American Journal of Hypertension, 2024, **37**, 493–502
https://doi.org/10.1093/ajh/hpae040
Advance access publication 5 April 2024
Original Article

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Trends in the Prevalence of Multiple Chronic Conditions Among US Adults With Hypertension From 1999–2000 Through 2017–2020

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BACKGROUND: The prevalence of many chronic conditions has increased among US adults. Many adults with hypertension have other chronic conditions.

METHODS: We estimated changes in the age-adjusted prevalence of multiple (≥3) chronic conditions, not including hypertension, using data from the National Health and Nutrition Examination Survey, from 1999–2000 to 2017–2020, among US adults with (n = 24,851) and without (n = 24,337) hypertension. Hypertension included systolic blood pressure (BP) ≥130 mm Hg, diastolic BP ≥80 mm Hg, or antihypertensive medication use. We studied 14 chronic conditions: arthritis, asthma, cancer, coronary heart disease, chronic kidney disease, depression, diabetes, dyslipidemia, hepatitis B, hepatitis C, heart failure, lung disease, obesity, and stroke.

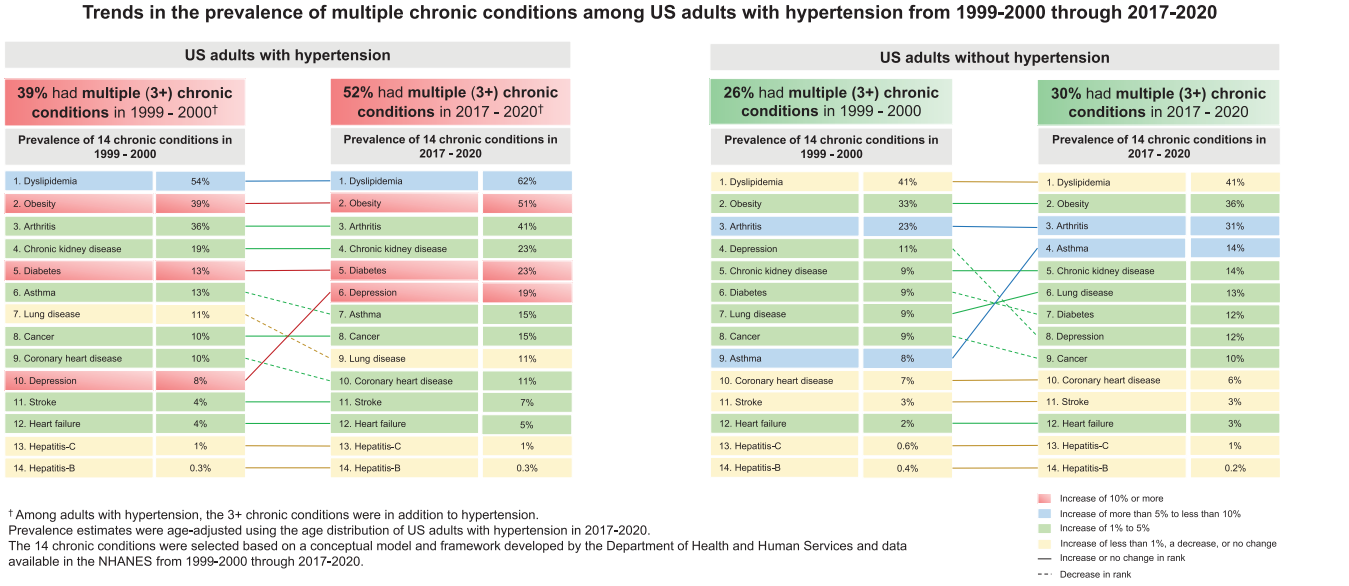
RESULTS: From 1999–2000 to 2017–2020, the age-adjusted mean number of chronic conditions increased more among US adults with vs. without hypertension (2.2 to 2.8 vs. 1.7 to 2.0; *P*-interaction <0.001). Also, the age-adjusted prevalence of multiple chronic conditions increased from 39.0% to 52.0% among US adults with hypertension and from 26.0% to 30.0% among US adults without hypertension (*P*-interaction = 0.022). In 2017–2020, after age, gender, and race/ethnicity adjustment, US adults with hypertension were 1.94 (95% confidence interval: 1.72–2.18) times as likely to have multiple chronic conditions compared to those without hypertension. In 2017–2020, dyslipidemia, obesity, and arthritis were the most common 3 co-occurring chronic conditions among US adults with and without hypertension (age-adjusted prevalence 16.5% and 3.1%, respectively).

CONCLUSIONS: In 2017–2020, more than half of US adults with hypertension had ≥3 additional chronic conditions, a substantial increase from 20 years ago.

Keywords: blood pressure; chronic conditions; epidemiology; hypertension; multimorbidity; NHANES.

Received 3 November 2023; **revised** 14 February 2024; **accepted** 20 March 2024.

