Differences in Hospital Readmission Risk across All Payer Groups in South Carolina

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Objective. To evaluate differences in hospital readmission risk across all payers in South Carolina (SC).

Data Sources/Study Setting. South Carolina Revenue and Fiscal Affairs Office (SCRFA) statewide all payer claims database including 2,476,431 hospitalizations in SC acute care hospitals between 2008 and 2014.

Study Design. We compared the odds of unplanned all-cause 30-day readmission for private insurance, Medicare, Medicaid, uninsured, and other payers and examined interaction effects between payer and index admission characteristics using generalized estimating equations.

Data Collection. SCRFA receives claims and administrative health care data from all SC health care facilities in accordance with SC state law.

Principal Findings. Odds of readmission were lower for females compared to males in private, Medicare, and Medicaid payers. African Americans had higher odds of readmission compared to whites across private insurance, Medicare, and Medicaid, but they had lower odds among the uninsured. Longer length of stay had the strongest association with readmission for private and other payers, whereas an increased number of comorbidities related to the highest readmission odds within Medicaid.

Conclusions. Associations between index admission characteristics and readmission likelihood varied significantly with payer. Findings should guide the development of payer-specific quality improvement programs.

Key Words. Hospital readmission, hospitals, all payer, administrative data

Implementation of the Affordable Care Act has held hospitals accountable for elevated readmission rates for select medical and surgical conditions over the past 5 years and has made hospital readmission an important quality metric (Axon and Williams 2011). Successful strategies have been developed to reduce hospital readmission rates (Hansen et al. 2011; Leppin et al. 2014),

and multiple federal and state programs focus on improving care transitions for hospitalized patients. These include Centers for Medicare and Medicaid Services (CMS) sponsored Community-Based Care Transitions demonstration projects, Hospital Engagement Networks, and state-based CMS quality improvement organizations (Brock et al. 2013; Centers for Medicare and Medicaid Services Innovation Center 2014; Centers for Medicare and Medicaid Services Partnership for Patients 2014).

Currently, the vast majority of the hospital readmissions literature is based on studies of Medicare data (Jencks, Williams, and Coleman 2009; Jha, Orav, and Epstein 2010; Lindenauer et al. 2010; Goodman, Fisher, and Chang 2011, 2013; Dharmarajan et al. 2013; Horwitz et al. 2014; Ranasinghe et al. 2014). Nevertheless, progress toward reducing hospital readmissions has been slow, with little documented change in the Medicare population between 2004 and 2010 (Goodman, Fisher, and Chang 2011, 2013), although some suggest recent readmission rate improvements (Gerhardt et al. 2013). Substantially less is known about hospital readmission risk associated with index admission characteristics for Medicaid patients, privately insured patients, and those without health insurance. In a recent analysis of 36.5 million hospital stays by Lopez-Gonzalez et al. (2012), 20.9 percent were Medicaid patients, 30.6 percent had private insurance, and 5.6 percent were self-pay patients. Each of these groups had differing distributions of age, gender, and comorbidities which might connote different readmission risks. Literature suggests that large-scale population-based studies of readmissions are needed to comprehend the variety of factors that can lead to a patient being readmitted (Jencks, Williams, and Coleman 2009).

Over 2,600 U.S. hospitals received reimbursement reductions from CMS in 2015 for higher than expected risk-adjusted 30-day all-cause hospital readmission rates for various conditions and surgeries (Centers for Medicare

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& Medicaid Services 2014; Rau 2014). In addition, reports suggest that state organizations and commercial insurance providers are contemplating, or have already implemented, reimbursement penalties related to hospital readmissions (Chang 2014; Chen, Scheffler, and Chandra 2014; Integrated Healthcare Association 2014a,b). In South Carolina (SC), Blue Cross/Blue Shield of SC will implement payment incentives for hospitals with lower than expected readmission rates (S. Stinson, MD, personal communication). Such readmission performance incentive programs can potentially foster innovation to improve hospital care transitions.

We performed a retrospective cohort study of acute care hospitalizations in SC to compare differences in the likelihood of hospital readmission across payers. Additionally, we examined both common index diagnoses and comorbidities leading to readmission and evaluated the effect of interactions between payer and index admission characteristics on the odds of readmission. To our knowledge, this is one of few studies to assess readmissions across multiple payer groups and the first to consider payer interactions.

METHODS

This population-based surveillance data analysis was conducted after securing approval from the Institutional Review Board of the University of SC. Data for this study were obtained from the SC Revenue and Fiscal Affairs Office (SCRFA). Since 1996, in accordance with SC state law, SCRFA has received health care data from all hospital inpatient facilities within the state.

Inclusion and Exclusion Criteria

Acute hospitalizations were eligible for inclusion if there were at least 30-day follow-up from the discharge date and the patient was between 18 and 100 years of age, discharged alive, and not transferred to another acute care hospital upon discharge. Based on these criteria, the initial cohort included 2,607,011 hospitalizations in SC acute care hospitals from January 1, 2008 to December 31, 2014. After excluding hospitalizations with incomplete administrative data, those discharged against medical advice, and admissions for “rehabilitation care; fitting of prostheses and adjustment devices” (CCS 254), a total of 2,476,431 hospitalizations served as the final study cohort for analysis. CCS refers to the Agency for Healthcare Research and Quality’s Clinical Classification Software (CCS) for deriving diagnosis categories based on

principal diagnoses (Agency for Healthcare Research and Quality 2014). As it would be impractical to analyze principal diagnoses using the vast quantity of International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis codes, CCS was used to group these codes into clinically meaningful categories.

