

Insurance Status and Hospital Care for Myocardial Infarction, Stroke, and Pneumonia

Omar Hasan, MBBS, MPH^{1,2}
E. John Orav, PhD¹
LeRoi S. Hicks, MD, MPH^{1,2,3}

¹ Department of Medicine, Division of General Medicine, Brigham and Women's Hospital, Boston, Massachusetts.

² Department of Medicine, Brigham and Women's-Faulkner Hospitalist Service, Brigham and Women's Hospital, Boston, Massachusetts.

³ Department of Health Care Policy, Harvard Medical School, Boston, Massachusetts.

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BACKGROUND: Despite widely documented variations in health care outcomes by insurance status, few nationally representative studies have examined such disparities in the inpatient setting.

OBJECTIVE: To determine whether there are insurance-related differences in hospital care for 3 common medical conditions.

DESIGN AND SUBJECTS: Retrospective database analysis of 154,381 adult discharges (age 18-64 years) with a principal diagnosis of acute myocardial infarction (AMI), stroke, or pneumonia from the 2005 Nationwide Inpatient Sample (NIS).

MEASUREMENTS: For each diagnosis, we compared in-hospital mortality, length of stay (LOS), and cost per hospitalization for Medicaid and uninsured patients with the privately insured.

RESULTS: Compared with the privately insured, in-hospital mortality among AMI and stroke patients was significantly higher for the uninsured (adjusted odds ratio [OR] 1.52, 95% confidence interval [CI] [1.24-1.85] for AMI and 1.49 [1.29-1.72] for stroke) and among pneumonia patients was significantly higher for Medicaid recipients (1.21 [1.01-1.45]). Excluding patients who died during hospitalization, LOS was consistently longer for Medicaid recipients for all 3 conditions (adjusted ratio 1.07, 95% CI [1.05-1.09] for AMI, 1.17 [1.14-1.20] for stroke, and 1.04 [1.03-1.06] for pneumonia), although costs were significantly higher for Medicaid recipients for only 2 of the 3 conditions (adjusted ratio 1.06, 95% CI [1.04-1.09] for stroke and 1.05 [1.04-1.07] for pneumonia).

CONCLUSIONS: In this nationally representative study of working-age Americans hospitalized for 3 common medical conditions, significantly lower in-hospital mortality was noted for privately insured patients compared with the uninsured or Medicaid recipients. Interventions to reduce insurance-related gaps in inpatient quality of care should be investigated.

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KEYWORDS: hospital cost, in-hospital mortality, insurance status, length of stay, uninsured.

Additional Supporting Information may be found in the online version of this article.

With about 1 in 5 working-age Americans (age 18-64 years) currently uninsured and a large number relying on Medicaid, adequate access to quality health care services is becoming increasingly difficult.¹ Substantial literature has accumulated over the years suggesting that access and quality in health care are closely linked to an individual's health insurance status.²⁻¹¹ Some studies indicate that being uninsured or publicly insured is associated with negative health consequences.^{12,13} Although the Medicaid program has improved access for qualifying low-income individuals, significant gaps in access and quality remain.^{2,5,11,14-19} These issues are likely to become more pervasive should there be further modifications to state Medicaid funding in response to the unfolding economic crisis.

Although numerous studies have focused on insurance-related disparities in the outpatient setting, few nationally representative studies have examined such disparities among hospitalized patients. A cross-sectional study of a large hospital database from 1987 reported higher risk-

adjusted in-hospital mortality, shorter length of stay (LOS), and lower procedure use among uninsured patients.⁹ A more recent analysis, limited to patients admitted with stroke, reported significant variation in hospital care associated with insurance status.¹⁵ Other studies reporting myocardial infarction registry and quality improvement program data are biased by the self-selection of large urban teaching hospitals.¹⁶⁻¹⁸ To our knowledge, no nationally representative study has focused on the impact of insurance coverage on hospital care for common medical conditions among working-age Americans, the fastest growing segment of the uninsured population.

