Journal of the American Heart Association

BRIEF COMMUNICATION

Sex-Specific Temporal Trends in Hypertensive Crisis Hospitalizations in the United States

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BACKGROUND: Despite recent improvements in hypertension control overall, the extent to which these trends apply to the most extreme forms of elevated blood pressure—hypertensive crises requiring hospitalization—in both women and men at risk remains unknown.

METHODS AND RESULTS: Using data from the National Inpatient Sample, we estimated sex-pooled and sex-specific temporal trends in hypertensive crisis hospitalization and case fatality rates over serial time periods: years 2002 to 2006, 2007 to 2011, and 2012 to 2014. Over the entire study period (years 2002–2014), there were an estimated 918 392±9331 hypertensive crisis hospitalizations and 4377±157 in-hospital deaths. Hypertensive crisis represented 0.23%±0.002% of all hospitalizations during the entire study period: 0.24%±0.002% for men and 0.22%±0.002% for women. In multivariable analyses adjusting for age, race or ethnicity, and cardiovascular conditions, the odds of experiencing a hospitalization primarily for hypertensive crisis increased annually for both men (odds ratio [OR], 1.083 per year; 95% CI, 1.08–1.09) and women (OR, 1.07 per year, 95% CI, 1.07–1.08) with a higher rate of increase observed in men compared with women (P<0.001). The multivariable-adjusted odds of death during hypertensive crisis hospitalization decreased annually and similarly for men (OR, 0.89 per year; 95% CI, 0.86–0.92) and for women (0.92 per year; 95% CI, 0.90–0.94).

CONCLUSIONS: Hypertensive crisis hospitalizations have steadily increased, slightly more among men than women, along with an observed increase in the burden of cardiovascular conditions. These trends, observed despite contemporaneous improvements in hypertension prevention and control nationwide, warrant further investigations to identify contributing factors that could be amenable to targeted interventions.

Key Words: hypertension ■ hypertensive crisis ■ sex differences

Hypertension remains by far the largest modifiable risk factor for major cardiovascular events including stroke, myocardial infarction, and heart failure. The prevalence, awareness, and control of hypertension among the population is reflected, in part, by temporal trends in rates of hospitalization for malignant hypertension or hypertensive crises—the most extreme clinical presentation of hypertension that requires urgent or emergent medical care.[1] Increasing evidence now underscores the importance of sex differences in manifestations of hypertension and associated outcomes.[2] Importantly, changes in the prevalence, control rate, and clinical sequela of hypertension have affected men and women differently. Although hypertension is more common in men at younger ages, prevalence rates in women surpass those in men in later life, with 81.2% of

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Supplemental Material is available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.121.021244

For Sources of Funding and Disclosures, see page 7.

JAHA is available at: www.ahajournals.org/journal/jaha

women compared with 73.4% of men >75 years classified as hypertensive. These findings may be attributable to both sex-specific survival bias and a more rapid age-related increase in blood pressure experienced by women, beginning as early as in the third decade of life.[3] Thus, to better understand how changes in hypertension-related risks may have changed over time and how they may differ between women and men, we conducted an a priori sex-specific temporal trends analysis of hypertension crisis–associated hospitalizations in the United States.

METHODS

Data that support the findings are available through the National Inpatient Sample database from the Healthcare Cost and Utilization Project.

Using data from the Healthcare Cost and Utilization Project (HCUP) Agency for Healthcare Research and Quality, Nationwide Inpatient Sample (NIS), we examined inpatient hospital admissions and case fatality for malignant hypertension between 2002 and 2014.[4] Briefly, NIS is a systematic random sample database of US community hospital discharges. The Nation*wide* Inpatient Sample was replaced by the Nation*al* Inpatient Sample starting in 2012. Before 2012, the sample unit included all discharges from a 20% random selection of all acute care hospitals in the nation stratified by census region, location, teaching status, ownership, and number of beds. From 2012 onwards, the NIS sampling method changed to increase the accuracy of national estimates by including ≈20% of all hospital discharges, excluding long-term acute care hospitals, and stratifying by the same factors, including more granular hospital region groupings.[5] As recommended by HCUP, we incorporated "trend weights" for the data collected during years 2002 through 2011 to account for the change in the sampling strategy applied from 2012 onwards. This approach allows for results of analyzing data collected from before and after 2012 to be comparable.[6]