Variable Specification

Following Horwitz et al. (2015), the outcome for this study was unplanned all-cause 30-day readmission after an admission for any condition. Any readmission which occurred within 30 days of a previous discharge date was eligible, excluding those that were considered planned. Planned readmissions were those including at least one of 32 commonly planned procedures or maintenance chemotherapy. However, these readmissions were only excluded from the definition if they also did not contain an acute illness or a complication of care. For these specifications, we used a predetermined list of CCS procedure categories and 26 discharge CCS condition categories, also originally compiled by Horwitz et al. (2015). The process for analytic cohort selection and specifying unplanned readmission is outlined in Figure 1.

Payer was designated as the primary payer on the medical claim and categorized as private (commercial insurance and private HMO), Medicare, Medicaid, uninsured (self-insured and indigent/charitable organization), and other payers (worker's compensation, Champus, State, and County). Index admission characteristics included gender (male or female), age (18–29, 30–39, 40–49, 50–59, 60–69, 70–79, or 80+ years), race (white, African American, or other), and urban/rural status, which was defined according to the 2010 Office of Management and Budget standards for defining metropolitan statistical areas and micropolitan statistical areas (2010 Standards for Delineating Metropolitan and Micropolitan Statistical Areas, 2010). Length of stay (LOS; ≤ 2 days, 3–5 days, or ≥ 6 days) was calculated as the difference in days between the discharge and admission dates.

Comorbidities were derived from the Elixhauser Comorbidity Index, which includes 30 specific comorbidities based on the ICD-9-CM coding manual (Elixhauser et al. 2013). Specifically, the enhanced ICD-9-CM coding algorithms (Quan et al. 2005) were used to define comorbidities in our study based on up to 14 secondary diagnosis codes recorded with the admission. Additionally, the number of comorbidities per hospitalization was classified into four categories (0, 1, 2, or ≥ 3).

Figure 1: Determination of Final Study Cohort and Definition of Unplanned All-Cause 30-Day Readmission

We expect moderate or high collinearity between certain analysis variables, such as Medicare payer and age groups 60–69, 70–79, and 80+ years, LOS, and comorbidity number.

Missing Data

Of 2,607,011 acute hospitalizations meeting the study inclusion criteria, 79,438 hospitalizations were excluded due to missing data on payer, gender, age, race, urban/rural status, dates of admission or discharge, patient identifier, or hospital identifier. This resulted in a cumulative missing prevalence of 3.0 percent for this study.

Analysis

Descriptive statistics were calculated to examine index admission characteristics of hospitalizations, including gender, age, race, urban/rural status, LOS, and number of comorbidities by payer. Additionally, annual readmission rates for each payer were plotted to observe trends in readmission by payer. For all unplanned all-cause 30-day readmissions, we determined the 10 most frequent conditions from the index admission for each payer using CCS diagnosis categories. Similarly, we identified the 10 most frequent comorbidities from the index admission, based on the Elixhauser Comorbidity Index, related to a subsequent readmission by payer. All data analyses were performed using *SAS for Windows, version 9.4* (SAS Institute Inc., Cary, NC).

Initially, unadjusted odds ratios (ORs) were calculated for each index admission characteristic to determine individual associations with 30-day readmission. We then incorporated these characteristics into a logistic regression model. To account for clustering at the hospital level, we used generalized estimating equations (GEEs) with an independent correlation matrix. Adjusted ORs were based on this main effects model. To test for payer interaction, we augmented the main effects models with interactions between payer and index admission characteristics. All interactions excluding payer by urban/rural status were significant at $\alpha \leq 0.05$, and the inclusion of interaction significantly decreased the Akaike information criterion (AIC). Removing the payer by urban/rural status interaction further decreased the AIC and resulted in our final model.

To test model robustness, we randomly selected 60 percent of the total observations and executed the final model with the resulting data. We

repeated this process 100 times with different randomly selected samples resulting in a total of 100 sets of estimates. In the cross-validation of 100 samples, estimates were consistent across samples and reflected our parameter estimates in the population.

RESULTS

Characteristics of the 2,476,431 included SC hospitalizations are shown in Table 1 by primary payer. In the total cohort, the majority of hospitalizations were for females (61.1 percent), whites (65.3 percent), and those living in urban areas (69.2 percent). Most hospitalizations had a LOS of ≤ 2 days (42.0 percent) or 3–5 days (37.3 percent), and nearly 80 percent of hospitalized patients had at least one comorbidity. Medicare was the primary payer for a large proportion of the cohort (40.6 percent), 30.1 percent had private insurance, 15.8 percent had Medicaid, 10.9 percent were uninsured, and 2.5 percent had another form of insurance. The cohort spanned 65 SC hospitals, ranging from 36 to 171,994 hospitalizations within the study period.

Of 271,365 readmissions, 30,135 were categorized as planned. Subsequently, 8,600 of planned readmissions were determined to include an acute illness or complication of care, thus resulting in 21,535 readmissions which were excluded. Therefore, there were a total of 249,830 readmissions which met the definition of unplanned all-cause 30-day readmission and an overall readmission rate of 10.1 percent. As displayed in Figure 2, annual readmission rates were highest among Medicare and Medicaid beneficiaries, lowest among private and alternate payers, and intermediate among the uninsured.

Of the most frequent principal diagnoses leading to unplanned readmission shown in Table 2, only diabetes mellitus with complications was seen across all payers. Congestive heart failure, COPD, and bronchiectasis, and pneumonia appeared in four of the five payer groups. Additionally, several conditions including sickle cell anemia, pancreatic disorders, alcohol-related disorders, renal failure, and spondylosis among others were specific to individual payers. In contrast to the principal diagnoses, 8 of 10 most frequent comorbidities shown in Table 3 were found across all payers, and hypertension was the most frequently occurring. Alcohol and drug abuse were outliers, found in only one or two payers, respectively.