To address this gap in knowledge, we analyzed a nationally representative hospital database to determine whether there are significant insurance-related disparities in in-hospital mortality, LOS, and cost per hospitalization for 3 common medical conditions among working-age adults, and, if present, to determine whether these disparities are due to differences in disease severity and comorbidities, and whether

these disparities are affected by the proportion of uninsured and Medicaid patients receiving care in each hospital.

Methods

Design and Subjects

We examined data from the 2005 Nationwide Inpatient Sample (NIS), a nationally representative database of hospital inpatient stays maintained by the Agency for Healthcare Research and Quality (AHRQ) as part of the Healthcare Cost and Utilization Project (HCUP).^{20,21} The NIS is a stratified probability sample of 20% of all US community hospitals, including public hospitals, academic medical centers, and specialty hospitals. Long-term care hospitals, psychiatric hospitals, and alcoholism/chemical-dependency treatment facilities are excluded. The 2005 NIS contains data on 7,995,048 discharges from 1054 hospitals located in 37 States and is designed to be representative of all acute care discharges from all US community hospitals.²¹

We identified discharges with a principal diagnosis of acute myocardial infarction (AMI), stroke, and pneumonia using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes specified in the AHRQ definitions of Inpatient Quality Indicators (Supporting Information Appendix).²² These 3 conditions are among the leading causes of noncancer inpatient deaths in patients under 65 years old,²³ and evidence suggests that high mortality may be associated with deficiencies in the quality of inpatient care.²⁴

We confined our analysis to patients 18 to 64 years of age, since this population is most at risk of being uninsured or underinsured.²⁵ We excluded pregnant women because they account for an unusually high proportion of uninsured discharges and were relatively few in our cohort.²⁶ In addition, we excluded patients transferred to another acute care hospital and patients missing payer source and discharge disposition. Our study protocol was approved by the Partners Human Research Committee.

Study Variables

We categorized insurance status as privately insured, uninsured, Medicaid, or Medicare. We defined "privately insured" patients as those having either Blue Cross or another commercial carrier listed as the primary payer and "uninsured" patients as those having either no charge or self-pay listed as the primary payer.²⁷ Other governmental payer categories were noted to share several characteristics with Medicare patients and comprised only a small proportion of the sample, and were thus included with Medicare. In order to account for NIS's sampling scheme and accurately apply sample weights in our analysis, we used Medicare as a separate category. However, since Medicare patients age 18 to 64 years represent a fundamentally different population that is primarily disabled or very ill, only results of privately insured, uninsured, and Medicaid patients are reported.

We selected in-hospital mortality as the outcome measure and LOS and cost per hospitalization as measures of

resource utilization. The NIS includes a binary indicator variable for in-hospital mortality and specifies inpatient LOS in integers, with same-day stays coded as 0. NIS's cost estimates are based on hospital cost reports submitted to the Centers for Medicare and Medicaid Services. To test the validity of our cost analyses, we performed parallel analyses using hospital charges as a measure of utilization (charges include hospital overhead, charity care, and bad debt). The resulting adjusted ratios differed little from cost ratios and we opted to report only the details of our cost analyses.

In order to assess the independent association between insurance status and the outcome measures listed above, we selected covariates for inclusion in multivariable models based on the existing literature. Patient covariates included: age group (18-34 years, 35-49 years, 50-64 years), sex (male/female), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other, missing), median income by zip code of residence (less than \$37,000, \$37,000-\$45,999, \$46,000-\$60,999, \$61,000 or more), admission through the emergency department (yes/no), admission on a weekend (yes/no), measures of disease severity, and comorbidity indicators. Measures of disease severity specific to each outcome are assigned in the NIS using criteria developed by Medstat (Medstat Disease Staging Software Version 5.2, Thomson Medstat Inc., Ann Arbor, MI). Severity is categorized into 5 levels, with a higher level indicating greater risk. We recorded comorbidities for each patient in our sample using HCUP Comorbidity Software, Version 3.2 (www.hcup-us.ahrq.gov/tools_software.jsp) based on comorbidity measures reported by Elixhauser et al.²⁸

