Trends in the Prevalence of Hospitalization Attributable to Hypertensive Diseases Among United States Adults Aged 35 and Older From 1980 to 2007

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We aimed to examine the trend in the prevalence of hospitalization attributable to hypertensive disease and its subtypes among United States adults aged ≥35 years from 1980 to 2007. Data (n = 4,598,488,000 hospitalized cases) from the National Hospital Discharge Surveys were used to examine the trends of hospitalized patients with first (the reason for admission) and patients with any second to seventh (a co-morbid condition when admission) diagnosis of hypertensive disease (International Classification of Disease, 9th Revision, Clinical Modification: 401 to 405) by gender and geographic region. Age-adjusted rates of disease were calculated using the United States 2000 standard population. The results show that age-adjusted hospitalization rates due to first diagnosis of hypertensive disease increased from 1.74% to 2.06% in men (p <0.01), and from 2.0% to 2.09% in women (p = 0.06) from 1980 to 1981 to 2006 to 2007. Age-adjusted rates due to any second to seventh diagnosis of hypertensive disease significantly increased from 7.06% to 35.09% in men (p <0.001), and from 7.88% to 31.98% (p <0.001) in women from 1980 to 1981 to 2006 to 2007. Patients with second to seventh diagnosis of essential hypertension and hypertensive chronic kidney disease had the highest and the second highest annual percent increases. Subjects living in the Southern region of the United States had the highest prevalence of hospitalization due to any second to seventh diagnosis of hypertensive disease compared with all other regions in 2006 to 2007. In conclusion, the prevalence of hospitalization due to hypertensive disease significantly increased in the United States from 1980 to 2007. **(Am J Cardiol 2013;112:694−699)**

Hypertension (or high blood pressure) is the most important cardiovascular risk factor worldwide, contributing to 1/2 of coronary heart disease cases and approximately 2/3 of the cerebrovascular disease burden.[1] In the United States, about 1 in 3 adults, an estimated 68 million people, have hypertension.[2] Although several studies have examined trends in the prevalence of hypertension using community-based population samples,[3−7] no studies have been conducted to examine the long-term trends of hospitalization attributable to hypertensive disease, including hypertension and its subtype diseases defined by the International Classification of Disease. Because of the limited resources available for hospitalization support and increasing healthcare costs, recognizing these trends and targeting interventions has become necessary. In the present study, we aimed to quantify and document these trends in hospitalization due to hypertensive disease and subtypes of hypertensive diseases among United States adults in the past 28 years. We hypothesized that there were significant increasing trends in hospitalization rates in patients with first (the reason for admission) and those with second to seventh (a co-morbid condition when admission) diagnosis of hypertensive disease. To test this hypothesis, we used data from nationally representative samples of the United States National Hospital Discharge Surveys (NHDS) from 1980 to 2007.[8]

Methods

The NHDS is conducted by the National Center for Health Statistics (NCHS). Details of the NHDS have been described elsewhere.[8] Briefly, the NHDS provides national estimates of hospital use on the basis of data from patients discharged from noninstitutional hospitals (exclusive of federal, military, and Veterans Administration hospitals) located in the 50 States and District of Columbia. Only short-stay hospitals (average length of stay of <30 days for all patients) or general (medical or surgical) hospitals are included in the surveys. Each year, the sample of hospital discharge diagnosis records represents approximately 1% of all inpatient hospitalizations across 4 regions (Northeast, Midwest, South, and West) in the United States. The sampling design assigns a discharge weight to each hospital record. The discharge weight is the number of hospitalizations that the hospital record represents. Use of these weights

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Table 1
Prevalence (%) of hospitalized patients aged ≥35 with first or with any second to seventh diagnosis of hypertensive diseases, National Hospital Discharge Surveys 1980 to 1981 and 2006 to 2007

