Thirty-Day Readmissions After Hospitalization for Hypertensive Emergency

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Abstract—Hypertensive emergency is a clinical entity with potentially serious health implications and high healthcare utilization. There is a lack of nationally representative data on incidence, causes, and predictors of 30-day readmission after hospitalization for hypertensive emergency. We used the 2013 to 2014 Nationwide Readmissions Database to identify index hospitalizations for hypertensive emergency. Primary outcome was all-cause unplanned 30-day readmission. Multivariable hierarchical logistic regression was used to identify independent predictors of readmission. There were 166 531 index hospitalizations for hypertensive emergency representative of 355 627 (SE, 9401) hospitalizations nationwide in 2013 to 2014. Mean age was 66.0 (SE, 0.14) years, and 53.7% were women. The overall incidence of unplanned 30-day readmissions was 17.8%. The most common causes of readmission were heart failure (14.2%), hypertension with complications (10.2%), sepsis (5.9%), acute kidney injury (5.1%), and cerebrovascular accident (5.1%). Noncardiovascular causes accounted for 57.9% of readmissions. We found age <65 years (odds ratio, 1.21; 95% CI, 1.17–1.25; $P<0.001$), female sex (odds ratio, 1.09; 95% CI, 1.07–1.12; $P<0.001$), comorbid disease burden, substance use disorders, and socioeconomic risk factors to be significant predictors of readmission. One out of 6 patients hospitalized for hypertensive emergency had an unplanned 30-day readmission. Heart failure, uncontrolled hypertension, and stroke were among the most frequent causes of readmission; however, over half of all readmissions were because of noncardiovascular causes. (*Hypertension*. 2019;73:60-67. DOI: 10.1161/HYPERTENSIONAHA.118.11691.)

● **Online Data Supplement**

Key Words: blood pressure ■ emergency ■ heart failure ■ hypertension ■ stroke

Hypertension affects nearly half of all US adults and is responsible for substantial burden of morbidity, mortality, and financial costs on the healthcare system.[1] The 2017 American College of Cardiology / American Heart Association High Blood Pressure guidelines are expected to increase the awareness of hypertension in the United States, especially among young adults.[2] Hypertensive emergency is a complication of uncontrolled hypertension and is defined as acute severe hypertension with evidence of target end-organ damage.[3] Approximately 1% to 2% of adults with hypertension will develop hypertensive emergency in their lifetime, and the incidence of hypertensive emergency has increased over the past decade.[4,5] There is a paucity of data on 30-day readmission rates after hospitalization for hypertensive emergency. In this study, using a national administrative database, we evaluated the incidence, causes, and predictors of 30-day readmissions after hospitalization for hypertensive emergency.

Methods

Data Source

Data used in this study, as well as methods to analyze these data, are published annually by the Agency for Healthcare Research and Quality. Datasets, analytic methods, and study materials used in the study will not be made available to other researchers by the study authors but can be obtained from the Healthcare Cost and Utilization Project database catalog. We used the 2013 to 2014 Nationwide Readmissions Database (NRD), which is a part of the Healthcare Cost and Utilization Project from the Agency for Healthcare Research and Quality.[6,7] The NRD is an all-payer national database of inpatient hospital stays that can be used to generate nationally representative estimates of readmission rates in the United States.[8] The NRD is composed of discharges included in the State Inpatient Databases of participating states. Twenty-one states participated in the 2013 NRD and 22 states in the 2014 NRD. Approximately 85% of all discharges from State Inpatient Databases of participating states have been included in the 2013 to 2014 NRD.[6,7] There are ≈15 million unweighted yearly discharges representative of ≈35 million discharges nationwide. Individual patients can be tracked across hospitalizations by a patient linkage variable. The study was

