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Differential Patterns and Outcomes of 20.6 Million Cardiovascular Emergency Department Encounters for Men and Women in the United States.

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ORIGINAL RESEARCH

Differential Patterns and Outcomes of 20.6 Million Cardiovascular Emergency Department Encounters for Men and Women in the United States

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BACKGROUND: We describe sex-differential disease patterns and outcomes of >20.6 million cardiovascular emergency department encounters in the United States.

METHODS AND RESULTS: We analyzed primary cardiovascular encounters from the Nationwide Emergency Department Sample between 2016 and 2018. We grouped cardiovascular diagnoses into 15 disease categories. The sample included 48.7% women; median age was 67 (interquartile range, 54–78) years. Men had greater overall baseline comorbidity burden; however, women had higher rates of obesity, hypertension, and cerebrovascular disease. For women, the most common emergency department encounters were essential hypertension (16.0%), hypertensive heart or kidney disease (14.1%), and atrial fibrillation/flutter (10.2%). For men, the most common encounters were hypertensive heart or kidney disease (14.7%), essential hypertension (10.8%), and acute myocardial infarction (10.7%). Women were more likely to present with essential hypertension, hypertensive crisis, atrial fibrillation/flutter, supraventricular tachycardia, pulmonary embolism, or ischemic stroke. Men were more likely to present with acute myocardial infarction or cardiac arrest. In logistic regression models adjusted for baseline covariates, compared with men, women with intracranial hemorrhage had higher risk of hospitalization and death. Women presenting with pulmonary embolism or deep vein thrombosis were less likely to be hospitalized. Women with aortic aneurysm/dissection had higher odds of hospitalization and death. Men were more likely to die following presentations with hypertensive heart or kidney disease, atrial fibrillation/flutter, acute myocardial infarction, or cardiac arrest.

CONCLUSIONS: In this large nationally representative sample of cardiovascular emergency department presentations, we demonstrate significant sex differences in disease distribution, hospitalization, and death.

Key Words: atrial fibrillation ■ essential hypertension ■ men ■ sex characteristics ■ stroke ■ United States ■ women

There are major differences in cardiovascular disease (CVD) patterns and outcomes between men and women.[1] Biological factors, sociodemographics, and health inequalities are key determinants of these sex-differential disease susceptibilities.[2–4] Complex psychosocial factors may also drive differences in health-seeking behaviors and health care use patterns in men and women, which may, in turn, influence health outcomes.[5–7]

Previous studies have highlighted differences in disease distribution among men and women hospitalized with CVD, as well as sex disparities in hospital treatments and in subsequent clinical outcomes.[8–11]

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CLINICAL PERSPECTIVE

What Is New?

- In this nationally representative sample of >20.6 million cardiovascular emergency presentations, we demonstrate differences in baseline disease burden, cardiovascular disease susceptibility, and clinical outcomes of men and women.
- The most common emergency department encounters in women were essential hypertension (16.0%), hypertensive heart or kidney disease (14.1%), and atrial fibrillation/flutter (10.2%). For men, the most common encounters were hypertensive heart or kidney disease (14.7%), essential hypertension (10.8%), and acute myocardial infarction (10.7%).
- Although women appeared lower risk overall, their risk of death was augmented within specific cardiovascular diseases, indicating potential target areas for health care improvement.

What Are the Clinical Implications?

- Our findings highlight differences in cardiovascular health care needs of men and women, which may be used to inform service planning and provision.
- In addition, our work encourages further research to understanding the underlying biologic and sociodemographic factors driving differential cardiovascular disease patterns and outcomes in men and women.

Nonstandard Abbreviations and Acronyms

NEDS	Nationwide Emergency Department Sample
SVT	supraventricular tachycardia

However, as these studies are limited to inpatients, they do not account for differential propensity to hospitalize men and women. Furthermore, they overlook the highest-risk patients who may not survive the first medical contact before admission. Thus, existing work presents an incomplete picture of sex disparities in acute cardiovascular care.

The emergency department (ED) is typically the first point of contact for patients presenting with acute CVD. The encounters and outcomes in the ED have the potential to importantly alter the trajectory of patients' diagnostic and treatment pathways. Existing work indicates sex differences in risk stratification and in the manifestation of symptoms in ED presentations.[12–14] Several others have identified, more specifically, sex differences in presentation, management, and outcomes of patients presenting with chest pain or suspected acute coronary syndrome (ACS).[15–18] However, there are limited data comparing the distribution and outcomes from a wider range of CVD ED presentations in men and women. Such analyses are key to understanding disparities in health care needs, informing service planning and provision, and reducing health inequalities.

We studied ED encounters in adults with a primary CVD diagnosis from the Nationwide Emergency Department Sample (NEDS) between 2016 and 2018, including >20.6 million nationally representative ED encounters in the United States. We first described disease-specific distribution of CVDs across 15 diagnostic categories, separately for men and women. Second, we examined sex differences in 2 key clinical outcomes of hospitalization and death separately for each CVD category, while adjusting for baseline sociodemographic and clinical factors.

METHODS

The data underlying this article are available through the NEDS at https://www.hcup-us.ahrq.gov/nedsoverview.jsp.

Data Source and Analysis Sample

The NEDS[19] is the largest all-payer ED database in the United States. Unweighted, it includes data from >30 million ED visits each year. Weighted, it estimates ≈145 million nationally representative ED encounters. The data set comprises discharge data for ED visits from 989 hospitals located in 40 States and the District of Columbia, approximating a 20% stratified sample of US hospital-owned EDs. The NEDS captures patients initially seen in the ED and subsequently admitted to the same hospital, as well as ED visits that do not result in a direct admission (ie, treat and release or transfer to another hospital).

Each ED encounter includes associated diagnostic labels recorded according to the *International Classification of Diseases* (*ICD*) codes, which from 2016 onward are as per the *International Classification of Diseases, Tenth Revision* (*ICD-10*). Patient demographic characteristics (eg, sex, age, race and ethnicity, urban-rural designation of residence, and national quartile of median household income for patient's ZIP code), expected payment source (eg, Medicare, Medicaid, private insurance, self-pay, no charge, and other insurance type), and hospital characteristics (eg, region, trauma center indicator, urban-rural location, and teaching status) are also available. In addition, there is record of whether an ED encounter resulted in admission. For those admitted, information is available

on inpatient stay, such as total charges and length of stay. Discharge destination is available for patients who were treated in the ED and not admitted directly to the hospital (eg, released home and transferred). ED and in-hospital all-cause death data are also available. For the present study, we included all ED encounters in adults (aged ≥18 years) with a primary CVD diagnosis recorded between 2016 and 2018. Cases with missing data on age, sex, or mortality were excluded from the analysis. Cases excluded because of missing data represented 0.2% (n=43 227) of the original data set (Figure S1).

Ethical Approval Statement

This study was conducted using anonymized routine health data. Ethical approval was not required.

Cardiovascular Diseases

CVDs were ascertained according to *ICD-10* codes and grouped into the following 15 disease categories: acute myocardial infarction (AMI; I21–I22), ischemic stroke (I63), intracranial hemorrhage (I60–I62), essential hypertension (I10), hypertensive crisis (I16), hypertensive heart or kidney disease (I11–I13), aortic aneurysm or dissection (I71), heart failure (I50), atrial fibrillation (AF)/flutter (I48), supraventricular tachycardia (SVT; I47.1), cardiac arrest (I46), pulmonary embolism (PE; I26), deep vein thrombosis (I82.4), valvular heart disease (I34–I37), and pericarditis (I30). These disease categories were selected to identify a broad range of acute conditions that could be unambiguously defined from *ICD-10* codes and reliably diagnosed in the ED setting. The diagnostic codes used are based on codes recorded at completion of the ED encounter.