Hospital covariates included: bed size (small, medium, large), ownership/control (private, government, private or government), geographic region (northeast, midwest, south, west), teaching status (teaching, non-teaching), and the proportion of uninsured and Medicaid patients (combined) admitted to each hospital for AMI, stroke, or pneumonia. The actual number of hospital beds in each bed size category varies according to a hospital's geographic region and teaching status.²⁷ Ownership/control, geographic region, and teaching status are assigned according to information from the American Hospital Association Annual Survey of Hospitals. The proportion of uninsured and Medicaid patients admitted to each hospital was found to have a non-monotonic relationship with the outcomes being assessed and was thus treated as a 6-level categorical variable with the following levels: 0% to 10%, 11% to 20%, 21% to 30%, 31% to 40%, 41% to 50%, and 51% to 100%.

Statistical Analysis

Summary statistics were constructed at the patient level and differences in proportions were evaluated with the chi-square test. We employed direct standardization, using the age and sex distribution of the entire cohort, to compute age-standardized and sex-standardized estimates for each insurance group and compared them using the chi-square

test for in-hospital mortality and *t* test for log transformed LOS and cost per hospitalization. For each condition, we developed multivariable logistic regression models for in-hospital mortality and multivariable linear regression models for log transformed LOS and cost. The patient was the unit of analysis in all models.

In order to elucidate the contribution of disease severity and comorbidities and the proportion of uninsured and Medicaid patients admitted to each hospital, we fitted 3 sequential models for each outcome measure: Model 1 adjusted for patient sociodemographic characteristics and hospital characteristics with the exception of the covariate for the proportion of uninsured and Medicaid patients, Model 2 adjusted for all covariates in the preceding model as well as patients' comorbidities and severity of principal diagnosis, and Model 3 adjusted for all previously mentioned covariates as well as the proportion of uninsured and Medicaid patients admitted to each hospital. We excluded patients who died during hospitalization from the models for LOS and cost. We exponentiated the effect estimates from the log transformed linear regression models so that the adjusted ratio represents the percentage change in the mean LOS or mean cost.

To determine whether the association between patients' insurance status and in-hospital mortality was modified by seeking care in hospitals treating a smaller or larger proportion of uninsured and Medicaid patients, we entered an interaction term for insurance status and proportion of uninsured and Medicaid patients in the final models (Model 3) for our primary outcome of in-hospital mortality. However, since no significant interaction was found for any of the 3 conditions, this term was removed from the models and results from the interaction models are not described. In order to assess model specification for the linear regression models, we evaluated the normality of model residuals and found that these were approximately normally distributed. Lastly, we attempted to test the robustness of our analyses by creating fixed effects models that controlled for hospital site but were unable to do so due to the computational limitations of available software packages that could not render fixed effects models with more than 1000 hospital sites.

For all variables except race/ethnicity, data were missing for less than 3% of patients, so we excluded these individuals from adjusted analyses. However, race/ethnicity data were missing for 29% of the sample and were analyzed in 3 different ways, namely, with the missing data treated as a separate covariate level, with the missing data removed from the analysis, and with the missing data assigned to the majority covariate level (white race). The results of our analysis were unchanged no matter how the missing values were assigned. As a result, missing values for race/ethnicity were treated as a separate covariate level in the final analysis.¹⁵ Sociodemographic characteristics of patients with missing race/ethnicity information were similar to those with complete data.

We used SUDAAN (Release 9.0.1, Research Triangle Institute, NC) to account for NIS's sampling scheme and generalized estimating equations to adjust for the clustering of patients within hospitals and hospitals within sampling strata.²⁹ In order to account for NIS's stratified probability sampling scheme, SUDAAN uses Taylor series linearization for robust variance estimation of descriptive statistics and regression parameters.^{30,31} We present 2-tailed *P* values or 95% confidence intervals (CIs) for all statistical comparisons.