Variable	With First Diagnosis of Hypertensive Disease			With Any Second to Seventh Diagnosis of Hypertensive Disease		
	1980–1981 (n = 4,811)	2006–2007 (n = 9,625)	p	1980–1981 (n = 22,516)	2006–2007 (n = 191,943)	p
	M/R (SEM/P)	M/R (SEM/P)		M/R (SEM/P)	M/R (SEM/P)	
Age (SEM)	63.0 (0.22)	63.8 (0.29)	0.03	66.0 (0.10)	68.3 (0.06)	<0.001
Men	1.72 (0.04)	1.88 (0.06)	0.03	8.05 (0.09)	40.17 (0.20)	<0.001
Women	2.24 (0.05)	2.16 (0.05)	0.24	9.94 (0.09)	39.95 (0.18)	<0.001
Region (SEP)						
West	1.55 (0.08)	2.02 (0.10)	<0.001	7.88 (0.16)	37.20 (0.32)	<0.001
Northeast	1.65 (0.06)	2.26 (0.08)	<0.001	9.72 (0.13)	40.05 (0.25)	<0.001
Midwest	1.88 (0.06)	1.79 (0.07)	0.38	9.47 (0.12)	40.69 (0.29)	<0.001
South	2.58 (0.06)	2.06 (0.07)	<0.001	9.00 (0.11)	41.00 (0.22)	<0.001

Hypertensive disease includes essential hypertension (ICD-9: 401), hypertensive heart disease (ICD-9: 402), hypertensive CKD (ICD-9: 403), hypertensive heart and CKD (ICD-9: 404), and secondary hypertension (ICD-9: 405).

First diagnosis of hypertensive disease: the reason for admission.

Any second to seventh diagnosis of hypertensive disease: hospitalization with co-morbid hypertensive disease.

M/R = mean or rate; SEM/P = Standard error of mean; SEP: standard error of proportion.

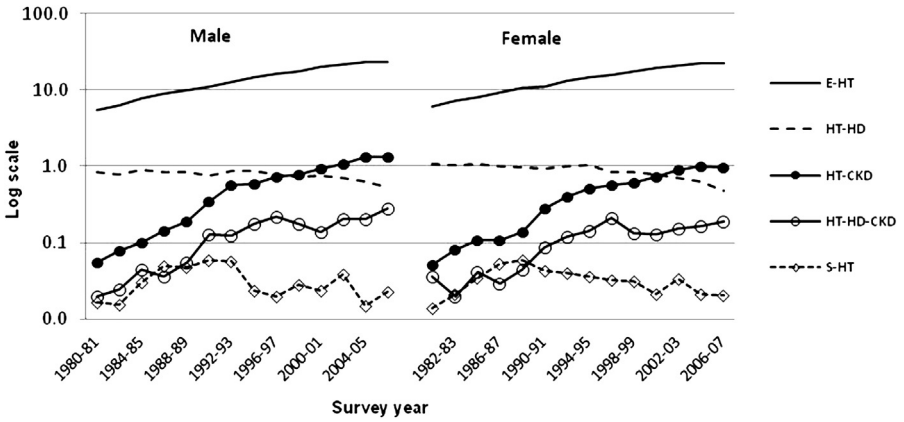

Figure 1. Age-adjusted prevalence (%) of hospitalized patients with any second to seventh diagnosis of hypertensive diseases by gender in NHDS 1980 to 2007.