Malignant hypertension was defined using primary diagnosis *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*), codes: 401.0, 402.00, 402.01, 403.00, 403.01, 404.00, 404.01, 404.02, 404.03, 405.01, 405.09, and 437.2. We defined 4 major cardiovascular conditions of interest using *International Classification of Diseases, Ninth Revision* (*ICD-9*), codes: (1) myocardial infarction (410.x, 412.x), (2) heart failure (398.91, 402.11, 402.91, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428.x), (3) cerebrovascular disease (362.34, 430.x–436.x, 437.0, 437.1, 437.3–437.9, 438.x), and (4) renal failure (403.11, 403.91, 404.02, 404.12, 404.13, 404.92, 404.93, 585.x, 586.x, 588.0, V42.0, V45.1, V56.x). To define cardiovascular conditions, we used relevant *ICD-9* codes established by the validated Charlson comorbidity score[7] while excluding those codes included in the definition of the outcome (ie, codes indicating malignant hypertension). Patients were assigned a comorbidity score on a scale of 0 to 4, with a single point given the presence of each of the 4 prespecified cardiovascular conditions (myocardial infarction, heart failure, cerebrovascular disease, and renal failure).

The number of hospital admissions with a primary diagnosis of malignant hypertension, total number of hospital admissions with any primary diagnosis, and number of deaths with a primary diagnosis of malignant hypertension were estimated using the SURVEYMEANS procedure in SAS (SAS Institute Inc). Patients aged <16 years and those transferred from another acute care hospital were excluded. Annual admission rates of malignant hypertension were calculated as the number of malignant hypertension admissions divided by the total number of admissions with any primary diagnosis. Annual case fatality rates for malignant hypertension were calculated as the number of deaths with a primary diagnosis of malignant hypertension divided by the total number of admissions with a primary diagnosis of malignant hypertension. Annual admission and case fatality rates were calculated overall and by sex. All estimates were calculated accounting for survey weights, clustering, and stratification in the NIS sampling design per HCUP recommendations.[4]

Additionally, we used multivariable logistic regression models to estimate the trends in odds of hospitalization and death related to malignant hypertension over time using the SURVEYLOGISTIC procedure in SAS (SAS Institute Inc). Covariates included age, race or ethnicity, obesity, hypercholesterolemia, diabetes, and the above prespecified cardiovascular conditions. Given that the prespecified cardiovascular conditions may be located on the causal pathway between malignant hypertension and the outcomes of interest, we also created models controlling only for age, race or ethnicity, obesity, hypercholesterolemia, and diabetes. The trends in hospitalization and death were compared by sex among the entire study period as well as within 3 distinct time windows: years 2002 to 2006 (period 1), years 2007 to 2011 (period 2), and years 2012 to 2014 period 3).

This study was approved by the Cedars-Sinai institutional review board with requirement for individual informed consent waived. All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc) and R version 3.6.3 (The R Foundation).

RESULTS

We observed an estimated 918 392±9331 primary hospitalizations for hypertensive crisis and 4377±157 in-hospital deaths caused by hypertensive crises during the study period. Overall, the mean age of patients hospitalized for hypertensive crisis was 60.2±0.1 years and 58.5%±0.1% were women, with most patients identifying as either non-Hispanic White (39.4±0.4%) or non-Hispanic Black (34.3±0.4%). Among those who died in-hospital during a hypertensive crisis admission, the mean age was 68.1±0.6 years and 60.0%±1.6% were women, with most patients identifying as either non-Hispanic White (43.4±1.7%) or non-Hispanic Black (31.0%±1.7%), and with 80.4%±1.3% having at least 1 cardiovascular condition including 46.8%±1.7% renal failure, 16.9%±1.3% myocardial infarction, 43.9%±1.7% heart failure, and 29.2%±1.5% cerebrovascular disease.

