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State-Level Hypertension Prevalence and Control Among Adults in the U.S.

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Abstract

Introduction: Improving hypertension control is a national priority. Electronic health record data have the potential to augment traditional surveillance systems. This study aimed to assess hypertension prevalence and control at the state level using a previously established electronic health record–based phenotype for hypertension.

Methods: Adult patients (N=11,031,368) were included from the IQVIA ambulatory electronic medical record–U.S. 2019 data set. IQVIA ambulatory electronic medical record comprises electronic health records from >100,000 providers and includes patients from every U.S. state and Washington DC. Authors compared hypertension prevalence and control estimates against those from the Behavioral Risk Factor Surveillance System 2019. Results were age-standardized and stratified by state and sociodemographic characteristics. Statistical analyses were conducted in 2022–2023.

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SUPPLEMENTAL MATERIAL
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Results: IQVIA ambulatory electronic medical record–U.S. patients had a median age of 55 years, and 56.7% were women. Overall age-standardized hypertension prevalence was higher in IQVIA ambulatory electronic medical record–U.S. (35.0%) than in the Behavioral Risk Factor Surveillance System (29.7%), however, state-level geographic patterns were similar, with the highest burden in the South and Appalachia. Similar patterns were also observed by sociodemographic characteristics in both data sets: hypertension prevalence was higher in older age groups (than younger), men (than women), and Black patients (than other races). Hypertension control varied widely across states: among states with >1% data coverage, control rates were lowest in Nevada (51.1%), Washington DC (52.0%), and Mississippi (55.2%); highest in Kansas (73.4%), New Jersey (72.3%), and Iowa (71.9%).

Conclusions: This study provided the first-ever estimates of hypertension control for all states and Washington DC. Electronic health record–based surveillance could support hypertension prevention and control efforts at the state level.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death among American adults and took 659,041 lives in 2019.[1] Hypertension or high blood pressure (BP), is a major risk factor for CVD.[2] Using the BP cut off values of ≥140/90 millimeters of mercury (mmHg), 30.7% of U.S. adults had hypertension in 2017–2018 based on the National Health and Nutrition Examination Survey (NHANES).[3] More than half of U.S. adults with hypertension do not have their blood pressure under control.[4] To support public health and clinical efforts to prevent and control hypertension, accurate and timely surveillance at state level is needed.[5,6] Public health practitioners and health professionals need subnational data to identify disparities, design programs, and implement and evaluate interventions.[5]

Although traditional surveillance systems with high-quality data offer valuable insights into the chronic disease landscape, these systems have limitations. One key source of state-level CVD surveillance data—the Behavioral Risk Factor Surveillance System (BRFSS)—only reflects self-reported hypertension awareness and does not have BP measurements, thus cannot be used to estimate hypertension control rates.[7,8] NHANES objectively measures BP and can assess hypertension control but does not provide direct state-level estimates.[9] These data sets also face challenges including multiyear lags in results dissemination and decreasing response rates.[10] Additional data sources can be leveraged to augment surveillance systems, such as electronic health records (EHRs), which are generated from clinical workflows and do not require survey development and data collection.[5,10] Diagnosis codes, BP measures, and medications are available in EHR data, which may help identify hypertension cases more reliably than self-reported hypertension status.[5] Previously, a hypertension electronic phenotype (e-phenotype) was constructed by this research team (hereafter referred to as “the team”) using a large-scale EHR data set. This study aimed to evaluate this hypertension e-phenotype at the state level and report state-level hypertension prevalence and control estimates.

METHODS

Study Population

The IQVIA Ambulatory Electronic Medical Records (AEMR)–U.S. data set (May 2021 release) in the Observational Medical Outcomes Partnership (OMOP) common data model (version 5.3) was used.[11] The AEMR-U.S. data were collected from >100,000 primary care and specialist healthcare providers for >76 million patients with face-to-face outpatient medical visits. AEMR-U.S. is deidentified for personal identifiable information and contains limited protected health information. In the 1-year measurement period (2019), there were 11,031,368 eligible patients: aged 18–79 years, with no end-stage renal disease, no pregnancy-related events, and no long-term, palliative, or hospice care. To identify patients among whom hypertension status could be reasonably assessed, patients with at least 1 complete BP measurement in the past 24 months were included (Appendix Table 1, available online). Data coverage was defined as state-level patient count in AEMR-U.S. divided by state population based on 2010 U.S. census. States with coverage <1% included Alaska, Hawaii, Idaho, Montana, Oklahoma, Rhode Island, Vermont, Washington, and Wisconsin (Appendix Figure 1, available online).