Unadjusted associations of individual admission characteristics with readmission are shown in Table 4 along with adjusted odds of readmission

Table 1: Characteristics of Hospitalizations by Primary Payer, 2008–2014 ($N = 2,476,431$)

	Private* ($n = 744,705$)	Medicare ($n = 1,006,061$)	Medicaid ($n = 392,303$)	Uninsured [†] ($n = 270,715$)	Other [‡] ($n = 62,647$)
Female	483,551 (64.9)	547,696 (54.4)	317,964 (81.1)	123,768 (45.7)	40,070 (64.0)
Urban	540,697 (72.6)	663,898 (66.0)	266,316 (67.9)	194,581 (71.9)	47,782 (76.3)
Age (M, SD)	46.8 (15.7)	69.2 (13.6)	35.0 (14.4)	44.4 (13.4)	41.3 (15.5)
18–29	130,259 (17.5)	13,995 (1.4)	190,139 (48.5)	47,786 (17.7)	20,179 (32.2)
30–39	139,010 (18.7)	24,225 (2.4)	72,935 (18.6)	47,895 (17.7)	10,362 (16.5)
40–49	126,202 (17.0)	52,037 (5.2)	46,603 (11.9)	69,463 (25.7)	9,364 (15.0)
50–59	173,142 (23.3)	105,950 (10.5)	54,632 (13.9)	70,133 (25.9)	12,559 (20.1)
60–69	129,674 (17.4)	263,695 (26.2)	23,812 (6.1)	30,537 (11.3)	9,269 (14.8)
70–79	30,662 (4.1)	323,515 (32.2)	2,441 (0.6)	3,010 (1.1)	619 (1.0)
80+	15,756 (2.1)	222,644 (22.1)	1,741 (0.4)	1,891 (0.7)	295 (0.5)
Race					
White	529,759 (71.1)	713,012 (70.9)	176,068 (44.9)	153,692 (56.8)	43,644 (69.7)
AA	191,606 (25.7)	278,114 (27.6)	182,761 (46.6)	97,036 (35.8)	14,568 (23.2)
Other	23,340 (3.1)	14,935 (1.5)	33,474 (8.5)	19,987 (7.4)	4,435 (7.1)
LOS (M, SD)	3.6 (4.2)	4.7 (5.1)	4.1 (6.5)	4.6 (6.8)	3.3 (4.9)
≤2 days	362,706 (48.7)	350,171 (34.8)	181,695 (46.3)	110,552 (40.8)	34,146 (54.5)
3–5 days	270,838 (36.4)	390,198 (38.8)	144,242 (36.8)	96,997 (35.8)	21,116 (33.7)
≥6 days	111,161 (14.9)	265,692 (26.4)	66,366 (16.9)	63,166 (23.3)	7,385 (11.8)
Comorbidities (M, SD)	1.7 (1.7)	3.3 (1.8)	1.5 (1.8)	2.2 (1.8)	1.2 (1.5)
0	242,361 (32.5)	54,406 (5.4)	172,293 (43.9)	54,432 (20.1)	27,839 (44.4)
1	162,256 (21.8)	124,615 (12.4)	71,332 (18.2)	56,999 (21.1)	13,797 (22.0)
2	129,374 (17.4)	191,246 (19.0)	47,459 (12.1)	55,801 (20.6)	9,248 (14.8)
3+	210,714 (28.3)	635,794 (63.2)	101,219 (25.8)	103,483 (38.2)	11,763 (18.8)

*Includes commercial insurance and private HMO.

†Includes self-insured and indigent/charitable organization.

‡Includes worker's compensation and other government (champus, state, county).
AA, African American; LOS, length of stay.

Figure 2: Annual Unadjusted 30-Day All-Cause Readmission Rates by Payer, 2008–2014

based on the main effects model, including payer, gender, urban/rural status, age, race, LOS, and number of comorbidities. In the model, Medicare and Medicaid populations had higher odds of readmission compared to those with private insurance, whereas those with other payers had lower odds. Females and those living in urban areas of SC were less likely to be readmitted compared to males and rural dwellers, respectively. African Americans had a higher likelihood of readmission compared to whites and other races. Adjusted odds of readmission also increased with longer LOS and higher number of comorbidities.

Table 5 shows adjusted odds ratios stratified by payer from our final model incorporating interactions between payer and admission characteristics. The odds of readmission decreased for females compared to males in the private, Medicare, and Medicaid payer groups, but there was no association between gender and readmission for uninsured and other payers. Within Medicare, the 60–69 and 70–79 age groups had slightly higher odds of readmission compared to the 80+ age group. Within Medicaid, those younger than 70 years old had a higher odds of readmission compared to older age groups, but readmission odds did not vary significantly

Table 2: Top 10 Conditions Leading to 30-Day Readmission by Payer, 2008–2014 ($N = 249,830$)

Rank	Private* ($n = 55,455$)	Medicare ($n = 122,918$)	Medicaid ($n = 43,472$)	Uninsured† ($n = 24,164$)	Other‡ ($n = 3,821$)
1	CHF; nonhypertensive (2,019, 3.6%)	CHF; nonhypertensive (9,874, 8.0%)	Sickle cell anemia (2,825, 6.5%)	DM with complications (1,587, 6.6%)	Early or threatened labor (172, 4.5%)
2	DM with complications (1,585, 2.9%)	COPD and bronchiectasis (6,425, 5.2%)	Pregnancy complications (2,424, 5.6%)	Pancreatic disorders (1,097, 4.5%)	Spondylosis, intervertebral disk disorders, and other back problems (172, 4.5%)
3	Hypertension complicating pregnancy/childbirth (1,551, 2.8%)	Pneumonia (5,378, 4.4%)	Early or threatened labor (2,377, 5.5%)	CHF; nonhypertensive (948, 3.9%)	Pregnancy complications (162, 4.2%)
4	Complication of device, implant, or graft (1,428, 2.5%)	Cardiac dysrhythmias (5,003, 4.1%)	DM with complications (2,020, 4.7%)	Alcohol-related disorders (869, 3.6%)	Surgical/medical complications (131, 3.4%)
5	Early or threatened labor (1,384, 2.5%)	Septicemia (4,270, 3.5%)	CHF; nonhypertensive (1,674, 3.9%)	Mood disorders (837, 3.5%)	Hypertension complicating pregnancy/childbirth (105, 2.8%)
6	Pregnancy complications (1,374, 2.5%)	Complication of device, implant, or graft (4,157, 3.4%)	Hypertension complicating pregnancy/childbirth (1,539, 3.5%)	Hypertension with complications and secondary hypertension (757, 3.1%)	Complication of device, implant, or graft (105, 2.8%)
7	Cardiac dysrhythmias (1,369, 2.5%)	Acute and unspecified renal failure (3,826, 3.1%)	COPD and bronchiectasis (1,135, 2.6%)	COPD and bronchiectasis (666, 2.8%)	DM with complications (101, 2.6%)
8	Coronary atherosclerosis and other heart disease (1,351, 2.4%)	DM with complications (3,541, 2.9%)	Birth complications (1,108, 2.6%)	Acute myocardial infarction (585, 2.4%)	Birth complications (95, 2.5%)