In sex-stratified analysis of all hypertensive crisis hospitalizations, women compared with men were more likely to be older (63.7±0.1 years 55.2±0.1 years, *P*<0.001), non-Hispanic White (41.1%±0.4% versus 36.9%±0.4%, *P*<0.001), and have a history of stroke (11.3%±0.1% versus 9.6%±0.1%, *P*<0.001), respectively. By contrast, men compared with men were more frequently non-Hispanic Black (36.3%±0.5% versus 32.9%±0.5%, *P*<0.001) and likely to have a history of myocardial infarction (7.9%±0.1% versus 6.7%±0.1%, *P*<0.001), heart failure (30.4%±0.2% versus 25.3%±0.2%, *P*<0.001), or renal failure (41.1%±0.3% versus 30.6%±0.2%, *P*<0.001), respectively (Table 1). Differences by sex persisted over time, with important trends appreciated. Specifically, the average age

Table 1. Demographic and Clinical Characteristics of Patients Admitted for Hypertensive Crisis and Those Who Died During Hospitalization for Hypertensive Crisis

Baseline characteristics	Overall: years 2002–2014		Years 2002–2006		Years 2007–2011		Years 2012–2014	
	Men	Women	Men	Women	Men	Women	Men	Women
Patients admitted for hypertensive crisis								
Age, mean±SD, y	55.23±0.08	63.71±0.08	54.39±0.14	63.18±0.15	54.98±0.13	63.68±0.15	56.19±0.11	64.22±0.12
Race or ethnicity, %								
Non-Hispanic White	36.90±0.40	41.12±0.40	33.31±0.73	37.81±0.74	35.76±0.74	40.39±0.75	41.12±0.50	45.05±0.51
Non-Hispanic Black	36.32±0.47	32.94±0.45	30.51±0.95	26.61±0.84	37.12±0.91	33.73±0.87	39.91±0.53	37.60±0.53
Hispanic/Latinx	8.73±0.21	7.61±0.20	7.19±0.38	6.38±0.33	8.38±0.38	7.49±0.40	10.35±0.30	8.87±0.28
Asian or other Pacific Islander	1.71±0.07	1.81±0.07	1.50±0.13	1.68±0.15	1.68±0.11	1.84±0.12	1.90±0.11	1.91±0.10
American Indian/Alaska Native	0.34±0.03	0.37±0.03	0.25±0.05	0.26±0.04	0.40±0.06	0.41±0.05	0.32±0.04	0.43±0.05
Other race	2.39±0.10	2.01±0.09	1.69±0.13	1.41±0.10	2.37±0.19	1.92±0.14	2.95±0.18	2.66±0.19
Missing race	13.62±0.48	14.13±0.46	25.54±1.09	25.85±1.00	14.28±0.94	14.22±0.86	3.45±0.27	3.48±0.24
Cardiovascular conditions, %	61.31±0.25	52.33±0.23	44.39±0.49	38.42±0.38	65.90±0.42	56.23±0.41	69.03±0.32	59.79±0.30
Myocardial infarction	7.88±0.12	6.68±0.09	5.92±0.19	4.99±0.14	7.74±0.20	6.82±0.15	9.59±0.20	8.03±0.16
Heart failure	30.41±0.23	25.28±0.19	25.43±0.44	20.91±0.32	31.09±0.40	25.99±0.34	33.49±0.33	28.29±0.28
Cerebrovascular disease	9.62±0.11	11.28±0.11	8.82±0.21	10.36±0.18	9.87±0.18	11.62±0.18	9.94±0.19	11.67±0.18
Renal failure	41.06±0.29	30.64±0.24	15.12±0.41	11.12±0.29	48.77±0.45	36.48±0.41	52.11±0.36	40.63±0.31
Comorbidity score, mean±SD	0.89±0.005	0.74±0.004	0.55±0.01	0.47±0.01	0.97±0.01	0.81±0.01	1.05±0.01	0.89±0.01
Patients with in-hospital mortality during admission for hypertensive crisis								
Age, mean±SD, y	63.32±0.81	71.33±0.69	61.84±1.35	68.54±1.13	64.46±1.32	72.21±1.11	64.19±1.52	74.82±1.30
Race or ethnicity, %								
Non-Hispanic White	39.23±2.60	46.18±2.21	33.37±3.88	41.60±3.45	36.45±4.27	44.22±3.59	54.43±5.61	57.63±4.59
Non-Hispanic Black	34.82±2.57	28.44±2.02	33.89±4.02	25.42±3.13	36.27±4.19	31.94±3.39	34.18±5.50	27.97±4.16
Hispanic/Latinx	8.04±1.56	3.23±0.76	7.33±2.53	2.23±1.01	9.13±2.63	4.70±1.47	7.59±2.94	2.54±1.45
Asian or other Pacific Islander	1.07±0.53	2.40±0.65	1.26±0.88	0.93±0.65	1.53±1.08	3.88±1.34	0±0	2.54±1.45
American Indian/Alaska Native	0.56±0.40	0.18±0.18	0.70±0.69	0.45±0.45	0.75±0.75	0±0	0±0	0±0
Other race	2.40±0.79	2.24±0.69	3.17±1.39	1.38±0.79	3.01±1.49	2.47±1.10	0±0	3.39±2.04
Missing race	13.88±1.95	17.33±1.84	20.27±3.50	27.99±3.44	12.85±3.22	12.80±2.65	3.80±2.15	5.93±2.44
Comorbidities, %	76.51±2.22	83.03±1.66	66.31±3.87	77.08±3.00	84.60±3.02	84.27±2.54	82.28±4.32	91.53±2.56
Myocardial infarction	18.89±2.13	15.60±1.60	22.20±3.35	14.20±2.39	17.41±3.56	14.25±2.47	15.19±4.32	20.34±3.87
Heart failure	40.94±2.65	45.84±2.18	33.68±4.02	47.23±3.48	46.36±4.27	41.88±3.50	45.57±5.77	50.00±4.60
Cerebrovascular disease	28.14±2.37	29.95±1.95	24.57±3.45	26.29±3.01	30.84±3.95	31.99±3.22	30.38±5.46	33.05±4.22
Renal failure	47.71±2.63	46.25±2.19	28.05±3.64	23.79±2.86	62.09±4.21	58.30±3.58	60.76±5.59	66.10±4.46
Comorbidity score, mean±SD	1.36±0.05	1.38±0.04	1.09±0.08	1.12±0.06	1.57±0.08	1.46±0.07	1.52±0.12	1.69±0.08

