원 저

Does Process Quality of Inpatient Care Serve as a Guide to Reduce Potentially Preventable Readmission (PPR)?

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〈Abstract〉

의료서비스의 과정적 질과 잠재적으로 예방 가능한 재입원율과의 관계

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Purpose: 본 연구는 미국 캘리포니아와 플로리다에 위치한 의료기관을 대상으로 급성심근경색증, 심부전, 폐렴을 주진단으로 받은 메디케어 입원환자들에게 제공된 의료서비스의 과정적 질과 잠재적으로 예방이 가능한 30일 이내 위험 보정 재입원율과의 관계를 살펴보았다.

Methods: 본 연구의 종속변수는 잠재적으로 예방이 가능한 30일 이내 위험 보정 질환별 재입원율이며 3M PPR 소프트웨어를 이용하여 재입원의 예방 가능 여부를 결정하였다. 미연방 의료 비용 및 이용 프로젝트 데이터베이스, 미국병원협회의 병원조사 자료, 미연방 보건복지부소속 메디케어 및 메디케이드 서비스 센터의 병원비교 자료를 이용하였다. 자료의 위계적 구조를 고려하여 다수준 로지스틱 회귀분석을 이용하여 분석하였다.

Findings: 의료서비스의 과정적 품질과 퇴원 후 30일 이내 잠재적 예방 가능 위험도 보정 재입원율과의 관계는 질환별로 차이를 보였다. 폐렴의 경우 의료서비스의 과정적 질은 30일 이내 잠재적 예방 가능 보정 재입원율과 유의한 부(-)의 관계를 보였으나, 급성심근경색증과 심부전의 경우 대체로 유의한 관계를 관찰할 수 없었다.

Practical Implications: 잠재적으로 예방 가능한 급성심근경색증, 심부전 재입원율을 줄이기 위해서는 의료기관에서 가이드라인으로 따를 수 있는 더욱 다양한 근거 중심의 과정적 질 지표의 개발에 대한 정부와 보건의료계의 노력이 필요하다.

Keywords: 예방가능 재입원율, 과정적 질, 의료기관, 다수준 분석

I. INTRODUCTION

Hospital performance for potentially preventable readmission rates (herein referred to as the PPR) is gaining momentum as a reportable quality indicator for pay-for-performance for hospitals. Fifteen states had incentives or reimbursement policies to reduce PPR in fiscal year 2014, and 10 had plans to implement reimbursement policy [1]. As of August 2017, 13 State Medicaid programs and

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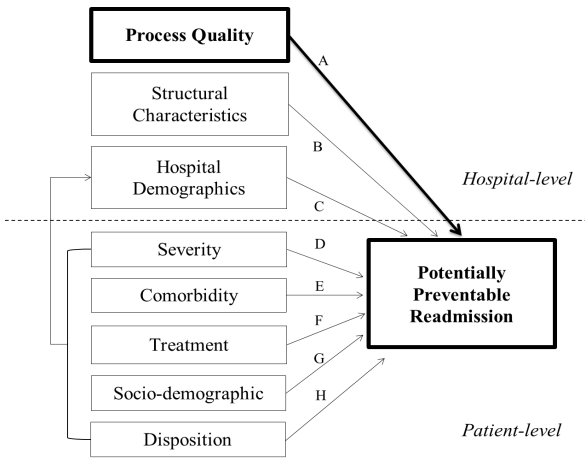
other state payers have adopted the 3M Potentially Preventable Readmissions (3M-PPR) software including, for public reporting, payment, and payment adjustment [2]. However, little is known about the link between the potentially preventable hospital readmission rates and quality of inpatient care. If PPR rates are to serve as a suitable marker of hospital performance, we need to make sure that hospital performance for quality of inpatient care during index hospitalization is inversely related to preventable hospital readmission rates.

Recent patient-level studies suggested no association between PPR software flagged readmissions and process quality of patient care during the index admission and after discharge for pneumonia[3], heart failure and AMI[4]. No hospital-level prior work to date has investigated the link between PPR rates and hospital performance for quality of inpatient care. A few relevant works, using data from OPTIMIZE-HF (Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients With Heart Failure) registry, have investigated the link, at hospital-level, between hospital performance for process quality of inpatient care for heart failure and all-cause or cardiovascular readmission after index hospitalization for heart failure[5,6]. While these studies generally suggest no association between hospital-level process quality of inpatient care for heart failure and cardiovascular or all-cause readmissions, it is uncertain whether the finding can be generalizable to PPR, to other medical conditions such as pneumonia or acute myocardial infarction, and to non-OPTIMIZE-HF institutions. The present work overcomes shortcomings and fills the gap in the prior literature by investigating the association between hospital performance for process quality of inpatient care and risk-adjusted, 30-day PPR after hospitalization for three common medical conditions- acute myocardial infarction, heart failure, and pneumonia-, controlling for organizational characteristics. This study contributes to the understanding of factors associated with the PPR rates. The specific aim of the present work is to investigate, at the hospital level, whether hospital performance for process quality of inpatient care delivered during initial hospitalization is related to PPR rates.