Continued

Table 2. Continued

Rank	Private* (n = 55,455)	Medicare (n = 122,918)	Medicaid (n = 43,472)	Uninsured† (n = 24,164)	Other‡ (n = 3,821)
9	Surgical/medical complications (1,334, 2.4%)	Fluid and electrolyte disorders (3,304, 2.7%)	Fluid and electrolyte disorders (1,032, 2.4%)	Septicemia (532, 2.2%)	COPD and bronchiectasis (86, 2.3%)
10	Pneumonia (1,323, 2.4%)	Coronary atherosclerosis and other heart disease (3,084, 2.5%)	Pneumonia (1,010, 2.3%)	Pneumonia (522, 2.2%)	Lower limb fracture (75, 2.0%)

*Includes commercial insurance and private HMO.

†Includes self-insured and indigent/charitable organization.

‡Includes worker's compensation and other government (champus, state, county). CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus.

Table 3: Top 10 Comorbidities Associated with 30-Day Readmission by Payer, 2008–2014 (N = 249,830)

Rank	Private* (n = 55,455)	Medicare (n = 122,918)	Medicaid (n = 43,472)	Uninsured† (n = 24,164)	Other‡ (n = 3,821)
1	Hypertension (26,171, 47.2%)	Hypertension (39,631, 32.2%)	Hypertension (16,791, 38.6%)	Hypertension (11,328, 46.9%)	Hypertension (1,401, 36.7%)
2	Fluid and electrolyte disorders (13,612, 24.6%)	Fluid and electrolyte disorders (39,604, 32.2%)	Fluid and electrolyte disorders (11,513, 26.5%)	Fluid and electrolyte disorders (7,411, 30.7%)	Fluid and electrolyte disorders (735, 19.2%)
3	DM, uncomplicated (11,001, 19.8%)	Chronic pulmonary disease (37,714, 30.7%)	Chronic pulmonary disease (8,619, 19.8%)	Alcohol abuse (4,536, 18.8%)	Chronic pulmonary disease (622, 16.3%)
4	Chronic pulmonary disease (9,572, 17.3%)	Renal failure (36,643, 29.8%)	DM, uncomplicated (7,104, 16.3%)	DM, uncomplicated (4,235, 17.5%)	DM, uncomplicated (585, 15.3%)
5	Cardiac arrhythmias (7,986, 14.4%)	DM, uncomplicated (35,430, 28.8%)	Renal failure (6,452, 14.8%)	Chronic pulmonary disease (4,210, 17.4%)	Depression (524, 13.7%)
6	Depression (7,160, 12.9%)	CHF (35,161, 28.6%)	CHF (5,798, 13.3%)	Depression (3,520, 14.6%)	Cardiac arrhythmias (395, 10.3%)
7	CHF (7,153, 12.9%)	Cardiac arrhythmias (33,359, 27.1%)	Depression (5,743, 13.2%)	Drug abuse (3,197, 13.2%)	Obesity (381, 10.0%)
8	Renal failure (7,015, 12.7%)	Depression (16,343, 13.3%)	Obesity (5,020, 11.6%)	CHF (3,181, 13.2%)	CHF (268, 7.0%)
9	Obesity (6,917, 12.5%)	Hypothyroidism (15,362, 12.5%)	Cardiac arrhythmias (4,198, 9.7%)	Cardiac arrhythmias (3,052, 12.6%)	Renal failure (245, 6.4%)
10	Hypothyroidism (4,691, 8.5%)	Obesity (12,663, 10.3%)	Drug abuse (4,176, 9.6%)	Renal failure (3,006, 12.4%)	Hypothyroidism (245, 6.4%)

*Includes commercial insurance and private HMO.

†Includes self-insured and indigent/charitable organization.

‡Includes worker's compensation and other government (champus, state, county).

§Counts within a payer group are not mutually exclusive.

CHF, congestive heart failure; DM, diabetes mellitus.