Outcomes

The outcomes of interest were hospitalization and death. Hospitalization was extracted from NEDS discharge destination data. Deaths were also available from NEDS and include all-cause death after ED presentation; we examined separately (1) ED death and (2) overall deaths, with the latter including deaths in ED and subsequent in-hospital deaths.

Statistical Analysis

Continuous variables are presented as median (25th–75th percentile), attributable to skewed data. Categorical data are presented as frequencies and percentages. Categorical variables were compared using the Pearson χ^2 test. Continuous variables were compared using Mann-Whitney *U* test. All analyses were weighted using the provided discharge weights, as per Healthcare Cost and Utilization Project recommendations.[20]

We calculated the proportion of admissions attributed to each CVD category, separately for men and women. We calculated the rates of hospitalization and death, stratified by primary CVD diagnosis and sex. We used multivariable logistic regression to estimate the association of sex (exposure of interest) with (1) hospitalization, (2) ED death, and (3) overall death (each set individually as the model outcome). Associations were examined separately for each CVD category. We excluded individuals who died in ED from the hospital admission outcome analysis. Hierarchical multilevel modeling was used to account for clustering/nesting of observations, by adjusting for the ED stratification and hospital clustering.[21] We further adjusted for the following covariates: region of hospital, location/teaching status of hospital, income, age, weekend admission, primary expected payer, smoking status, previous myocardial infarction, previous cerebrovascular accident, dementia, dyslipidemia, obesity, thrombocytopenia, and other comorbidities (malignancy, anemias, chronic lung disease, coagulopathy, diabetes, liver disease, peripheral vascular disorders, and chronic renal failure). The associations are reported as odds ratios (ORs), along with the corresponding 95% CIs and *P* values. Statistical analysis was performed on IBM SPSS version 26 and Stata MP version 17.0. Statistical significance was based on the 2-tailed 0.05 level, without any multiplicity adjustment.

RESULTS

Baseline Characteristics

The analysis sample comprised 20.6 million weighted ED encounters in adults (48.7% women) with a primary cardiovascular diagnosis and recording of baseline demographics that fulfilled inclusion criteria (Figure 1 and Figure S1). The baseline characteristics of the sample are summarized in Table 1. The median age for men was lower than for women (64 versus 69 years). Most encounters were recorded in metropolitan hospitals (85.0%), with the majority being in teaching centers (58.9%). The payer for most encounters was Medicare or Medicaid (68.6%). Men were more likely to be uninsured or to have their encounter covered privately.

Overall, men had greater preexisting comorbidity burden than women, particularly with regard to cardiometabolic risk factors (Table 1). Men were more likely to be smokers and were more likely to have dyslipidemia, diabetes, previous AMI, or peripheral vascular disease. Women had higher rates of hypertension, obesity, anemia, cerebrovascular disease, and valvular heart disease.

Overall CVD Distribution and Outcomes

The most common reasons for ED visits for women were essential hypertension (16.0%), hypertensive

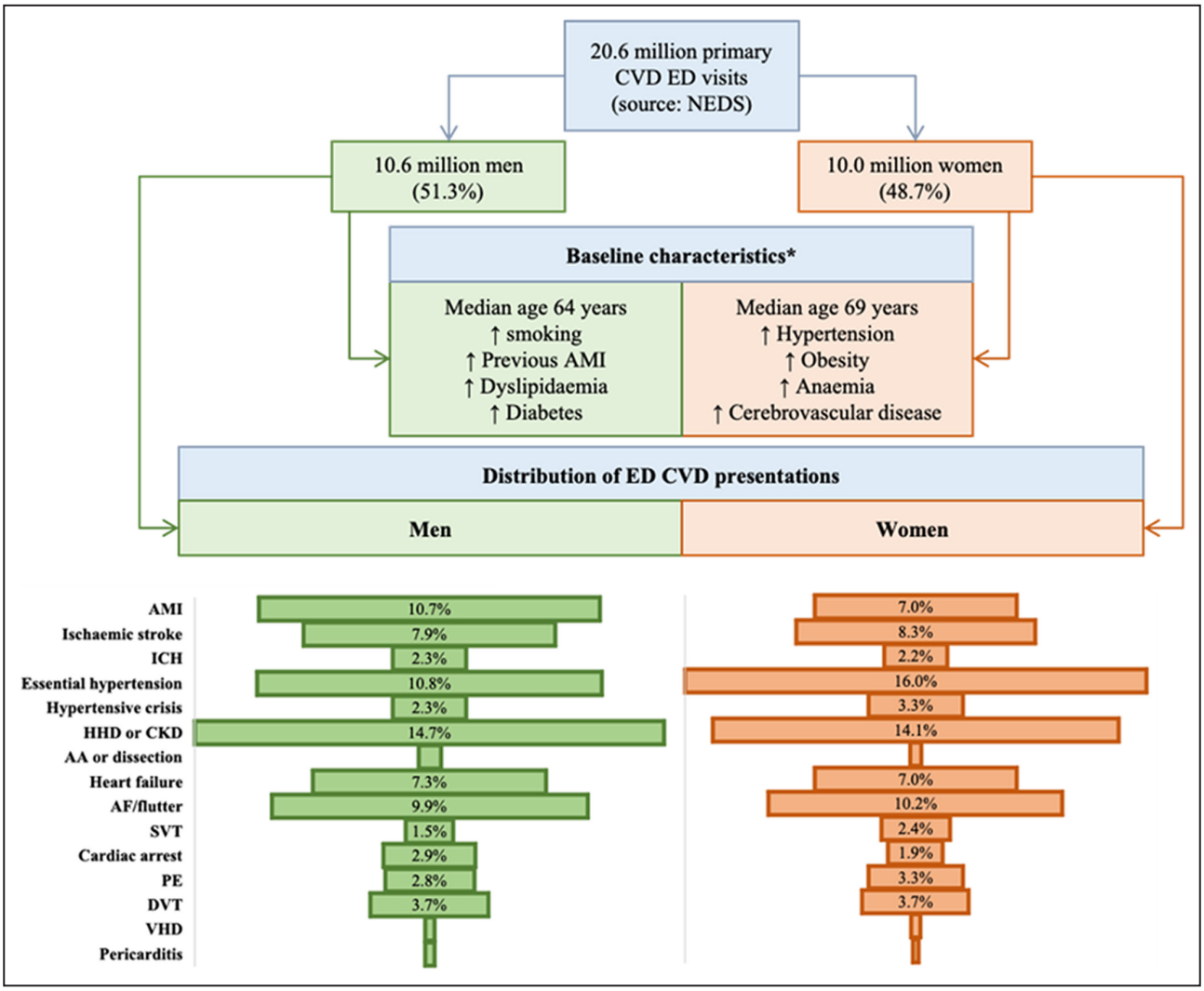

Figure 1. Overview of study sample and sex distribution of emergency department (ED) cardiovascular presentations.
*Arrows indicate relative frequency of risk factor (eg, there were more smokers among men than women). AA indicates aortic aneurysm; AF, atrial fibrillation; AMI, acute myocardial infarction; CKD, chronic kidney disease (hypertensive); CVD, cardiovascular disease; DVT, deep vein thrombosis; HHD, hypertensive heart disease; ICH, intracranial hemorrhage; NEDS, Nationwide Emergency Department Sample; PE, pulmonary embolism; SVT, supraventricular tachycardia; and VHD, valvular heart disease.

heart or kidney disease (14.1%), and AF/flutter (10.2%). For men, the top 3 ED encounters were hypertensive heart or kidney disease (14.7%), essential hypertension (10.8%), and AMI (10.7%). Women were significantly more likely than men to present with essential hypertension, hypertensive crisis, AF/flutter, SVT, PE, or ischemic stroke. However, men were more likely to present with AMI or cardiac arrest. Frequency of encounters with other conditions was generally comparable between men and women (Figure 2 and Table 2).