Results

Patient and Hospital Characteristics

The final cohort comprised of 154,381 patients discharged from 1018 hospitals in 37 states during calendar year 2005 (Table 1). This cohort was representative of 755,346 working-age Americans, representing approximately 225,947 cases of AMI (29.9%), 151,812 cases of stroke (20.1%), and 377,588 cases of pneumonia (50.0%). Of these patients, 47.5% were privately insured, 12.0% were uninsured, 17.0% received Medicaid, and 23.5% were assigned to Medicare. Compared with the privately insured, uninsured and Medicaid patients were generally younger, less likely to be white, more likely to have lower income, and more likely to be admitted through the emergency department. Of the 1018 hospitals included in our study, close to half (44.3%) were small, with bedsize ranging from 24 to 249. A large number of hospitals were located in the South (39.9%), and 14.9% were designated teaching hospitals.

Compared with privately insured patients, a larger proportion of uninsured and Medicaid patients had higher predicted mortality levels (Table 2). Medicaid patients had a disproportionately higher predicted LOS, whereas predicted resource demand was higher among privately insured patients. Hypertension (48%), chronic pulmonary disease (29.5%), and uncomplicated diabetes (21.5%) were the 3 most common comorbidities in the study cohort, with a generally higher prevalence of comorbidities among Medicaid patients.

In-Hospital Mortality

Compared with the privately insured, age-standardized and sex-standardized in-hospital mortality for AMI and stroke was significantly higher for uninsured and Medicaid patients (Table 3). Among pneumonia patients, Medicaid recipients had significantly higher in-hospital mortality compared with privately insured and uninsured patients.

After multivariable adjustment for additional patient and hospital characteristics, uninsured AMI and stroke patients continued to have significantly higher in-hospital mortality compared with the privately insured (Table 4). Among pneumonia patients, Medicaid recipients persisted in having significantly higher in-hospital mortality than the privately insured.

TABLE 1. Characteristics of Patients With Acute Myocardial Infarction, Stroke, and Pneumonia by Insurance Category, 2005 Nationwide Inpatient Sample

Characteristic*	Privately insured (n = 73,256)	Uninsured (n = 18,531)	Medicaid (n = 26,222)
Principal diagnosis (%)			
Acute myocardial infarction	36.7	31.2	19.7
Stroke	20.6	23.7	19.9
Pneumonia	42.7	45.2	60.4
Age group (%)			
18-34 years	6.8	13.0	13.7
35-49 years	27.6	36.9	33.2
50-64 years	65.7	50.1	53.2
Male sex (%)	59.3	62.3	46.6
Race or ethnicity (%)			
White	55.7	41.5	38.0
Black	7.6	14.8	16.6
Hispanic	4.8	10.5	10.4
Other race	3.6	4.7	5.2
Missing	28.4	29.0	29.7
Median income by ZIP code (%)			
<\$37,000	21.5	36.7	43.0
\$37,000-\$45,999	25.2	27.8	27.1
\$46,000-\$60,999	26.3	20.3	17.6
>\$61,000	24.8	11.5	8.4
Emergency admission (%)	63.3	75.6	72.9
Weekend admission (%)	24.5	26.2	25.1
Hospital bed size (%)			
Small	8.9	10.3	11.4
Medium	24.0	22.3	25.9
Large	67.1	67.5	62.8
Hospital control (%)			
Private	33.8	34.8	34.4
Government (nonfederal)	6.7	9.7	8.3
Private or government	59.5	55.5	57.3
Hospital region (%)			
Northeast	17.4	12.5	17.6
Midwest	25.7	19.4	20.9
South	39.5	56.8	42.4
West	17.4	11.3	19.2
Teaching hospital (%)	41.7	43.8	43.3

NOTE: Because of rounding, percentages may not equal 100.

*For all comparisons, differences are significant at $P < 0.01$ using the chi-square test.