AEMR-U.S. estimates were compared with those in BRFSS, which is a state-based, random, digit-dial landline and cellphone survey.[12] BRFSS follows a rigorous survey design, and collects data such as health-risk behaviors, chronic disease outcomes, and healthcare access from about 500,000 adults each year.[13] A total of 418,268 participants completed the BRFSS survey in 2019, among whom 409,810 resided in 49 states and the District of Columbia (DC). Data were unavailable for New Jersey in 2019. Sequential exclusions were done: 35,475 participants aged <18 or >79 years; 2,067 participants who were pregnant; and 1,289 participants with incomplete information for hypertension awareness were excluded. The analytical sample size from BRFSS was 370,979. To account for the survey design, all BRFSS-related analyses were weighted to produce representative estimates at the state level.

Measures

The measures included are hypertension (suspected hypertension in AEMR-U.S. and self-reported hypertension in BRFSS), hypertension control (in AEMR-U.S. only), and covariates including sociodemographic variables, BMI, current smoking status, and diabetes status. In AEMR-U.S., suspected hypertension was identified using an established e-phenotype based on: ≥1 hypertension diagnosis code, ≥2 high BP measurements (BP ≥140/90 mmHg), or ≥1 prescription for antihypertensive medication. Details about this e-phenotype can be found in Appendix Table 1 (available online).[14] The BP threshold (≥130/80 mmHg) in the 2017 American College of Cardiology (ACC) and American Heart Association (AHA) hypertension guideline was not used, because of potential lag in adopting the new thresholds in clinical practice.[15] In BRFSS, self-reported hypertension was defined as answering *yes* to *Have you ever been told by a health professional that you have high blood pressure?* Those who answered *no* or who were told that they had borderline high BP or had high BP only during pregnancy were considered not to have hypertension.

In AEMR-U.S., among patients identified as having suspected hypertension and who had at least 1 BP measurement, hypertension control was defined as the most recent systolic BP <140 and diastolic BP <90 mmHg in 2019, which aligned with the electronic clinical quality measure for controlling high BP.[16] Data on BP measurements and hypertension control were not available in BRFSS.

Sociodemographic variables including age, sex, and race were included from both data sets. In AEMR-U.S., race and ethnicity were collapsed into 1 variable, which may cause loss of true racial ethnic identity data at the patient level. Therefore, Hispanic (0.4%), other including multiracial (4.6%), and unknown race and ethnicity (18.1%) were combined into a new other category. A few risk factors for hypertension were also included from AEMR-U.S.: (1) BMI: height and weight data were cleaned via the R package *growthcleanr*, and then used to calculate BMI (weight in kg divided by height in m^2)[17]; (2) Current smoking status: people who currently smoke were identified based on codes in the domains of conditions, procedures, observations, and observation results; and (3) Diabetes status: patients with diabetes were determined based on a combination of diagnosis codes, medications, and HbA1c, as adapted from the SUPREME-DM algorithm.[18] All variables in BRFSS were based on self-reported data and were consistent with the definitions used in the Centers for Disease Control and Prevention division for Heart Disease and Stroke Prevention's Data Trends & Maps online tool.[19]

Statistical Analysis

The team conducted descriptive analyses for the covariates and reported them for AEMR-U.S. and BRFSS, respectively. Crude or age-standardized hypertension prevalence estimates were compared between the two data sets, overall and by state, visually (via maps, highlight tables, bar charts, and scatterplots). Age standardization was based on the age distribution in the 2010 U.S. census and was grouped into 18–44 years, 45–64 years, and 65–79 years.

The team used maps to observe and compare geographic patterns in age-standardized hypertension prevalence. State-level results were grouped into quartiles separately for AEMR-U.S. and BRFSS to allow for comparison between data sets. For example, a state with the darkest shade of blue in both maps represented the highest quartile for hypertension prevalence in both AEMR-U.S. and BRFSS. A similar map was constructed for age-standardized state-level prevalence of hypertension control (AEMR-U.S. only).