We observed sex differential rates of hospitalization and death, which varied between CVD categories. Discharge destinations are summarized in Table S1. Overall for women, the poorest clinical outcomes were observed after admission with an intracranial event (Tables 2 and 3). Following an ED encounter with intracranial hemorrhage, compared with men, women had significantly higher odds of hospitalization, death in ED, and overall death (Table 3). Women presenting with PE had lower odds of hospitalization. Following an AF/flutter encounter, women had higher odds of hospital admission, whereas men had greater odds of death in ED and overall death. Men with AMI had significantly higher odds of death in ED and overall death. Men also had poorer outcomes following visits with hypertensive heart or kidney disease, with greater odds of death in ED and overall death.

Hypertension and Related Conditions

For both men and women, essential hypertension, hypertensive crises, and hypertension-related end-organ damage were prominent reasons for ED visits (Table 2

Table 1. Baseline Participant Characteristics and Summary of Outcomes

Variable	Whole cohort	Men	Women	*P* value*
Weighted records, n (%)	20637269	10593137 (51.3)	10044132 (48.7)	
Age, median (IQR), y	67 (54–78)	64 (53–75)	69 (56–81)	<0.001
Hospital location, %				
Northeast	17	17.1	17	<0.001
Midwest	22.6	22.2	23	
South	42.4	42	42.9	
West	17.9	18.7	17.1	
Hospital location/teaching status, %				
Metropolitan nonteaching	26.1	25.9	26.3	<0.001
Metropolitan teaching	58.9	59.3	58.4	
Nonmetropolitan	15.4	14.8	15.4	
Weekend admission	24.6	24.5	24.6	
Median ZIP code income, %				
First quartile	33.2	32.6	33.8	<0.001
Second quartile	27.1	27.1	27.1	
Third quartile	21.7	21.8	21.5	
Fourth quartile	18	18.5	17.6	
Expected primary payer, %				
Medicare	56.7	52.2	61.4	<0.001
Medicaid	11.9	12.2	11.6	
Private	22.2	24.3	19.9	
Uninsured	6.4	7.6	5.2	
No charge	0.3	0.4	0.3	
Other	2.5	3.4	1.6	
Prevalent baseline comorbidities, %				
Previous AMI	9	10.9	6.9	<0.001
Cerebrovascular disease	5.7	5.6	5.9	<0.001
Heart failure	31.1	31.8	30.3	<0.001
Valvular disease	8.9	8.0	9.7	<0.001
Atrial fibrillation/flutter	26.3	26.8	25.8	<0.001
Hypertension	75.5	74.4	76.6	<0.001
Dyslipidemia	37.6	39.3	35.8	<0.001
Diabetes	30.2	31.1	29.2	<0.001
Smoking	35.2	41.5	28.4	<0.001
Peripheral vascular disease	5.7	5.9	5.4	<0.001
Chronic lung disease	19	17.8	20.2	<0.001
Chronic renal failure	20.9	22.5	19.2	<0.001
Obesity	12.6	12.1	13.0	<0.001
Anemia	15.8	15.1	16.5	<0.001
Thrombocytopenia	2.8	3.4	2.1	<0.001
Coagulopathy	1.3	1.3	1.3	<0.001
Dementia	5.1	4	6.3	<0.001
Chronic liver disease	0.8	0.9	0.7	<0.001
Malignancy	3.4	3.7	3.2	<0.001
Clinical outcomes				
Inpatient admission, %	50.7	52.3	49.1	<0.001
LOS, median (IQR), d	3 (2–6)	3 (2–5)	3 (2–6)	<0.001
Death (ED), %	2.2	2.6	1.7	<0.001
Death (in hospital), %	1.7	1.7	1.6	<0.001
Death (total), %	3.8	4.3	3.3	<0.001

AMI indicates acute myocardial infarction; ED, emergency department; IQR, interquartile range; and LOS, length of stay.
**P* value for men vs women.

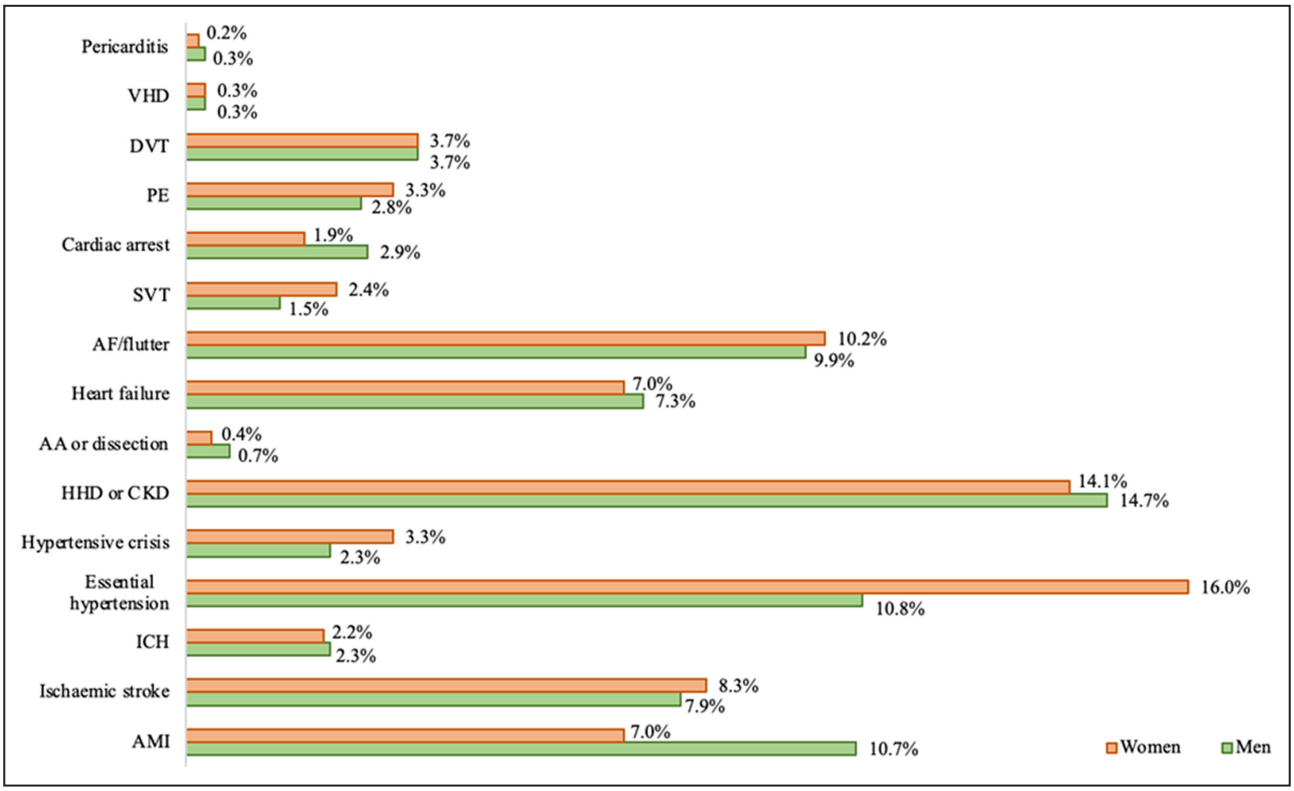

Figure 2. Emergency department encounters grouped into disease-specific categories expressed as percentages of all cardiovascular encounters separately for men (green) and women (orange).
AA indicates aortic aneurysm; AF, atrial fibrillation; AMI, acute myocardial infarction; CKD, chronic kidney disease (hypertensive); DVT, deep vein thrombosis; HHD, hypertensive heart disease; ICH, intracranial hemorrhage; PE, pulmonary embolism; SVT, supraventricular tachycardia; and VHD, valvular heart disease.

and Figure 2). Essential hypertension was the most common diagnosis among women, accounting for 16.0% of all primary CVD encounters. Men were less likely to be labeled with essential hypertension as their primary diagnosis (10.8% of all CVD attendances). The rates of hospitalization after an encounter with essential hypertension were low for both men and women (2.6% and 2.8%, respectively), and there were few associated deaths (<0.1%) (Table 2 and Figure 3).