LOS

Among AMI and stroke patients, age-standardized and sex-standardized mean LOS was significantly longer for the uninsured and Medicaid recipients compared with the privately insured (Table 3). Among pneumonia patients, the uninsured had a slightly shorter mean LOS compared with the privately insured whereas Medicaid recipients averaged the longest LOS.

These insurance-related disparities in LOS among pneumonia patients persisted after multivariable adjustment (Table 4). Among AMI patients, only Medicaid recipients persisted in having a significantly longer LOS than the privately insured. Among stroke patients, both the uninsured and Medicaid recipients averaged a longer LOS compared with the privately insured.

TABLE 2. Measures of Disease Severity and Comorbid Conditions in Patients With Acute Myocardial Infarction, Stroke, and Pneumonia by Insurance Category, 2005 Nationwide Inpatient Sample

Characteristic*	Privately insured (n = 73,256)	Uninsured (n = 18,531)	Medicaid (n = 26,222)
Medstat disease staging [†] (%)			
Mortality level 1	50.8	45.4	36.7
Mortality level 2	44.0	49.1	56.7
Mortality level 3	5.3	5.5	6.7
Length of stay level 1	66.8	71.6	53.8
Length of stay level 2	28.5	24.5	39.3
Length of stay level 3	4.8	3.8	6.9
Resource demand level 1	45.2	54.2	48.5
Resource demand level 2	40.5	34.2	39.2
Resource demand level 3	14.2	11.7	12.3
Coexisting medical conditions (%)			
Congestive heart failure	4.7	4.8	10.1
Valvular disease	2.8	2.0	2.7
Pulmonary circulation disease	0.8	0.6	1.5
Peripheral vascular disease	3.2	2.2	3.2
Paralysis	1.2	0.8	3.5
Other neurological disorders	2.4	1.9	7.3
Chronic pulmonary disease	23.6	22.4	37.7
Uncomplicated diabetes	19.6	18.6	23.4
Complicated diabetes	3.3	2.1	4.9
Hypothyroidism	5.6	2.7	4.7
Renal failure	3.0	1.9	5.6
Liver disease	1.6	2.5	4.4
Peptic ulcer disease	<0.5	<0.5	<0.5
AIDS	0.1	0.1	0.4
Lymphoma	1.1	0.4	0.6
Metastatic cancer	2.1	0.7	2.2
Non-metastatic solid tumor	1.5	0.8	2.1
Collagen vascular diseases	2.3	0.9	2.3
Coagulopathy	2.7	2.4	3.4
Obesity	10.3	8.2	9.3
Weight loss	1.6	1.8	3.3
Fluid and electrolyte disorders	18.3	19.4	23.8
Chronic blood loss anemia	0.6	0.6	0.8
Deficiency anemias	8.6	8.5	13.4
Alcohol abuse	3.3	9.8	8.3
Drug abuse	1.9	10.2	9.8
Psychoses	1.5	1.9	6.8
Depression	7.2	4.8	9.9
Hypertension	48.0	44.1	45.7

NOTE: Because of rounding, percentages may not equal 100.

Abbreviation: AIDS, acquired immune deficiency syndrome.

*For all comparisons, differences are significant at $P < 0.01$ using the chi-square test.

[†]The original Medstat disease staging system comprised 5 levels. Due to the small number of patients in levels 1, 2, and 3, we collapsed these into a single level and named it as level 1; we subsequently renamed levels 4 and 5 as levels 2 and 3, respectively. These levels correspond with the severity of the principal diagnosis, with higher levels indicating more severe disease on admission.