II. CONCEPTUAL MODEL

The conceptual model guiding this work is displayed in Figure 1. Because we investigate hospital effects on patient outcomes, we formulate a hierarchical model wherein patients are nested in hospitals. The constructs illustrated in Figure 1 are measured at two levels. Patient characteristics and the outcome, PPR, are measured on patients and hospital level factors, including process quality, are measured on hospitals. We highlight two key constructs in this study with bold lines around the boxes: process quality and the outcome-whether patients are readmitted for potentially preventable reason(s) or not. Our research questions are captured in Arrow A. The rest of the arrows -B, C, D, E, F, G, and H- represent variables that are controlled in the study.



<Figure 1> Conceptual Framework for Process Quality and Potentially Preventable Readmission

The within hospital regression coefficients express the associations of patient-level explanatory variables on the patient outcome (PPR) within a given hospital; the between hospital regression coefficients express the associations of the hospital-level explanatory variables on the group mean of the patient outcome (PPR rate). Process quality is measured on hospitals, not on patients. We capture process quality with hospitals' adherence to recommended clinical process of care. Specifically, the construct of process quality is operationalized in an aggregate measure: the proportion of patients who received the recommended care out of all the patients who were eligible for the recommended care. We examine the link between hospitals' performance for process quality and the group mean of PPR, i.e., PPR rate, which is captured by Arrow A (Research Question 1). We hypothesize that hospitals with better performance for process quality of inpatient care would have lower PPR rates. This hypothesized association is controlled for patients' risk factors and hospital characteristics.

We capture patient clinical characteristics with following measures: severity (measured by prior hospitalization), comorbidity (measured by Elixhasuer comorbid conditions), and cardiac procedures for AMI patients (measured by coronary artery bypass graft or percutaneous transluminal coronary angioplasty). The association between clinical characteristics and outcome is captured in Arrow D, E, and F. We capture patient socio-demographic characteristics with following measures: age, sex, race, income (measured by median household income state quartile for patient ZIP Code), which is captured by Arrow G. We also control patients' discharge location, which is captured in Arrow H. The structural and demographic characteristics of the hospitals (Arrow A and C) are included for purposes of statistical control. We capture hospital structure with following measures: hospital ownership status, teaching intensity, Magnet status (a proxy of nurse care environments), condition-specific hospital volume (a proxy of experience with managing condition), capacity to perform cardiac catherization (a proxy of high-tech cardiac services), Medicare disproportionate-share hospital (DSH) index (a proxy of the proportion of poor patients), and system affiliation. We capture hospital demographic composition with the following measures: condition-specific average number of Elixhauser comorbid condition, and condition-specific proportion of patients having a history of hospitalization. We capture hospital location with Metropolitan Statistical Area.

III. METHODS

1. Subjects and Databases

Is better process quality of inpatient care associated with lower PPR rates across hospitals? To answer the research inquiry, three diagnosis-based patient cohorts were defined as follows: patients aged 65 years or older enrolled in Medicare fee-for-service program for 2007 who had been discharged from the acute care hospital in California and Florida with the principal diagnosis of heart failure (International Classification of Disease, Ninth Revision, Clinical Modification [ICD-9-CM] codes 402.01, 402.11, 402.91, 404.01, 404.03, 404.11. 404.13, 404.91, 404.93, or 428.0-428.9, acute myocardial infarction (ICD-9-CM codes 410.0-410.9), and pneumonia (ICD-9-CM codes 480.8, 480.9, 481, or 482.0-487.0). The conditions were selected in that they are common, costly causes of hospitalization. Since this study used state-level discharge records, rather than national-level records, out-of-state patients' readmissions could not be ascertained. Therefore,

out-of-state patients were excluded. Patients who died are excluded because they are not eligible for readmissions. An admission with a discharge status of "left against medical advice" was also excluded because hospitals did not have the opportunity to deliver intended care.