Table 1. Diagnosis Codes Used to Define the Study Population

Variables Used to Define the Study Population	ICD-9 Codes Used
Codes for acute hypertension	
Primary malignant hypertension	401.0
Secondary malignant hypertension	405.01 and 405.09
Malignant hypertensive heart or kidney disease	402.00, 402.01, 403.00, 403.01, 404.00, 404.01, 404.02, 404.03
Codes for end-organ damage	
Retinal hemorrhage	362.81
Papilledema with increased intracranial pressure	377.01
Acute or unspecified (not chronic) heart failure	428.0, 428.1, 428.20, 428.21, 428.23, 428.30, 428.31, 428.33, 428.40, 428.41, 428.43, 428.9
Acute myocardial infarction	410.x, 410.xx
Ruptured aortic aneurysm or aortic dissection	414.12, 443.21, 443.22, 443.23, 443.24, 443.29, 441.x
Subarachnoid hemorrhage	430.x
Intracerebral hemorrhage	431.x
Hypertensive encephalopathy	437.2
Nontraumatic extradural hemorrhage	432.x
Cerebral thrombosis	434.x
Transient cerebral ischemia	435.x
Other cerebrovascular disease	436.x

ICD-9 indicates *International Classification of Diseases, Ninth Revision*.

Figure 1. Selection of index hospitalizations for hypertensive emergency in the 2013 to 2014 Nationwide Readmissions Database.

exempt from Institutional Review Board approval from the primary institution because the study utilized a publicly available database containing deidentified patient-level data.

Identification of Cases

Hypertensive emergency hospitalizations were defined as records with primary or secondary diagnosis codes for acute hypertension and at least 1 additional diagnosis code for end-organ damage (Table 1; Figure 1). This approach for identification of hypertensive emergency is similar to a prior study using an administrative database.[4]

Outcome Measures

Primary outcome was unplanned all-cause 30-day readmission. Causes of readmission were ascertained using Clinical Classification Software codes in the primary diagnosis field. The cause of readmission was designated as cardiovascular if *International Classification of Diseases, Ninth Revision* codes for the principal diagnosis of readmission fell within the range 390 to 459 (diseases of the circulatory system).

Sensitivity Analysis

We performed a sensitivity analysis to ascertain whether our results were sensitive to a more restrictive definition of hypertensive emergency. This subsample for sensitivity analysis was defined as index admissions with a primary or a secondary diagnosis code of acute hypertension with an additional primary or secondary diagnosis code of acute heart failure (HF), hypertensive encephalopathy, or papilledema. All other criteria used to define the subsample for sensitivity analysis were identical to that used for the full study sample. Using this subsample of index admissions, we ascertained incidence, causes, and predictors of unplanned all-cause 30-day readmission, similar to the primary analysis.
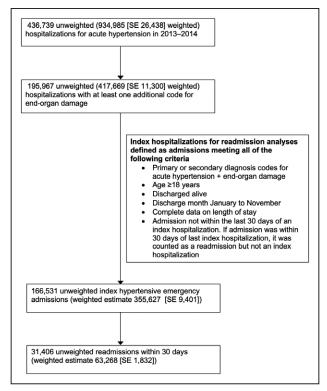
Statistical Analysis

We used survey analysis techniques to account for data clustering and stratification. Differences in continuous variables were tested using linear regression, whereas differences in categorical variables were tested using logistic regression. Univariable and multivariable hierarchical logistic regression models were used to identify independent predictors of readmission. We included a hospital-level random intercept to account for within-hospital correlation in 30-day readmission risk. Hierarchical models were unweighted as per the recommendations of the Agency for Healthcare Research and Quality for conducting hierarchical modeling using HCUP (Healthcare Cost and Utilization Project) data.[9] Improvement in model fit from the null model was tested by a change in Akaike Information Criterion and Bayesian Information Criterion compared with the null model. Lower values of Akaike Information Criterion and Bayesian Information Criterion for the full model are supportive of improvement in model fit compared with the null model. A *P* value of ≤0.05 was considered significant. All analyses were conducted using Stata MP 15.1 (Stata Corp, College Station, TX).