Graphical Abstract



Hypertension is a major risk factor for many diseases; worldwide, 7.8 million deaths can be attributed to hypertension annually.[1] In the United States, the annual average direct and indirect cost of hypertension was estimated to be $52.2 billion in 2018–2019, and 119,997 deaths in 2020 were due to hypertension.[1] According to the 2017—March 2020 US National Health and Nutrition Examination Survey (NHANES), 48% of US adults have hypertension, defined by systolic blood pressure (SBP) ≥130 mm Hg, diastolic blood pressure (DBP) ≥80 mm Hg, or self-reported use of antihypertensive medication.[2] Hypertension has been associated with increased risk for other chronic health conditions, including chronic kidney disease, dementia, diabetes, heart failure, and stroke.[1,3,4] Therefore, a high proportion of adults with hypertension may have multiple coexisting chronic conditions. The coexistence of multiple chronic conditions has been associated with lower quality of life, higher healthcare costs, and an increased risk of hospitalization and mortality.[5,6]

The prevalence of several chronic conditions, including diabetes, heart failure, and obesity, has increased among US adults over the past 20 years.[7–9] Additionally, the proportion of US adults with hypertension who have uncontrolled blood pressure (BP), defined as SBP ≥130 mm Hg or DBP ≥80 mm Hg, increased between 2013–2014 and 2017–2018.[10] Uncontrolled BP is associated with an increased incidence of several chronic health conditions.[11,12] Given these associations, it is likely that the percentage of US adults with hypertension who have multiple chronic conditions has increased over the past several decades. Estimating the trends in multiple chronic conditions and identifying the most common chronic conditions present among US adults with hypertension could inform the need for programs to coordinate healthcare, identify approaches for improving quality of life, and reduce the risk for adverse outcomes and healthcare costs in this high-risk population.

The goal of the current analysis was to estimate changes in the prevalence of multiple chronic conditions, defined in the current study as ≥3 chronic conditions, among US adults with hypertension from 1999–2000 through 2017–2020. For comparison, we estimated changes among US adults without hypertension over the same period. We also assessed the most common combinations of 3 and 4 chronic conditions in US adults with and without hypertension in 2017–2020. These analyses were conducted using the US NHANES data.

METHODS

Study population

Since 1999–2000, the National Center for Health Statistics of the US Centers for Disease Control and Prevention (CDC) has conducted NHANES as 2-year cross-sectional surveys that provide nationally representative data on the health and nutritional status of the noninstitutionalized US population.[13] Each 2-year cycle includes a different and independent sample of the noninstitutionalized US population. Due to the COVID-19 pandemic, the NHANES 2019–2020 cycle stopped in March 2020 and these data were combined with the 2017–2018 cycle.[14] For the current analysis, we included 10 NHANES cycles, the nine 2-year cycles conducted from 1999–2000 through 2015–2016, and the 2017 to March 2020 cycle. During this period, a total of 49,188 participants were ≥20 years old, not pregnant, completed the NHANES interview and examination, and had complete data on the chronic conditions included in the current analysis (Supplementary Figure S1 online). Of the 49,188 participants, 24,851 and 24,337 had and did not have hypertension, respectively. The CDC approved the protocol for each NHANES cycle and participants provided written informed consent. The IRB at the University of Alabama at Birmingham considered the analysis of NHANES data to be exempt research. The NHANES data used for this analysis are available on the CDC website.

Data collection

Trained staff collected NHANES data during an in-home interview and a study visit conducted at a mobile examination center. During the in-home interview, participants were asked about their age, gender, race, ethnicity, and having a prior diagnosis of arthritis, asthma, cancer, chronic bronchitis, chronic obstructive pulmonary disease, coronary heart disease, emphysema, heart failure, high cholesterol, myocardial infarction, and stroke. Participants in NHANES 1999–2000 and 2001–2002 completed one 24-hour dietary recall while those in NHANES 2003–2004 through 2017–2020 completed two 24-hour dietary recalls. Nutrient intake from the 2

dietary recalls were averaged. Using the dietary data, we estimated the Dietary Approaches to Stop Hypertension (DASH) diet score.[15] Physical activity was defined as reporting any weekly moderate or vigorous activity. Being a nondrinker was defined as consuming no alcohol and being a nonsmoker was defined as not currently smoking cigarettes. Participants were asked about taking antihypertensive medication, cholesterol-lowering medication, insulin, or oral glucose-lowering medication, and the names of all prescription medications taken in the 30 days prior to the interview were recorded by staff who reviewed the containers.

During the mobile examination center visit, weight, height, and BP were measured, and blood and spot urine samples were collected. Weight and height were used to calculate body mass index. The blood samples were used to determine hepatitis B antibodies and surface antigen, and hepatitis C RNA, and to measure glycated hemoglobin (HbA1c), total and high-density lipoprotein (HDL) cholesterol, and serum creatinine. Non-HDL cholesterol was calculated as total cholesterol minus HDL cholesterol. The estimated glomerular filtration rate was calculated using the creatinine-based 2021 Chronic Kidney Disease Epidemiology Collaboration equation without race.[16] Albumin-to-creatine ratio was calculated using urine albumin and creatinine.[17]

Measurement of BP and definition of hypertension

After 5 minutes of seated rest, 3 BP measurements were obtained at 30-second intervals by trained and certified physicians. In NHANES, BP was measured using a mercury sphygmomanometer from 1999–2000 through 2015–2016, and an oscillometric device in 2017–2020.[18,19] Using the results from the evaluation of the differences in mean SBP and DBP when measured by the 2 devices, we calibrated the oscillometric BP measurements to the mercury measurements by adding 1.5 mm Hg to oscillometric-measured SBP and subtracting 1.3 mm Hg from oscillometric-measured DBP.[20] We used the mean of the 3 SBP and DBP measurements. Hypertension was defined according to the 2017 American College of Cardiology (ACC)/American Heart Association (AHA) BP guideline as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg, or self-reported use of antihypertensive medication.[21] Between 2003 and 2017, hypertension in the United States was defined using the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7).[22] In a sensitivity analysis, we defined hypertension as mean SBP ≥140 mm Hg, mean DBP ≥90 mm Hg, or self-reported use of antihypertensive medication based on the JNC7 guideline.