permits calculations of nationally representative numbers of hospitalizations. Information collected from hospital records includes date of birth, gender, race, date of discharge, length of stay (i.e., hospitalization), discharge status, and ≤7 discharge diagnoses (i.e., first to seventh—listed). In the NHDS, the first diagnosis of a disease indicates the principal cause of hospitalization, and any second to seventh diagnosis of a disease indicates a co-morbid condition. All conditions are coded according to the International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM). In the study, we tested all subtypes of hypertensive disease coded by ICD-9-CM (401 to 405), because they have a direct and/or an indirect effect on the risk of cardiovascular disease. The subtypes of hypertensive disease include (1) essential hypertension (ICD-9-CM: 401), (2) hypertensive heart disease (ICD-9-CM: 402), (3) hypertensive chronic kidney disease (CKD, ICD-9-CM: 403), (4) hypertensive heart and CKD (ICD-9-CM: 404), and (5) secondary hypertension (ICD-9-CM: 405). We examined the subtypes of hypertensive disease, as we wanted to test which subtype disease strongly contributed to the overall changes of the trends in hypertensive disease. All information collected in the NHDS is held in the strictest confidence according to law. The NCHS Research Ethics Review Board has reviewed and approved the NHDS protocol. Data used in the present analysis are de-identified for personal identifications and obtained following the criteria of Centers for Disease Control and Prevention's NCHS for the public use.[8]

A serial analysis was conducted to test the study hypothesis. In the first-group data analyses, we estimated the crude and age-standardized hospitalization rates due to hypertensive disease from 1980 to 2007 for men and women separately. The age standardization was done using the direct method with the United States 2000 standard population. The trends were examined for those with first and any second to seventh diagnosis of hypertensive disease. Changes in age-standardization rates of hypertensive disease are depicted using log-scale figures, and differences in the rates by region are depicted using the Geographic Information System.

In the third-group data analysis, trends of hypertensive disease from 1980 to 2007 were tested using the formula:

Table 2
Annual percent changes in age-adjusted rate of patients with first or any second and seventh diagnosis of hypertensive disease from 1980 to 2007

Variable	Changes from 1980 to 2007		p
	Regression Coefficient	Estimated Annual % Change	
	b (SE)	Rate (SE)	
With first diagnosis of hypertensive disease			
Men: total hypertensive disease	0.014 (0.004)	1.44 (0.38)	0.003
Women: total hypertensive disease	0.010 (0.005)	0.96 (0.46)	0.06
With any second to seventh diagnosis of hypertensive disease			
Men			
Total hypertensive disease	0.062 (0.002)	6.44 (0.21)	<0.001
Subtypes of hypertensive disease			
E-HT	0.057 (0.002)	5.90 (0.24)	<0.001
HT-HD	−0.013 (0.003)	−1.26 (0.33)	0.002
HT-CKD	0.054 (0.003)	5.54 (0.30)	<0.001
HT-HD-CKD	0.009 (0.001)	0.94 (0.11)	<0.001
S-HD	−0.020 (0.017)	−2.00 (1.76)	0.27
Women			
Total hypertensive disease	0.055 (0.002)	5.64 (0.19)	<0.001
Subtypes of hypertensive disease			
E-HT	0.052 (0.002)	5.32 (0.21)	<0.001
HT-HD	−0.025 (0.004)	−2.46 (0.41)	<0.001
HT-CKD	0.040 (0.002)	4.13 (0.24)	<0.001
HT-HD-CKD	0.007 (0.001)	0.66 (0.10)	<0.001
S-HT	0.002 (0.016)	0.19 (1.62)	0.91

Hypertensive disease (ICD-9: 401 to 405).
Estimated annual % change = $100 \times (e^{b}-1)$.
E-HT = essential hypertension; HT-CKD = hypertensive CKD; HT-HD = hypertensive heart disease; HT-HD-CKD = hypertensive heart and CKD; SE = standard error; S-HT = secondary hypertension.

$У_i = a + \beta\chi_i$, in which $У_i$ is the natural logarithm of the rates and χ_i is calendar years.[9,10] The estimated percentage change was computed using $100 \times (e^{\beta}-1)$.

In the fourth-group data analyses, we applied multivariate logistic regression analysis technique to estimate odds ratios of risk factors for hospitalizations due to first and any second to seventh diagnosis of hypertensive disease. These risk factors included age (per 10 years), gender (men vs women), regions (Northeast, Midwest, South, and West), and survey periods (1990 to 1999 and 2000 to 2007 vs 1980 to 1989).

In the study, we did not analyze racial or ethnical differences because >10% to 20% of patients had missing data on race or ethnicity in the NHDS.

