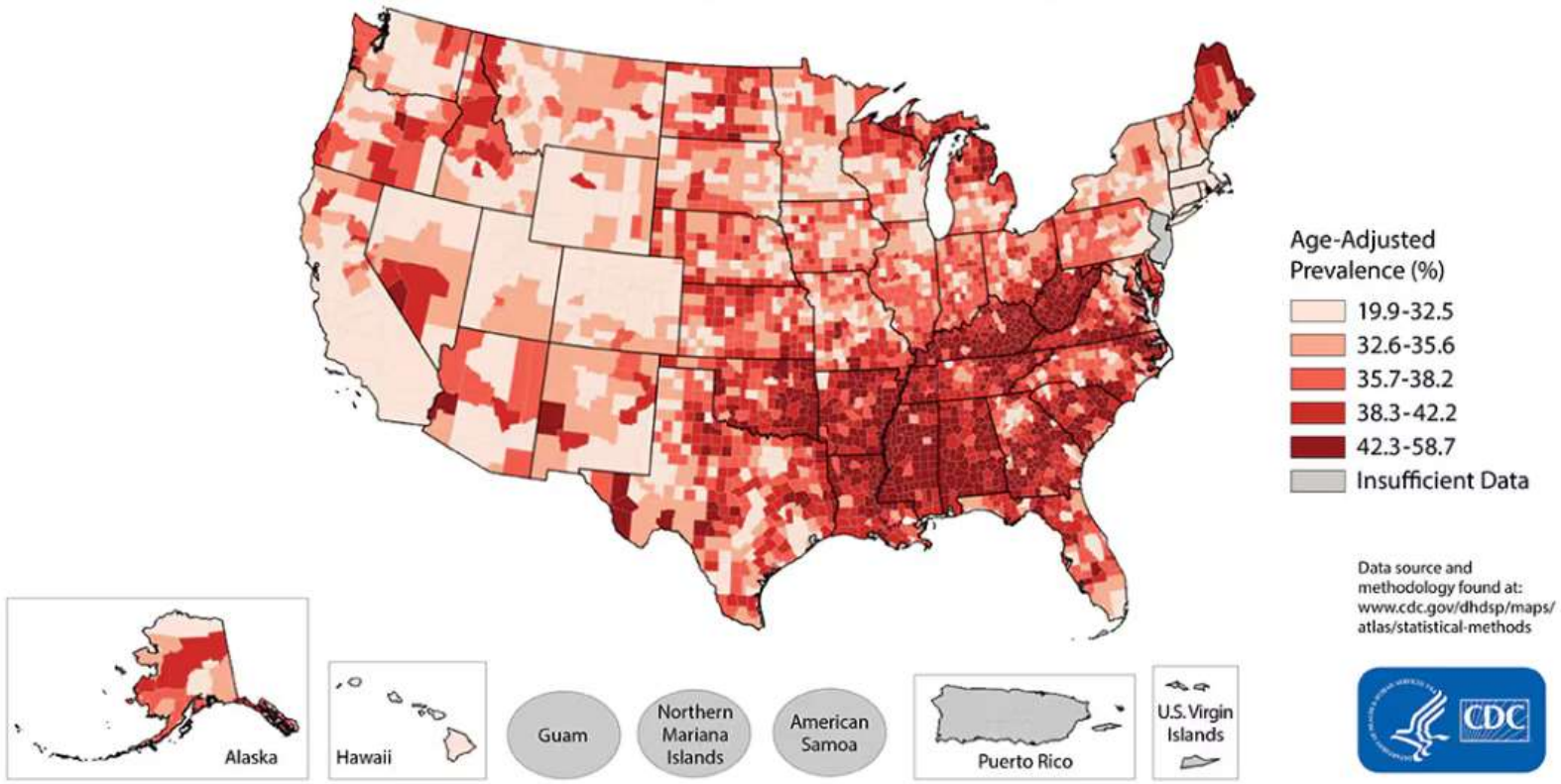
	US Pop. (ACS) 2018-2022 (N=334,369,975)	Pursuant (All) 2017-2024 (Obs = 40,868,043)	Pursuant (Analytic) 2017-2024 (N = 1,200,340)
Age group			
18 to <20	4%	2%	3%
20 to <45	**43%**	**42%**	**57%**
45 to <65	32%	38%	32%
65 and over	**21%**	**18%**	**9%**
Male	49%	55%	52%
Race/ethnicity			
NH White	**59%**	**51%**	**42%**
NH Black	**12%**	**14%**	**18%**
NH Asian	6%	5%	7%
NH Other	5%	6%	6%
Hispanic	**19%**	**24%**	**26%**
Urban	86%	82%	83%

ACS 2018-2022: *https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2022*
RUCC 2023: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/

Distribution of Pursuant analytic sample (2017-2024)



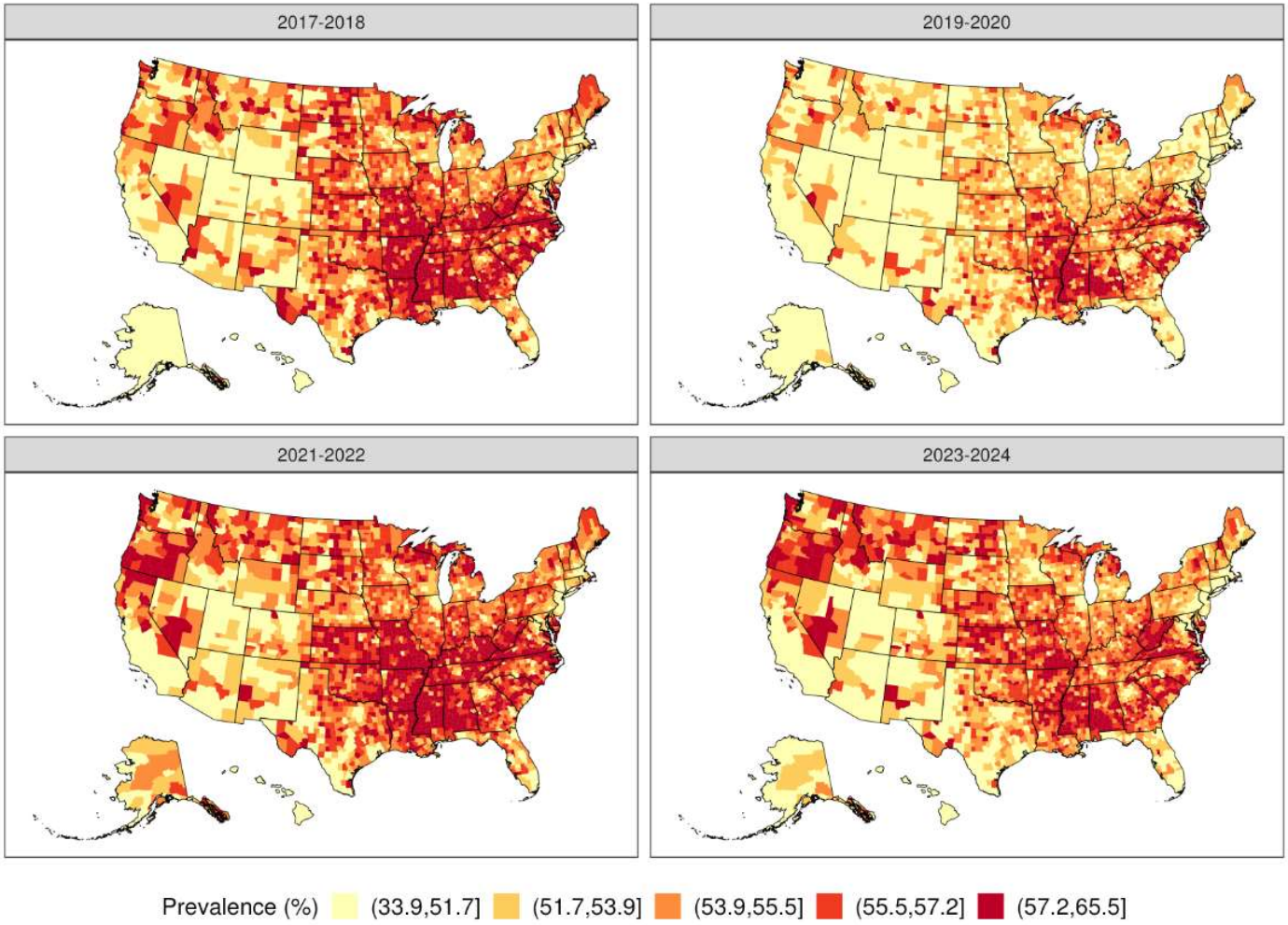
BRFSS 2019 county estimates of hypertension awareness