of patients admitted for hypertensive crisis increased during the study period for both men (54.4±0.1 years in period 1 to 56.2±0.1 years in period 3, $P<0.001$) and women (63.2±0.2 years in period 1 to 64.2±0.1 years in period 3, $P<0.001$). The burden of comorbid conditions for both sexes also increased over time (0.55±0.01 in period 1 to 1.05±0.01 in period 3 for men [$P<0.001$] and 0.47±0.01 in period 1 to 0.89±0.01 in period 3 for women [$P<0.001$]).

Among patients who died during hospitalization for hypertensive crisis, sex-specific demographic and clinical variables mirrored those of the admitted population, with women being on average older (71.3±0.7 versus 63.3±0.8 years, $P<0.001$), more frequently non-Hispanic White (46.2%±2.2% versus 39.2%±2.6%, $P=0.042$), and more likely to have a history of stroke (30.0%±2.0% versus 28.1%±2.4%, $P<0.001$) and heart failure (45.8%±2.2% versus 40.9%±2.7%, $P=0.153$) than men. Men were more frequently Hispanic and had higher rates of prior myocardial infarction and renal failure (Table 1). Similar to the admitted population, differences by sex persisted over time; however, trends in the prevalence of cardiovascular conditions varied. Specifically, the frequency of myocardial infarction increased for women but decreased for men.

During the study period, hypertensive crisis represented 0.23%±0.002% of all hospitalizations,