Table 4: Bivariable (Unadjusted) and Multivariable (Adjusted) Association of Index Admission Characteristics with 30-Day Readmission

<i>Characteristics</i>	<i>Unadjusted OR (95% CI)</i>	<i>Adjusted[†] OR (95% CI)</i>
Payer		
Medicare	1.73 (1.61, 1.86)*	1.46 (1.40, 1.53)*
Medicaid	1.55 (1.44, 1.67)*	1.52 (1.42, 1.62)*
Uninsured	1.22 (1.11, 1.34)*	0.97 (0.89, 1.06)
Other	0.81 (0.72, 0.91)*	0.91 (0.85, 0.98)*
Private	REF	REF
Female	0.80 (0.77, 0.84)*	0.90 (0.87, 0.93)*
Urban	0.88 (0.82, 0.94)*	0.92 (0.87, 0.96)*
Age		
18–29	0.67 (0.58, 0.77)*	1.61 (1.45, 1.79)*
30–39	0.85 (0.75, 0.95)*	1.75 (1.60, 1.92)*
40–49	1.08 (0.99, 1.18)	1.64 (1.51, 1.77)*
50–59	0.75 (0.61, 0.91)*	2.35 (2.02, 2.74)*
60–69	1.10 (1.05, 1.16)*	1.29 (1.23, 1.35)*
70–79	1.08 (1.05, 1.12)*	1.12 (1.09, 1.16)*
80+	REF	REF
Race		
AA	1.32 (1.26, 1.38)*	1.17 (1.13, 1.21)*
Other	0.74 (0.56, 0.99)*	0.93 (0.71, 1.23)
White	REF	REF
Length of stay		
≥6 days	2.37 (2.26, 2.49)*	1.78 (1.71, 1.86)*
3–5 days	1.46 (1.40, 1.52)*	1.28 (1.24, 1.32)*
≤2 days	REF	REF
Comorbidities		
3+	3.06 (2.83, 3.31)*	2.77 (2.57, 2.99)*
2	1.99 (1.86, 2.14)*	1.94 (1.81, 2.08)*
1	1.53 (1.43, 1.63)*	1.52 (1.43, 1.61)*
0	REF	REF

* $p \leq .05$.

[†]Adjusted for covariates shown.

AA, African American; CI, confidence interval; OR, odds ratio.

for those between 18 and 69 years old. African Americans had higher odds of readmission across private insurance, Medicare, and Medicaid, but had lower odds among the uninsured compared to whites. Increased LOS and number of comorbidities were consistently associated with higher odds of readmission across all payers. LOS had the strongest association within private and other payer groups, whereas an increasing number of comorbidities related to the highest odds of readmission within the Medicaid group.

Table 5: Multivariable (Adjusted) Association of Index Admission Characteristics with 30-Day Readmission Stratified by Payer

	Adjusted [†] OR (95% CI)				
	Private	Medicare	Medicaid	Uninsured	Other
Female	0.95 (0.92, 0.99)*	0.94 (0.92, 0.96)*	0.72 (0.65, 0.80)*	0.97 (0.90, 1.03)	1.01 (0.89, 1.16)
Age					
18–29	1.19 (1.03, 1.37)*	3.00 (2.66, 3.39)*	2.03 (1.63, 2.52)*	1.24 (0.91, 1.69)	1.70 (1.22, 2.37)*
30–39	1.09 (0.95, 1.26)	2.64 (2.37, 2.94)*	2.24 (1.79, 2.80)*	1.39 (1.01, 1.89)*	1.59 (1.13, 2.23)*
40–49	1.09 (0.96, 1.23)	1.76 (1.64, 1.89)*	2.19 (1.75, 2.74)*	1.38 (1.02, 1.89)*	1.39 (0.99, 1.95)
50–59	1.01 (0.90, 1.14)	1.48 (1.41, 1.56)*	1.90 (1.56, 2.32)*	1.28 (0.95, 1.74)	1.33 (0.96, 1.86)
60–69	1.03 (0.94, 1.14)	1.22 (1.16, 1.27)*	1.75 (1.45, 2.11)*	1.33 (0.98, 1.81)	1.37 (0.97, 1.95)
70–79	1.10 (1.02, 1.17)*	1.12 (1.08, 1.15)*	1.16 (0.95, 1.41)	1.22 (0.79, 1.89)	1.19 (0.74, 1.90)
80+	REF	REF	REF	REF	REF
Race					
AA	1.15 (1.09, 1.20)*	1.20 (1.16, 1.24)*	1.21 (1.13, 1.30)*	0.91 (0.88, 0.95)*	1.00 (0.91, 1.10)
Other	0.76 (0.69, 0.83)*	1.02 (0.91, 1.15)	1.02 (0.53, 1.98)	0.95 (0.65, 1.40)	0.66 (0.55, 0.80)*
White	REF	REF	REF	REF	REF
Length of stay					
≥6 days	2.22 (2.12, 2.34)*	1.63 (1.57, 1.70)*	1.64 (1.42, 1.89)*	1.59 (1.45, 1.75)*	2.46 (2.13, 2.84)*
3–5 days	1.36 (1.29, 1.42)*	1.27 (1.24, 1.30)*	1.15 (1.02, 1.30)*	1.21 (1.12, 1.32)*	1.36 (1.27, 1.47)*
≤2 days	REF	REF	REF	REF	REF
Comorbidities					
3+	2.59 (2.44, 2.75)*	2.02 (1.82, 2.23)*	3.36 (2.82, 4.02)*	2.21 (1.94, 2.52)*	2.85 (2.58, 3.16)*
2	1.76 (1.65, 1.89)*	1.41 (1.29, 1.55)*	2.36 (2.02, 2.76)*	1.66 (1.39, 1.99)*	2.05 (1.82, 2.31)*
1	1.39 (1.30, 1.49)*	1.18 (1.08, 1.29)*	1.70 (1.53, 1.90)*	1.31 (1.18, 1.45)*	1.56 (1.33, 1.83)*
0	REF	REF	REF	REF	REF

* $p \leq .05$.
[†]Adjusted for gender, urban/rural status, age, race, LOS, comorbidities, and their interactions with payer (payer*urban/rural was excluded as it was not significant).
AA, African American; CI, confidence interval; OR, odds ratio.

DISCUSSION

Our study findings are unique because previous literature has not concurrently compared all payers to examine interactions between index admission characteristics and payer group. Our results indicate that Medicare patients have consistently higher annual readmission rates compared to all other payer groups and were similar compared to previous studies of readmission in Medicare populations (Jencks, Williams, and Coleman 2009; Lindenauer et al. 2010; Horwitz et al. 2014). While there was not an obvious change in readmission rates over the study period as a whole, we noticed a slight decline within Medicaid and Medicare in the last few years. This finding is in line with a recent report that suggests modest improvements in readmission rates in the Medicare population (Gerhardt et al. 2013).