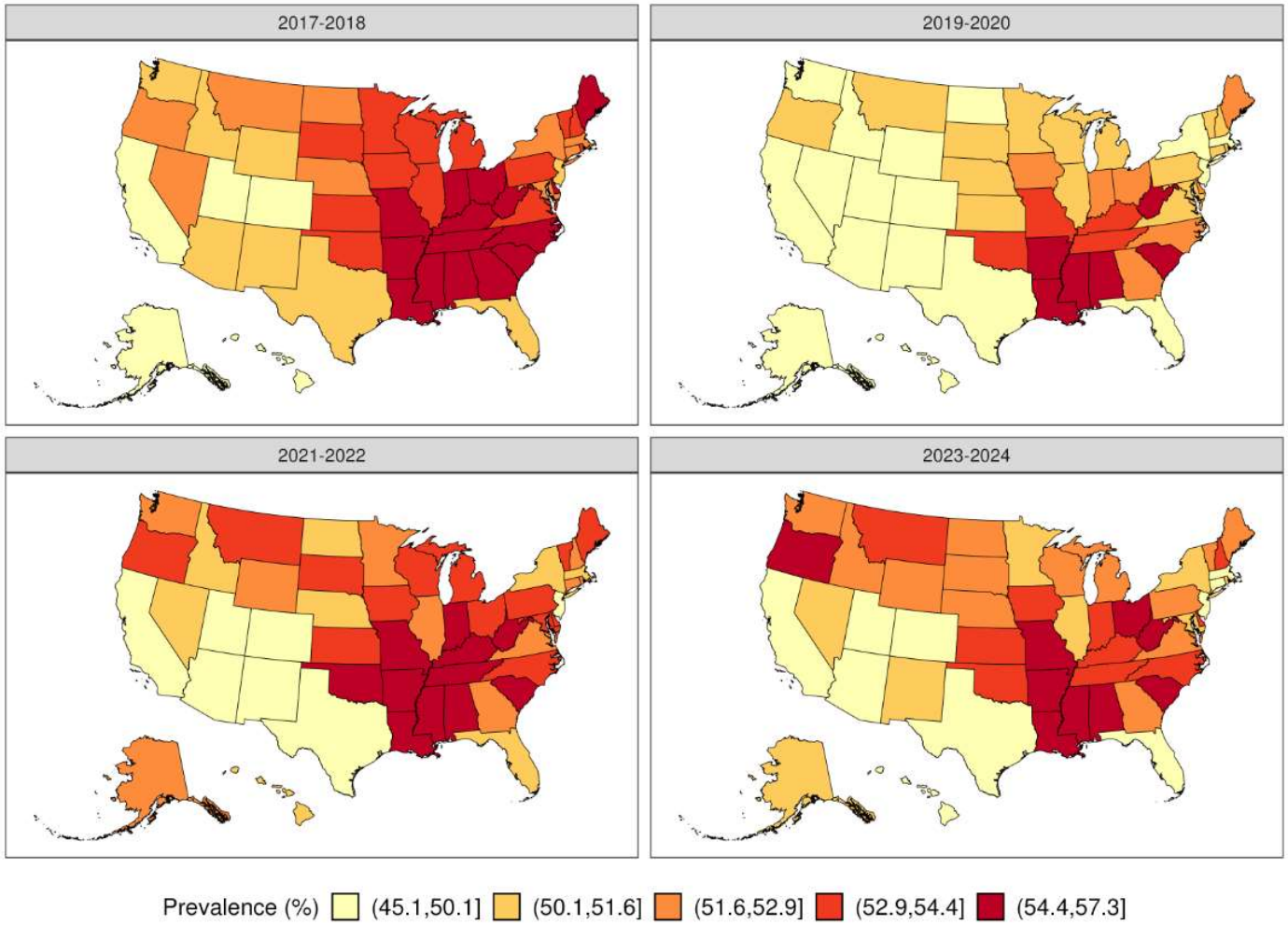
BRFSS: Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?

Main results

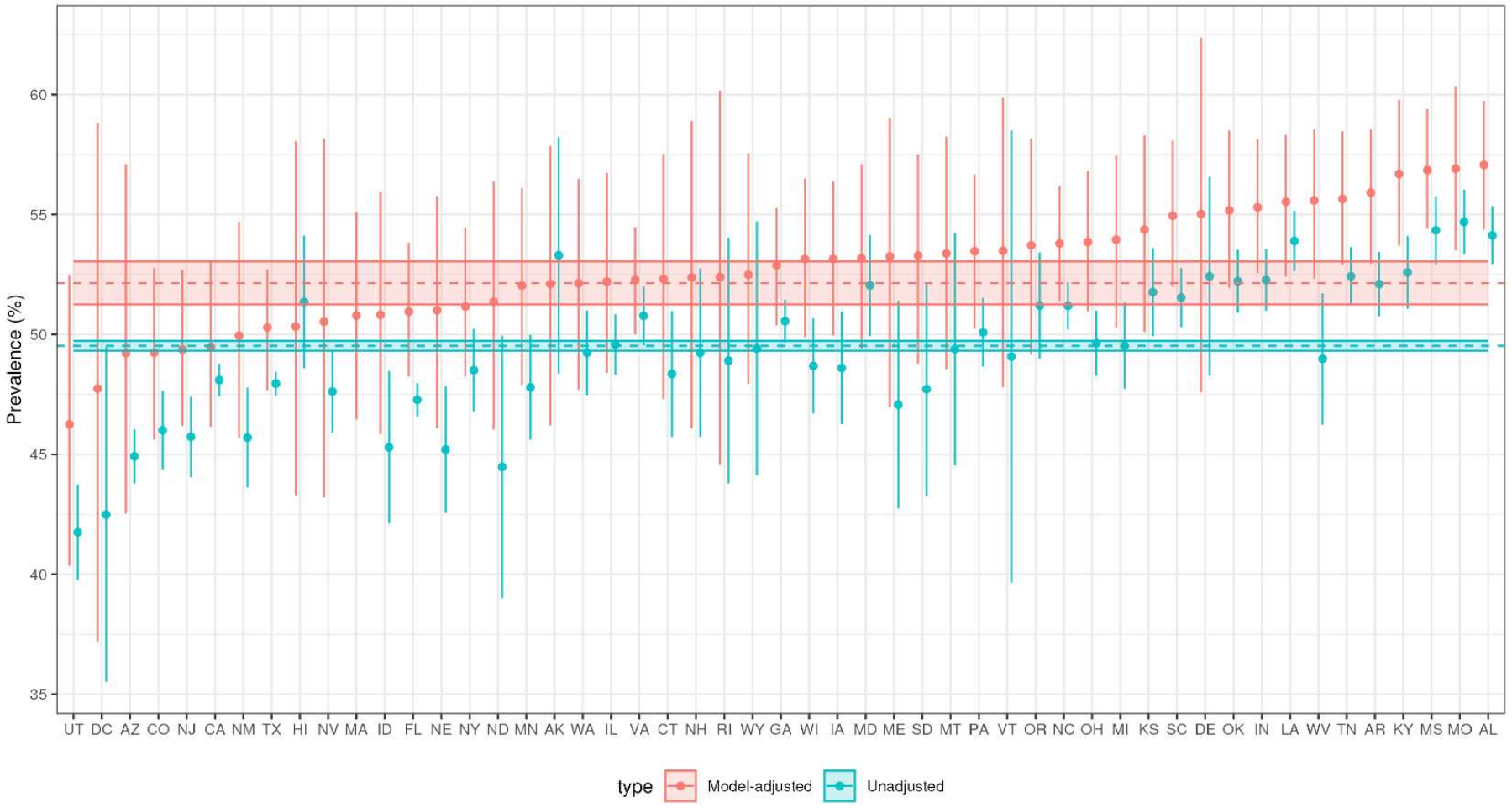
County estimates of stage 2 prevalence from Pursuant