All data analyses were performed using SAS software version 9.2 (SAS Institute Inc., Cary, North Carolina, 2010). SAS survey procedures that take into account the complex sample design of the NHDS were used.

Results

Table 1 lists the significant differences in mean age and prevalence of hospitalized patients with first and any second to seventh diagnosis of hypertensive disease, except for women and those living in the Midwest region of the United States with the first diagnosis of hypertensive disease from 1980 to 1981 to 2006 to 2007.

Age-adjusted prevalence rates of hypertensive disease with first diagnosis increased from 1.74% in 1980 to 1981 to 2.06% in 2006 to 2007 in men ($p = 0.003$), and from 2.00% to 2.09% in women ($p = 0.06$) during the same period. The age-adjusted prevalence for those with any second to seventh diagnosis of hypertensive disease increased from 7.06% in 1980 to 1981 to 35.09% in 2006 to 2007 in men ($p < 0.001$) and from 7.88% to 31.98% in women ($p < 0.001$) during the same period. Figure 1 depicts the trend in log values that among those with any second to seventh diagnosis, essential hypertension, hypertensive CKD, and hypertensive heart and CKD dramatically increased from 1980 to 1981 to 2006 to 2007 in men and women.

The annual percent increase in the rate of those with the first diagnosis of hypertensive disease was 1.44% in men (test for trend, $p = 0.003$) and 0.96% in women ($p = 0.06$; Table 2). The annual percent increase in those with any second to seventh diagnosis of hypertensive disease was 6.44% in men ($p < 0.001$) and 5.64% in women ($p < 0.001$). Subtypes essential hypertension and hypertensive CKD were the top 2 contributors to the increasing trends in both genders.

Figure 2 depicts the increasing trends in age-adjusted prevalence of hypertensive disease with any second to seventh diagnosis in 4 regions of the country. Subjects living in the Western region had the lowest prevalence of hypertensive disease in both men and women, and subjects living in the South had the highest prevalence in men (36.68%) and women (34.23%) in 2006 to 2007. Similar geographic variations, with the highest rates in the South, were observed in patients with the first diagnosis of hypertensive disease (data not shown).

Table 3 lists the multivariate-adjusted odds ratios of associated predictors for hypertensive disease in the total study periods. Patients in 2000 to 2007 had 1.22 times higher risk (95% confidence interval 1.19 to 1.25) of hospitalization with first diagnosis of hypertensive disease, and had 4.02 times higher risk (95% confidence interval 3.99 to 4.09) of hospitalization with any second to seventh diagnosis of hypertensive disease than their corresponding counterparts in 1980 to 1989. Patients living in the South had 1.36 times higher risk (1.31 to 1.40), and 1.21 times higher risk of hospitalization with first, and any second to seventh diagnosis of hypertensive disease than those who lived in the West.

Discussion

The present study has 4 principal findings: (1) the prevalence of hospitalized patients with first diagnosis of hypertensive disease significantly increased in men from 1980 to 2007 (an annual 1.44% increase), (2) the annual percent increases in hospitalized patients with any second to seventh diagnosis of hypertensive disease significantly increased in men (6.44%) and women (5.64%) from 1980 to 2007, (3) patients with co-morbid hypertensive CKD rapidly increased in men (an annual 5.54% increase) and women (an annual 4.13% increase) during the study period, and (4)