Outcome definition

We selected chronic conditions based on a conceptual model and framework developed by the Department of Health and Human Services and data available in the NHANES cycles used in the current analysis.[23] We evaluated 14 chronic conditions defined in Supplementary Table S1 online: arthritis, asthma, cancer excluding nonmelanoma skin cancer, coronary heart disease, chronic kidney disease, depression, diabetes, dyslipidemia, hepatitis B, hepatitis C, heart failure, lung disease (chronic obstructive pulmonary disease, emphysema, and chronic bronchitis), obesity, and stroke. Although a cut-point of ≥2 has been used to define multiple chronic conditions, there is currently no consensus on its operational definition.[24] In the current study, the primary outcome was ≥3 chronic conditions due to a stronger association with increased healthcare resources, greater difficulties with activities of daily living, and increased risk for cognitive impairment with 3 or more compared to 2 or fewer chronic conditions.[25] In a secondary analysis, we grouped chronic conditions into different body systems and defined complex multimorbidity as ≥3 chronic conditions affecting ≥3 different body systems.[26] Specifically, we mapped each of the 14 chronic conditions to their corresponding chapters from the World Health Organization's International Classification of Diseases, Tenth Revision (ICD-10), considering that each ICD-10 chapter corresponds to a different body system.[27] We included the 8 body systems defined in Supplementary Table S1 online.

Statistical analysis

The analyses described below were performed separately for US adults with and without hypertension. Summary statistics for participant characteristics were estimated for each NHANES cycle. The number of antihypertensive medication classes being taken was estimated for those with hypertension. The age-adjusted prevalence of each chronic condition was estimated for each NHANES cycle, and the 10 most common combinations of 3 and 4 chronic conditions were estimated using NHANES 2017–2020. The age-adjusted mean number of chronic conditions and prevalence of multiple chronic conditions were estimated for each NHANES cycle. Among those with hypertension, the age-adjusted mean number and prevalence of multiple chronic conditions were estimated for those taking and not taking antihypertensive medication, separately. In a sensitivity analysis, the age-adjusted mean number and prevalence of multiple chronic conditions were estimated for US adults with and without hypertension as defined by the JNC7 guideline.

For each NHANES cycle, we estimated the prevalence of multiple chronic conditions among US adults with and without hypertension, separately, within age groups (20–39, 40–59, 60–74, and ≥75 years) and the age-adjusted prevalence of multiple chronic conditions within gender and race/ethnicity subgroups. Linear time trends across NHANES cycles were assessed using linear regression and logistic regression as appropriate. An exploratory analysis to assess the statistical significance of differences in linear time trends for US adults with vs. without hypertension was conducted using an interaction term between NHANES cycle and hypertension status.

Using the most recent cycle, NHANES 2017–2020, we pooled participants with and without hypertension and estimated the prevalence ratio for having multiple chronic conditions associated with having vs. not having hypertension overall and within age, gender, and race/ethnicity subgroups. Prevalence ratios were estimated in Poisson regression models that included age, gender, and race/ethnicity as covariates. The age-adjusted mean number of body system diseases and prevalence of complex multimorbidity were estimated in each NHANES cycle for US adults with and without hypertension, separately.

Age adjustment was conducted using direct standardization, with the standard being the population of US adults with hypertension in 2017–2020: 12.4%, 34.3%, 36.9%, and 16.4% for those 20–39, 40–59, 60–74, and ≥75 years of age, respectively. Analyses were conducted using the survey commands in SAS V14 (SAS Institute, Cary, NC) and accounted for the complex sampling design of NHANES. Weights applied in all analyses to produce estimates for the noninstitutionalized US adults. These weights were recalibrated based on the proportion of participants missing data by age, sex, and race–ethnicity, assuming that data within these strata were missing at random.

RESULTS

During 1999–2000 to 2017–2020, the mean age was between 53 and 57 years old among US adults with hypertension, and 38 and 42 years old among those without hypertension (Table 1).

Table 1. Characteristics of US adults ≥20 years with and without hypertension, NHANES 1999–2000 through 2017–2020