Cost per Episode

For all 3 conditions, the uninsured had significantly lower age-standardized and sex-standardized costs compared with the privately insured (Table 3). However, Medicaid patients had higher costs than the privately insured for all three

TABLE 3. Age-Standardized and Sex-Standardized In-Hospital Mortality and Resource Use for 3 Common Medical Conditions by Insurance Category, 2005 Nationwide Inpatient Sample

	Privately Insured	Uninsured	Medicaid
In-hospital mortality, rate per 100 discharges (SE)			
Acute myocardial infarction	2.22 (0.10)	4.03 (0.31)*	4.57 (0.34)*
Stroke	7.49 (0.27)	10.46 (0.64)*	9.89 (0.45)*
Pneumonia	1.75 (0.09)	1.74 (0.18)	2.48 (0.14)*
Length of stay, mean (SE), days			
Acute myocardial infarction	4.17 (0.06)	4.46 (0.09) [†]	5.85 (0.16) [†]
Stroke	6.37 (0.13)	7.15 (0.25) [†]	9.28 (0.30) [†]
Pneumonia	4.89 (0.05)	4.64 (0.10) [†]	5.80 (0.08) [†]
Cost per episode, mean (SE), dollars			
Acute myocardial infarction	21,077 (512)	19,977 (833) [†]	22,452 (841)
Stroke	16,022 (679)	14,571 (1,036) [†]	18,462 (824) [†]
Pneumonia	8,223 (192)	7,086 (293) [†]	9,479 (271) [†]

NOTE: Age-standardized and sex-standardized using the age and sex distribution of the entire cohort for direct standardization. These are unadjusted figures.

Abbreviations: SE, standard error.

*Significantly different from privately insured at $P < 0.001$ using the chi-square test.

[†]Significantly different from privately insured at $P < 0.05$ using the t-test; log transformations were used to approximate normal distribution.

conditions, significantly so among patients with stroke and pneumonia.

These insurance-related disparities in costs persisted in multivariable analyses (Table 4). The uninsured continued to have lower costs compared with the privately insured, significantly so for patients with AMI and pneumonia. Among stroke and pneumonia patients, Medicaid recipients continued to accrue higher costs than the uninsured or privately insured.

Discussion

In this nationally representative study of working-age Americans hospitalized for 3 common medical conditions, we found that insurance status was associated with significant variations in in-hospital mortality and resource use. Whereas privately insured patients experienced comparatively lower in-hospital mortality in most cases, mortality risk was highest among the uninsured for 2 of the 3 common causes of noncancer inpatient deaths. Although previous studies have examined insurance-related disparities in inpatient care for individual diagnoses and specific populations, no broad overview of this important issue has been published in the past decade. In light of the current economic recession and national healthcare debate, these findings may be a prescient indication of a widening insurance gap in the quality of hospital care.

There are several potential mechanisms for these disparities. For instance, Hadley et al.⁹ reported significant underuse of high-cost or high-discretion procedures among the uninsured in their analysis of a nationally representative sample of 592,598 hospitalized patients. Similarly, Burstin et al.¹⁰ found that among a population of 30,195 hospital-

ized patients with diverse diagnoses, the uninsured were at greater risk for receiving substandard care regardless of hospital characteristics. These, and other similar findings,^{7,8,19} are suggestive of differences in the way uninsured patients are generally managed in the hospital that may partly explain the disparities reported herein.

More specifically, analyses of national registries of AMI have documented lower rates of utilization of invasive, potentially life-saving, cardiac interventions among the uninsured.^{16,17} Similarly, a lower rate of carotid endarterectomy was reported among uninsured stroke patients from an analysis of the 2002 NIS.¹⁵ Other differences in inpatient management unmeasured by administrative data, such as the use of subspecialists and allied health professionals, may also contribute.³² Unfortunately, limitations in the available data prevented us from being able to appropriately address the important issue of insurance related differences in the utilization of specific inpatient procedures.