Results

Baseline Characteristics and Outcomes of Index Hospitalization

There were 195 967 unweighted hospitalizations for hypertensive emergency representative of 417 669 (SE, 11 300) hospitalizations nationally. Of these, 3.8% died during the initial hospitalization. Using the criteria outlined in Figure 1, we identified 355 627 (SE, 9 401) weighted index hospitalizations for hypertensive emergency.

Mean age was 66.0 (SE, 0.14) years, and 53.7% were women. Common comorbidities included diabetes mellitus without complications (31.8%), HF (34.4%), and chronic kidney disease (34.6%). The most common forms of end-organ involvement were acute HF (63.2%) and acute ischemic stroke

Table 2. Baseline Patient and Hospital Characteristics

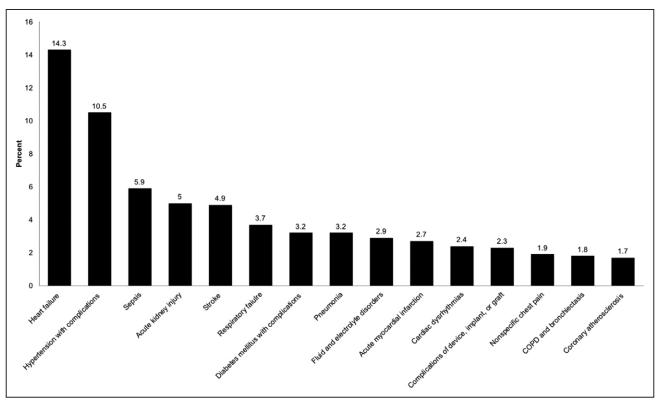| Baseline Characteristics for All Index Admissions	
Demographics	Mean (SE) or Percent for Continuous and Categorical Variables, Respectively
Age, y, mean (SE)	66.0 (0.14)
Females	53.7%
Median income for patient's ZIP code	
First quartile	40.2%
Second quartile	27.4%
Third quartile	19.2%
Fourth quartile	13.1%
Primary payer	
Medicare	64.1%
Medicaid	11.6%
Private insurance	14.2%
Self-pay	6.8%
No charge	0.9%
Other	2.5%
Hospital characteristics	
Bed size	
Small	11.8%
Medium	25.7%
Large	62.6%
Teaching status	
Metropolitan nonteaching	36.8%
Metropolitan teaching	52.8%
Nonmetropolitan hospital	10.4%
Hospital control	
Government, nonfederal	11.1%
Private, not-for-profit	68.4%
Private, investor-owned	20.6%
Comorbidities	
Diabetes mellitus without complications	31.8%
Diabetes mellitus with complications	13.5%
Heart failure	34.4%
CKD	34.6%
Stage 1	0.2%
Stage 2	1.8%
Stage 3	13.5%
Stage 4	6.4%
Stage 5	11.6%
Not otherwise specified	8.5%
End-stage renal disease	12.7%
Valvular heart disease	6.5%

(*Continued*)

Table 2. Continued

Baseline Characteristics for All Index Admissions	
Demographics	Mean (SE) or Percent for Continuous and Categorical Variables, Respectively
Obesity	22.0%
Peripheral vascular disease	13.5%
Chronic lung disease	24.6%
Pulmonary circulation disease	4.5%
Chronic liver disease	2.3%
Coagulopathy	5.4%
Drug abuse	5.2%
Alcohol abuse	4.7%
Charlson comorbidity index, mean (SE)	3.22 (0.01)
End-organ involvement	
Acute or unspecified heart failure	63.2%
Acute myocardial infarction	12.6%
Ruptured aortic aneurysm or dissection	4.3%
Hypertensive encephalopathy	5.4%
Subarachnoid, intracerebral, or nontraumatic extradural hemorrhage	5.8%
Cerebral thrombosis, transient cerebral ischemia, other cerebrovascular disease	22.2%
Papilledema with increased intracranial pressure	0.01%
Retinal hemorrhage	0.1%
Index hospitalization outcomes	
Length of stay in days, mean (SE)	7.0 (0.06)
Cost of index hospitalization in 2018 US dollars, mean (SE)	16 623 (185)
Disposition	
Routine	56.4%
Transfer to short-term hospital	1.3%
Transfer to skilled nursing facility or intermediate care facility	21.7%
Home health care	19.1%
Discharge against medical advice	1.5%