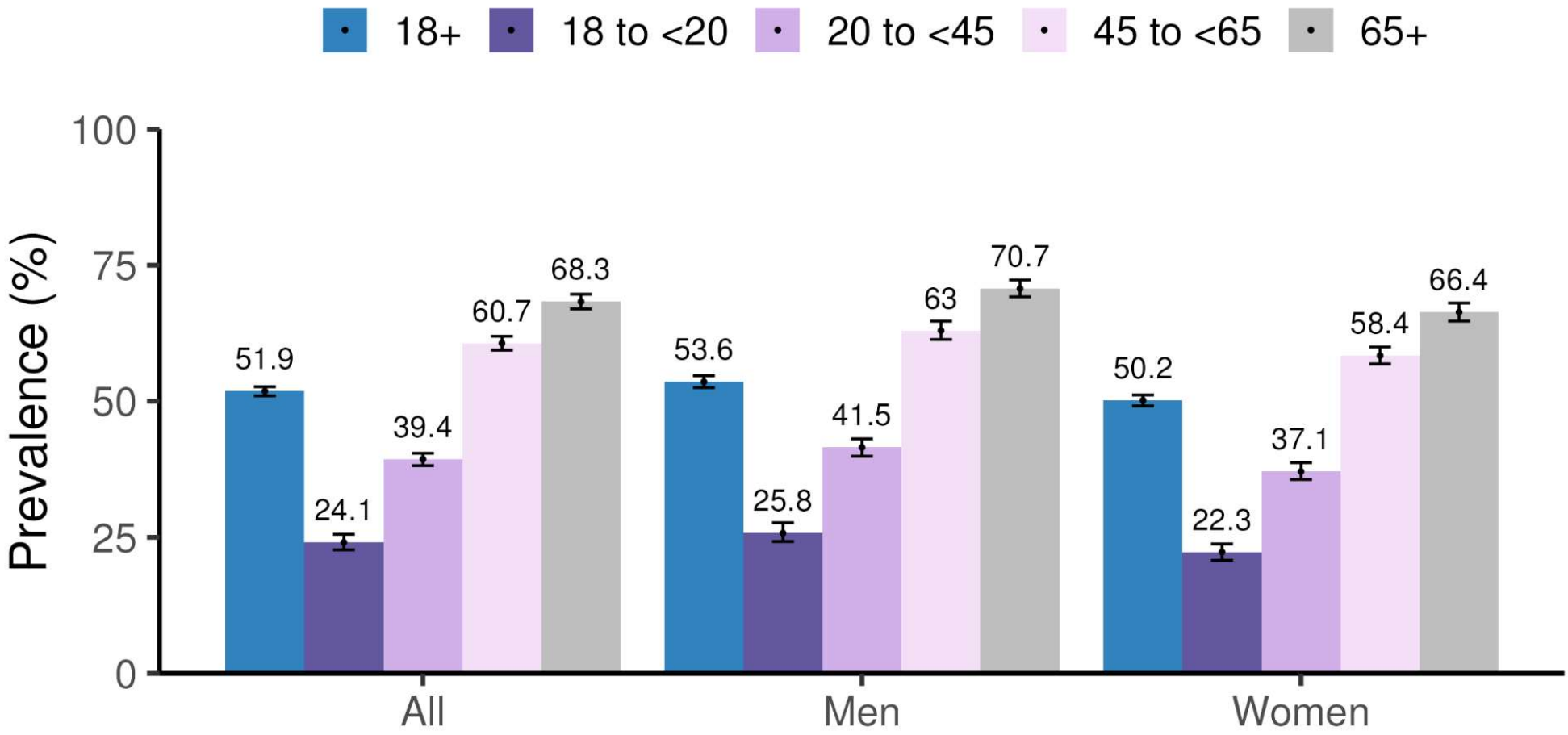
State estimates of stage 2 prevalence from Pursuant



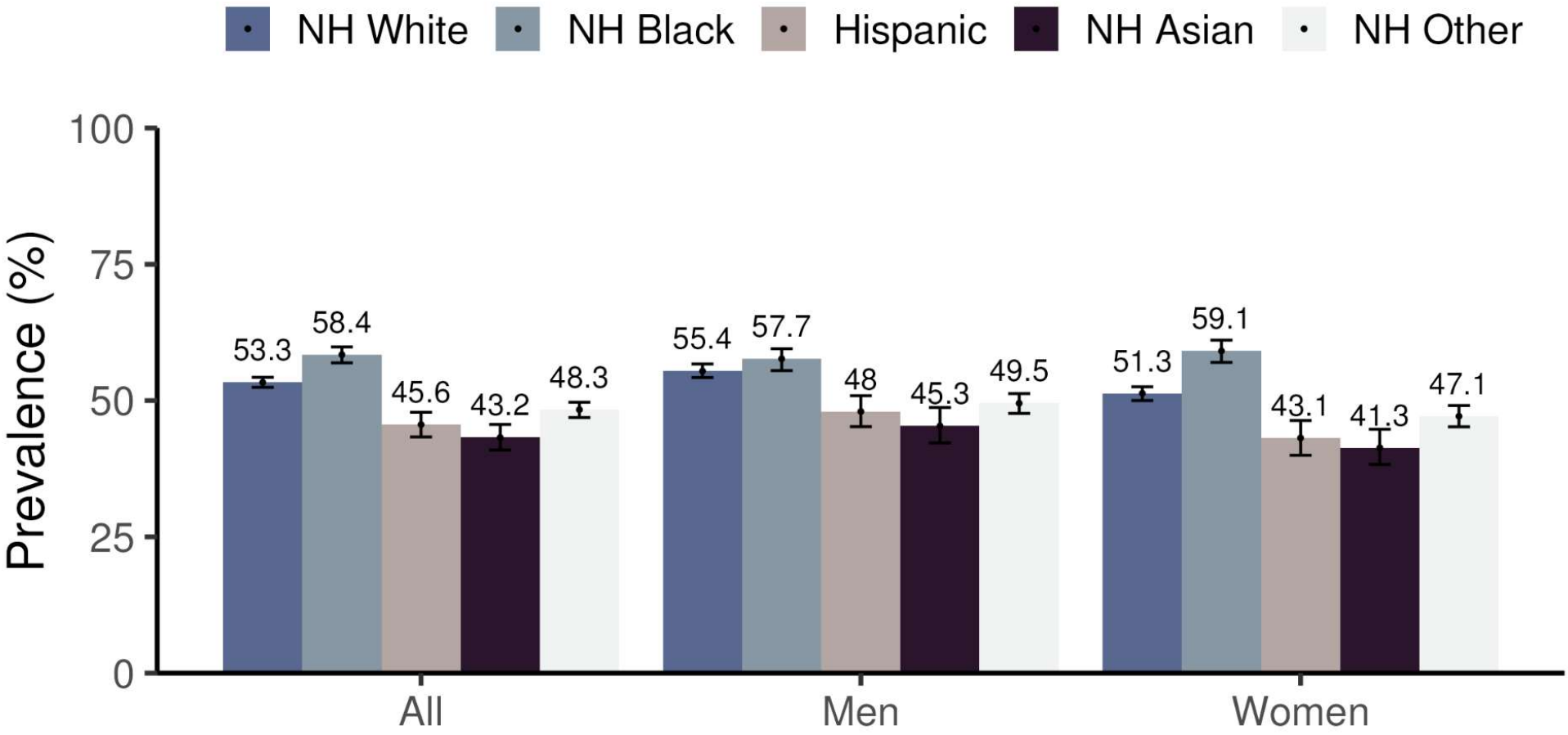
Model vs. data: stage 2 prevalence (Pursuant 2021-2022)



Stage 2 hypertension by age and sex (Pursuant 2017-18)



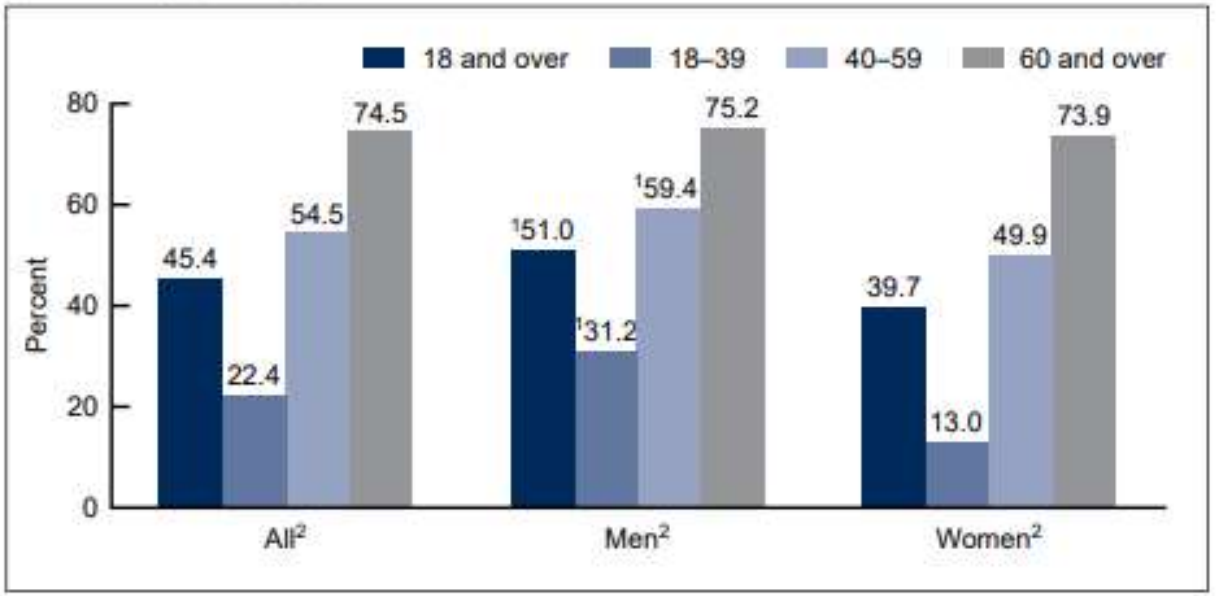
Stage 2 hypertension by race and sex (Pursuant 2017-18)