For further comparison, the team generated a bivariate map to illustrate the level of agreement between the quartile classification of hypertension prevalence in the two data sets. States that showed agreement between quartiles (e.g., a state that was in the first quartile using the AEMR-U.S. cut offs and in the first quartile using the BRFSS cut offs) were concordant states, and the rest were discordant states.

Additionally, the tables with crude hypertension prevalence were converted into highlight tables to depict the variation in hypertension estimates by sociodemographic characteristics. Highlight tables used color scales to aid pattern recognition: red indicated higher prevalence; white, median prevalence; and blue, lower prevalence. Similarly, crude hypertension control estimates were depicted in a highlight table, using a similar color scheme: red indicated worse (lower) hypertension control; white, median control; and blue, better (higher) hypertension control.

The team used SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA) for AEMR-U.S. data, SAS SUDAAN software package (version 9.4, SAS Institute Inc., Cary, NC, USA) for BRFSS data, R (version 4.1.2, R Core Team, Vienna, Austria), and ArcGIS Pro (version 2.9.0, 2021, Esri Inc., Redlands, CA, USA) for data visualization. Statistical analyses were conducted from 2022–2023. This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy (45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. Sect. 241[d]; 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. Sect. 3,501 et seq.).

RESULTS

Patients in AEMR-U.S. were older than the weighted BRFSS population (median 55.0 years vs 45.7 years) (Table 1). In AEMR-U.S., 56.7% were women, whereas in BRFSS, half (50.4%) were women. AEMR-U.S. had lower percentages of Black (8.0%) and Asian (2.2%) adults than BRFSS (11.9% and 5.4%, respectively). At the state level, AEMR-U.S. had slightly higher percentages of female patients across states, more patients in the 65–79-year age category, and fewer patients in the 18–64-year category than BRFSS, as well as comparable race distributions, with some state-level variations (Appendix Figure 2, available online).

Overall, age-standardized hypertension prevalence was 35.0% in AEMR-U.S. and 29.7% in BRFSS (Figure 1). Patterns of hypertension prevalence by age group, sex, and race were consistent between AEMR-U.S. and BRFSS: hypertension prevalence increased with age, was higher in men than in women, and was the highest among Black individuals and lowest among Asian individuals in both data sets (Figure 1). Approximately 87.8% of those identified as having hypertension in AEMR-U.S. were prescribed ≥1 antihypertensive medications, whereas 74.7% of the BRFSS participants who were hypertension-aware reported the use of antihypertension medications (Table 1).

At the state-level, geographic patterns in hypertension prevalence were comparable between AEMR-U.S. and BRFSS (Figure 2). Only 4 states (Wyoming, Alabama, South Carolina, and Missouri) had >10% difference in hypertension prevalence estimates between the two data sets (Appendix Table 2, available online). Based on the highlight tables, there were wider fluctuations in hypertension prevalence across states in AEMR-U.S. than in BRFSS (Appendix Table 3, available online). In both data sets, the highest hypertension burden was in the South and the Appalachian region (Figure 2). The bivariate map illustrates that 70% of states had concordance in hypertension prevalence based on quartile classifications: 8 states were in the first quartile (lowest prevalence) in both data sets, 7 states and Washington DC in the second, 9 in the third, and 10 in the fourth quartile (Appendix Figure 3, available online). Comparability between the data sets was also observed by sex (Appendix Figure 4, available online).

In AEMR-U.S., the 3 states with data coverage ≥1% and the lowest hypertension control rates were Nevada (51.1%), Washington DC (52.0%), and Mississippi (55.2%) (Figure 3). The remaining states in the lowest quartile of hypertension control were mostly in the South (Figure 3). The states with data coverage ≥1% and the highest proportions of hypertension control were Kansas (73.4%), New Jersey (72.3%), and Iowa (71.9%) (Figure 3). Women had slightly better hypertension control than men. Unlike hypertension prevalence that increases with age, hypertension control prevalence did not vary markedly across age strata in the highlight tables (Appendix Table 4, available online).