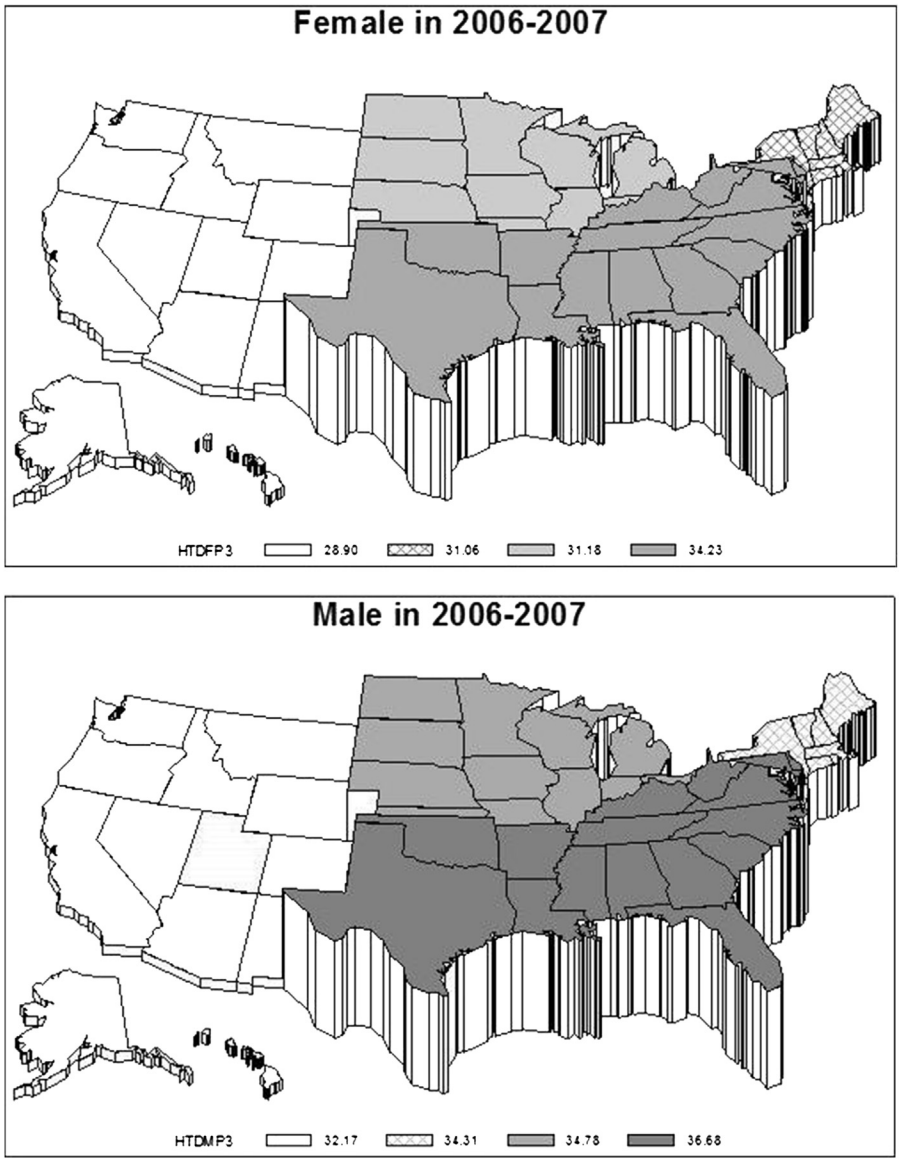

Figure 2. Mapping the age-adjusted prevalence (%) of hospitalized patients with any second to seventh diagnosis of hypertensive diseases across 4 United States regions by gender in NHDS 2006 to 2007.

people living in the Southern United States had the highest prevalence of co-morbid hypertensive disease compared with those living in the other regions in 2006 to 2007.

The prevalence of hypertensive disease (including hypertension and subtypes of hypertension-related disease) has been extensively studied in noninstitutional (nonhospitalized) populations.[3–6] However, until now there was little information on the burden of hospitalization attributable to hypertensive disease. The present study is the first to examine a 28-year trend of hospitalized patients with first and any second to seventh diagnosis of hypertensive disease. The significantly increased trend of those with any second to seventh diagnosis could be attributable to an increase in risk factors, but could also have better captured the co-morbidities of admitted patients as physicians are more attuned to the relation between baseline co-morbidities and outcomes. Although a detailed analysis related to the cause of hospitalization due to hypertensive disease is beyond the data availability in the present study, findings from our study emphasize an increased burden of hospitalization in patients with hypertensive disease.