CKD indicates chronic kidney disease.

or transient ischemic attack (22.2%). Most patients were covered under Medicare (64.1%), whereas 11.6% were covered under Medicaid and 14.2% by private insurance. Most hospitalizations occurred at hospitals classified as large (62.6%) and metropolitan teaching hospitals (52.8%). Mean length of stay was 7 days, and mean cost was $16 623 (Table 2).

Incidence, Causes, and Predictors of 30-Day Readmission

Overall incidence of readmission was 17.8%. Of the patients who were readmitted, 42.1% had a cardiovascular cause of readmission. The 5 most common causes

Figure 2. The 15 most common principal diagnoses associated with 30-d readmissions. COPD indicates chronic obstructive pulmonary disease.

of readmission were HF (14.3%), hypertension with complications (10.5%), sepsis (5.9%), acute kidney injury (5%), and stroke (4.9%; Figure 2). A complete list of the 15 most common principal diagnoses accounting for 67% readmissions is presented in Table S1 in the online-only Data Supplement. Noncardiovascular causes accounted for 57.9% of all readmissions. Of the total 30-day readmissions, 36.1% of readmissions occurred within a week of discharge (Figure 3). A quarter of readmissions were to a different hospital than the index admission. We found several independent predictors of readmission, including age<65, female sex, comorbidity burden, primary payer, substance use
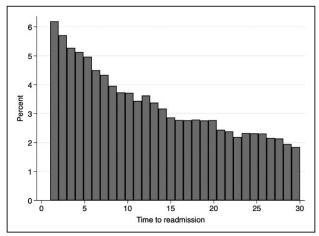
disorders, socioeconomic status, prolonged hospital stay, and discharge disposition (Table 3). Differences in Akaike Information Criterion (−7404.3) and Bayesian Information Criterion (−7013.5) for the full model compared with the null model indicated strong support for the full model. Likelihood ratio test showed significant improvement in model fit for the full model compared with the null model ($P<0.001$; Table 3).

Sensitivity Analysis

A total of 110 158 index admissions representative of 235 069 (SE, 6266) index admissions nationwide were hospitalized with hypertensive emergency based on the more restrictive case definition, constituting 66.1% of the full study cohort. Mean age was 65.9 (SE, 0.15) years, and 55% were women. Overall incidence of unplanned all-cause 30-day readmission was 20.1%. The most common causes of readmission were HF (17.3%), hypertension with complications (11.1%), sepsis (5.7%), acute kidney injury (5.3%), and respiratory failure (4.2%; Figure S1). Noncardiovascular causes accounted for 57.9% of the readmissions. Predictors of readmission were consistent with the primary analysis (Table S2).

Discussion

We found several potentially clinically relevant findings in this study. Patients hospitalized with hypertensive emergency have a high 30-day readmission rate of 18%. HF, uncontrolled hypertension, and stroke are the most common cardiovascular causes of readmission, but more than half of all readmissions are for noncardiovascular causes. Nearly two-thirds of all 30-day readmissions occur within 2 weeks of hospital

Figure 3. Distribution of time-to-readmission among patients who were readmitted within 30 d of discharge. Of the patients who were readmitted, 36.1% were readmitted within 7 d, and 61.1% were readmitted within 14 d.