Although women were more likely to present with an acute hypertensive crisis (Table 2), they were less likely to be subsequently admitted (Table 3). After adjustment for baseline covariates, women had significantly lower odds of hospitalization (OR, 0.87 [95% CI, 0.85–0.90]; $P<0.001$) or death (OR, 0.66 [95% CI, 0.48–0.92]; $P=0.01$) following such presentations (Table 3).

Women were less likely than men to present with late-stage end-organ consequences of hypertension: specifically, hypertensive heart or kidney disease. These presentations required hospitalization in over three quarters of cases. In fully adjusted models, women had lower odds of hospitalization (OR, 0.92 [95% CI, 0.88–0.96]; $P<0.001$), death in ED (OR, 0.67 [95% CI, 0.45–0.99]; $P=0.05$), or overall death (OR, 0.76 [95% CI, 0.71–0.82]; $P<0.001$) following such presentations (Table 3). Women also had fewer presentations with aortic aneurysm or dissection than men (0.4% versus 0.7%); however, they had both significantly higher odds of hospitalization (OR, 1.08 [95% CI, 1.00–1.16]; $P=0.05$) and death (OR, 1.11 [95% CI, 1.02–1.21]; $P=0.02$) (Table 3).

AMI and Related Conditions

AMI presentations were significantly more common in men than in women (Figures 2 and 3 and Table 2). Men presenting with AMI had significantly higher risk of death both in the ED and overall (Table 3).

Men were more likely to present with cardiac arrest than women (2.9% versus 1.9%; $P<0.001$) and had higher odds of death following such presentations. Following an ED visit with cardiac arrest, in fully adjusted models, compared with men, women had significantly lower odds of death in ED (OR, 0.90 [95% CI, 0.87–0.94]; $P=0.01$) and lower odds of overall death (OR, 0.94 [95% CI, 0.87–0.99]; $P=0.04$). Accordingly, women had significantly higher odds of hospitalization following such encounters (OR, 1.17 [95% CI, 1.06–1.18]; $P<0.001$).

Table 2. Summary of the Distribution of Cardiovascular Presentations and Outcomes by Sex and Disease

Variable	Whole cohort	Men	Women	*P* value
Acute myocardial infarction, n (%)	1 829 582 (8.9)	1 129 478 (10.7)	700 104 (7.0)	<0.001
Death (ED), %	0.6	0.6	0.7	<0.001
Death (overall), %	4.2	4.0	4.7	<0.001
Hospitalization, %	79.1	78.9	79.5	<0.001
Length of stay, median (IQR), d	3 (2–5)	3 (2–5)	3 (2–5)	<0.001
Ischemic stroke, n (%)	1 662 441 (8.1)	834 387 (7.9)	828 054 (8.3)	<0.001
Death (ED), %	0.1	<0.1	0.1	<0.001
Death (overall), %	2.9	2.7	3.1	<0.001
Hospitalization, %	79.8	79.4	80.2	<0.001
Length of stay, median (IQR), d	3 (2–6)	3 (2–6)	3 (2–6)	<0.001
Intracranial hemorrhage, n (%)	460 816 (2.2)	239 587 (2.3)	221 229 (2.2)	<0.001
Death (ED), %	1.2	0.9	1.5	<0.001
Death (overall), %	13.5	12.5	14.7	<0.001
Hospitalization, %	61.4	61.6	61.1	<0.001
Length of stay, median (IQR), d	5 (2–10)	5 (2–10)	5 (2–10)	<0.001
Essential hypertension, n (%)	2 750 235 (13.3)	1 141 325 (10.8)	1 608 910 (16.0)	<0.001
Death (ED), %	<0.1	<0.1	<0.1	<0.001
Death (overall), %	<0.1	<0.1	<0.1	<0.001
Hospitalization, %	2.7	2.6	2.8	<0.001
Length of stay, median (IQR), d	2 (1–3)	2 (1–3)	2 (1–3)	0.01
Hypertensive crisis, n (%)	573 542 (2.8)	239 088 (2.3)	334 454 (3.3)	<0.001
Death (ED), %	<0.1	<0.1	<0.1	<0.001
Death (overall), %	0.1	0.1	0.1	<0.001
Hospitalization, %	49	51.8	47.1	<0.001
Length of stay, median (IQR), d	2 (1–4)	2 (1–4)	2 (1–4)	0.003
Hypertensive heart or kidney disease, n (%)	2 978 454 (14.4)	1 560 507 (14.7)	1 417 947 (14.1)	<0.001
Death (ED), %	<0.1	<0.1	<0.1	0.20
Death (overall), %	1.7	1.8	1.7	<0.001
Hospitalization, %	75.3	74.6	76.0	<0.001
Length of stay, median (IQR), d	4 (2–6)	4 (2–6)	4 (3–6)	<0.001
Aortic aneurysm or dissection, n (%)	121 175 (0.6)	67 785 (0.7)	44 390 (0.4)	<0.001
Death (ED), %	2.7	2.5	3.2	<0.001
Death (overall), %	9.1	8.3	10.4	<0.001
Hospitalization, %	44.8	44.5	45.4	0.002
Length of stay, median (IQR), d	5 (2–9)	5 (2–10)	5 (2–9)	<0.001
Heart failure, n (%)	1 476 720 (7.2)	775 088 (7.3)	701 632 (7.0)	<0.001
Death (ED), %	0.1	0.1	0.1	0.24
Death (overall), %	1.8	1.7	1.8	<0.001
Hospitalization, %	62.1	61.1	63.2	<0.001
Length of stay, median (IQR), d	4 (2–6)	4 (2–6)	4 (2–6)	<0.001
Atrial fibrillation/flutter, n (%)	2 056 294 (10.0)	1 040 889 (9.9)	1 014 405 (10.2)	<0.001
Death (ED), %	<0.1	<0.1	<0.1	0.18
Death (overall), %	0.5	0.4	0.6	<0.001
Hospitalization, %	50.5	49.1	52.0	<0.001
Length of stay, median (IQR), d	3 (2–4)	2 (1–4)	3 (2–4)	<0.001
Supraventricular tachycardia, n (%)	395 098 (1.9)	158 835 (1.5)	236 263 (2.4)	<0.001
Death (ED), %	<0.1	<0.1	<0.1	0.05

(*Continued*)