	NHANES cycle									
	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014	2015–2016	2017–2020
With hypertension										
Total number in millions (95% CI)	86.5 (73.5, 99.6)	89.4 (81.4, 97.3)	92.2 (76.0, 108.3)	93.3 (81.3, 105.3)	94.5 (82.2, 106.8)	95.9 (81.3, 110.5)	102.0 (83.5, 120.4)	101.2 (90.7, 111.7)	108.3 (95.9, 120.7)	110.7 (102.5, 118.9)
Mean (95% CI) age, y	53.5 (52.2, 54.8)	53.2 (52.2, 54.3)	54.9 (53.8, 56.0)	55.2 (53.0, 57.4)	55.6 (55.0, 56.3)	55.9 (54.9, 56.9)	55.7 (54.3, 57.2)	56.6 (56.0, 57.2)	56.0 (54.6, 57.4)	57.0 (55.9, 58.2)
Age, y, %										
20–39	22.5	21.8	16.9	16.0	16.1	16.8	16.3	14.8	16.7	15.8
40–59	39.5	42.3	44.7	45.1	42.5	40.5	41.3	39.5	39.6	36.8
0–74	26.0	22.8	24.9	25.5	26.3	28.4	28.5	32.2	29.2	32.8
≥75	12.0	13.1	13.5	13.4	15.1	14.3	13.9	13.5	14.5	14.6
Men, %	53.1	52.4	51.9	51.9	51.0	51.4	51.8	50.4	51.1	51.3
Race/ethnicity, %										
Non-Hispanic White	71.8	72.8	74.2	75.1	72.6	69.9	69.2	68.1	65.0	64.2
Non-Hispanic Black	12.3	13.0	12.4	13.2	12.8	13.8	13.8	13.8	13.4	13.7
Non-Hispanic Asian							4.1	4.2	5.3	5.4
Hispanic	11.2	8.9	8.3	7.5	9.9	10.0	10.5	11.3	12.6	12.5
Other Race	4.6	5.3	5.1	4.2	4.7	6.3	2.4	2.5	3.7	4.2
Non-smoker, %	80.0	78.5	80.1	78.9	81.0	84.2	83.0	81.6	82.6	83.7
Non-drinker, %	35.1	35.3	36.3	30.7	33.8	29.2	24.8	26.8	28.7	27.7
Any moderate or vigorous physical activity, %	53.9	61.0	59.2	62.7	66.4	64.3	66.4	64.3	69.7	71.1
Mean (95% CI) DASH diet score	2.2 (2.1, 2.3)	2.2 (2.1, 2.3)	1.9 (1.8, 2.1)	2.2 (2.1, 2.3)	2.1 (2.0, 2.2)	2.3 (2.2, 2.3)	2.2 (2.1, 2.4)	2.1 (2.1, 2.2)	2.0 (2.0, 2.1)	1.9 (1.8, 2.0)
Number of prescription medications not including antihypertensive medication, %										
0	44.8	41.5	33.1	34.9	33.3	34.2	32.2	29.0	32.4	32.2
1	25.4	23.5	24.3	24.5	24.5	24.1	25.9	25.1	25.4	23.5
2	15.1	15.2	20.4	18.5	18.4	19.3	20.6	17.0	16.9	17.9
≥3	14.7	19.8	22.2	22.2	23.9	22.5	21.3	28.8	25.3	26.4
Number of classes of antihypertensive medication, %										
0	60.8	60.7	52.2	50.9	47.0	45.6	45.6	41.4	44.9	43.6
1	23.1	22.0	24.7	25.4	28.1	28.2	29.0	30.8	30.4	30.8
2	12.0	12.4	14.7	14.4	16.7	16.3	17.0	17.4	16.9	15.5
≥3	4.2	5.0	8.4	9.4	8.3	9.9	8.5	10.4	7.8	10.1
Without hypertension										
Total number in millions (95% CI)	100.7 (91.3, 110.1)	106.0 (94.6, 117.4)	109.8 (94.3, 125.4)	112.5 (97.0, 128.0)	118.5 (103.5, 133.4)	120.6 (106.5, 134.8)	119.5 (104.1, 134.9)	125.1 (109.8, 140.5)	123.3 (106.0, 140.6)	127.4 (112.0, 142.8)
Mean (95% CI) age, y	38.5 (37.9, 39.1)	39.2 (38.2, 40.2)	39.7 (38.6, 40.7)	40.2 (39.0, 41.3)	40.2 (39.2, 41.1)	40.2 (39.2, 41.2)	40.6 (39.3, 41.9)	40.6 (39.7, 41.6)	41.3 (39.9, 42.8)	41.3 (40.3, 42.2)
Age, y, %										
20–39	60.1	54.8	55.6	53.9	53.6	51.8	52.0	52.2	52.0	52.6
40–59	31.1	37.0	34.3	35.4	36.5	37.2	35.7	35.6	33.3	32.4
60–74	6.8	6.3	7.1	7.5	7.6	8.7	10.0	9.4	12.2	12.0
≥75	2.0	1.9	3.0	3.2	2.3	2.2	2.3	2.7	2.6	3.0
Men, %	45.4	45.8	46.1	46.8	46.7	46.7	45.7	47.2	46.6	46.2

Table 1. Continued

	NHANES cycle									
	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014	2015–2016	2017–2020
Race/ethnicity, %										
Non-Hispanic White	69.6	71.0	70.6	69.6	67.5	66.8	64.3	64.3	63.2	61.4
Non-Hispanic Black	9.4	9.0	10.0	10.0	10.0	9.4	9.4	9.2	9.5	9.4
Non-Hispanic Asian							6.1	6.2	6.2	6.5
Hispanic	17.0	16.6	13.8	14.1	15.6	16.3	17.5	17.5	17.5	18.8
Other Race	4.1	3.4	5.5	6.3	7.0	7.5	2.7	2.8	3.7	3.9
Non-smoker, %	71.4	72.6	70.1	73.0	74.4	75.8	78.5	79.4	80.8	83.2
Non-drinker, %	26.5	26.3	26.5	26.6	24.3	20.7	19.8	23.1	24.4	18.4
Any moderate or vigorous physical activity, %	64.6	70.8	70.6	71.2	77.0	75.1	76.1	76.7	80.4	81.0
Mean (95% CI) DASH diet score	2.2 (2.1, 2.4)	2.2 (2.1, 2.3)	2.0 (1.9, 2.1)	2.1 (2.0, 2.2)	2.2 (2.1, 2.3)	2.4 (2.3, 2.5)	2.3 (2.2, 2.4)	2.2 (2.1, 2.3)	2.2 (2.1, 2.3)	1.9 (1.8, 2.0)
Number of prescription medications not including antihypertensive medication, %										
0	58.1	55.9	56.9	58.5	56.5	56.6	56.5	56.5	58.8	56.1
1	24.4	25.0	22.8	21.2	23.2	23.5	24.7	22.9	21.9	23.1
2	10.3	12.1	9.9	12.0	11.2	11.7	10.2	10.9	9.9	11.3
≥3	7.2	7.0	10.4	8.4	9.2	8.1	8.6	9.8	9.4	9.5

The table shows total number in millions when weighted to the US population (95% confidence interval) or percentages. Hypertension was defined as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg or self-reported use of antihypertensive medication. Non-Hispanic Asian were included within "Other Race" in the public-use NHANES dataset prior to the 2011–2012 cycle.