Of particular importance is the variation noted by payer in the conditions leading to readmission. Diabetes mellitus was a leading diagnosis across all payer groups, although by volume of readmissions, congestive heart failure (noted in four of the five payer groups) was the leading diagnosis. The prevalence of these conditions, as well as pneumonia and COPD (also seen in four of the five payer groups), reinforces the importance of these strategic targets for focused work. Importantly, given population differences, the specific programs that have been developed emphasizing Medicare populations may need to be tailored for other groups. Of high interest is the recognition that sickle cell anemia, a lifelong condition with significant risks of morbidity and mortality, is the leading diagnosis related to readmission for the Medicaid population, but it is not present in any other category. Further analyses of this population and within payers of other subpopulations with high readmission frequency, such as pancreatic disorders and alcohol use disorders, are needed to explore specific health needs that could be targeted as a component of an overall readmission reduction strategy.

When evaluating comorbid conditions most associated with readmission, we saw remarkable consistency with 8 of the 10 comorbid conditions seen across all payer groups. Interestingly, fluid and electrolyte disorders were seen across all groups, creating an important target of attention toward discharge planning, as it is broadly linked to readmission and is an acute problem, unlike many of the other comorbid conditions associated with readmission. Another interesting finding is the presence of depression in all categories, as the subject of mental health and how to address it has been a topic of discussion lately. Likewise, renal failure contributes in all payers was

an important comorbidity for readmission and was a top-five comorbidity in the Medicaid group. These findings create new opportunities to focus work on readmissions with the potential to enhance patient-centered models that could broadly benefit the population.

With respect to subject characteristics, we observed that females were less likely to be readmitted compared to males for the privately insured, Medicare, and Medicaid, as has been observed in prior studies (Anderson and Steinberg 1985; Krumholz et al. 1997). Generally, women have been recognized as health care decision makers and have a higher overall utilization of health care services compared to men (Bertakis et al. 2000). Additionally, there is a known impact of gender on health that is multifactorial, with women having longer life expectancy overall which may indicate a protective effect of gender on known negative health outcomes such as readmission (Baker et al. 2014). This association was particularly present in Medicaid patients, where females were 0.72 times less likely to be readmitted. There are several confounding components, including the dominance of this population by women, attributed in part to Medicaid availability for low-income women during pregnancy and mothers of young children who may qualify. Qualification for non-pregnant, nonparents is stricter, resulting in an impoverished male population that may not have health benefits through Medicaid consistently, a factor that is known to constitute higher risk when benefits are available.

Our findings are consistent with work by Joynt, Orav, and Jha (2011), who examined hospitalized Medicare recipients and found that black patients had higher odds of 30-day readmission. They also discovered that patients discharged from minority-serving hospitals had higher readmission rates than those from nonminority-serving hospitals. Our current findings provide further evidence of racial differences in hospital readmission rates and offer initial evidence beyond the Medicare population (Tsai, Orav, and Joynt 2014). This is especially important in Medicaid populations where African Americans are disproportionately represented in SC. Racial and ethnic disparities in care are well documented, and these findings further highlight the need to identify and address disparities in care (2013 National Healthcare Disparities Report, 2014).

In this study, those living in rural areas were more likely to be readmitted compared to patients in urban areas based on the analysis of main effects, but we did not find a significant interaction between urban/rural status and payer. Approximately, 17 percent of U.S. residents dwell in rural areas, and these individuals face significant disparities in disease prevalence, access to care, and health outcomes (Spoont et al. 2011; Meit et al. 2014; Weissman

et al. 2015). Rural residents are more likely be hospitalized for ambulatory care-sensitive conditions, be diagnosed at a later cancer stage, and experience worse outcomes for chronic kidney disease (Spoont et al. 2011). Moreover, rural dwellers have significantly lower health-related quality of life (Weeks et al. 2004). These observations highlight the need for further study of hospitalized patients from rural areas as well as program development to mitigate the known additional risk these individuals experience across the board.

This study was dependent on administrative data records, which may include incomplete data, lack clinical precision or detail, and contain coding errors, and it relied on an assumption of coding accuracy and completion, as well as clinical precision to define unplanned readmission and identify index admission principal diagnoses and comorbidities. Although this assumption may hold true in the majority of cases, we must still take this limitation into account. Additionally, the possible failure to accurately isolate the principal diagnosis based on administrative records might be a limitation. The principal diagnosis, or the diagnosis determined to be the main reason for the hospitalization, may be misreported as a result of nonclinical decisions or reimbursement incentives.

Furthermore, we excluded 3 percent of patients from the starting cohort who do not have a known payer or did not have complete administrative data. Although we feel the risk is minimal due to the small prevalence of missing values, it may be possible that the exclusion of these patients influenced our findings, especially if exclusions were disproportionate by payer. Another limitation worth noting is the use of hospital data from a single state. There are several hospitals located just over SC state boundaries in North Carolina and Georgia. We were unable to track index admissions or readmissions to these hospitals, which may have reduced readmission rates in our data or influenced findings. Nonetheless, patients admitted or readmitted to out-of-state hospitals were unlikely to have a major effect on results as only 17.6 percent of patients were admitted to more than one hospital during the study period.