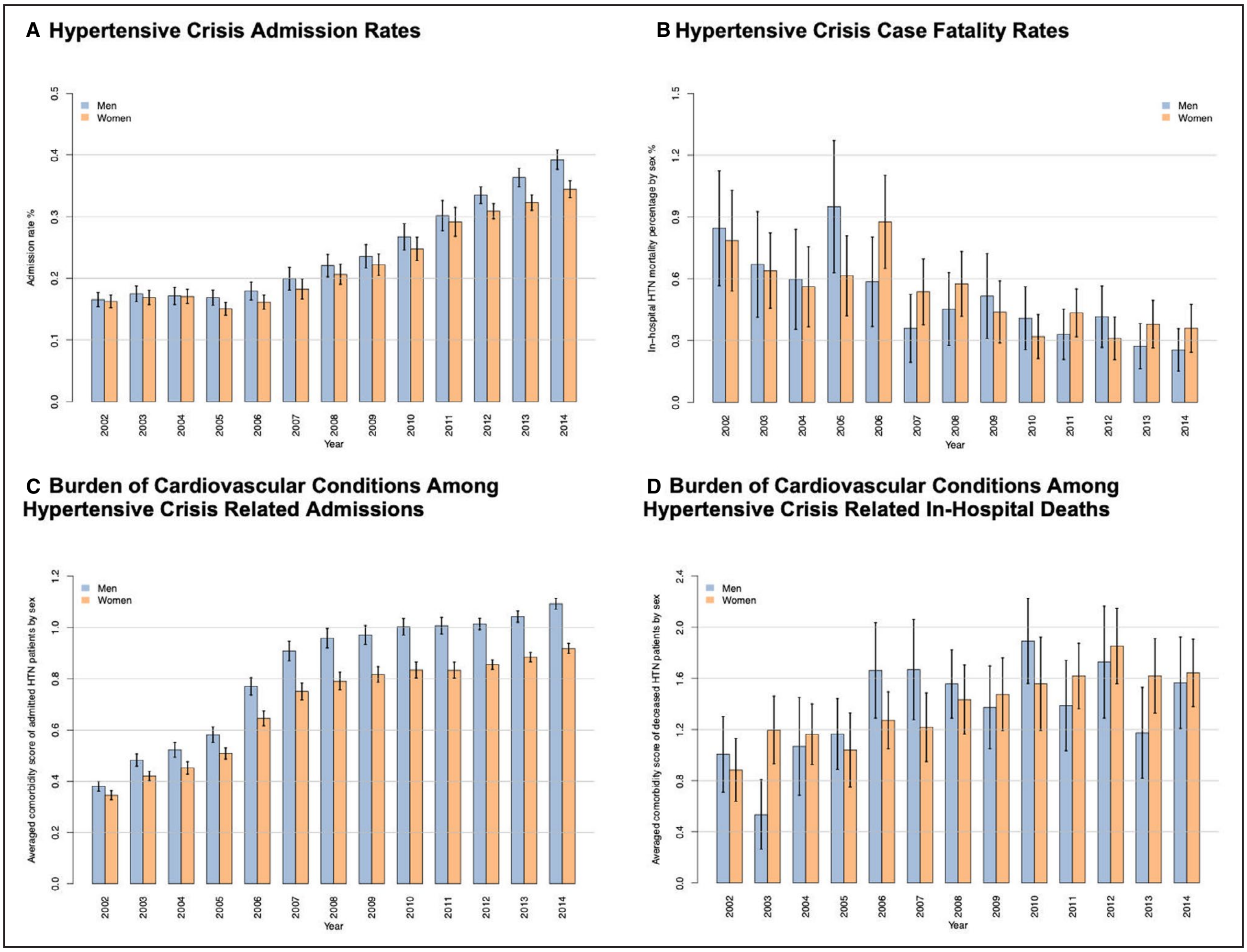

Figure. Sex-specific temporal trends in hypertensive crisis hospitalizations, case fatality, and cardiovascular conditions in the United States (2002–2014).

Using data from the Healthcare Cost and Utilization Project (HCUP) Agency for Healthcare Research and Quality, Nationwide Inpatient Sample (NIS), we calculated sex-specific hospital admission (**A**) and case fatality (**B**) rates for hypertensive crisis for each year. Hospital admission rate was calculated by dividing the number of hospital admissions for hypertensive crisis by the total number of hospitalizations in a given year. Case fatality rate was calculated by dividing the number of in-hospital deaths during hospitalization attributable to hypertensive crisis by the total number of hospitalizations for hypertensive crisis in a given year. Burden of cardiovascular conditions was calculated for patients admitted with hypertensive crisis (**C**) and those who died during hospitalization for hypertensive crisis (**D**) for each year. Cardiovascular condition burden was defined using a comorbidity score, with 1 point given for the presence of 4 cardiovascular conditions (myocardial infarction, heart failure, cerebrovascular disease, and renal failure). Cardiovascular conditions were identified based on *International Classification of Diseases, Ninth Revision* (*ICD-9*), codes (see text).