Abbreviations: CI, confidence interval; DASH, Dietary Approaches to Stop Hypertension; DBP, diastolic blood pressure; NHANES, National Health and Nutrition Examination Survey; SBP, systolic blood pressure.

A higher percentage of US adults with vs. without hypertension were nonsmokers and nondrinkers and a higher percentage of US adults without vs. with hypertension participated in moderate or vigorous physical activity. For both US adults with and without hypertension, the mean DASH diet scores were 2.2 in 1999–2000 and 1.9 in 2017–2020. Dyslipidemia, obesity, and arthritis were the 3 most common individual chronic conditions among US adults with and without hypertension in each cycle (Supplementary Table S2 online). In NHANES 2017–2020, an estimated 16.5% and 3.1% of US adults with and without hypertension, respectively, had a combination of arthritis, dyslipidemia, and obesity (Table 2). In this same period, 6.3% and 1.1% of US adults with and without hypertension, respectively, had a combination of arthritis, diabetes, dyslipidemia, and obesity.

Trends in multiple chronic conditions among US adults with and without hypertension

From 1999–2000 to 2017–2020, US adults with hypertension experienced a larger increase in the age-adjusted mean number of chronic conditions, from 2.2 to 2.8, compared to US adults without hypertension, which increased from 1.7 to 2.0 (*P*-interaction <0.001; Figure 1, left panel and Supplementary Table S3 online, top panel). The age-adjusted prevalence of multiple chronic conditions increased from 39% to 52% between 1999–2000 and 2017–2020 among US adults with hypertension, and from 26% to 30% among US adults without hypertension (*P*-interaction = 0.022; Figure 1, right panel and Supplementary Table S3 online, bottom panel). Between 1999–2000 and 2017–2020, the age-adjusted mean number of chronic conditions increased more among US adults with hypertension taking antihypertensive medication, from 2.8 to 3.3, than among US adults with hypertension not taking antihypertensive medications, which increased from 1.8 to 2.1 (*P*-interaction = 0.046; Figure 2, left panel and Supplementary Table S4 online, top panel). In this same period, the age-adjusted prevalence of multiple chronic conditions increased from 53% to 64% among US adults with hypertension taking antihypertensive medications and from 28% to 34% among US adults with hypertension not taking antihypertensive medication (*P*-interaction = 0.038; Figure 2, right panel and Supplementary Table S4 online, bottom panel).

Sensitivity analysis defining hypertension based on the JNC7 guideline

When hypertension was defined according to the JNC7 guideline (i.e., SBP ≥140 mm Hg, DBP ≥90 mm Hg, or self-reported use of antihypertensive medication), the age-adjusted mean number of chronic conditions increased from 2.5 to 3.0 among US adults with hypertension and from 1.7 to 2.0 among US adults without hypertension, respectively (Supplementary Table S5 online, top panel). The prevalence of multiple chronic conditions increased from 44% to 57% among US adults with hypertension and from 28% to 31% among US adults without hypertension (Supplementary Table S5 online, bottom panel).

Trends in multiple chronic conditions across age, gender, and race/ethnicity subgroups

From 1999–2000 to 2017–2020, the prevalence of multiple chronic conditions increased within all age categories (Supplementary Figure S2 online) and for men and women (Supplementary Figure S3 online) with hypertension. Among US adults with hypertension, the prevalence of multiple chronic conditions increased from 1999–2000 to 2017–2020 among non-Hispanic White, non-Hispanic Black, and Hispanic US adults (Supplementary Figure S4 online). For US adults without hypertension, the prevalence of multiple chronic conditions increased from 1999–2000 to 2017–2020 for those who reported being Hispanic race/ethnicity.

Table 2. The 10 most common combinations of 3 and 4 chronic conditions in 2017–2020 among US adults with and without hypertension, separately

Combinations of 3 chronic conditions	Percentage	Combinations of 4 chronic conditions	Percentage
With hypertension		**With hypertension**	
Arthritis, dyslipidemia, obesity	16.5	Arthritis, diabetes, dyslipidemia, obesity	6.3
Diabetes, dyslipidemia, obesity	12.8	Arthritis, depression, dyslipidemia, obesity	5.5
Chronic kidney disease, dyslipidemia, obesity	9.2	Chronic kidney disease, diabetes, dyslipidemia, obesity	5.4
Arthritis, chronic kidney disease, dyslipidemia	9.1	Arthritis, chronic kidney disease, dyslipidemia, obesity	5.0
Arthritis, diabetes, dyslipidemia	8.8	Arthritis, chronic kidney disease, diabetes, dyslipidemia	4.0
Arthritis, depression, dyslipidemia	8.4	Arthritis, asthma, dyslipidemia, obesity	3.9
Chronic kidney disease, diabetes, dyslipidemia	8.2	Arthritis, dyslipidemia, lung disease, obesity	3.5
Depression, dyslipidemia, obesity	7.8	Arthritis, cancer, dyslipidemia, obesity	3.3
Arthritis, depression, obesity	7.1	Arthritis, coronary heart disease, dyslipidemia, obesity	3.1
Arthritis, diabetes, obesity	6.7	Depression, diabetes, dyslipidemia, obesity	3.1
Without hypertension		**Without hypertension**	
Arthritis, dyslipidemia, obesity	3.1	Arthritis, diabetes, dyslipidemia, obesity	1.1
Diabetes, dyslipidemia, obesity	2.4	Arthritis, cancer, dyslipidemia, obesity	0.8
Arthritis, diabetes, dyslipidemia	2.0	Arthritis, dyslipidemia, lung disease, obesity	0.8
Arthritis, asthma, obesity	1.8	Arthritis, depression, dyslipidemia, obesity	0.8
Arthritis, depression, dyslipidemia	1.7	Arthritis, asthma, dyslipidemia, obesity	0.7
Arthritis, cancer, dyslipidemia	1.7	Chronic kidney disease, diabetes, dyslipidemia, obesity	0.7
Arthritis, dyslipidemia, lung disease	1.6	Arthritis, asthma, depression, dyslipidemia	0.7
Arthritis, depression, obesity	1.6	Arthritis, asthma, lung disease, obesity	0.6
Arthritis, asthma, dyslipidemia	1.6	Arthritis, cancer, dyslipidemia, lung disease	0.6
Arthritis, lung disease, obesity	1.4	Arthritis, coronary heart disease, dyslipidemia, obesity	0.6