The study confirmed a decreased trend in hypertensive heart disease, which is consistent with a decreased trend in heart disease in recent decades.[10] However, the present study adds to new evidence of a rapid and significant increasing trend in patients with second to seventh diagnosis of hypertensive CKD. Although this increase may be partly because of an increased awareness of CKD and the fact that it is easier to diagnose CKD using creatinine, this increased trend in CKD is very likely attributable to the increased trend of patients with hypertension.[11–18] Although a cause-effect relation between hypertension and CKD cannot be interpreted using data from the present study because of the nature of the cross-sectional study design, great attention

Table 3
Multivariate-adjusted odds ratios (95% confidence interval [CI]) of age, gender, survey year, and regions for patients with first or any second to seventh diagnosis of hypertensive diseases, NHDS 1980 to 2007

Variable	Hypertensive Disease					
	First Diagnosis			Second to Seventh Diagnosis		
	OR	95% CI	p	OR	95% CI	p
Age per 10 yrs	1.01	1.00−1.01	0.04	1.27	1.27−1.28	<0.0001
Men vs women	1.16	1.13−1.19	<0.0001	1.08	1.07−1.08	<0.0001
Survey year						
1980−1989	1			1		
1990−1999	1.03	1.01−1.06	0.01	2.17	2.15−2.19	<0.0001
2000−2007	1.22	1.19−1.25	<0.0001	4.02	3.99−4.06	<0.0001
Test for trend	<0.0001			<0.0001		
Regions						
Northeast vs West	1.11	1.07−1.15	0.29	1.17	1.15−1.18	<0.0001
Midwest vs West	1.05	1.02−1.09	<0.0001	1.13	1.11−1.14	<0.0001
South vs West	1.36	1.31−1.40	<0.0001	1.12	1.11−1.13	<0.0001

First diagnosis of hypertensive disease: patients with first diagnosis of disease (ICD-9: 401-405).
Second to seventh diagnosis of hypertensive disease: patients with any second to seventh diagnosis of disease (ICD-9: 401-405).
OR = odds ratio.

should be paid to this increase in patients with hypertensive CKD. Hypertensive CKD may represent a silent epidemic and may subsequently lead to an increased risk of mortality from heart disease and stroke.

Geographic variations in the prevalence of hypertension in general population have been reported. The present study extended previous studies by providing evidence of the prevalence of hypertensive disease in hospitalized patients, with the highest rate in the southern United States. Although further studies are requested to examine the determinants of hypertensive disease, findings from the present study emphasize health disparity issue in the disease distribution across the regions.

Strengths of the present study include a nationally representative sample of adults in the United States, substantial sample size, a 28-year study period, and a vigorous and hypothesis-driven biostatistical analysis. However, the results of the present study should be interpreted in light of several considerations. First, the NHDS did not include Veteran Affair or military hospitals, which may result in underestimating the overall prevalence of patients with hypertensive disease in the country. Second, as in similar studies, administrative datasets do not record exact reasons for admission, such as whether patients have well or poorly controlled hypertension, and it may also contain bias in disease diagnoses because of the procedures of disease assessments in different hospitals. Third, the NHDS did not include information about readmission status. It is not possible to identify patients who had multiple hospitalizations from the NHDS. Thus the trends reflect the number of hospitalizations rather than individuals. Although a portion of the increase in hypertensive disease might have been derived from more frequent rehospitalizations of those diagnosed with hypertensive disease, this possibility is unlikely to explain the trend of a continuously increasing hypertensive disease rate in the past 28-year study period.[10,19]

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Disclosures

LL and YA contributed to the study concept and analysis design. LL had full access to the data used in the study, conducted data analysis, and wrote the manuscript. ZL participated in the data analysis and contributed to the mapping of disease using Geographic Information System. YA, MC, XH, ZL, EC, and HJE provided critical review and comments for important intellectual content of the manuscript.

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