These disparities may also be indicative of differences in severity of illness that are not captured fully by the MedStat disease staging criteria. The uninsured might have more severe illness at admission, either due to the presence of more advanced chronic disease or delay in seeking care for the acute episode. AMI and stroke are usually the culmination of long-standing atherosclerosis that is amenable to improvement through timely and consistent risk-factor modification. Not having a usual source of medical care,^{6,33} inadequate screening and management of known risk-factors,^{3,34} and difficulties in obtaining specialty care⁵ among the uninsured likely increases their risk of being hospitalized with more advanced disease. The higher likelihood of being admitted through the emergency department¹⁹ and on weekends⁹ among the uninsured lends credence to the possibility of delays in seeking

TABLE 4. Multivariable-Adjusted In-Hospital Mortality and Resource Use for 3 Common Medical Conditions by Insurance Category, 2005 Nationwide Inpatient Sample

	Model 1*	Model 2 [†]	Model 3 [‡]
In-hospital mortality, adjusted odds ratio (95% CI)			
Acute Myocardial Infarction			
Uninsured vs. privately insured	1.59 (1.35-1.88)	1.58 (1.30-1.93)	1.52 (1.24-1.85)
Medicaid vs. privately insured	1.83 (1.54-2.18)	1.22 (0.99-1.50)	1.15 (0.94-1.42)
Stroke			
Uninsured vs. privately insured	1.56 (1.35-1.80)	1.50 (1.30-1.73)	1.49 (1.29-1.72)
Medicaid vs. privately insured	1.32 (1.15-1.52)	1.09 (0.93-1.27)	1.08 (0.93-1.26)
Pneumonia			
Uninsured vs. privately insured	0.99 (0.81-1.21)	1.12 (0.91-1.39)	1.10 (0.89-1.36)
Medicaid vs. privately insured	1.41 (1.20-1.65)	1.24 (1.04-1.48)	1.21 (1.01-1.45)
Length of stay, adjusted ratio (95% CI) [§]			
Acute Myocardial Infarction			
Uninsured vs. privately insured	1.00 (0.98-1.02)	1.00 (0.98-1.02)	1.00 (0.98-1.02)
Medicaid vs. privately insured	1.17 (1.14-1.21)	1.07 (1.05-1.09)	1.07 (1.05-1.09)
Stroke			
Uninsured vs. privately insured	1.06 (1.02-1.10)	1.08 (1.04-1.11)	1.07 (1.04-1.11)
Medicaid vs. privately insured	1.30 (1.26-1.34)	1.17 (1.14-1.20)	1.17 (1.14-1.20)
Pneumonia			
Uninsured vs. privately insured	0.95 (0.93-0.97)	0.96 (0.94-0.99)	0.96 (0.94-0.98)
Medicaid vs. privately insured	1.15 (1.13-1.17)	1.04 (1.03-1.06)	1.04 (1.03-1.06)
Cost per episode, adjusted ratio (95% CI) [§]			
Acute Myocardial Infarction			
Uninsured vs. privately insured	0.97 (0.95-0.99)	0.99 (0.97-1.00)	0.99 (0.97-1.00)
Medicaid vs. privately insured	1.01 (0.98-1.04)	0.99 (0.97-1.01)	0.99 (0.97-1.01)
Stroke			
Uninsured vs. privately insured	0.97 (0.93-1.02)	1.00 (0.96-1.03)	1.00 (0.97-1.03)
Medicaid vs. privately insured	1.17 (1.13-1.21)	1.06 (1.04-1.09)	1.06 (1.04-1.09)
Pneumonia			
Uninsured vs. privately insured	0.95 (0.92-0.97)	0.98 (0.96-1.00)	0.98 (0.96-1.00)
Medicaid vs. privately insured	1.17 (1.15-1.19)	1.05 (1.04-1.07)	1.05 (1.04-1.07)

NOTE: Using multivariable logistic regression models for in-hospital mortality and multivariable linear regression models for log transformed length of stay and cost per episode.

Abbreviation: CI, confidence interval.

* Model 1 adjusted for patients' age group, sex, race, income, emergency admission, and weekend admission and for hospitals' bed size, control, region, and teaching status.

[†] Model 2 adjusted for all the covariates in model 1 and comorbidities and severity of principal diagnosis.