Comparison to NHANES and BRFSS

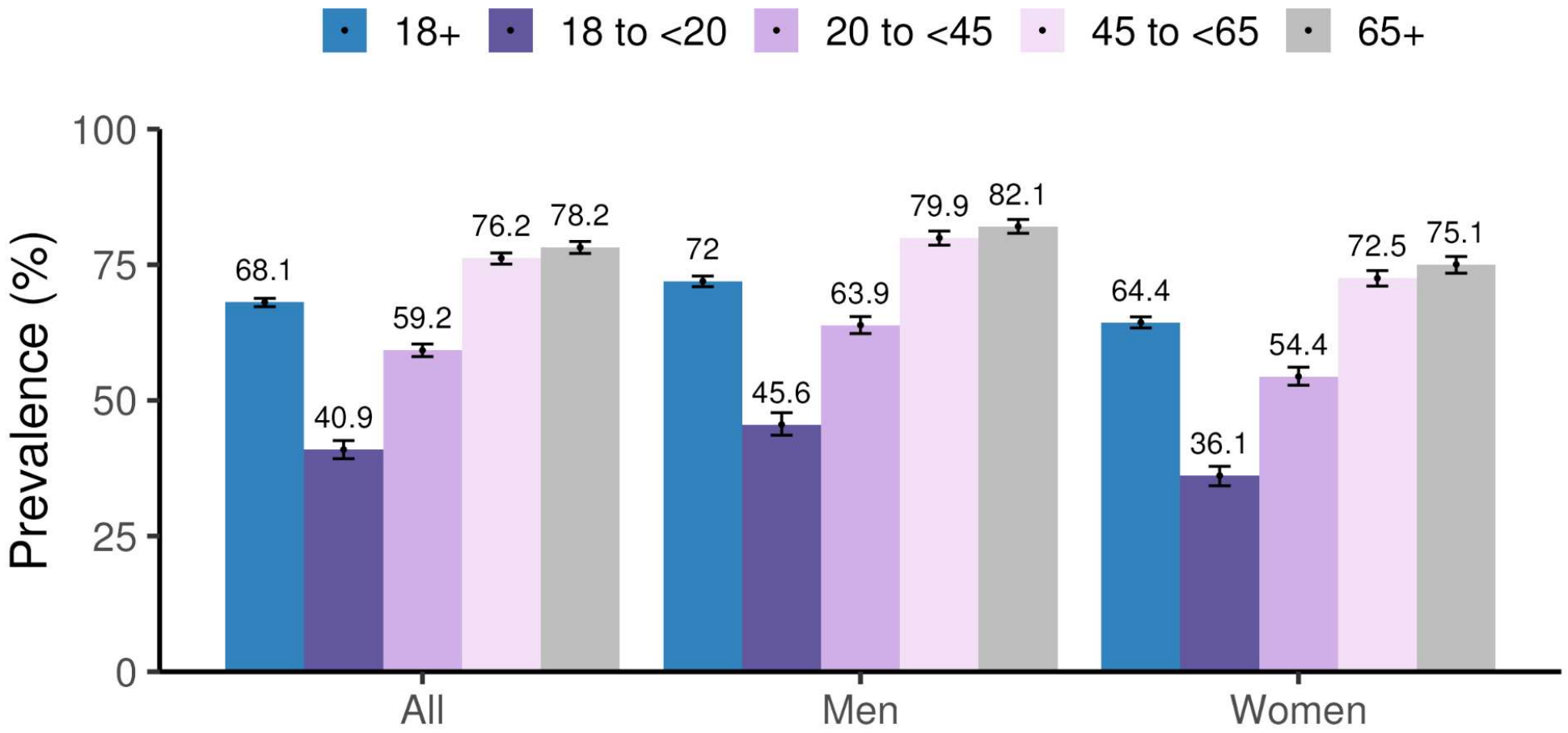
General hypertension by age and sex (NHANES 2017-18)

Figure 1. Prevalence of hypertension among adults aged 18 and over, by sex and age: United States, 2017–2018



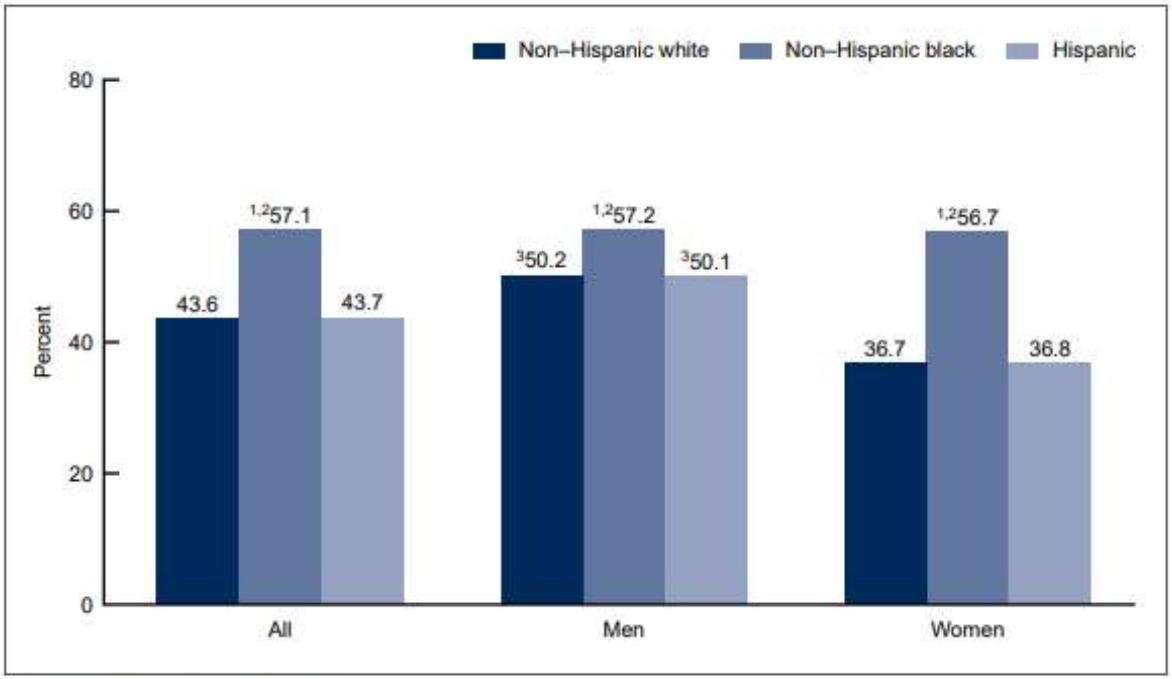
[1]Significantly different from women within the same age group.
[2]Significant increasing trend by age.
NOTES: Hypertension is defined as systolic blood pressure greater than or equal to 130 mmHg or diastolic blood pressure greater than or equal to 80 mmHg, or currently taking medication to lower blood pressure. Estimates for age group 18 and over are age adjusted by the direct method to the U.S. Census 2000 population using age groups 18–39, 40–59, and 60 and over. Crude estimates are 48.2% for all persons, 52.5% for men, and 44.0% for women. Access data table for Figure 1 at: https://www.cdc.gov/nchs/data/databriefs/db364-tables-508.pdf#1.
SOURCE: NCHS, National Health and Nutrition Examination Survey, 2017–2018.