Table 2. Odds of Hypertensive Crisis Admission and Case Fatality Over Time by Sex and Time Period

Models	Men OR (95% CI)	Women OR (95% CI)	*P* value*
Model 1†			
Admission risk			
Overall years	1.084 (1.078–1.090)	1.075 (1.070–1.079)	<0.001
2002–2006	1.01 (0.99–1.04)	0.99 (0.97–1.01)	0.03
2007–2011	1.10 (1.07–1.14)	1.10 (1.07–1.13)	0.70
2012–2014	1.08 (1.05–1.11)	1.06 (1.03–1.09)	0.07
Case fatality risk‡			
Overall years	0.901 (0.874–0.928)	0.930 (0.907–0.953)	0.13
2002–2006	0.99 (0.88–1.12)	1.03 (0.91–1.15)	0.72
2007–2011	0.97 (0.86–1.09)	0.91 (0.83–1.01)	0.36
2012–2014	0.82 (0.61–1.09)	1.09 (0.87–1.36)	0.12
Model 2§			
Admission risk			
Overall years	1.083 (1.077–1.088)	1.073 (1.069–1.078)	<0.001
2002–2006	1.01 (0.99–1.04)	0.99 (0.97–1.01)	0.03
2007–2011	1.10 (1.07–1.14)	1.10 (1.07–1.13)	0.70
2012–2014	1.08 (1.05–1.11)	1.06 (1.03–1.09)	0.07
Case fatality risk‡			
Overall years	0.890 (0.863–0.918)	0.921 (0.897–0.944)	0.11
2002–2006	0.98 (0.86–1.11)	1.02 (0.90–1.14)	0.67
2007–2011	0.96 (0.85–1.09)	0.90 (0.81–1.00)	0.34
2012–2014	0.80 (0.60–1.07)	1.07 (0.85–1.34)	0.12

**P* values are for difference in odds ratios (ORs) between men and women within each time period.

†Model 1 for the admission outcome is adjusted for age, race or ethnicity, obesity, hypercholesterolemia, and diabetes.

‡Models for case fatality outcome are adjusted for the same covariates as for the admission outcome except for hypercholesterolemia, which was excluded because of small sample size.

§Model 2 for the admission outcome is adjusted model 1 covariates plus myocardial infarction, congestive heart failure, cerebrovascular disease, and renal failure.

0.24%±0.002% for men and 0.22%±0.002% for women. Annual admission rates increased in both sexes from 2002 to 2014 (Figure), more so in men, such that the admission rate was higher in men than in women by 2014 (0.39%±0.01% versus 0.34%±0.01%, *P*<0.001) (Table S1). In multivariable analyses adjusting for age, race or ethnicity, obesity, hypercholesterolemia, and diabetes, the odds of experiencing a hospitalization primarily for hypertensive crisis increased annually for both men (odds ratio [OR], 1.084 per year; 95% CI, 1.078–1.090) and women (OR, 1.075 per year; 95% CI, 1.070–1.079), with a higher rate of increase observed in men compared with women (*P*<0.001) (Table 2). Similarly, following the addition of the predefined cardiovascular conditions (myocardial infarction, heart failure, cerebral vascular disease, and renal failure) to the model, the odds of experiencing a hospitalization primarily for hypertensive crisis also increased annually for both men (OR, 1.083 per year; 95% CI, 1.08–1.09) and women (OR, 1.073 per year; 95% CI, 1.07–1.08), again with a higher rate of increase observed in men compared with women (*P*<0.001) (Table 2). During period 1, the annual change in odds of hypertensive crisis hospitalization was not significant for men (OR, 1.01; 95% CI, 0.99–1.04) or women (0.99; 95% CI, 0.97–1.01), although the odds of hypertensive crisis hospitalization increased for both men and women during period 2 (men: OR, 1.10 [95% CI, 1.07–1.14]; women: OR, 1.10 [95% CI, 1.07–1.13]) and period 3 (men: OR, 1.08 [95% CI, 1.05–1.11]; women: OR, 1.06 [95% CI, 1.03–1.09]).

The overall case fatality rate for those admitted with hypertensive crisis was 0.48%±0.02%, 0.46%±0.02% for men and 0.49%±0.02% for women. Annual case fatality rates were similar by sex and decreased from years 2002 to 2014 for both men and women (Figure).