Table 3.   Results of Univariable and Multivariable Hierarchical Logistic Regression Models for All-Cause 30-d Readmission

Covariates	Unadjusted OR (95% CI)	P Value	Adjusted OR (95% CI)*	P Value
Age <65 y	1.02 (1.00–1.05)	0.10	1.21 (1.17–1.25)	<0.001
Female sex	1.10 (1.07–1.13)	<0.001	1.09 (1.07–1.12)	<0.001
Primary payer				
Medicare	Reference		Reference	
Medicaid	1.15 (1.11–1.20)	<0.001	1.05 (1.002–1.10)	0.04
Private insurance	0.54 (0.52–0.56)	<0.001	0.63 (0.60–0.66)	<0.001
Self-pay	0.51 (0.48–0.55)	<0.001	0.61 (0.57–0.66)	<0.001
No charge	0.50 (0.42–0.59)	<0.001	0.61 (0.51–0.72)	<0.001
Other	0.66 (0.60–0.72)	<0.001	0.71 (0.65–0.78)	<0.001
Missing	0.53 (0.35–0.81)	<0.001	0.57 (0.37–0.86)	0.008
Income quartile of patient's ZIP code				
First	Reference		Reference	
Second	0.92 (0.89–0.95)	<0.001	0.97 (0.94–1.00)	0.06
Third	0.88 (0.85–0.91)	<0.001	0.95 (0.91–0.99)	0.007
Fourth	0.83 (0.79–0.87)	<0.001	0.93 (0.89–0.97)	0.002
Missing	0.87 (0.78–0.97)	0.01	0.94 (0.84–1.04)	0.23
Hospital characteristics				
Hospital bed size				
Small	Reference		Reference	
Medium	1.09 (1.02–1.15)	0.007	1.05 (0.99–1.11)	0.08
Large	1.11 (1.05–1.17)	<0.001	1.07 (1.01–1.12)	0.02
Teaching status				
Metropolitan nonteaching	Reference		Reference	
Metropolitan teaching	0.97 (0.93–1.00)	0.07	0.98 (0.95–1.02)	0.36
Nonmetropolitan hospital	0.89 (0.84–0.95)	<0.001	0.94 (0.88–1.00)	0.054
Hospital control				
Government, nonfederal	Reference		Reference	
Private, not-for-profit	1.04 (0.98–1.10)	0.19	1.01 (0.96–1.06)	0.78
Private, investor-owned	1.14 (1.07–1.22)	<0.001	1.10 (1.03–1.16)	0.003
Comorbidities				
DM with complications	1.64 (1.59–1.70)	<0.001	1.20 (1.16–1.24)	<0.001
Chronic kidney disease	1.85 (1.81–1.90)	<0.001	1.20 (1.16–1.24)	<0.001
End-stage renal disease	2.21 (2.14–2.29)	<0.001	1.46 (1.41–1.52)	<0.001
Valvular heart disease	1.11 (1.05–1.16)	<0.001	1.03 (0.98–1.09)	0.29
Obesity	0.89 (0.86–0.91)	<0.001	0.86 (0.83–0.89)	<0.001
Peripheral vascular disease	1.28 (1.24–1.33)	<0.001	1.10 (1.06–1.15)	<0.001
Chronic lung disease	1.44 (1.40–1.48)	<0.001	1.19 (1.16–1.23)	<0.001
Pulmonary circulation disease	1.37 (1.30–1.45)	<0.001	1.09 (1.03–1.16)	0.003
Chronic liver disease	1.63 (1.52–1.75)	<0.001	1.27 (1.18–1.37)	<0.001
Coagulopathy	1.24 (1.18–1.31)	<0.001	1.02 (0.97–1.08)	0.41
Drug abuse	1.37 (1.30–1.44)	<0.001	1.32 (1.25–1.40)	<0.001
Charlson comorbidity index >3	1.93 (1.88–1.98)	<0.001	1.25 (1.21–1.29)	<0.001