General hypertension by age and sex (Pursuant 2017-18)



General hypertension by race and sex (NHANES 2017-18)

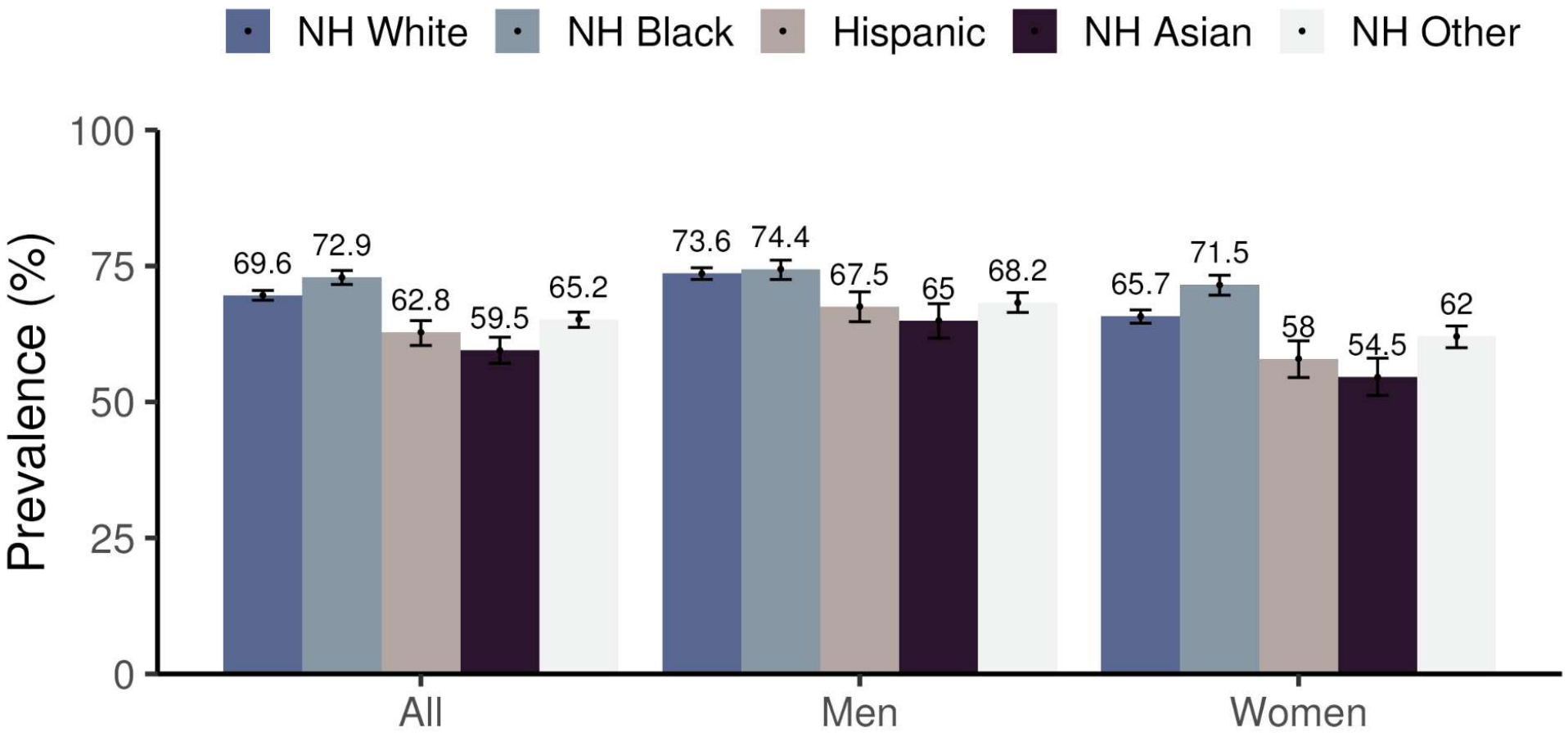
Figure 2. Age-adjusted prevalence of hypertension among adults aged 18 and over, by sex and race and Hispanic origin: United States, 2017–2018



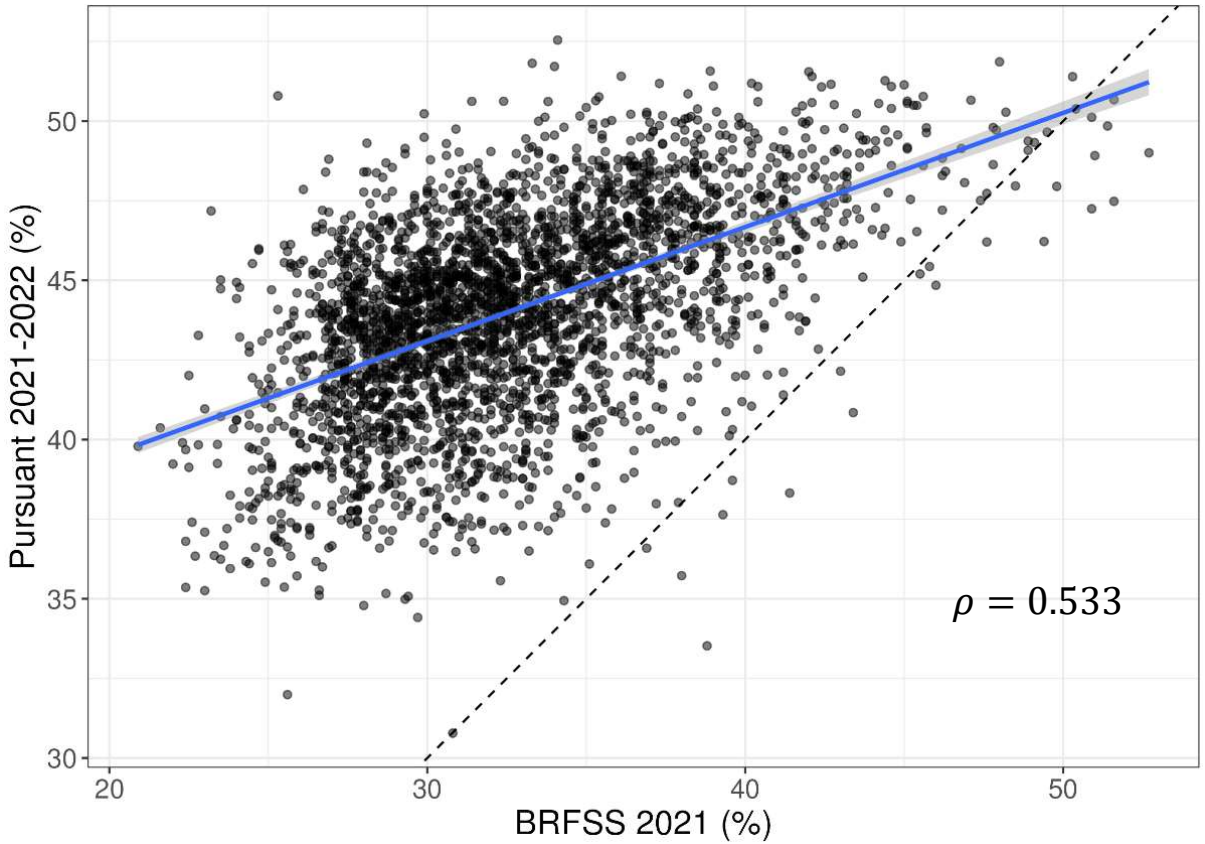
[1]Significantly different from non-Hispanic white.
[2]Significantly different from Hispanic.
[3]Significantly different from women in the same race and Hispanic-origin group.
NOTES: Hypertension is defined as systolic blood pressure greater than or equal to 130 mmHg or diastolic blood pressure greater than or equal to 80 mmHg, or currently taking medication to lower blood pressure. All estimates are age adjusted by the direct method to the U.S. Census 2000 population using age groups 18–39, 40–59, and 60 and over. Access data table for Figure 2 at: https://www.cdc.gov/nchs/data/databriefs/db364-tables-508.pdf#2.
SOURCE: NCHS, National Health and Nutrition Examination Survey, 2017–2018.

https://www.cdc.gov/nchs/data/databriefs/db364-h.pdf

General hypertension by race and sex (Pursuant 2017-18)



Pursuant vs. BRFSS: hypertension awareness (2021-2022)



BRFSS: Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?
Pursuant: Have you ever been diagnosed with high blood pressure?

Conclusions

Conclusions

EMORY UNIVERSITY

1. Pursuant users are younger, less white, and most likely have higher rates of hypertension compared to the U.S. national population

Conclusions

EMORY UNIVERSITY

1. Pursuant users are younger, less white, and most likely have higher rates of hypertension compared to the U.S. national population
2. County-level Pursuant estimates of hypertension awareness are positively associated with that from BRFSS ($\rho = 0.533$)

Conclusions

EMORY UNIVERSITY

1. Pursuant users are younger, less white, and most likely have higher rates of hypertension compared to the U.S. national population
2. County-level Pursuant estimates of hypertension awareness are positively associated with that from BRFSS ($\rho = 0.533$)
3. Pursuant estimates of hypertension prevalence capture known geographic and demographic trends and are available for 2024

Conclusions

EMORY UNIVERSITY

1. Pursuant users are younger, less white, and most likely have higher rates of hypertension compared to the U.S. national population
2. County-level Pursuant estimates of hypertension awareness are positively associated with that from BRFSS ($\rho = 0.533$)
3. Pursuant estimates of hypertension prevalence capture known geographic and demographic trends and are available for 2024
4. The MRP can estimate hypertension prevalence or awareness at any aggregate geographic or demographic level with uncertainty

Conclusions

EMORY UNIVERSITY

1. Pursuant users are younger, less white, and most likely have higher rates of hypertension compared to the U.S. national population
2. County-level Pursuant estimates of hypertension awareness are positively associated with that from BRFSS ($\rho = 0.533$)
3. Pursuant estimates of hypertension prevalence capture known geographic and demographic trends and are available for 2024
4. The MRP can estimate hypertension prevalence or awareness at any aggregate geographic or demographic level with uncertainty

KEY: Pursuant kiosk data + MRP have the potential to be the basis for a real-time passive surveillance system of the hypertension care cascade

Recommendations to Pursuant kiosk

Recommendations to Pursuant kiosk

- Attach a high blood pressure specific questionnaire to the blood pressure monitor (maybe right before to encourage higher response rate)

Recommendations to Pursuant kiosk

- Attach a high blood pressure specific questionnaire to the blood pressure monitor (maybe right before to encourage higher response rate)
  - Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?
  - Are you currently taking prescription medicine for your high blood pressure?