Hypertension was defined as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg, or self-reported use of antihypertensive medication.
Abbreviations: DBP, diastolic blood pressure; SBP, systolic blood pressure.

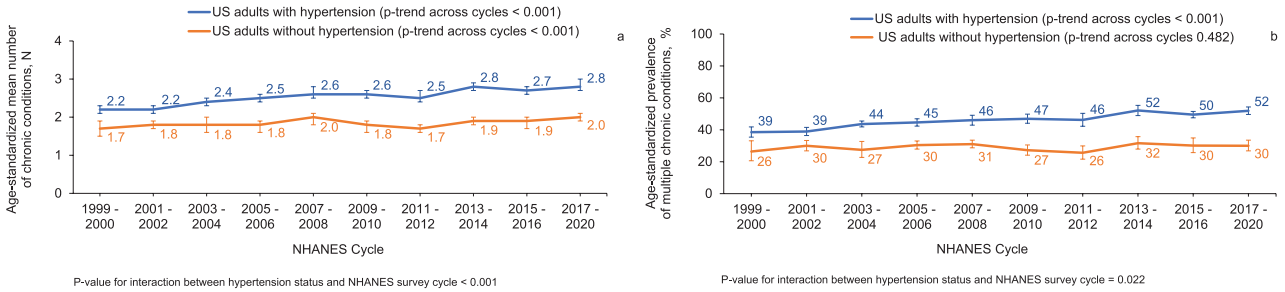


Figure 1. Age-standardized mean number of chronic conditions (**a**) and age-standardized prevalence of multiple chronic conditions (**b**) among US adults ≥20 years old. Hypertension was defined as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg, or self-reported use of antihypertensive medication. Having multiple chronic conditions was defined as ≥3 of any of the following chronic conditions: arthritis, asthma, cancer excluding nonmelanoma skin cancer, chronic kidney disease, coronary heart disease, depression, diabetes, dyslipidemia, heart failure, hepatitis B, hepatitis C, lung disease (including chronic bronchitis, chronic obstructive pulmonary disease, or emphysema), obesity, and stroke. Age was standardized to the age distribution of US adults with hypertension in 2017–2020 (12.4% for 20–39 years, 34.3% for 40–50 years, 36.9% for 60–74 years, and 16.4% for ≥75 years). Error bars represent 95% confidence intervals. Abbreviations: DBP, diastolic blood pressure; NHANES, National Health and Nutrition Examination Survey; SBP, systolic blood pressure.

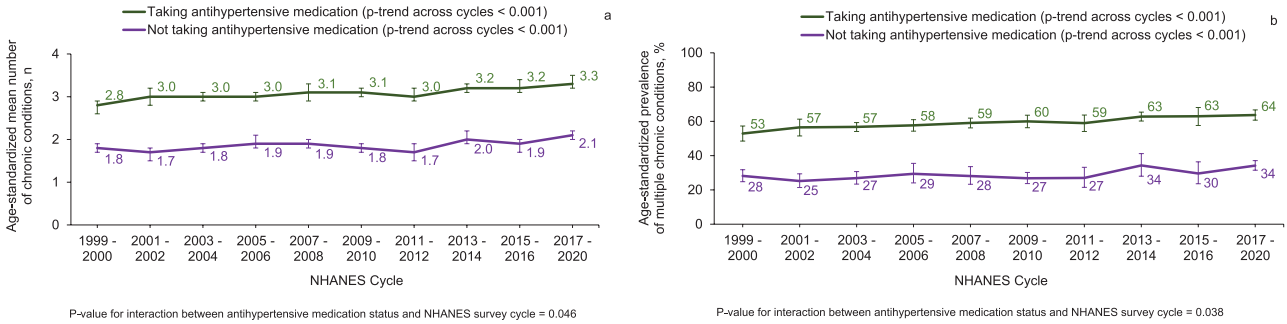


Figure 2. Age-standardized mean number of chronic conditions (**a**) and age-standardized prevalence of multiple chronic conditions (**b**) among US adults ≥20 years old with hypertension. Hypertension was defined as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg, or self-reported use of antihypertensive medication. Having multiple chronic conditions was defined as ≥3 of any of the following chronic conditions: arthritis, asthma, cancer excluding nonmelanoma skin cancer, chronic kidney disease, coronary heart disease, depression, diabetes, dyslipidemia, heart failure, hepatitis B, hepatitis C, lung disease (including chronic bronchitis, chronic obstructive pulmonary disease, or emphysema), obesity, and stroke. Age was standardized to the age distribution of US adults with hypertension in 2017–2020 (12.4% for 20–39 years, 34.3% for 40–50 years, 36.9% for 60–74 years, and 16.4% for ≥75 years). Error bars represent 95% confidence intervals. Abbreviations: DBP, diastolic blood pressure; NHANES, National Health and Nutrition Examination Survey; SBP, systolic blood pressure.