In summary, this analysis of a statewide all payer cohort of acute hospitalizations found significant differences in risk of readmission across payer groups with regard to index admission characteristics, including age, gender, race, urban/rural status, LOS, and number of comorbidities. While some of these findings reflect earlier work, others carry specific clinical and health policy import. For instance, the effects of gender, age, and race on 30-day readmission odds varied in terms of magnitude and direction depending upon the primary payer, highlighting the variability of high-risk groups between payer groups. Additionally, we found similarities and differences between the

highest frequency index admission principal diagnoses and comorbidities related to subsequent readmission indicating which conditions, when targeted, require a payer-specific approach or may be affected by a more general approach. These findings emphasize the importance of developing interventions and policies to target specific payers, as risk factors differ by group and should guide the development of payer-specific quality improvement programs among all payer groups, particularly non-Medicare populations. For instance, specific programs directed at the Medicaid population have recently been developed by Boutwell et al. (2014), and some states have developed effective outpatient case management programs to prevent recurrent hospitalizations among high-risk Medicaid enrollees (Jackson et al. 2013). Such successful models of care should be adopted, modified, and expanded broadly to other payer populations as well.

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REFERENCES

- Agency for Healthcare Research and Quality. 2014. "Clinical Classifications Software (CCS) 2014" [accessed on January 1, 2015]. Available at <https://www.hcup-us.ahrq.gov/toolssoftware/ccs/CCSUsersGuide.pdf>
- Anderson, G. F., and E. P. Steinberg. 1985. "Predicting Hospital Readmissions in the Medicare Populations." *Inquiry* 22: 251–8.
- Axon, R. N., and M. V. Williams. 2011. "Hospital Readmission as an Accountability Measure." *Journal of the American Medical Association* 305 (5): 504–5.

- Baker, P., S. L. Dworkin, S. Tong, I. Banks, T. Shand, and G. Yamey. 2014. "The Men's Health Gap: Men Must be Included in the Global Health Equity Agenda." *Bulletin of the World Health Organization* 92: 618–20.
- Bertakis, K. D., R. Azari, L. J. Helms, E. J. Callahan, and J. A. Robbins. 2000. "Gender Differences in the Utilization of Health Care Services." *Journal of Family Practice* 49 (2): 147–52.
- Boutwell, A. E., J. Snow, J. Maxwell, A. Bourgoin, and S. Genetti. 2014. *Hospital Guide to Reducing Medicaid Readmissions*. Rockville, MD: Agency for Healthcare Research and Quality.
- Brock, J., J. Mitchell, K. Irby, B. Stevens, T. Archibald, A. Goroski, and J. Lynn. 2013. "Association between Quality Improvement for Care Transitions in Communities and Rehospitalizations among Medicare Beneficiaries." *Journal of the American Medical Association* 309 (4): 381–91.
- Centers for Medicare & Medicaid Services. 2014. "Readmissions Reduction Program (HRRP)" [accessed on November 2014]. Available at <https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html>
- Centers for Medicare and Medicaid Services Innovation Center. 2014. "Community Based Care Transitions Program" [accessed on November 1, 2014]. Available at <http://innovation.cms.gov/initiatives/CCTP/index.html>
- Centers for Medicare and Medicaid Services Partnership for Patients. 2014. "About the Partnership: Hospital Engagement Networks" [accessed on December 1, 2014]. Available at <http://partnershipforpatients.cms.gov/about-the-partnership/hospital-engagement-networks/thehospitalengagementnetworks.html>
- Chang, D. C. 2014. "Aligning Private Sector Incentives with Health Care Quality: Need for Quality-Adjusted Hospital Bond Ratings." *Annals of Surgery* 260 (1): 3–4.
- Chen, C., G. Scheffler, and A. Chandra. 2014. "Readmission Penalties and Health Insurance Expansions: A Dispatch from Massachusetts." *Journal of Hospital Medicine* 9 (11): 681–7.
- Dharmarajan, K., A. F. Hsieh, Z. Lin, H. Bueno, J. S. Ross, L. I. Horwitz, J. A. Barreto-Filho, N. Kim, L. G. Suter, S. M. Bernheim, and E. E. Drye. 2013. "Hospital Readmission Performance and Patterns of Readmission: Retrospective Cohort Study of Medicare Admissions." *British Medical Journal* 347: f6571.
- Elixhauser, A., C. Steiner, D. R. Harris, and R. M. Coffey. 2013. "Comorbidity Measures for Use with Administrative Data." *Medical Care* 36 (1): 8–27.
- Gerhardt, G., A. Yemane, P. Hickman, A. Oelschlaeger, E. Rollins, and N. Brennan. 2013. "Medicare Readmission Rates Showed Meaningful Decline in 2012." *Medicare & Medicaid Research Review* 3 (2): E1–E12.
- Goodman, D., E. Fisher, and C. Chang. 2011. *After Hospitalization: A Dartmouth Atlas Report on Post-Acute Care for Medicare Beneficiaries*. Lebanon, NH: The Dartmouth Institute for Health Policy and Clinical Practice.
- Hansen, L. O., R. S. Young, K. Hinami, A. Leung, and M. V. Williams. 2011. "Interventions to Reduce 30-Day Rehospitalization: A Systematic Review." *Annals of Internal Medicine* 155 (8): 520–8.