Recommendations to Pursuant kiosk

- Attach a high blood pressure specific questionnaire to the blood pressure monitor (maybe right before to encourage higher response rate)
  - Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?
  - Are you currently taking prescription medicine for your high blood pressure?
- Why?

Recommendations to Pursuant kiosk

EMORY UNIVERSITY

- Attach a high blood pressure specific questionnaire to the blood pressure monitor (maybe right before to encourage higher response rate)
  - Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure?
  - Are you currently taking prescription medicine for your high blood pressure?
- Why?

Real-time county-level surveillance of the entire hypertension care cascade does not yet exist, but would be essential to policymakers and strongly demonstrate the value of the Pursuant kiosks.

Questions for Pursuant

Questions for Pursuant

1. How recent of data can we incorporate into this analysis (Sept. 24')?

Questions for Pursuant

1. How recent of data can we incorporate into this analysis (Sept. 24')?
   - This will be extremely impressive to the public health community and highlight Pursuant's ability to provide fast, real-time surveillance data.

Questions for Pursuant

EMORY UNIVERSITY

1. How recent of data can we incorporate into this analysis (Sept. 24')?
   - This will be extremely impressive to the public health community and highlight Pursuant's ability to provide fast, real-time surveillance data.

2. Are there details on how the blood pressure monitor sensors are calibrated?

Questions for Pursuant

EMORY UNIVERSITY

1. How recent of data can we incorporate into this analysis (Sept. 24')?
   - This will be extremely impressive to the public health community and highlight Pursuant's ability to provide fast, real-time surveillance data.

2. Are there details on how the blood pressure monitor sensors are calibrated?
   - This will be important for communicating our methods.

Questions for Pursuant

EMORY UNIVERSITY

1. How recent of data can we incorporate into this analysis (Sept. 24')?
   - This will be extremely impressive to the public health community and highlight Pursuant's ability to provide fast, real-time surveillance data.

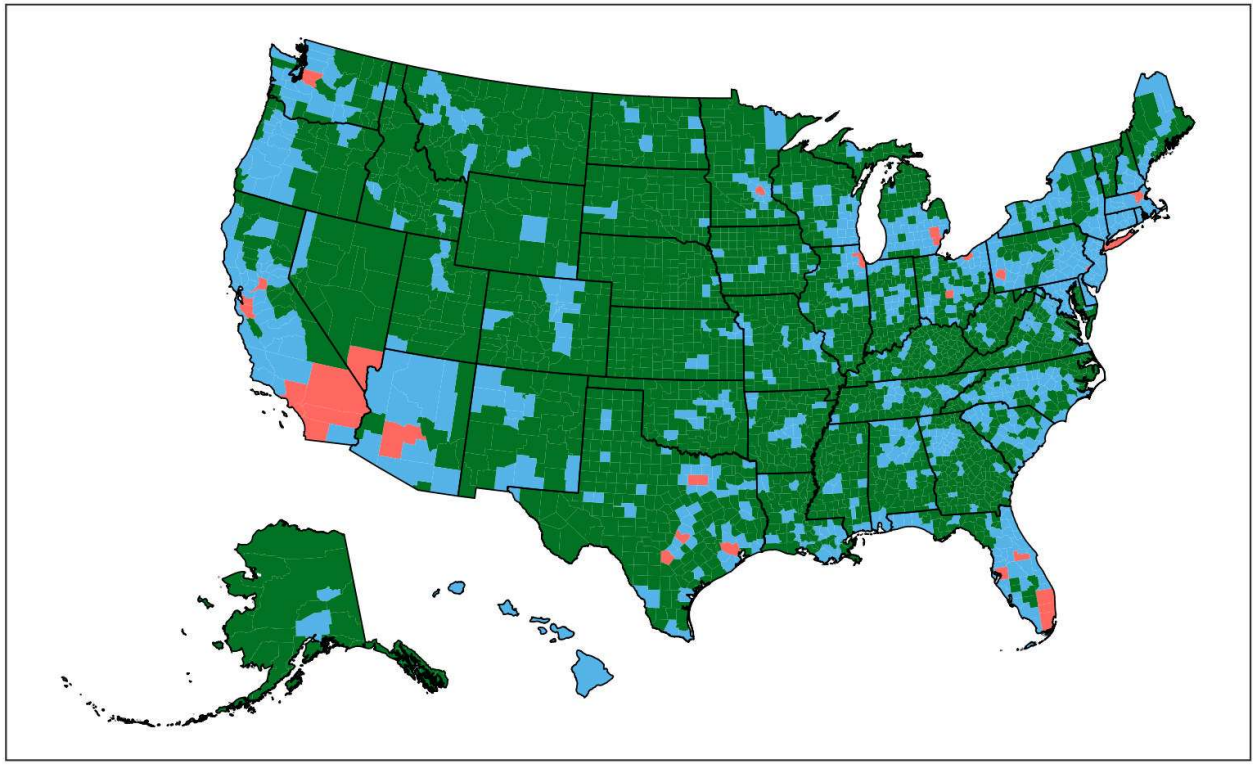
2. Are there details on how the blood pressure monitor sensors are calibrated?
   - This will be important for communicating our methods.

3. Was there any mass software/hardware update or change to blood pressure monitors from 2017-2024? Are all monitors standardized across the country?

Thank you!

Questions?

ACS Population (2018-2022)



Sensitivity Analyses

EMORY UNIVERSITY

Below are some areas to explore to test the robustness of our results.

Hypertension definition

- Current: Mean of blood pressure measurements above 140/90 or diagnosed
- Alternative: Instead of mean, consider hypertensive if any of the multiple measurements are above 140/90

Deduplication strategy

- Current: Deduplicating on session ID, pseudo-ID (DOB, gender, race/ethnicity, location), and 2-yr interval (2017-18, 2019-20, etc.)
- Alternative: Incorporate specific time at measurement into deduplication strategy, shorten time interval for averaging over measurements, understand behavior of “power users” better