In multivariable analyses adjusting for age, race or ethnicity, obesity, hypercholesterolemia, and diabetes, the odds of death during hospitalization primarily for hypertensive crisis decreased annually for both men (OR, 0.901 per year; 95% CI, 0.874–0.928) and women (OR, 0.930 per year; 95% CI, 0.907–0.953), although change in the odds of death during hospitalization was not statistically significant for either sex during specific time periods (Table 2). Similarly, following the addition of the predefined cardiovascular conditions to the model, the odds of death during hospitalization primarily for hypertensive crisis again decreased annually for both men (OR, 0.890 per year; 95% CI, 0.863–0.918) and women (OR, 0.921 per year; 95% CI, 0.897–0.944), although change in the odds of death during hospitalization was not statistically significant for either sex during specific time periods (Table 2). Similarly, the difference in rates of decrease between men and women was not statistically significant overall or by time period. Notably, the overall cardiovascular condition burden of patients who died during hospitalization for hypertensive crisis increased for both men and women from period 1 to period 3 (Figure).

DISCUSSION

Our analysis of national data over a 13-year period demonstrates that annual hypertensive crisis hospitalizations have steadily increased in both men and women, with the rate of increase slightly higher among men, along with an observed increase in the burden of cardiovascular conditions. Importantly, these trends occurred despite the decreasing prevalence and increasing rates of hypertension control nationally.[1,8] Fortunately, among patients admitted for hypertensive crisis, case fatality rates have been steadily decreasing in both sexes.

Hypertension continues to represent one of the largest modifiable risk factors for cardiovascular disease, contributing to an estimated 25% of all cardiovascular events annually in the United States. Large epidemiologic studies indicate that hypertension control at the national level improved during the study period, increasing from 31.8% in 2000 to 53.8% in 2014.[8] Prevalence of hypertension among the general population also decreased during the study period even while the absolute burden of hypertension increased, indicating that millions of Americans have remained at excess risk for cardiovascular events caused by elevated blood pressure.[9] Beyond prevalence, data from the National Health and Nutrition Examination Survey indicate differences in hypertension control by sex and age, with controlled blood pressure more frequently achieved in younger women compared with younger men but then also being more common among older men than older women (aged >65 years).[10] Recent data using pooled longitudinal cohorts have demonstrated that women remain at increased risk for hypertension-related cardiovascular events such as stroke, heart failure, and myocardial infarction even after achieving the same numeric blood pressure levels as men.[11] Taken together, these data indicate that hypertension continues to affect a large proportion of the population and that although control rates have improved, effects of uncontrolled hypertension are experienced unequally among subgroups including the sexes.

Despite improving rates of reported hypertension control from years 2002 to 2014, we observed that hypertensive crisis admissions steadily increased during this same time period. Multiple factors may have contributed to this apparent paradox. We recognize that improved outpatient control of chronic hypertension may be only indirectly related or even unrelated to risk for hypertensive crisis in at-risk individuals. Factors that may predispose to hypertensive crisis include missed medication doses, use of antihypertensive medications with rapid onset and offset of action, use of medications that inadvertently raise blood pressure (eg, NSAIDS and steroids), provoked salt sensitivity, and other gene-exposure interactions that may promote episodes of severe hypertension.[12–16] If reported improving rates of hypertension control and our findings of worsening rates of hypertensive crisis simultaneously represent true nationwide trends, then these data together may reflect a progressive divergence between subgroups of individuals with hypertension or between subtypes of hypertension or both. Intriguingly, results were similar in analyses both adjusting and not adjusting for comorbid cardiovascular conditions. This finding suggests that factors beyond major cardiovascular comorbidities may be contributing to increasing hypertensive crisis hospitalizations and, to identify the potential drivers of risk, further studies are warranted.

Amidst the increasing admission rates for hypertensive crises, we observed the trend to be particularly pronounced for men. Although men had a greater burden of comorbid conditions than women, the sex difference in hospitalization rates remained even when controlling for cardiovascular conditions. Men admitted with hypertensive crisis also tended to be younger than admitted women, consistent with the known trend of blood pressure control worsening for women later in life. By contrast, despite being on average older, women had fewer cardiovascular conditions but similar case fatality rates to men. This paradox suggests that the presence of clinically severe hypertension in women may confer even higher risk than in men, and above and beyond the age-adjusted impact of cardiovascular conditions. Alternatively, since cardiovascular conditions appear to account for less of this increased risk in women than in men, there may exist female-specific pathways through which hypertension may increase risk of mortality. The extent to which unmeasured comorbid risk traits could be contributing to this sexual dimorphism is unknown.[17]