DISCUSSION

Using an EHR data set of 11 million U.S. adults in 2019, the team generated the first state-level hypertension control estimates in all states and Washington DC, based on measured and documented data rather than self-reported data. Observed state-level hypertension control ranged from 51.1% to 73.4% among states with data coverage of ≥1%. Hypertension prevalence was also calculated using AEMR-U.S. and was compared with BRFSS estimates. AEMR-U.S. hypertension estimates were consistently higher than BRFSS, which was expected given that AEMR-U.S. captures undiagnosed hypertension and reflects an older, care-seeking population. Geographic patterns were also comparable, with the South and the Appalachian region bearing the heaviest hypertension burden.

In 2020, the U.S. Surgeon General issued a call of action to improve hypertension control.[20] This study was the first to use EHR data to estimate hypertension control at the state level. Based on BP <140/90 mmHg, the age-adjusted prevalence of hypertension control was higher in AEMR-U.S. 2019 (64.1%) than in NHANES 2017–2020 (48.2%).[21] One possible explanation was that some NHANES participants may have had hypertension but were not in care or were unaware of their hypertension status.[21] In addition, Banerjee et al. found that patients with a recorded hypertension diagnosis were much more likely to be on an antihypertensive medication than those without a diagnosis but had abnormal BP measurements.[22] This could also be the case in AEMR-U.S. Achieving better hypertension control still faces an uphill battle and requires concerted actions among stakeholders.[20]

Subnational estimates are essential for designing and implementing public health programs.[5] The observed hypertension geographic patterns were consistent with those reported by Ezzati et al., who used the relationship between systolic BP in NHANES and self-reported hypertension status in BRFSS to model state-level burden of uncontrolled hypertension. They emphasized the need for interventions to control hypertension in the South and the Appalachian region.[8] In this study, the overall patterns of hypertension prevalence were comparable between AEMR-U.S. and BRFSS across all states. However, there was noticeable discordance between the two data sets in a few states, particularly in Wyoming. In a few states, patients were considerably older in AEMR-U.S. than in BRFSS; poor representation of the state population in the AEMR-U.S. for these states may also have played a role. Despite the differences, AEMR-U.S. and BRFSS demonstrated agreement on the states with the highest hypertension burden in the bivariate map, which highlighted the potential of using EHR data to complement traditional surveillance.

In addition to consistency at the state level, EHR-derived hypertension estimates have been comparable with BRFSS estimates at the county level in a study of 13 Massachusetts counties by Klompas et al.[5] In their study, hypertension estimates were higher in BRFSS than in EHR, which was the opposite from the current findings for Massachusetts. This may be because of the differences between our case definitions. Klompas et al. defined hypertension in EHR as either ≥2 high BP measurements within 1 year or the combination of ICD diagnosis codes and prescription of antihypertensive medication (single agents). In this study, the team could identify patients based on diagnosis codes alone in AEMR-U.S. Additional diagnosis codes were also included, consistent with CDC surveillance definitions.[23] In addition, the medication list included both single agents and fixed-dose combinations, following the 2017 ACC/AHA guideline.[15]

Differences in data collection methods between AEMR-U.S. and BRFSS may help explain differences in hypertension prevalence estimates between the two data sets. AEMR-U.S. data were generated through clinical activities for ambulatory care, whereas BRFSS was designed for surveillance purposes. AEMR-U.S. comprises an older, care-seeking patient population, not randomly selected individuals. In contrast, BRFSS participants were enrolled based on random-digit-dial landline and cellphone surveys, thus were representative of the population in each state. The hypertension estimates in AEMR-U.S. were higher than those in BRFSS, which is expected given the different case definitions: BRFSS relied on self-reported hypertension awareness, was subject to recall bias, and was unable to capture undiagnosed hypertension; whereas the AEMR-U.S. e-phenotype included diagnosis codes, BP measurements, and antihypertensive medications and thus captured undiagnosed as well as diagnosed hypertension. In addition, it is difficult to know how hypertension awareness changed after the introduction of the 2017 ACC/AHA guideline BP cut offs. As the 2017 guideline filtered into practice, some BRFSS participants may have been told they had hypertension with BP values between 130/80 and 140/90 mmHg, and they may or may not be eligible for medication at the lower threshold. Further surveillance could examine changes in trends in hypertension diagnosis and management (in AEMR-U.S.) and in awareness (BRFSS) that might reflect the impacts of guideline implementation over time.