Current Surveillance Approaches

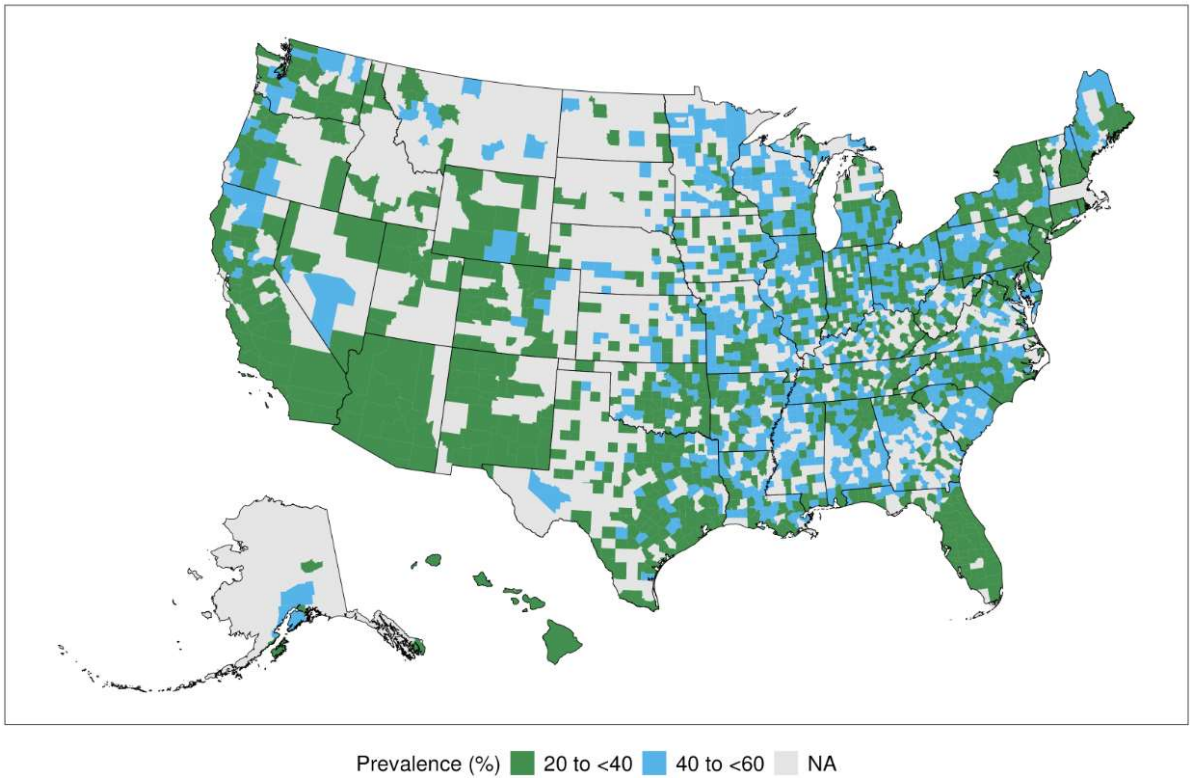
EMORY UNIVERSITY

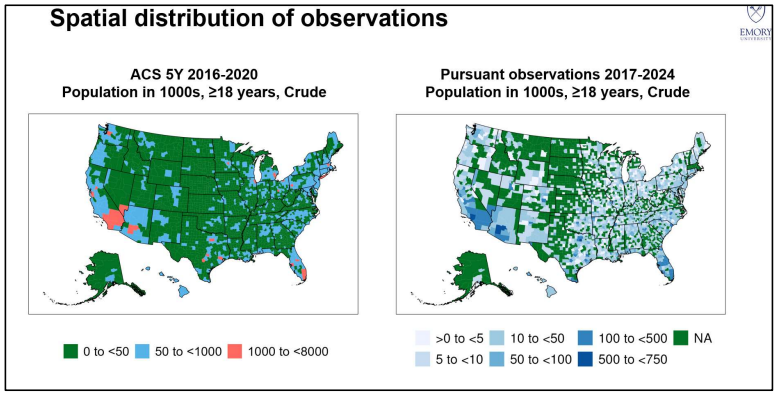
BRFSS 2021	Epic Cosmos
CDC develops questionnaires in collaboration with states and other stakeholders	Health systems with Epic EHR choose to participate in Cosmos
Random digit dialing to create a probability sample of adults (>= 18 years)	Epic anonymizes and harmonizes data through the Care Everywhere platform
Interviews conducted by state health departments or contractors in English/Spanish/Other	Data follows the Epic Cosmos Data Model, different from other EHR database formats (OMOP, PCORnet)
Sampling weights constructed for probability of selection and adjusted for non-response and to align with US Census counts	No adjustment for health system contribution. Health systems may not include all their data in Cosmos. Patients may use other health systems
Numerator: Have you ever been told by a doctor, nurse, or other health professional that you have high blood pressure? = Yes **Denominator**: All respondents	**Numerator**: Counts of patients with Hypertension code or Antihypertensive Prescription* **Denominator**: Adult patients with at least one encounter in 2021-2022

* This is not available for counties with <10 cases and currently does not include measured high blood pressure

Direct estimate of county-level prevalence from Pursuant

Pursuant (2021-2022), Obs = 11,526,017
High Blood Pressure (%), ≥18 years, Crude

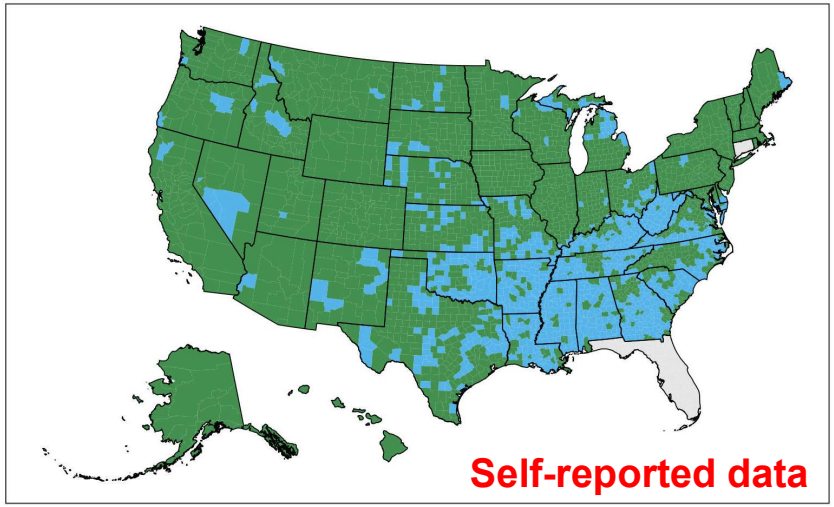




Estimates of county-level prevalence from BRFSS and Cosmos

EMORY UNIVERSITY

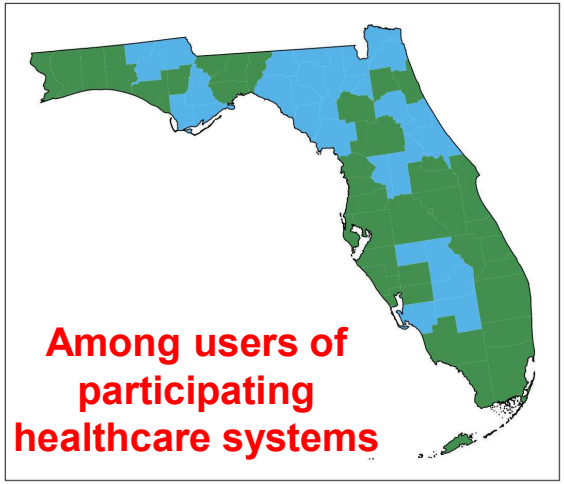
BRFSS 2021
High Blood Pressure (%), ≥18 years, Crude



20 to <40 40 to <60 NA

https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-County-Data-20/swc5-untb/about_data

Epic Cosmos 2021-2022
Hypertension or Antihypertensive Prescription (%), ≥18 years, Crude
N = 5,495,399 patients