Prevalence ratios for having multiple chronic conditions

In 2017–2020, US adults with hypertension were 1.94 (95% confidence interval: 1.72–2.18) times as likely to have multiple chronic conditions compared to their counterparts without hypertension after age, gender, and race/ethnicity adjustment (Table 3). The prevalence of multiple chronic conditions was more common among US adults with vs. without hypertension within each subgroup defined by age, gender, and race/ethnicity.

Complex multimorbidity

From 1999–2000 to 2017–2020, US adults with hypertension experienced a larger increase in the age-adjusted mean number of affected body systems compared to US adults without hypertension (*P*-interaction <0.001; Figure 3, left panel and Supplementary Table S6 online, top panel). The age-adjusted prevalence of complex multimorbidity increased among US adults with and without hypertension (*P*-interaction = 0.386; Figure 3, right panel and Supplementary Table S6 online, bottom panel).

DISCUSSION

There are several findings from the current study with clinical and public health implications.

First, the mean number of chronic conditions and the prevalence of multiple chronic conditions and complex multimorbidity increased substantially between 1999–2000 and 2017–2020 among US adults with hypertension. Second, in 2017–2020, over 50% of US adults with hypertension had multiple chronic conditions. Third, US adults with hypertension were more likely to have multiple chronic conditions compared to their counterparts without hypertension. Fourth, among US adults with hypertension, the mean number of chronic conditions was higher for those taking vs. not taking antihypertensive medication.

Between 1999–2000 and 2017–2020, the prevalence of multiple chronic conditions and complex multimorbidity increased by ≥10 percentage points among US adults with hypertension. Several of these conditions are likely to increase further as it has been projected that obesity, diabetes, heart failure, and several other chronic conditions will increase over the next several decades.[28,29] Among those with hypertension, suboptimal adherence to antihypertensive medication is common and has been associated with poor BP control and adverse outcomes, including stroke, myocardial infarction, heart failure, and death.[30,31] The high prevalence of multiple chronic conditions among those with hypertension may have implications for medication nonadherence in this population, leading to poor BP control and adverse outcomes. Having

multiple chronic conditions has been associated with increased mortality and barriers to antihypertensive medication adherence, including worse quality of life, longer hospital stays, increased medication regimen cost, higher medication burden, and more complex dosage schedules.[31,32]

Table 3. Prevalence ratios for having multiple chronic conditions among US adults with vs. without hypertension, overall and within age, gender, and race/ethnicity subgroup, NHANES 2017–2020

	Prevalence ratio (95% CI)
Overall	1.94 (1.72–2.18)
Age group, y	
20–39	3.53 (2.20–5.66)
40–59	2.37 (2.00–2.80)
60–74	1.62 (1.33–1.96)
≥75	1.34 (1.00–1.80)
Gender	
Men	1.86 (1.47–2.36)
Women	2.04 (1.84–2.25)
Race/ethnicity	
Non-Hispanic White	1.93 (1.68–2.21)
Non-Hispanic Black	2.21 (1.77–2.75)
Non-Hispanic Asian	1.95 (1.37–2.76)
Hispanic	1.90 (1.35–2.68)
Other Race	1.60 (0.85–3.02)

The overall prevalence ratio was adjusted for age, gender, and race/ethnicity.
The age-stratified prevalence ratios were adjusted for gender and race/ethnicity.
The gender-stratified prevalence ratios were adjusted for age and race/ethnicity.
The race/ethnicity-stratified prevalence ratios were adjusted for age and gender.
Hypertension was defined as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg, or self-reported use of antihypertensive medication.
Having multiple chronic conditions was defined as ≥3 of any of the following chronic conditions: arthritis, asthma, cancer excluding nonmelanoma skin cancer, chronic kidney disease, coronary heart disease, depression, diabetes, dyslipidemia, heart failure, hepatitis B, hepatitis C, lung disease (including chronic bronchitis, chronic obstructive pulmonary disease, or emphysema), obesity, and stroke.
Abbreviations: CI, confidence interval; DBP, diastolic blood pressure; NHANES, National Health and Nutrition Examination Survey; SBP, systolic blood pressure.

The high prevalence of multiple chronic conditions in US adults with hypertension will likely demand substantial clinician time. A prior study estimated that a primary care physician with 2,500 patients would require over 14 hours per workday to manage BP along with dyslipidemia, obesity, and arthritis, the 3 most common chronic conditions experienced by US adults with hypertension in the current study.[33] This is clearly not feasible for a single physician. However, team-based care, which is cost-effective for the management of BP, could offset about 65% of services to other healthcare team members, including pharmacists, health counselors, and dietitians, and allow for collaborative patient-centered care, providing more time for physicians to focus on complex cases.[33,34]

Although the majority of US adults with hypertension have multiple chronic conditions, most guidelines focus on managing 1 condition, and effective strategies and interventions to improve outcomes in older patients are limited.[35,36] The healthcare received by adults with hypertension and multiple chronic conditions might not necessarily correspond to optimal guideline-recommended treatment for each condition.[37,38] Rather, individuals with hypertension may benefit from a personalized approach that balances the risks and benefits of treatment.