The case definition for hypertension differed between AEMR-U.S. and BRFSS. In AEMR, the team used a comprehensive e-phenotype that requires multiple data elements. Use of comprehensive EHR-based hypertension phenotypes as such is supported by other studies.[5,24–26] For example, Teixeira and colleagues evaluated several e-phenotypes using structured and unstructured fields of EHR data and concluded that combining multiple information sources led to the best case identification.[25] They also stated that to develop hypertension algorithms without narrative texts, the combination of normalized ICD codes, BP, and medications would yield optimal performance.[25] Also of note is that the AEMR-U.S. e-phenotype was developed under the Observational Medical Outcomes Partnership (OMOP) common data model, thus allowing for easy application to other data sets in the same data model.[11] Future efforts are needed to further validate this hypertension e-phenotype, adapt it to additional data sources, and investigate appropriate methods to reduce inferential biases.

Limitations

This study had limitations. First, although the AEMR-U.S. 2019 had high coverage, it was not representative of the U.S. population.[27] AEMR-U.S. coverage also varied across states, so the degree of representation of the underlying state population may have varied across states. In addition, EHR contributor bias and under-representation outside of the catchment areas of the healthcare system were possible. Second, there may be selection bias owing to sociodemographic differences in healthcare availability and accessibility. For instance, lower percentages of Black than White working-age adults had health insurance coverage, according to U.S. Census Bureau. Among those with coverage, White adults were more likely than Black adults to have private insurance.[28] Third, because of limitations in how race and ethnicity data were collected in AEMR-U.S., the team was unable to report estimates for Hispanic individuals. Based on a systematic review about social determinants of health data, even when data from Hispanic patients were available in EHR, they were more prone to data quality issues than other races and ethnicities.[29] More efforts are needed to develop reliable measures in states with sufficient Hispanic populations. Lastly, factors specific to this data set (such as proportion of primary versus specialist providers) and analytic choices (such as use of most recent rather than year-average BP to assess hypertension control) could affect results observed. Despite extensive efforts to evaluate this EHR-based e-phenotype, gold standard validation methods were not possible (e.g., chart review) because of the proprietary nature of IQVIA data.[30,31] Additional validation efforts in other data sets could enhance understanding of the e-phenotype.

CONCLUSIONS

Improving population-level hypertension control is a national priority.[20] In this study, the team leveraged a large EHR data set to provide, to the best of our knowledge, the first-ever state-level hypertension control estimates in the U.S. and demonstrated similar patterns in hypertension prevalence by sociodemographic and geographic characteristics between BRFSS and AEMR-U.S. In this era of transition for public health surveillance systems, this work highlights the value of using real-world data to augment disease surveillance.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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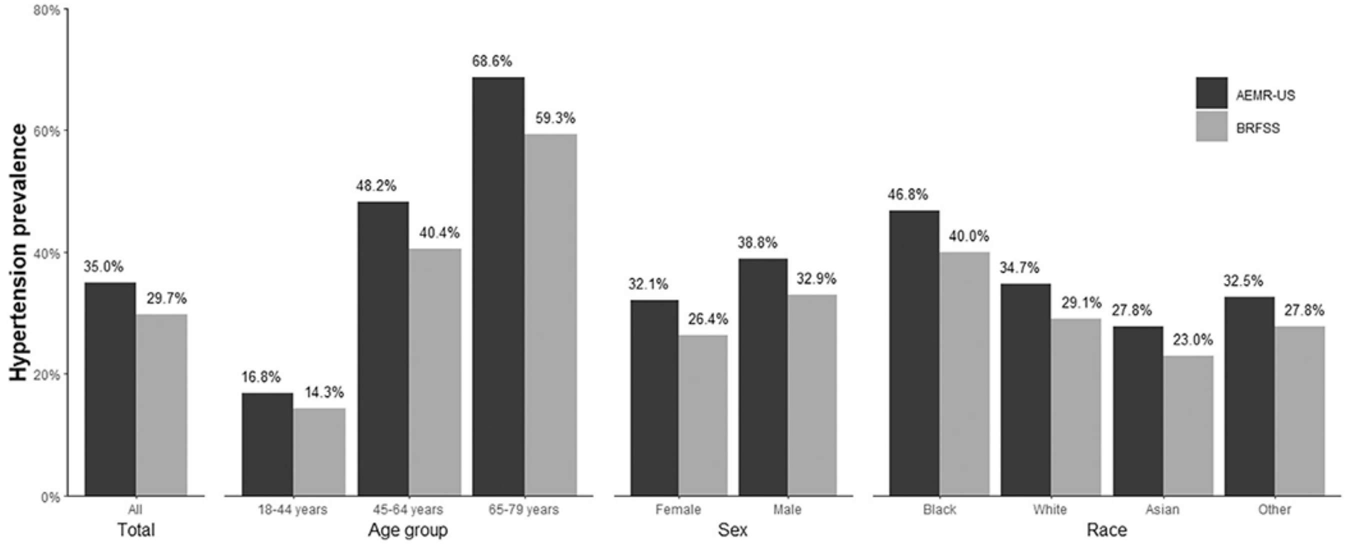