Table 2. Continued

Variable	Whole cohort	Men	Women	*P* value
Death (overall), %	0.1	0.2	0.1	<0.001
Hospitalization, %	23.7	27.0	21.5	<0.001
Length of stay, median (IQR), d	2 (1–4)	2 (1–4)	2 (1–4)	0.001
Cardiac arrest, n (%)	495 406 (2.4)	304 532 (2.9)	190 874 (1.9)	<0.001
Death (ED), %	82.7	83.4	81.5	<0.001
Death (overall), %	87.9	88.1	87.4	<0.001
Hospitalization, %	6.8	6.3	7.7	<0.001
Length of stay, median (IQR), d	2 (0–4)	2 (1–5)	1 (0–4)	0.006
Pulmonary embolism, n (%)	627 547 (3)	300 247 (2.8)	327 300 (3.3)	<0.001
Death (ED), %	0.2	0.2	0.2	0.23
Death (overall), %	2.4	2.3	2.6	<0.001
Hospitalization, %	76.1	75.8	76.4	<0.001
Length of stay, median (IQR), d	3 (2–5)	3 (2–5)	3 (2–5)	<0.001
Deep vein thrombosis, n (%)	759 795 (3.7)	388 420 (3.7)	371 375 (3.7)	<0.001
Death (ED), %	<0.1	<0.1	<0.1	0.83
Death (overall), %	0.3	0.2	0.3	<0.0001
Hospitalization, %	34.6	33.7	35.6	<0.001
Length of stay, median (IQR), d	3 (2–6)	3 (2–5)	3 (2–6)	<0.001
Valvular heart disease, n (%)	69 902 (0.3)	35 429 (0.3)	34 473 (0.3)	0.001
Death (ED), %	0.1	0.1	<0.1	<0.001
Death (overall), %	2.5	2.6	2.5	0.39
Hospitalization, %	75.1	78.1	72.0	<0.001
Length of stay, median (IQR), d	5 (2–10)	5 (2–11)	5 (2–9)	<0.001
Pericarditis, n (%)	54 266 (0.3)	35 292 (0.3)	18 974 (0.2)	<0.001
Death (ED), %	<0.1	<0.1	<0.1	0.32
Death (overall), %	0.5	0.4	0.5	0.11
Hospitalization, %	54.4	51.3	60.2	<0.001
Length of stay, median (IQR), d	2 (1–4)	2 (1–4)	3 (2–5)	<0.001

ED indicates emergency department; and IQR, interquartile range.

Despite similar rates of presentation with heart failure, women had greater odds of hospital admission (OR, 1.10 [95% CI, 1.08–1.12]; *P*<0.001), but lower odds of death either in the ED (OR, 0.95 [95% CI, 0.90–0.99]; *P*=0.05) or overall (OR, 0.93 [95% CI, 0.87–0.98]; *P*=0.02) (Table 3).

Stroke

Ischemic stroke appeared more commonly in women than men (8.3% versus 7.9%; *P*<0.001), with most cases (79.8% in whole cohort) being hospitalized (Table 2 and Figure 2). In fully adjusted models, women had higher odds of hospitalization following an ischemic stroke presentation (OR, 1.02 [95% CI, 1.00–1.04]; *P*=0.05) and had higher odds of death in ED (OR, 1.27 [95% CI, 1.01–1.53]; *P*=0.05), but they had slightly lower odds of death overall (OR, 0.92 [95% CI, 0.84–0.99]; *P*=0.05) (Table 3).

Intracranial hemorrhage was a less common presentation than ischemic stroke, occurring with comparable frequency in men and women. However, following an ED encounter with intracranial hemorrhage, women had significantly higher odds of hospitalization (OR, 1.04 [95% CI, 1.01–1.08]; *P*=0.04), death in the ED (OR, 1.41 [95% CI, 1.25–1.58]; *P*<0.001), or death overall (OR, 1.18 [95% CI, 1.14–1.22]; *P*<0.001).

Arrhythmias

Both AF/flutter and SVTs were more commonly recorded in women than men. The requirement for hospitalization was overall greater following AF/flutter (50.5% in whole cohort) than SVT (23.7% in whole cohort) presentations (Table 2 and Figure 3). Women with AF/flutter had higher odds of hospitalization (OR, 1.08 [95% CI, 1.05–1.12]; *P*<0.001) and longer length of stay (Figure S2), but lower odds of death in the ED (OR, 0.40 [95% CI, 0.25–0.65]; *P*<0.001) or overall death (OR, 0.91 [95% CI, 0.84–0.99]; *P*=0.03). Women with SVT had lower odds of hospitalization (OR, 0.79 [95% CI, 0.76–0.82]; *P*<0.001) and lower odds of overall death

Table 3. Odds of Hospitalization or All-Cause Death After ED Encounter With Specified Diseases in Women, Compared With Men, in Fully Adjusted Logistic Regression Models

Variable	Hospitalization*	ED death	Overall death
Any cardiovascular admission	0.89 (0.86–0.92) *P*<0.001	0.59 (0.54–0.64) *P*<0.001	0.72 (0.68–0.77) *P*<0.001
Acute myocardial infarction	0.96 (0.91–1.01) *P*=0.14	0.81 (0.77–0.84) *P*<0.001	0.91 (0.84–0.97) *P*=0.006
Ischemic stroke	1.02 (1.00–1.04) *P*=0.05	1.27 (1.01–1.53) *P*=0.05	0.92 (0.84–0.99) *P*=0.05
Intracranial hemorrhage	1.04 (1.01–1.08) *P*=0.04	1.41 (1.25–1.58) *P*<0.001	1.18 (1.14–1.22) *P*<0.001
Essential hypertension	1.01 (0.96–1.06) *P*=0.43	N/A	N/A
Hypertensive crisis	0.87 (0.85–0.90) *P*<0.001	N/A	0.66 (0.48–0.92) *P*=0.01
Hypertensive heart or kidney disease	0.92 (0.88–0.96) *P*<0.001	0.67 (0.45–0.99) *P*=0.05	0.76 (0.71–0.82) *P*<0.001
Aortic aneurysm or dissection	1.08 (1.00–1.16) *P*=0.05	1.02 (0.87–1.18) *P*=0.83	1.11 (1.02–1.21) *P*=0.02
Heart failure	1.10 (1.08–1.12) *P*<0.001	0.95 (0.90–0.99) *P*=0.05	0.93 (0.87–0.98) *P*=0.02
Atrial fibrillation/flutter	1.08 (1.05–1.12) *P*<0.001	0.40 (0.25–0.65) *P*<0.001	0.91 (0.84–0.99) *P*=0.03
Supraventricular tachycardia	0.79 (0.76–0.82) *P*<0.001	0.71 (0.24–2.10) *P*=0.54	0.74 (0.62–0.86) *P*<0.001
Cardiac arrest	1.17 (1.06–1.18) *P*<0.001	0.90 (0.87–0.94) *P*=0.01	0.94 (0.87–0.99) *P*=0.04
Pulmonary embolism	0.90 (0.87–0.93) *P*<0.001	1.05 (0.84–1.34) *P*=0.61	1.05 (0.98–1.13) *P*=0.14
Deep vein thrombosis	0.92 (0.90–0.94) *P*<0.001	1.07 (0.29–4.80) *P*=0.93	0.98 (0.81–1.18) *P*=0.83
Valvular heart disease	0.71 (0.65–0.78) *P*<0.001	N/A	0.92 (0.75–1.12) *P*=0.41
Pericarditis	1.01 (0.92–1.11) *P*=0.73	N/A	0.88 (0.48–1.43) *P*=0.51

Hierarchical multilevel modeling was used to account for clustering/nesting of observations (see Methods). Multivariable logistic regression models were further adjusted for: region of hospital, location/teaching status of hospital, income, age, weekend admission, primary expected payer, smoking status, previous myocardial infarction, previous cerebrovascular accident, dementia, dyslipidemia, obesity, thrombocytopenia, and other comorbidities (malignancy, anemias, chronic lung disease, coagulopathy, diabetes, liver disease, peripheral vascular disorders, and chronic renal failure). Each cell represents a separate model. The analysis sample for each model includes individuals with ED presentations indicated in the first column. The model outcomes are hospitalization or all-cause mortality (set separately), as indicated in column heads. The exposure of interest is sex, with male sex set as the reference level. The results are thus odds of the outcome in women, compared with men, while adjusting for the aforementioned covariates, expressed as an odds ratio (95% CI) and *P* value. ED indicates emergency department; N/A, not applicable indicates outcomes were too few to examine associations.