- Horwitz, L. I., C. Partovian, Z. Lin, J. N. Grady, J. Herrin, M. Conover, J. Montague, C. Dillaway, K. Bartczak, L. G. Suter, and J. S. Ross. 2014. "Development and Use of an Administrative Claims Measure for Profiling Hospital-Wide Performance on 30-Day Unplanned Readmission." *Annals of Internal Medicine* 161 (10 Suppl): S66–75.
- Horwitz, L. I., J. Grady, D. Cohen, Z. Lin, M. Volpe, C. K. Ngo, A. L. Masica, T. Long, J. Wang, M. Keenan, and J. Montague. 2015. "Development and Validation of an Algorithm to Identify Planned Readmissions from Claims Data." *Journal of Hospital Medicine* 10 (10): 670–7.
- Integrated Healthcare Association. 2014a. *Recommended Measure Set for Measurement Year 2014*. Washington, DC: National Committee for Quality Assurance.
- Integrated Healthcare Association. 2014b. *Pay for Performance Overview*. Washington, DC: National Committee for Quality Assurance.
- Jackson, C. T., T. K. Trygstad, D. A. DeWalt, and C. A. DuBard. 2013. "Transitional Care Cut Hospital Readmissions for North Carolina Medicaid Patients with Complex Chronic Conditions." *Health Affairs* 32 (8): 1407–15.
- Jencks, S. F., M. V. Williams, and E. A. Coleman. 2009. "Rehospitalizations among Patients in the Medicare Fee-for-Service Program." *New England Journal of Medicine* 360 (14): 1418–28.
- Jha, A. K., E. J. Orav, and A. M. Epstein. 2010. "The Effect of Financial Incentives on Hospitals That Serve Poor Patients." *Annals of Internal Medicine* 153 (5): 299–306.
- Joynt, K. J., E. J. Orav, and A. K. Jha. 2011. "Thirty-Day Readmission Rates for Medicare Beneficiaries by Race and Site of Care." *Journal of the American Medical Association* 305: 675–81.
- Krumholz, H. M., E. M. Parent, N. Tu, V. Vaccarino, Y. Wang, M. J. Radford, and J. Hennen. 1997. "Readmissions after Hospitalization for Congestive Heart Failure among Medicare Beneficiaries." *Archives of Internal Medicine* 157: 99–104.
- Leppin, A. L., M. R. Gionfriddo, M. Kessler, J. P. Brito, F. S. Mair, K. Gallacher, Z. Wang, P. J. Erwin, T. Sylvester, K. Boehmer, and H. H. Ting. 2014. "Preventing 30-Day Hospital Readmissions: A Systematic Review and Meta-Analysis of Randomized Trials." *Journal of the American Medical Association Internal Medicine* 174 (7): 1095–107.
- Lindenauer, P. K., S. M. Bernheim, J. N. Grady, Z. Lin, Y. Wang, Y. Wang, A. R. Merrill, L. F. Han, M. T. Rapp, E. E. Drye, and S. L. T. Normand. 2010. "The Performance of US Hospitals as Reflected in Risk-Standardized 30-Day Mortality and Readmission Rates for Medicare Beneficiaries with Pneumonia." *Journal of Hospital Medicine* 5 (6): E12–8.
- Lopez-Gonzalez, L., G. T. Pickens, R. Washington, and A. J. Weiss. 2012. "Characteristics of Medicaid and Uninsured Hospitalizations, 2012: Statistical Brief #182." Healthcare Cost and Utilization Project Statistical Brief [accessed on November 1, 2014]. Available at <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb182-Medicaid-Uninsured-Hospitalizations-2012.jsp>
- Meit, M., A. Knudson, T. Gilbert, A. T. Yu, E. Tanenbaum, and E. Ormson. 2014. *The 2014 Update of the Rural-Urban Chartbook*. Bethesda, MD: Rural Health Research & Policy Centers.

- Office of Management and Budget. 2010. 2010 Standards for Delineating Metropolitan and Micropolitan Statistical Areas; Notice [accessed on August 1, 2014]. Available at http://www.whitehouse.gov/sites/default/files/omb/assets/fedreg_2010/06282010_metro_standards-Complete.pdf
- Quan, H., V. Sundararajan, P. Halfon, A. Fong, B. Burnand, L. Jean-Christophe Luthi, D. Saunders, Cynthia. A. Beck, Thomas. E. Feasby, and William. A. Ghali. 2005. "Coding Algorithms for Defining Comorbidities in ICD-9-CM and ICD-10 Administrative Data." *Medical Care* 43 (11): 1130–9.
- Ranasinghe, I., Y. Wang, K. Dharmarajan, A. F. Hsieh, S. M. Bernheim, and H. M. Krumholz. 2014. "Readmissions after Hospitalization for Heart Failure, Acute Myocardial Infarction, or Pneumonia among Young and Middle-Aged Adults: A Retrospective Observational Cohort Study." *PLoS Medicine* 11 (9): e1001737.
- Rau, J. 2014. "Medicare Fines 2,610 Hospitals in Third Round of Readmission Penalties" [accessed on December 1, 2014]. Available at <http://khn.org/news/medicare-readmissions-penalties-2015/>
- Robert Wood Johnson Foundation. 2013. "The Revolving Door: A Report on U.S. Hospital Readmissions" [accessed on September 1, 2014]. Available at <http://www.rwjf.org/content/dam/farm/reports/reports/2013/rwjf404178>
- SAS Institute. 2013. *SAS (release 9.4) Statistical Software*. Cary, NC: SAS Institute.
- Spoont, M., N. Greer, J. Su, P. Fitzgerald, and I. Rutks. 2011. *Rural vs. Urban Ambulatory Health Care: A Systematic Review*. Washington, DC: Department of Veterans Affairs Health Services Research & Development Service.
- Tsai, T. C., E. J. Orav, and K. J. Joynt. 2014. "Disparities in Surgical 30-Day Readmission Rates for Medicare Beneficiaries by Race and Site of Care." *Annals of Surgery* 259: 1086–90.
- U.S. Department of Health and Human Services. 2014. 2013 National Healthcare Disparities Report. Rockville, MD: Agency for Healthcare Research and Quality.
- Weeks, W. B., L. E. Kazis, Y. Shen, Z. Cong, X. S. Ren, D. Miller, and A. Lee. 2004. "Differences in Health-Related Quality of Life in Rural and Urban Veterans." *American Journal of Public Health* 94: 1762–7.
- Weissman, S., W. Duffus, M. Vyayaharkar, H. Chakraborty, A. Samantapudi, and A. Albrecht. 2015. "Rural-Urban Differences in HIV Viral Loads and Progression to AIDS among New HIV Cases." *Southern Medical Journal* 108 (3): 180–8.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.