Figure 1.

Hypertension prevalence by sociodemographic characteristics in AEMR-U.S. 2019 and BRFSS 2019.

Note: Crude prevalence was shown for each age group; age-standardized prevalence was shown for the total populations, by sex and by race. Age standardization was based on 2010 U.S. census age groups of 18–44 years, 45–64 years, and 65–79 years.

AEMR-U.S., IQVIA Ambulatory Electronic Medical Record-U.S.; BRFSS, The Behavioral Risk Factor Surveillance System.

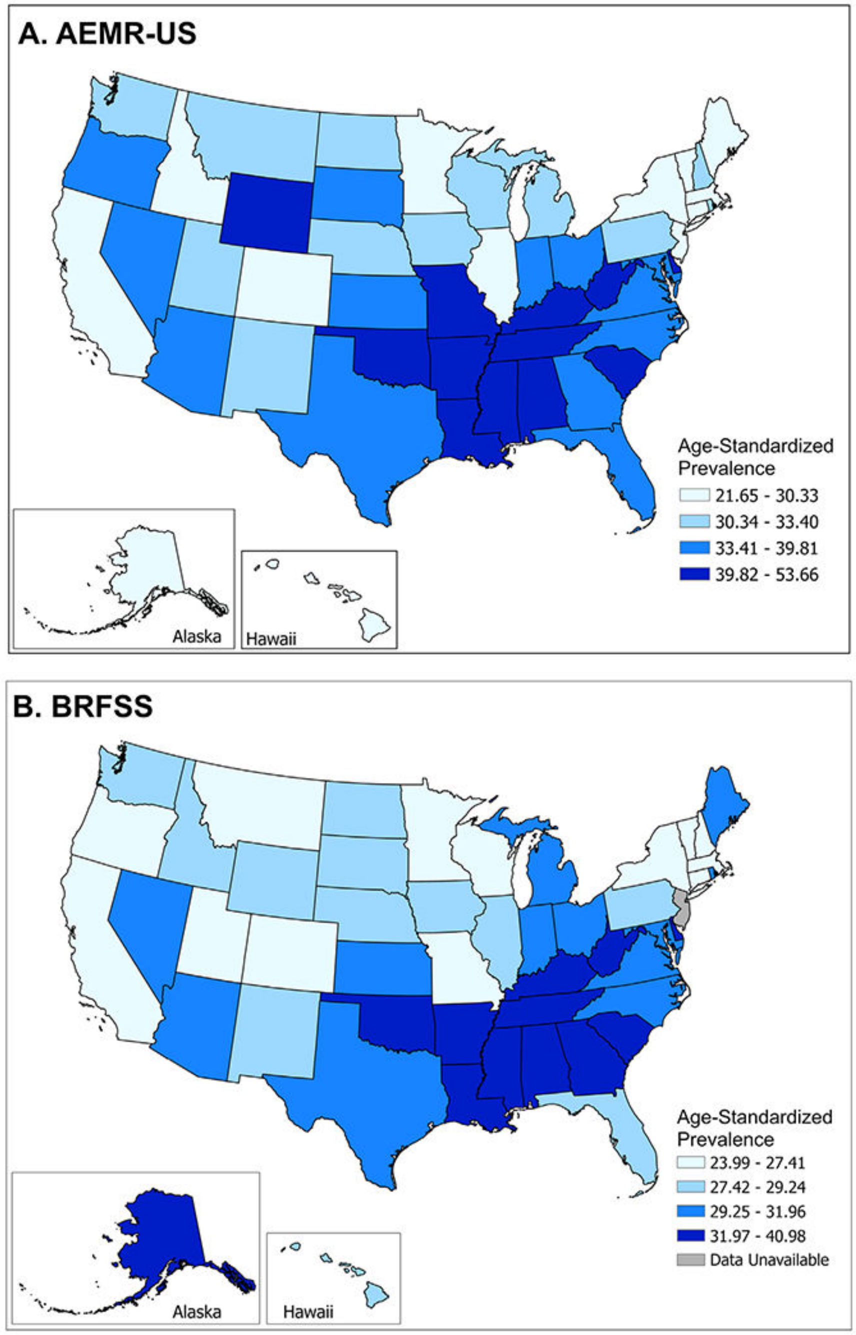

Figure 2.

Age-standardized hypertension prevalence at the state level in AEMR-U.S. 2019 and BRFSS 2019.

Note: The cut points were based on the quartiles of prevalence in the two data sets. Age standardization was based on 2010 U.S. census age groups of 18–44 years, 45–64 years, and 65–79 years.

AEMR-U.S., IQVIA Ambulatory Electronic Medical Record-U.S.; BRFSS, The Behavioral Risk Factor Surveillance System.