The prevalence of multiple chronic conditions increased between 1999–2000 and 2017–2020 among US adults without hypertension. This increase indicates the need for population-level interventions to prevent chronic conditions. Lifestyle modifications such as weight loss, physical activity, and a heart-healthy diet can potentially prevent hypertension and many chronic conditions.[39] Additionally, lowering BP may be beneficial among people without hypertension.[40] An analysis from the Multi-Ethnic Study of Atherosclerosis showed that higher BP, even in the range considered normal, is associated with increased cardiovascular risk.[11]

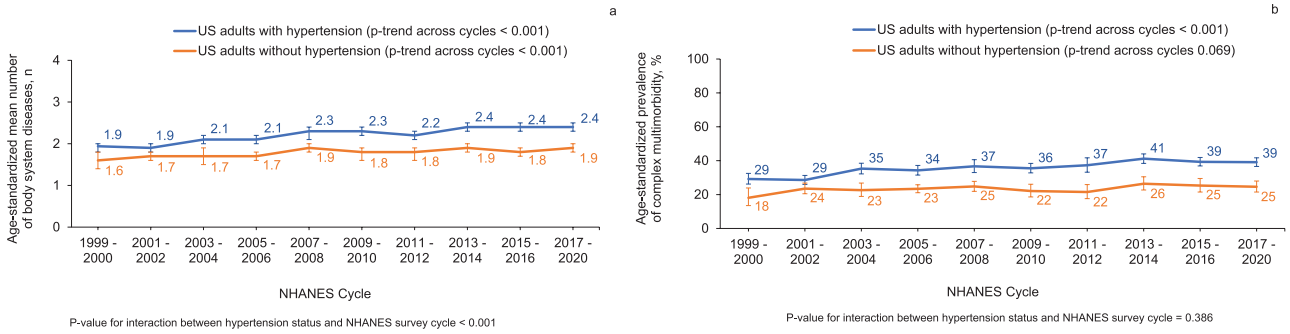


Figure 3. Age-standardized mean number of body system diseases (**a**) and age-standardized prevalence of complex multimorbidity (**b**) among US adults ≥20 years old. Body systems were defined using the following chapters of the International Classification of Disease, tenth revision, corresponding to the 14 chronic conditions included in the current analysis (see Supplementary Table S1 online): (i) Certain infectious or parasitic diseases—includes hepatitis B and hepatitis C. (ii) Diseases of circulatory system—includes coronary heart disease, heart failure, and stroke. (iii) Diseases of the genitourinary system—includes chronic kidney disease. (iv) Diseases of the musculoskeletal system and connective tissue—includes arthritis. (v) Diseases of the respiratory system—includes chronic obstructive pulmonary disease, emphysema, chronic bronchitis, and asthma. (vi) Endocrine, nutritional, or metabolic diseases—includes dyslipidemia, obesity, and diabetes. (vii) Mental, behavioral, and neurodevelopmental disorders—includes depression. (viii) Neoplasms—includes cancer excluding nonmelanoma skin cancer. Hypertension was defined as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg, or self-reported use of antihypertensive medication. Complex multimorbidity was defined as ≥3 chronic conditions affecting ≥3 different body systems. Chronic conditions included arthritis, asthma, cancer excluding nonmelanoma skin cancer, chronic kidney disease, coronary heart disease, depression, diabetes, dyslipidemia, heart failure, hepatitis B, hepatitis C, lung disease (including chronic bronchitis, chronic obstructive pulmonary disease, or emphysema), obesity, and stroke. Age was standardized to the age distribution of US adults with hypertension in 2017–2020 (12.4% for 20–39 years, 34.3% for 40–50 years, 36.9% for 60–74 years, and 16.4% for ≥75 years). Error bars represent 95% confidence intervals. Abbreviations: DBP, diastolic blood pressure; NHANES, National Health and Nutrition Examination Survey; SBP, systolic blood pressure.

The current analysis has several strengths. NHANES data provide nationally representative estimates for noninstitutionalized US adults and used rigorous procedures for data collection. BP was measured following a standardized protocol. The extensive data collection in NHANES allowed us to assess 14 chronic conditions based on the US Health and Human Services strategic framework.[23] This study has several limitations. BP was measured at a single visit, while the 2017 ACC/AHA BP guideline recommends estimating BP using the average of measurements at 2 or more visits. Several chronic conditions were self-reported. Some chronic conditions in the US Health and Human Services framework including dementia and osteoporosis were not assessed in all NHANES cycles; human immunodeficiency virus infection was not assessed in all NHANES participants.

In conclusion, the prevalence of multiple chronic conditions has increased from 1999–2000 to 2017–2020 among US adults with hypertension. In 2017–2020, the majority of US adults with hypertension had ≥3 chronic conditions in addition to having hypertension. These data indicate that most US adults with hypertension may need additional healthcare resources beyond managing BP. Strategies to promote cardiovascular disease prevention and healthy aging for US adults with hypertension may benefit from including a multidisciplinary team that can manage coexisting conditions.

SUPPLEMENTARY DATA

Supplementary materials are available at *American Journal of Hypertension* (http://ajh.oxfordjournals.org).

ACKNOWLEDGMENTS

The authors are grateful for the National Health and Nutrition Examination Survey participants.

CONFLICT OF INTEREST

C.J. Alanaeme, L. Ghazi, O.P. Akinyelure, Y. Wen, A. Christenson, B. Poudel, L. Chen, K. Foti, M.T. Long, and P. Muntner have no disclosures. E.E. Dooley received the American Heart Association Career Development Award (23CDA1049277, https://doi.org/10.58275/AHA.23CDA1049277.pc.gr.167990). S.T. Hardy receives research support from the National Heart, Lung, and Blood Institute through K01HL164763. C.B. Bowling gets support from the National Institute on Aging (R01AG062502). L.D. Colantonio receives research support from Amgen.

DISCLOSURES

This manuscript was sent to Guest Editor, Hillel W. Cohen, MPH, DrPH for editorial handling and final disposition.

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