Data on inpatient hospital discharges records for the 24-month period from January 1, 2006, through December 31, 2007 were drawn from complete hospital discharges in the Healthcare Cost and Utilization Project State Inpatient Database (herein referred to as the HCUP-SID) of the Agency for Healthcare Research and Quality (herein referred to as the AHRQ) and the Supplemental Files for Revisit Analyses (herein referred to as the Revisit Files). The HCUP-SID is the largest collection of all-payer, uniform, state-based, inpatient administrative data. The HCUP database contains discharge-level rather than patient-level data, and there is no unique patient identifier that can serve to track readmissions. To facilitate analyses that focus on multiple hospital stays by the same patient, AHRQ created the Revisit Files which can be linked to the HCUP state-level databases to identify multiple patient visits in the hospital setting while adhering to strict privacy regulations. Two data periods were used in the analysis. From HCUP-SID database for the 12-month period from January 1, 2007, through December 31, 2007, we tracked PPR, severity, comorbidities, and post-discharge characteristics. Next, the HCUP-SID file for the 12-month period from January 1, 2006, through December 31, 2006 was used to track history of hospitalization within 1 year before the index admission.

Data on quality of inpatient care were obtained from the Centers for Medicare and Medicaid Services (CMS) Hospital Compare database for 2007. The measures of quality of inpatient care cover the corresponding clinical conditions that were tracked for readmissions: heart failure, acute myocardial infarction, and pneumonia, between January 1 and December 31, 2007.

We used two data sources for hospital characteristics: American Hospital Association Annual Survey of Hospitals files and the HCUP-SID file. Data on hospital structural characteristics (such as size and ownership status) where patients were treated during initial hospitalizations were obtained from the American Hospital Association Annual Survey of Hospitals files for 2007. The American Hospital Association Annual Survey of Hospitals collects data each year from hospitals nationwide regardless of their membership status and typically obtains an overall response rate of 85% or greater (AHA, 1999). Data on hospital operational and demographic characteristics (such as mean number of patient comorbid conditions and condition-specific hospital volume) were directly derived from inpatient discharge records from HCUP-SID file.

To create the analytical file, inpatient discharge records from the HCUP-SID file were linked to the AHA-ASH files for information on hospitals where patients were treated during index hospitalization. The HCUP-SID file provides information on the hospital identifier used by AHA. Then, this dataset was merged with CMS Hospital Compare database using Medicare provider number.

The HCUP datasets are publicly available, are consistent with the definition of limited data sets under the Health Insurance Portability and Accountability Act Privacy Rule, and contain no direct patient identifiers.

2. Variables & Measures

1) Dependent Variable: Potentially Preventable Readmissions (PPR)

Our outcome variable is a dichotomous measure

of whether a patient was readmitted for potentially preventable reasons (coded 0) or not (coded 1). We employed the PPR methodology developed by 3M Health Information Systems. 3M PPR algorithm defines PPRs as return hospitalizations within a specified time interval that may have resulted from deficiencies in the process of care in the initial admission, inadequate discharge planning, or lack of post discharge follow-up [7]. The detailed 3M PPR methodology can be found elsewhere [8]. We used across-hospital readmissions rather than same-hospital readmissions. Using same-hospital readmission may generate a serious bias in favor of institutions whose patients are readmitted elsewhere [9]. We employed 30-days as readmission time interval because the shorter readmission window is useful for evaluating quality of care during index hospitalization.

2) Explanatory variable: Clinical Process Quality

The explanatory variable for the present study is hospital-level process quality of inpatient care. Process measures are procedures, treatments, or interventions that are designed to improve patient outcomes. Unlike outcome measure, such as mortality and readmission rates, process measures reflect actionable for quality improvement activities as they are under the control of hospitals and health care providers [10]. In addition, process measures may provide positive spillover effects, such as raising health care providers' awareness about clinical guidelines and enhancing overall commitment to a high quality of care [11]. Hospitals that better adhere to the recommended clinical process care may devote their resources improving quality of care and hence, are likely to perform well in other process and outcome measures. Hence, hospitals' performance for process quality metrics may be an indicator for a latent construct of unobserved aspects of quality of inpatient care.

We used CMS Hospital Compare hospital process of quality measure set. The Hospital Quality Alliance (HQA), a national public-private collaboration between the CMS and hospital organizations, report hospitals' performance on process of care measures through the Hospital Compare. These measures evaluate a hospital's adherence to recommended clinical process of care for heart attack, heart failure and pneumonia. Six of the measures assess process quality of care for heart attack, three of the measures assess process quality of care for heart failure, and six of measures assess clinical process quality of care for pneumonia. Beneficial effects of these measures on the readmission are well documented [12-15].