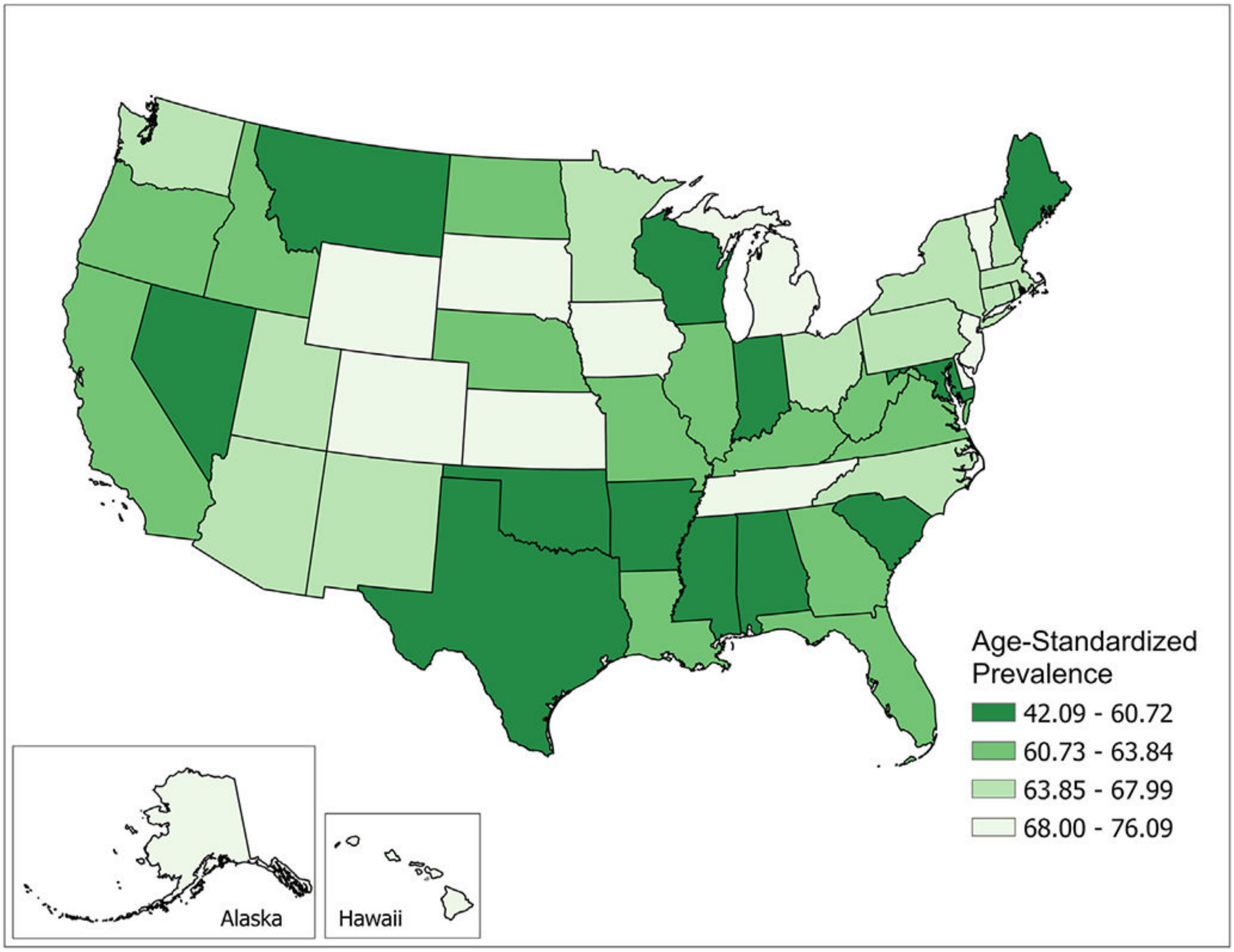

Figure 3.

Age–standardized hypertension control prevalence at the state level in AEMR-U.S. 2019. *Note*: The cut points were based on the quartiles of prevalence. Hypertension control was defined as the most recent blood pressure measurement <140/90 mmHg in 2019, among patients who had at least 1 complete BP measurement in 2019 and were identified as having hypertension by the AEMR-U.S. e-phenotype. The National Health and Nutrition Examination Survey 2017-2020 estimates for hypertension control was 48.2%. States with data coverage <1% (AEMR-U.S. patient count divided by U.S. census population in the same state) included Alaska, Hawaii, Idaho, Montana, Oklahoma, Rhode Island, Vermont, Washington, and Wisconsin.

AEMR-U.S., IQVIA Ambulatory Electronic Medical Record-U.S.

Table 1.

Characteristics of the Study Populations in AEMR-U.S. 2019 and BRFSS 2019, Respectively

Characteristics	AEMR-U.S.	BRFSS (weighted)[a]
Sample size	11,031,368	370,979
Age, year, median (IQR)	55.0 (39.0–66.0)	45.7 (31.2–60.0)
Age groups, years		
18–44	32.0	47.7
45–64	39.5	34.5
65–79	28.5	17.8
Sex, %		
Women	56.7	50.4
Men	43.3	49.6
Race, %[b]		
Asian	2.2	5.4
Black	8.0	11.9
White	66.8	60.5
Other	23.1	22.2
Risk factors		
BMI, kg/m^2, median (IQR)	28.8 (24.9–33.6)	27.3 (23.7–31.4)
Obesity, %[c]	37.2	29.0