(Continued)

Table 3. Continued

Covariates	Unadjusted OR (95% CI)	P Value	Adjusted OR (95% CI)*	P Value
End-organ involvement				
Acute or unspecified heart failure	1.92 (1.87–1.98)	<0.001	1.37 (1.32–1.42)	<0.001
Acute myocardial infarction	0.95 (0.91–0.98)	0.004	1.00 (0.96–1.04)	0.87
Stroke or transient ischemic attack	0.54 (0.52–0.56)	<0.001	0.76 (0.73–0.80)	<0.001
Length of stay > median	1.44 (1.40–1.47)	<0.001	1.25 (1.22–1.29)	<0.001
Disposition				
Routine	Reference		Reference	
Transfer to short-term hospital	1.48 (1.33–1.64)	<0.001	1.60 (1.44–1.78)	<0.001
Transfer to skilled nursing facility or intermediate care facility	1.35 (1.31–1.39)	<0.001	1.29 (1.24–1.33)	<0.001
Home health care	1.36 (1.32–1.41)	<0.001	1.24 (1.20–1.28)	<0.001
Discharge against medical advice	2.44 (2.24–2.66)	<0.001	2.20 (2.01–2.40)	<0.001
Unknown	0.31 (0.16–0.61)	<0.001	0.34 (0.17–0.68)	0.002

Differences in AIC and BIC for full model vs null model indicate strong support for the full model. Likelihood ratio test showed a statistically significant improvement in model fit ($P<0.001$) for the full model compared with the null model. AIC indicates Akaike Information Criterion; BIC, Bayesian Information Criterion; DM, diabetes mellitus; and OR, odds ratio.

*AIC for full model–AIC for null model= −7404.3, BIC for full model–BIC for null model= −7013.5.

discharge. Age <65 years, female sex, comorbidities, such as diabetes mellitus, chronic kidney disease, substance use disorder, and socioeconomic risk factors, are significant predictors of 30-day readmission.

Consistent with our study findings, prior studies have demonstrated substantial readmission burden among patients hospitalized with severe hypertension. In a multicenter cross-sectional study, Gore et al[10] studied the 90-day readmission rates after acute severe hypertension and found a 90-day readmission rate of 35%. Insurance status and comorbidities, such as HF, chronic kidney disease, and substance abuse, were significant predictors of readmission. In our study, age <65 years was associated with higher odds of 30-day readmission. Similar age trends in 30-day readmission were observed among all hospitalized patients in a recent study using the NRD, where age ≥65 years was associated with significantly lower adjusted odds of readmission compared with age 45 years.[11] Potential explanations may include higher rates of medication nonadherence and substance use disorders in younger patients[12] and positive spillover effects of readmission reduction strategies implemented by hospitals to avoid penalties under the Centers for Medicare and Medicaid Services Hospital Readmission Reduction Program. The latter may have an ancillary benefit of reducing readmissions for nontarget conditions in older patients.[13]

More than half the readmissions were noncardiovascular in nature. This is consistent with the readmission patterns noted for other chronic cardiovascular conditions, such as HF and myocardial infarction.[14,15] Comprehensive readmission reduction strategies, including focus on socioeconomics, healthcare access, and transitions in care may improve short-term readmission rates. Future studies are needed to determine if early outpatient follow-up, self-monitoring of blood pressure, and blood pressure control to guideline-recommended

targets may lessen this readmission burden. This is particularly relevant because early follow-up has been shown to be associated with fewer all-cause 30-day readmissions in patients with HF.[16]

Our study findings have important clinical and health policy implications. In this study, we observed that the 30-day readmission rates for hypertensive emergency are comparable to that reported for other common cardiovascular conditions, such as HF and acute myocardial infarction.[14,15] This is particularly relevant because unlike HF and myocardial infarction, hypertensive emergency is not targeted under the current Centers for Medicare and Medicaid Services Hospital Readmission Reduction Program to incentivize hospitals to reduce 30-day readmission rates. Furthermore, with the increasing incidence and decreasing mortality rates for hypertensive emergency,[4,5] its readmission burden would be expected to increase. Targeting and lessening the burden of readmissions in patients with severe hypertension may impact overall excess healthcare expenditures in this population.[17] Future studies are needed to determine what proportion of 30-day readmissions among patients with hypertensive emergency is preventable.