*Patients who died in ED were excluded from this analysis.

(OR, 0.74 [95% CI, 0.62–0.86]; *P*<0.001); there was no significant sex difference in ED deaths (Table 3).

Venous Thromboembolism

Although the frequency of deep vein thrombosis encounters was comparable among men and women (Figure 2 and Table 2), PE presentations were significantly more common in women (3.3%) than men (2.8%). A greater proportion of PE encounters resulted in hospital admission (76.1% in whole cohort) than deep vein thrombosis (34.6% in whole cohort) encounters (Table 2 and Figure 3). Compared with men, women had lower odds of hospitalization following ED visit with either PE (OR, 0.90 [95% CI, 0.87–0.93]; *P*<0.001) or deep vein thrombosis (OR, 0.92 [95% CI, 0.90–0.94]; *P*<0.001) (Table 3).

Valvular Heart Disease

Valvular heart disease was an uncommon reason for ED visit, accounting for only 0.3% of all CVD presentations for both men and women (Figure 2 and Table 2); of these, 78.1% required hospitalization in men and 72.0% required hospitalization in women (Figure 3 and Table 2). In fully adjusted models, following ED presentation with valvular heart disease, women had lower odds of inpatient admission than men (OR, 0.71 [95% CI, 0.65–0.78]; *P*<0.001). The proportion of deaths following valvular heart disease presentations was low

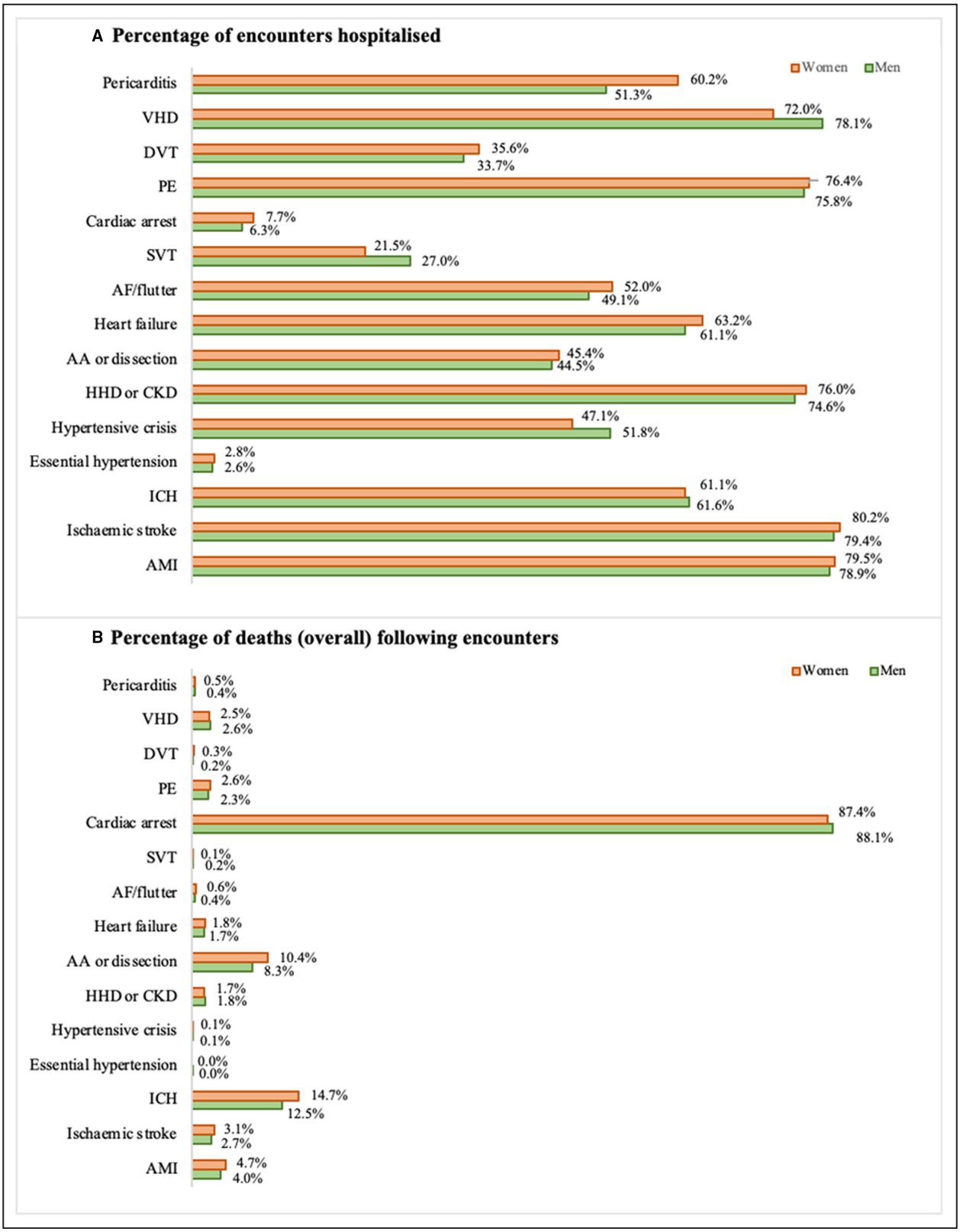

Figure 3. The percentage of cardiovascular encounters followed by hospitalization (A) or death (B), stratified by disease in men (green) and women (orange).

AA indicates aortic aneurysm; AF, atrial fibrillation; AMI, acute myocardial infarction; CKD, chronic kidney disease (hypertensive); DVT, deep vein thrombosis; HHD, hypertensive heart disease; ICH, intracranial hemorrhage; PE, pulmonary embolism; SVT, supraventricular tachycardia; and VHD, valvular heart disease.

(<3% for both men and women), and there was no evidence of sex differential risk of death (Table 3).

Pericarditis

A total of 0.2% of CVD encounters were attributed to pericarditis in women; the corresponding figure in men was 0.3% (Figure 2 and Table 2). Of the men presenting with pericarditis, 51.3% were hospitalized, compared with 60.2% of women (Figure 3 and Table 2). In models adjusting for demographic and clinical factors, there was no statistically significant difference in risk of hospitalization between men and women. Following presentation with pericarditis, 0.3% of women and 0.5% of the men died; the risk of death did not appear statistically different in fully adjusted models (Table 3).

DISCUSSION

Summary of Findings

In this large nationally representative sample of ED visits from the United States, we observed sex differences in the distribution of CVD presentations, hospitalization rates, and risk of death. The cohort presenting to ED with a primary CVD diagnosis included a smaller proportion of women, who were older than the men, and with a lower comorbidity burden. Men had poorer overall baseline cardiometabolic profile, although women had higher rates of obesity, hypertension, and cerebrovascular disease.

Women were more likely to present with essential hypertension, hypertensive crises, ischemic stroke, AF/flutter, SVT, or PE. Men were more likely to present with AMI or cardiac arrest. Women presenting with intracranial events, aortic aneurysm or dissection, and PE had higher odds of death than men. Men had higher odds of death following presentations with AMI, cardiac arrest, hypertensive heart or kidney disease, hypertensive crises, or heart failure. We also observed sex differences in the propensity toward hospital admission, which varied by CVD category.