Diabetes, %[d]	15.1	11.1
Current smokers, %	10.3	16.0
Crude hypertension prevalence, %[e]	44.0	31.3
Antihypertensive medications, %[f]		
Prescribed ≥1 medications	87.8	—
Self–reported medication use	—	74.7

[a]BRFSS 2019 weighted, applied appropriate survey weights.

[b]IQVIA combines race and ethnicity in one filed, which may cause loss of true racial ethnic identity data at the patient level; cannot ascertain whether Black, White, and Asian categories are Hispanic or Non-Hispanic; and Other category contained patients with Hispanic ethnicity, multiracial identification, other races, and unknown.

[c]Obesity was based on BMI ≥30 kg/m^2 among adults aged ≥20 years.

[d]Diabetes information in AEMR-U.S. was for adults ≥20 years based on a published algorithm (SUPREME-DM).

[e]Crude prevalence. Hypertension in AEMR-U.S. was defined using a 3-criteria e-phenotype (≥1 diagnosis code, ≥2 blood pressure ≥140/90mmHg, or ≥1 prescription of antihypertensive medication); hypertension in BRFSS was self-reported hypertension awareness. Age standardization was based on U.S. 2010 census age groups of 18–44, 45–64, and 65–79 years.

[f]Medications were calculated only among people with suspected (AEMR) or self-aware (BRFSS) hypertension.

AEMR-U.S., IQVIA Ambulatory Electronic Medical Record-U.S.; BRFSS, The Behavioral Risk Factor Surveillance System.