Our study is subject to certain limitations. First, the NRD is an administrative database, and identification of cases was based on a combination of *International Classification of Diseases, Ninth Revision* codes. Therefore, the study may be susceptible to changes in coding practices and miscoding. However, we used a robust definition of hypertensive emergency that has previously been used for identification of hypertensive emergency in administrative datasets.[4] Moreover, our findings were insensitive to a more restrictive case definition of hypertensive emergency which limited the inclusion criteria to a relatively homogeneous subsample of the main study cohort. Second, follow-up of individual patients in the NRD is based on a patient linkage variable.

Therefore, records with missing or unverified linkage numbers are excluded from the NRD. Third, residual measured or unmeasured confounding may have influenced some of these findings. Fourth, granular patient-level data, such as blood pressure measurements, drugs used to treat hypertensive emergency, and medication adherence and timeliness of follow-up visits after discharge were not available in the NRD database. Therefore, we were unable to ascertain the readmission risk associated with these potentially modifiable factors, which may be targeted in the early postdischarge period to prevent unplanned 30-day readmissions. Lastly, follow-up in the NRD in limited to calendar year of admission, therefore, readmission analysis was limited to the year of admission.

Perspectives

In conclusion, we found that hypertensive emergency hospitalizations were associated with a high burden (≈15%–20%) of 30-day readmissions. Although these readmissions are commonly for HF, uncontrolled hypertension, and stroke, more than half are related to noncardiovascular causes. Future studies should evaluate strategies to minimize the burden of 30-day readmission after hospitalization for hypertensive emergency.

Sources of Funding

None.

Disclosures

References

1. Muntner P, Carey RM, Gidding S, Jones DW, Taler SJ, Wright JT Jr, Whelton PK. Potential US population impact of the 2017 ACC/AHA high blood pressure guideline. *Circulation*. 2018;137:109–118. doi: 10.1161/CIRCULATIONAHA.117.032582

2. Vaduganathan M, Pareek M, Qamar A, Pandey A, Olsen MH, Bhatt DL. Baseline blood pressure, the 2017 ACC/AHA high blood pressure guidelines, and long-term cardiovascular risk in SPRINT. *Am J Med*. 2018;131:956–960.

3. Varon J, Marik PE. The diagnosis and management of hypertensive crises. *Chest*. 2000;118:214–227.

4. Janke AT, McNaughton CD, Brody AM, Welch RD, Levy PD. Trends in the incidence of hypertensive emergencies in US emergency departments from 2006 to 2013. *J Am Heart Assoc*. 2016;5:e004511.

5. Shah M, Patil S, Patel B, Arora S, Patel N, Garg L, Agrawal S, Jacobs L, Steigerwalt SP, Martinez MW. Trends in hospitalization for hypertensive emergency, and relationship of end-organ damage with in-hospital mortality. *Am J Hypertens*. 2017;30:700–706. doi: 10.1093/ajh/hpx048

6. Agency for Healthcare Research and Quality. Introduction to the HCUP Nationwide Readmissions Database (NRD) 2013 [Internet]. https://www.hcup-us.ahrq.gov/db/nation/nrd/NRD_Introduction_2013.jsp. Accessed June 15, 2018.

7. Agency for Healthcare Research and Quality. Introduction to the HCUP Nationwide Readmissions Database (NRD) 2014 [Internet]. https://www.hcup-us.ahrq.gov/db/nation/nrd/NRD_Introduction_2010-2014.jsp. Accessed June 15, 2018.