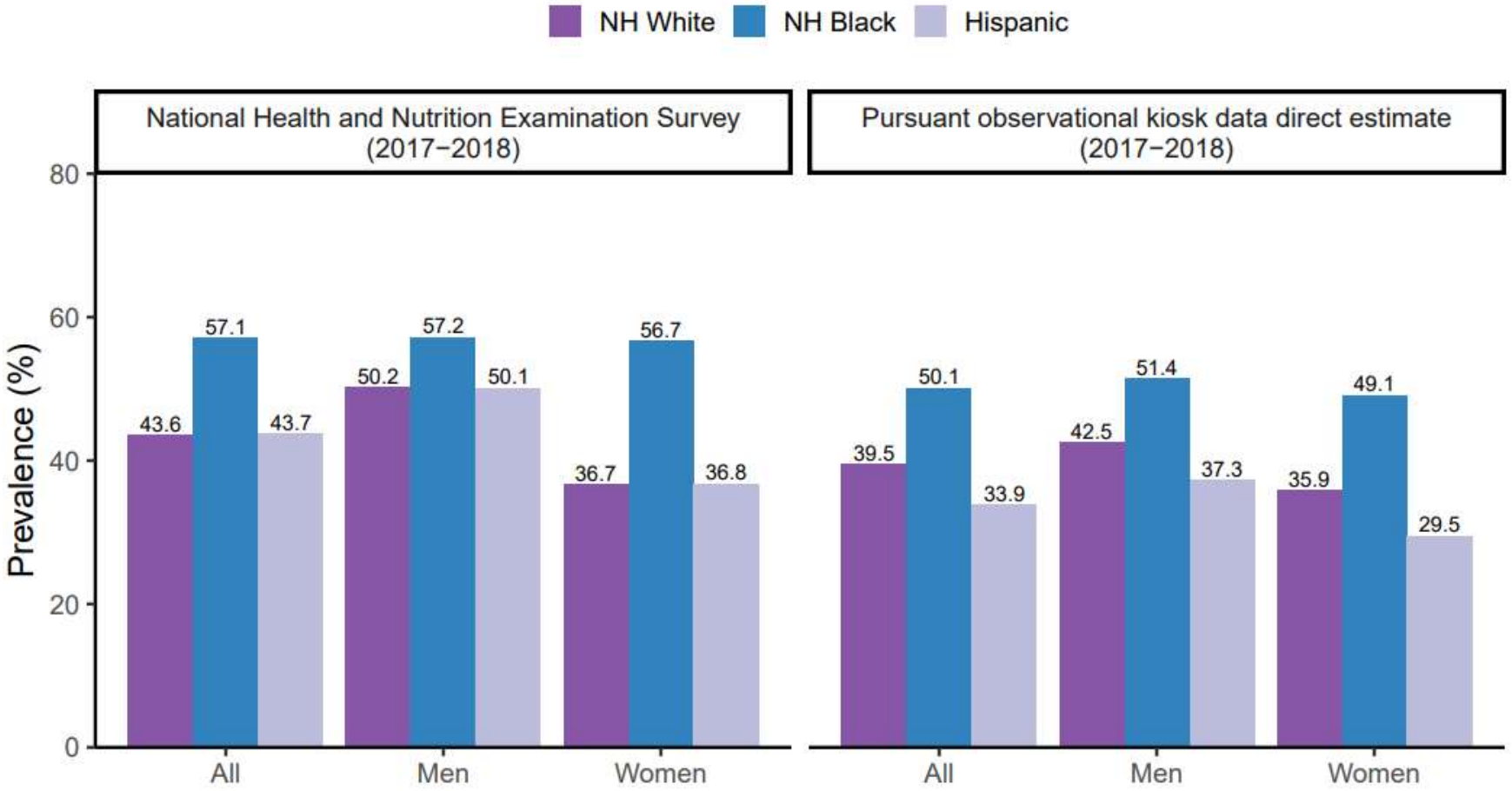


20 to <40 40 to <60

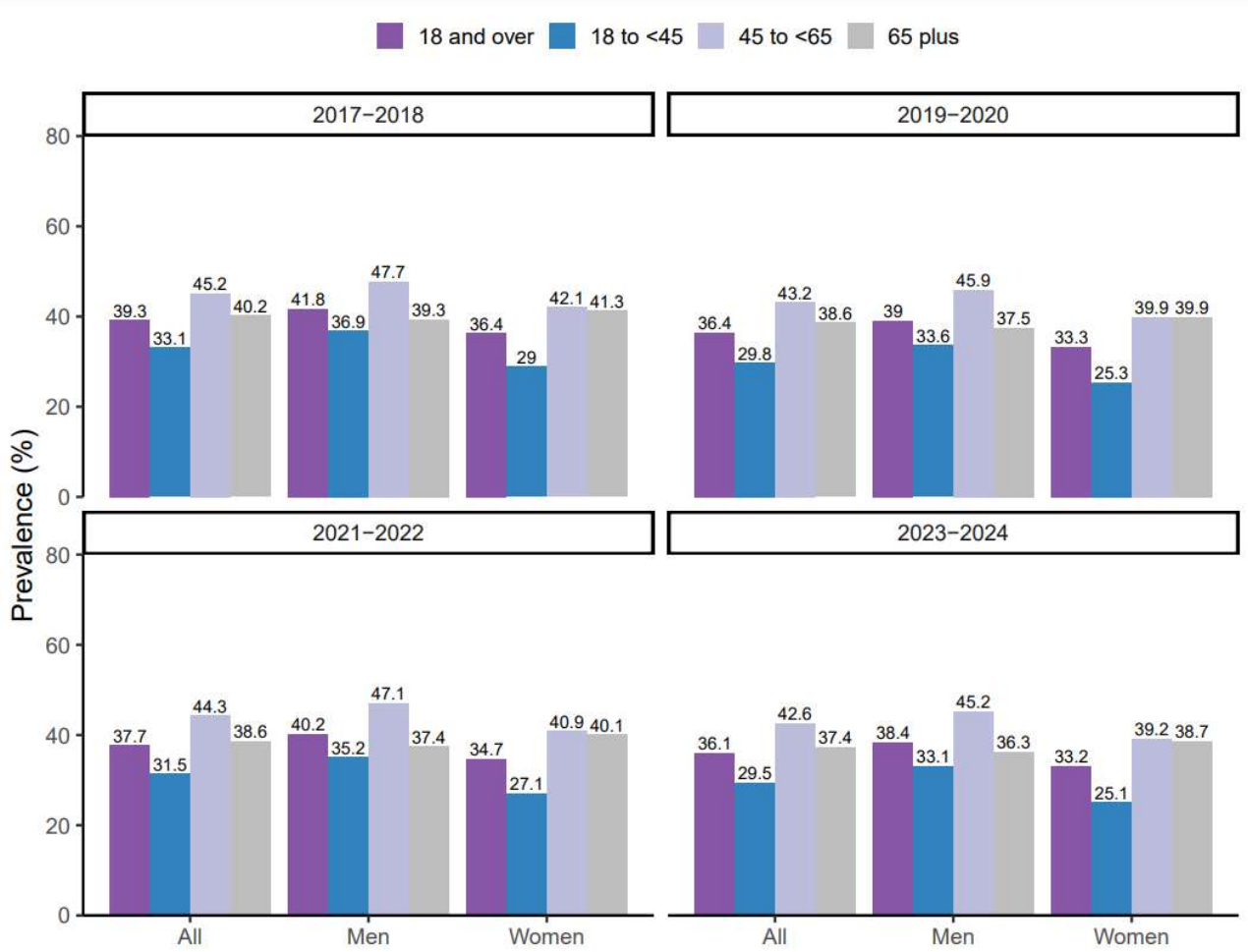
https://cosmos.epichosted.com/EpicCareLink_AUTH/common/epic_main.asp
Patients 18 years or older between Jan 2021 and Dec 2022 with either Diagnosis code (I10) or Prescription for Antihypertensives.

12.6% of hypertension cases (N = 2,311,992) did not have a known county

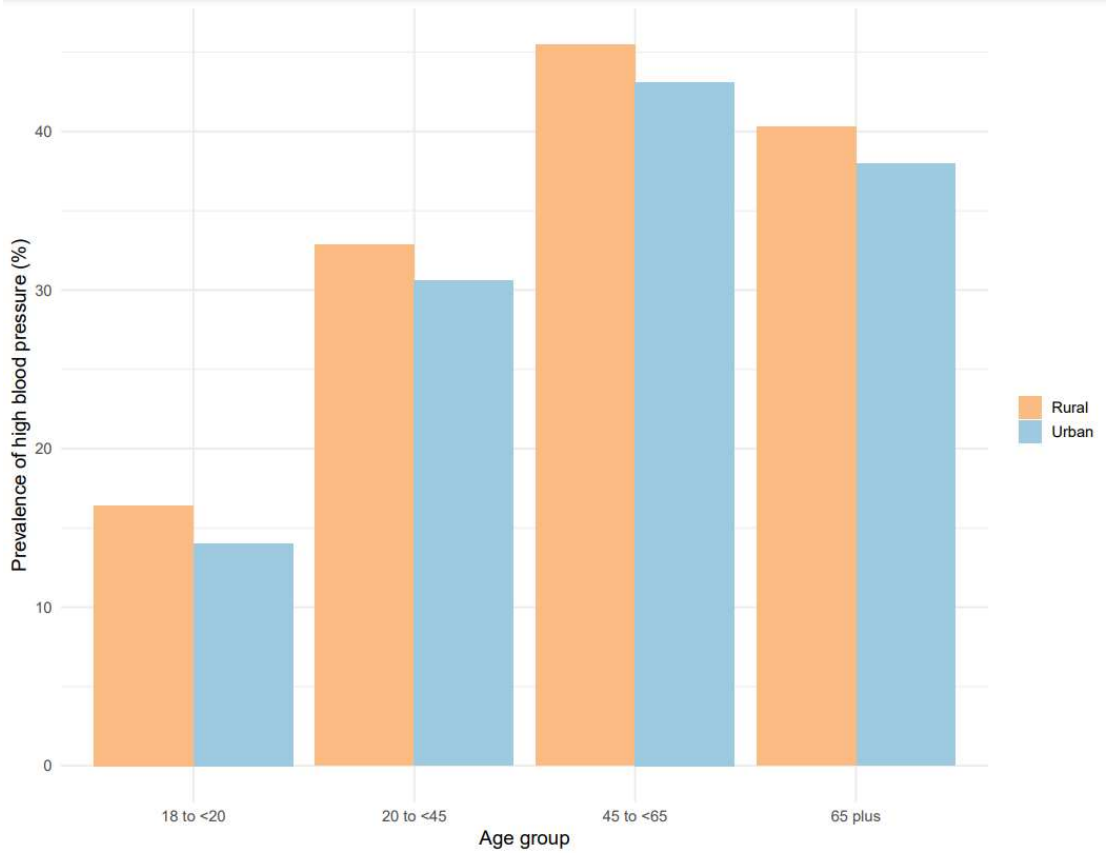
Prevalence of hypertension among adults 18 and over by sex and race/ethnicity (2017-2018)



Pursuant direct estimate by age group, sex, year range



Prevalence of hypertension from Pursuant by age and urban/rural status (Unadjusted)



Potential Reasons

EMORY UNIVERSITY

Selection Bias

- Are patients with high blood pressure less likely to use kiosks for monitoring?
- Are older patients with high blood pressure less likely to use kiosks, and measure their BP elsewhere (home, clinic)?
- Are there regional/socio-demographic patterns in routine usage?

Information Bias

- Do older patients (with high blood pressure) have trouble using kiosks?
- Do kiosks perform better for specific population groups or for different cuff sizes?