[‡] Model 3 adjusted for all the covariates in model 2 and the proportion of uninsured and Medicaid patients in each hospital. Interaction terms were not included in any of these 3 models.

[§] Patients who died were excluded from models for length of stay and cost. Ratios are the antilog of the beta coefficients and can be interpreted in the original scale of the data as the impact relative to the reference level. Log transformations were used to approximate normal distribution.

care. All of these are potential mediators of higher AMI and stroke mortality in uninsured patients.

Finally, these mortality differences could also be due to the additional risks imposed by poorly managed comorbidities among uninsured patients. Although we controlled for the presence of comorbidities in our analysis, we lacked data about the severity of individual comorbidities. A recent study reported significant lapses in follow-up care after the onset of a chronic condition in uninsured individuals under 65 years of age.³⁴ Other studies have also documented insurance related disparities in the care of chronic diseases^{3,35} that were among the most common comorbidities in our cohort.

Most of the reasons for insurance-related disparities noted above for the uninsured are also applicable to Medicaid patients. Differences in the intensity of inpatient

care,^{7,8,15-19} limited access to health care services,^{2,14} unmet health needs,⁵ and suboptimal management of chronic medical conditions³⁵ were also reported for Medicaid patients in prior research. These factors likely contributed to the higher in-hospital mortality in this patient population, evidenced by the sequential decrease in odds after adjusting for comorbidities and disease severity. Medicaid patients hospitalized for stroke were noted to have significantly longer LOS, which could plausibly be due to difficulties with arranging appropriate discharge disposition; the higher likelihood of paralysis among these patients¹⁵ would likely necessitate a higher frequency of rehabilitation facility placement. The higher costs for Medicaid patients with stroke and pneumonia may potentially be the result of these patients longer LOS. Although cost differences between the uninsured and privately insured were

statistically significant, these were not large enough to be of material significance.

Limitations

Our study has several limitations. Since the NIS does not assign unique patient identifiers that would permit tracking of readmissions, we excluded patients transferred to another acute-care hospital from our study to avoid counting the same patient twice. However, only 10% of hospitalized patients underwent transfer for cardiac procedures in the National Registry of Myocardial Infarction, with privately insured patients more likely to be transferred than other insurance groups.¹⁷ Since these patients are also more likely to have better survival, their exclusion likely biased our study toward the null. The same is probable for stroke patients as well.

Some uninsured patients begin Medicaid coverage during hospitalization and should ideally be counted as uninsured but were included under Medicaid in our analysis. They are also likely to be state- and plan-specific variations in Medicaid and private payer coverage that we could not incorporate into our analysis. In addition, we were unable to include deaths that may have occurred shortly after discharge, even though these may have been related to the quality of hospital care. Furthermore, although the 3 conditions we studied are common and responsible for a large number of hospital deaths, they make up about 8% of total annual hospital discharges,²³ and caution should be exercised in generalizing our findings to the full spectrum of hospitalizations. Lastly, it is possible that unmeasured confounding could be responsible for the observed associations. Uninsured and Medicaid patients are likely to have more severe disease, which may not be adequately captured by the administrative data available in the NIS. If so, this would explain the mortality association rather than insurance status.^{36,37}

Conclusions

Significant insurance-related differences in mortality exist for 2 of the leading causes of noncancer inpatient deaths among working-age Americans. Further studies are needed to determine whether provider sensitivity to insurance status or unmeasured sociodemographic and clinical prognostic factors are responsible for these disparities. Policy makers, hospital administrators, and physicians should be cognizant of these disparities and consider policies to address potential insurance related gaps in the quality of inpatient care.

Address for correspondence and reprint requests:

LeRoi S. Hicks, MD, MPH, Division of General Medicine, Brigham and Women's Hospital, 1620 Tremont Street, 3rd Floor, Boston, MA 02120-1613; Telephone: 617-732-5500 ext. 32537; Fax: 617-732-7072; E-mail: lhicks1@partners.org Received 20 March 2009; revision received 21 November 2009; accepted 30 January 2010.

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