Comparison With Existing Literature

Existing work has demonstrated sex differential patterns of CVD among hospitalized cohorts[8,9] and disparities in inpatient management and clinical outcomes of men and women.[10,11,22] However, as these studies are restricted to patients already admitted to hospital, they do not capture the differential tendency to hospitalize men and women. Furthermore, these studies exclude the highest-risk patients who may have died before hospitalization. Examining CVD encounters in the ED and their subsequent related outcomes provides a more complete picture of the cardiovascular health care needs of men and women, as it captures encounters before hospitalization. Existing studies of sex differences in CVD ED encounters are limited to studies of suspected ACS presentations.[15–17] Thus, in the present analysis, we aimed to better understand the full spectrum of the acute cardiovascular health care needs of men and women, by examining the distribution of 15 CVD diagnostic categories in men and women presenting to the ED, as well as sex disparities in hospitalization and subsequent risk of death.

A high proportion of ED CVD visits in our sample was attributed to hypertensive diseases. Essential hypertension was the most common CVD diagnosis in women and second most common in men. These presentations rarely resulted in inpatient admission (<3%), and there were few associated deaths, suggesting that these visits mostly related to routine management of uncomplicated hypertension. The use of the ED in this context is likely a reflection of limited access to more appropriate primary care services within the US health care system. Indeed, in nations with universal health care, such ED visits would be expected to be less frequent than was observed in our sample. Attendances for essential hypertension were more common in women, which may reflect higher rate of preexisting hypertension in women (76.6% versus 74.4%). These findings may also reflect poorer control of hypertension or poorer access to primary care in women. It is also possible that women were more diligent in seeking medical care for their suboptimally treated blood pressure. Indeed, previous work has demonstrated lower health care use by men across multiple health care settings.[6] Further supporting these suppositions, in our sample, although men were less likely to present to the ED with essential hypertension, they were slightly more likely to present with long-term consequences of hypertension-related end-organ damage (hypertensive heart or kidney disease) and were more likely to die following such presentations, suggesting longer duration of exposure to poorly controlled hypertension than women. On the other hand, women had higher rates of death following intracranial hemorrhage and aortic aneurysm/dissection presentations. Overall, it appears that there are sex differences in health-seeking behaviors for the management of hypertension and that, although both men and women may present with serious long-term consequences of poor hypertension control, the distribution and associated risks vary by sex.

A total of 10.0% of all CVD visits in the whole cohort was attributed to AF/flutter, occurring commonly in both men and women. The incidence and prevalence of AF are increasing in the general population,[23] driven largely by aging populations and clustering of cardiometabolic factors. We found AF/flutter ED visits to be more frequent in women than in men. This may be attributed to preponderance of several risk factors for AF among women in our sample; specifically, women

were older and had greater rates of obesity and hypertension than men. Greater obesity is thought to have a mechanistic role in perpetuating AF through electroanatomic remodeling.[24] Indeed, among the classic vascular risk factors, body mass index has been found to explain the largest proportion of AF risk.[25] Our findings highlight the growing importance of AF and highlight potential factors that may be driving sex differences in disease rates. Given the increasing burden of AF and its known associations with stroke and greater mortality,[25] evaluating multifactorial aspects of its pathophysiology and their relevance to sex-specific risk stratification and disease prevention strategies is a public health priority.

In our sample, women were more likely than men to attend the ED with PE. These findings may relate to female-specific risk factors for venous thromboembolism, such as obesity, contraceptive pill use, and pregnancy. These factors may predispose women to increased occurrence of PE, greater thrombotic burden, and the development of high-risk thromboembolisms. Indeed, in a large registry study of patients with acute PE, Tanabe et al[26] found a significantly greater number of severe cases with massive embolism and higher subsequent 30-day mortality risk in women compared with men. Our findings suggest greater propensity for PE in women. Our observation that women presenting with PE were less likely to be hospitalized may indicate that associated risks in women are underestimated.

As expected, AMI appeared more commonly in men than women. Although there was little sex difference in rates of hospitalization following AMI, men had significantly higher risk of death (both in the ED and overall). Furthermore, men were more likely to present with cardiac arrest and heart failure and had higher risk of subsequent death; although we cannot be certain about the underlying cause of these presentations, the most common cause for both conditions is coronary heart disease. Thus, our results suggest higher rates of AMI in men than women and greater risk of adverse associated outcomes, both in the context of the initial acute infarct and with regard to potential medium- and longer-term complications of cardiac arrest and heart failure. In a prospective analysis of 970 patients presenting to the ED with suspected ACS, Hess et al[17] report, similar to our findings, higher rates of confirmed AMI in men compared with women. They also report higher rates of coronary angiography in men than women, but state that this was appropriate for probability of disease.[17] Preciado et al[16] evaluated risk stratification of 34 715 patients presenting to the ED with suspected ACS. Consistent with our observations, they report higher risk of AMI and subsequent death in men compared with women.[16] As with Hess et al,[17] they additionally indicate that the higher risk in men is appropriately reflected in the risk stratification procedure. Similarly, in a smaller retrospective review of 182 patients presenting to ED with chest pain, Silbergleit and McNamara[27] report higher rates of hospitalization and evaluation for coronary artery disease in men than women, but do not find evidence of any difference in ED chest pain evaluations. These observations are further corroborated by Kaul et al,[28] who studied 54 134 patients presenting to the ED with suspected ACS; they report that although there were lower rates of hospitalization and coronary revascularization in women, this did not translate into poorer outcomes (in terms of 1-year mortality), indicating that these management decisions were likely to be appropriate. Our findings in this large cohort of patients presenting to the ED confirm previous reports of higher rates and risk of AMI in men than women.

Our findings indicate that, although there were disease-specific variations, following an ED visit with any CVD encounter, women were less likely to be hospitalized or to die (ED and overall), even after adjustment for baseline demographic and clinical variables. Consistently, in a study comparing risk stratification of 148 825 men and women in the ED, Candel et al[12] report higher risk of adverse outcomes for men across all triage categories and for almost all presenting complaints. Although this may indicate true higher risk of adverse outcomes in men, there may be several explanations for the observations in our study. First, it is possible that women have lower-risk acute CVD presentations that may be safely managed in the ED without requirement for inpatient care. Future insight may be gained by incorporating details of disease severity in future research. An alternative possibility is that there is disproportionate inappropriate discharge of women from the ED. Indeed, previous work has indicated that women experience longer system delays and delays in receiving correct CVD diagnoses and guideline-directed therapies.[3,29] Lower hospitalization rates also have a potential secondary impact on our observed risk of death. The death outcomes in our analysis include deaths in the ED or in hospital. As we do not track deaths outside the ED or hospital settings, there may be unobserved deaths in nonhospitalized individuals. If women are inappropriately discharged from ED and subsequently die at home or in another setting, these events will not be accounted for in our analysis. Thus, in this way, there is theoretically potential for artefactual underestimation of risk of death in women. On balance, it is likely that the lower rate of adverse outcomes in women is driven by genuine lower-risk presentations and perhaps inflated by lower tendency to hospitalization. Given strong evidence in previous work demonstrating systemic undertreatment of women, further studies looking at severity of disease presentations and tracking outcomes for the whole cohort are needed to allow more complete understanding of these issues and for definitive conclusions.