Several limitations of this study merit consideration. The retrospective study design precludes definitive conclusions regarding causality. The relatively rare outcome of hypertensive crisis admission, however, makes sizable prospective studies infeasible. Although our analyses adjusted for a number of demographic and clinical covariates, there are yet unmeasured potential confounders that may have influenced our results (eg, lifestyle and behavioral factor such as diet, exercise, and smoking). Our findings are likely also related to individual-level variations in treatment and adherence to antihypertensive therapies; given these important variables were not available in our data, they warrant investigation in future studies. In the current analysis, correct classification is particularly dependent on correct coding of individuals with versus those without hypertensive crisis; patients could have been misclassified in either direction (ie, nondifferential) for a variety of reasons. Although presence of coding errors and nondifferential misclassification are more likely to have produced an underestimate rather than overestimate of associations,[18] the latter cannot be ruled out and so future replication studies are warranted. The administrative nature of the data precludes granular details regarding reasons for admission and death in each case, limiting ability to discern whether the causes of hypertensive crises have changed over time. We also studied events spanning the 2012 NIS sampling redesign; however, the use of "trend weights" in our analyses allowed for comparability among the pre- and post-redesign time periods.[4,5] Finally, our analyses were limited to the populations studied, including the racial or ethnic groups described; thus, generalizability to populations not captured by the NIS population would require further investigation.

In summary, our analyses of ≈1 million hospitalizations for hypertensive crises accrued over a 12-year period demonstrate that such hospitalizations are steadily increasing over time. Although associated case fatality rates are decreasing, the rising tide of admissions for the most extreme clinical manifestations of uncontrolled blood pressure—occurring despite contemporaneous improvements in hypertension prevention and control nationwide—warrant further investigation. While at-risk individuals appear more likely to be men and with a greater burden of cardiovascular conditions, women maintain in-hospital mortality rates that are similar to those in men despite having a lower burden of cardiovascular conditions. Additional studies are needed to further clarify overall and sex-specific risks associated with hypertension that tends to present as clinically severe enough to require hospitalization.

ARTICLE INFORMATION

Received June 1, 2021; accepted December 9, 2021.

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Sources of Funding

This study was funded in part by National Institutes of Health grants R01-HL134168, R01-HL131532, R01-HL143227, R01-HL142983, R01-HL146158, K23-HL153888, and U54-AG065141; National Center for Advancing Translational Sciences grant UL1TR000124; and the Edythe L. Broad and the Constance Austin Women's Heart Research Fellowships, the Barbra Streisand Women's Cardiovascular Research and Education Program, the Linda Joy Pollin Women's Heart Health Program, the Erika Glazer Women's Heart Health Project, and the Adelson Family Foundation, Cedars Sinai Medical Center, Los Angeles, California.
The funding sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the article; or the decision to submit the article for publication.

Disclosures

None.

Supplemental Material

Table S1

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Supplemental Material

Table S1. Admission and case fatality rates per year, by sex

Year	Admission rate (%)		Case fatality rate (%)	
	Men	Women	Men	Women
Overall	0.24±0.002	0.22±0.002	0.46±0.02	0.49±0.02
2002	0.17±0.01	0.16±0.01	0.85±0.14	0.78±0.12
2003	0.18±0.01	0.17±0.01	0.67±0.13	0.64±0.09
2004	0.17±0.01	0.17±0.01	0.60±0.12	0.56±0.10
2005	0.17±0.01	0.15±0.01	0.95±0.16	0.61±0.10
2006	0.18±0.01	0.16±0.01	0.59±0.11	0.88±0.12
2007	0.20±0.01	0.18±0.01	0.36±0.08	0.54±0.08
2008	0.22±0.01	0.21±0.01	0.45±0.09	0.57±0.08
2009	0.24±0.01	0.22±0.01	0.52±0.11	0.44±0.08
2010	0.27±0.01	0.25±0.01	0.41±0.08	0.32±0.05
2011	0.30±0.01	0.29±0.01	0.33±0.06	0.43±0.06
2012	0.33±0.01	0.31±0.01	0.42±0.08	0.31±0.05
2013	0.36±0.01	0.32±0.01	0.27±0.06	0.38±0.06
2014	0.39±0.01	0.34±0.01	0.25±0.05	0.36±0.06