8. Agency for Healthcare Research and Quality. HCUP Methods Series: Calculating Nationwide Readmissions Database (NRD) Variances [Internet]. https://www.hcup-us.ahrq.gov/reports/methods/2017-01.pdf. Accessed June 15, 2018.

9. Agency for Healthcare Research and Quality. HCUP Methods Series: Hierarchical Modeling Using HCUP Data [Internet]. https://www.hcup-us.ahrq.gov/reports/methods/2007_01.pdf. Accessed June 15, 2018.

10. Gore JM, Peterson E, Amin A, Anderson FA Jr, Dasta JF, Levy PD, O'Neil BJ, Sung GY, Varon J, Wyman A, Granger CB; STAT Investigators. Predictors of 90-day readmission among patients with acute severe hypertension. The cross-sectional observational Studying the Treatment of Acute hyperTension (STAT) study. *Am Heart J*. 2010;160:521.e1–527.e1. doi: 10.1016/j.ahj.2010.06.032

11. Berry JG, Gay JC, Joynt Maddox K, Coleman EA, Bucholz EM, O'Neill MR, Blaine K, Hall M. Age trends in 30 day hospital readmissions: US national retrospective analysis. *BMJ*. 2018;360:k497.

12. Gupta P, Patel P, Štrauch B, et al. Risk factors for nonadherence to antihypertensive treatment. *Hypertension*. 2017;69:1113–1120. doi: 10.1161/HYPERTENSIONAHA.116.08729

13. Demiralp B, He F, Koenig L. Further evidence on the system-wide effects of the hospital readmissions reduction program. *Health Serv Res*. 2018;53:1478–1497. doi: 10.1111/1475-6773.12701

14. Bergethon KE, Ju C, DeVore AD, Hardy NC, Fonarow GC, Yancy CW, Heidenreich PA, Bhatt DL, Peterson ED, Hernandez AF. Trends in 30-Day readmission rates for patients hospitalized with heart failure: findings from the Get With The Guidelines-Heart Failure Registry. *Circ Heart Fail*. 2016;9:e002594.

15. Khera R, Jain S, Pandey A, Agusala V, Kumbhani DJ, Das SR, Berry JD, de Lemos JA, Girotra S. Comparison of readmission rates after acute

myocardial infarction in 3 patient age groups (18 to 44, 45 to 64, and ≥65 years) in the United States. *Am J Cardiol*. 2017;120:1761–1767. doi: 10.1016/j.amjcard.2017.07.081

16. Hernandez AF, Greiner MA, Fonarow GC, Hammill BG, Heidenreich PA, Yancy CW, Peterson ED, Curtis LH. Relationship between early physician follow-up and 30-day readmission among Medicare beneficiaries hospitalized for heart failure. *JAMA*. 2010;303:1716–1722.

17. Kirkland EB, Heincelman M, Bishu KG, Schumann SO, Schreiner A, Axon RN, Mauldin PD, Moran WP. Trends in healthcare expenditures among US adults with hypertension: national estimates, 2003–2014. *J Am Heart Assoc*. 2018;7:e008731. doi: 10.1161/JAHA.118.008731

Novelty and Significance

What Is New?

- We determined incidence, causes, and predictors of 30-day readmissions after hospitalization for hypertensive emergency.

What Is Relevant?

- Hospitalizations for hypertensive emergency are associated with a 30-day readmission rate of 18%, comparable to target conditions included in the Centers for Medicare and Medicaid Services Hospital Readmission Reduction Program. Younger age, female sex, comorbidity burden, and socioeconomic factors are important predictors of readmission.

Summary

Hospitalizations for hypertensive emergency are associated with a substantial burden of 30-day readmission. A majority of these readmissions are related to noncardiovascular conditions. We found multiple predictors of readmission that could help inform readmission reduction strategies.