Our findings highlight important disparities in distribution and outcomes of cardiovascular ED encounters between men and women. A multitude of factors are likely implicated in driving these observed differences. Differences in patterns of CVD in men and women are well documented.[30–32] Although underlying biologic mechanisms are incompletely understood, differences in hormonal levels, cardiometabolic burden, and lifestyle factors have all been proposed as potential explanations.[33–35] Further mechanistic research is warranted to better understand the drivers of differences in propensity to specific CVDs in men and women. Such biologic factors likely partially explain the sex differences in our analysis. Socioeconomic and demographic disadvantages are further highly important considerations that influence both accessibility and quality of health care. Previous work has highlighted that ethnicity, educational level, income, employment status, and deprivation are important determinants of cardiovascular risk.[36,37] Our study contributes an important step toward describing, from an epidemiologic perspective, sex differences in emergency cardiovascular encounters and outcomes. There is need for further high-quality data to understand and address the specific factors driving differences in cardiovascular health care experiences of men and women

Strengths and Limitations

In using the NEDS resource, we were able to extract ED encounter-level data from a large nationally representative sample in the United States. This enabled examination of differential disease patterns and outcomes for a wide range of common and uncommon CVDs. The detailed baseline demographic and clinical data permitted comprehensive characterization of the study sample and adequate adjustment for confounders in modeling analyses. We used *ICD-10* codes for ascertainment of CVDs, which provided a standardized method for diagnostic classification. However, this approach may be subject to coding and misclassification errors. In our study, the diagnostic labels were based on codes recorded on discharge from the ED; at this early stage of presentation, the definitive diagnosis may not be apparent. Indeed, diagnoses in the ED may be revised once more information becomes available later in the patient journey. These potential errors are more problematic for conditions with insidious onset and potentially subjective diagnostic criteria (eg, pericarditis), and less so for conditions with more definitive diagnostic criteria (AMI and stroke). Another related important consideration is that our analysis would not have identified individuals who were incorrectly labeled with non-CVD diagnosis in the ED. Thus, we cannot evaluate whether misdiagnosis of CVD occurs differently amongst patient groups. Other pertinent issues include timing and accuracy of final cardiovascular diagnoses after the ED encounter. The present data source does not allow verification of the diagnostic labels beyond the ED. Further studies dedicated to examination of these considerations would be of interest. As the NEDS produces encounter-level data, we cannot distinguish multiple attendances by the same individual, and it is not possible to track longer-term outcomes at an individual patient level. Our analysis includes all-cause death, which is restricted to deaths occurring in the ED or within hospital. This is because deaths occurring outside of these settings or after longer periods of time are not covered by NEDS. Thus, we cannot evaluate deaths in individuals who were discharged from the ED. Furthermore, cause of death information is not available, which means that inferences about disease-specific mortality risk are not possible.

CONCLUSIONS

In this large nationally representative sample of cardiovascular ED presentations, we demonstrate differences in baseline disease burden, CVD susceptibility, and clinical outcomes of men and women. Although women appeared lower risk overall, their risk of death was augmented within specific CVDs, indicating potential target areas for health care education and improvement. Thus, our findings highlight differences in health care needs of men and women, which may be used to inform service planning and provision. In addition, our work encourages further research to understanding the underlying factors driving differential CVD patterns and outcomes in men and women.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Table S1
Figures S1–S2

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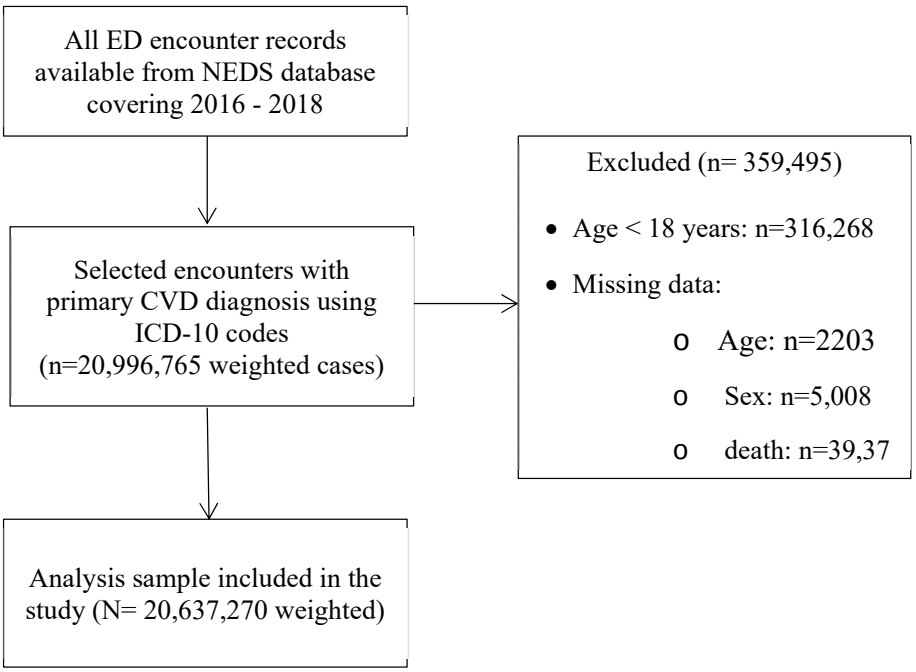
SUPPLEMENTAL MATERIAL

Table S1. Discharge destination

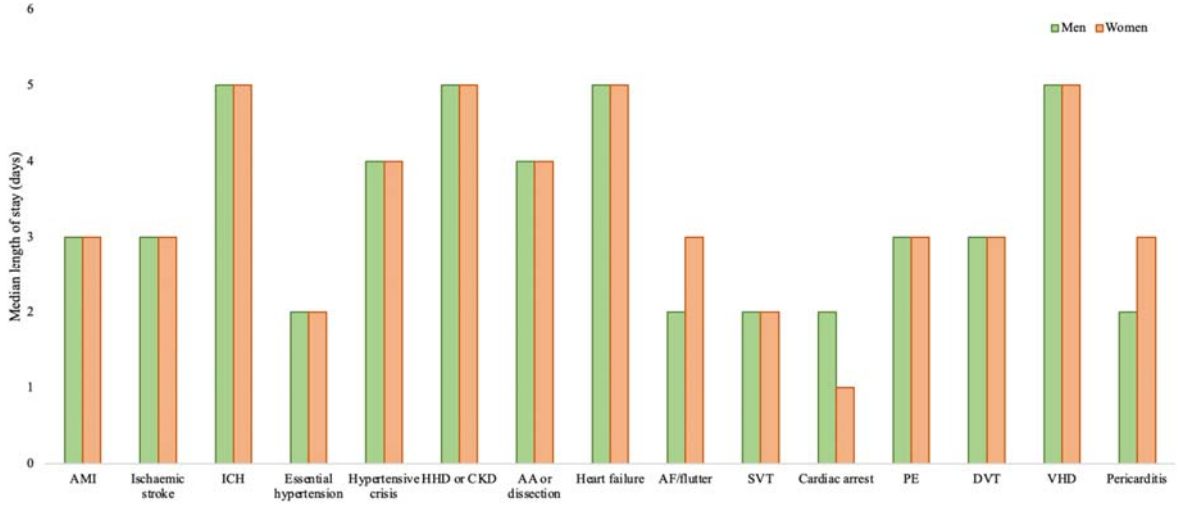
	Whole Cohort	Men	Women
Home	38.6%	36.1%	41.3%
Short term hospital	5.6%	6.1%	5.1%
Other (Nursing Facility, Intermediate Care Facility, etc)	1.4%	1.3%	1.4%
Home Health Care	0.5%	0.4%	0.6%
Against medical advice	1%	1.2%	0.8%
Inpatient admission	50.7%	52.3%	49.1%
Died in emergency department	2.2%	2.6%	1.7%

Figure S1. Sample selection flowchart



CVD: cardiovascular disease, ICD-10: international classification of disease 10th revision, NEDS: Nationwide Emergency Department Sample

Figure S2. Median length of stay for individuals hospitalised after emergency department encounter with specified cardiovascular diagnoses



AA: aortic aneurysm; AF: atrial fibrillation; AMI: acute myocardial infarction; CKD: chronic kidney disease (hypertensive); DVT: deep vein thrombosis; HHD: hypertensive heart disease; ICH: intracranial haemorrhage; PE: pulmonary embolism; VHD: valvular heart disease