Measures for heart attack include: (1) aspirin at arrival; (2) aspirin at discharge; (3) beta-blocker at arrival; (4) angiotensin converting enzyme (ACE) inhibitor for left ventricular systolic (LVS) dysfunction; (5) fibrinolytic medication within 30 Minutes of arrival; and (6) PCI within 90 minutes of arrival. Measures for heart failure include: (1) written discharge instructions or education material that address activity level, diet, discharge medication, follow-up appointment, weight monitoring, and what to do if symptoms worsen; (2) evaluation of left ventricular function; and (3) prescription of an angiotensin converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) at discharge to eligible patients with left ventricular systolic dysfunction without contraindications. Measures for pneumonia include: (1) pneumococcal vaccination, (2) initial antibiohjotic timing; (3) influenza vaccination; (4) blood culture performed in the emergency department prior to initial antibiotic received in hospital; (5) appropriate initial antibiotic selection; and (6) oxygenation assessment. For each measure, a hospital's performance was calculated as the proportion of all eligible patients

who received the indicated care. To ensure the stability of the measures, hospitals with fewer than 15 patients for an individual measure were excluded.

Composite measures enable us to improve the ability to detect differences by capturing the spectrum of care of a condition into a single measure [16,17]. Hence, we also constructed two condition-specific composite measures from the individual measures. First, composite measures at admission and at discharge within conditions were calculated using a weighted average of performance across all measures, respectively. AMI measures assessed at admission included: 1) aspirin at arrival, 2) beta-blocker at arrival, and 3) percutaneous coronary interventions (PCI) within 90m of arrival. AMI measures assessed at discharge included: 1) angiotensin converting enzyme inhibitor (ACE Inhibitor) or Angiotensin Receptor Blockers (ARB) for Left Ventricular Systolic Dysfunction (LVSD), 2) aspirin at discharge, and 3) beta-blocker at discharge. Pneumonia measures assessed at admission included: 1) assessed and given influenza vaccination and 2) assessed and given pneumococcal vaccination. Pneumonia measures assessed at discharge included: 1) initial antibiotic(s) within 6h after arrival, 2) oxygenation assessment, 3) the most appropriate initial antibiotic(s), and 4) initial emergency room (ER) blood culture performed prior to first hospital dose of antibiotics. There was no HF composite measure assessed at admission. HF measures assessed at discharge included: 1) ACE inhibitor or ARB for LVSD, 2) evaluation of LVS Function, and 3) discharge instructions.

Second, a global composite measure was calculated by aggregating all individual measures within conditions using a weighted average of performance across all measures. A global measure was not calculated for heart failure because there was no admission composite measure. Therefore, for pneumonia and AMI, three composite measures (i.e., admission composite measure, discharge composite measure, and global composite measure) were constructed, respectively, and for heart failure, only one composite measure (i.e., discharge composite measure) was calculated. Hospitals with fewer than 15 patients for an individual measure were not included in the calculation of the composite score. However, as long as a hospital reported a denominator of at least 15 cases for at least one measure, the hospital had composite scores.

We adjusted patients' clinical, socio-demographical, and post discharge characteristics that may influence the likelihood of patient being readmitted for potentially preventable reasons. We captured patients' socio-demographic background by several measures: age, sex, race/ethnicity, and median household income state quartile for patient ZIP Code. We captured patients' severity by history of hospitalization within 1 year. We identified patients' comorbid conditions with Elixhauser index by a series of dummy variables of whether patients had a comorbid condition or not. We captured disposition of the patient at discharge. For patients with acute myocardial infarction, we captured the location of acute myocardial infarction by two dummy variables of whether patients had an "anterior AMI" or not and whether patients had an "other AMI" or not. In addition, we also captured cardiac procedures by dummy variables of whether patients with acute myocardial infarction underwent coronary artery bypass graft or not and of whether patients underwent percutaneous transluminal coronary angioplasty (PTCA) or not.

We controlled for a number of hospital level factors, including structural, operational, and demographic characteristics of hospitals. Structural and operational characteristics included hospital ownership status, teaching intensity, Medicare

disproportionate-share hospital (DSH) index as a proxy of the proportion of poor patients, whether a hospital had a better nurse care environments or not, measured by Magnet status, whether a hospital was affiliated with health care systems or not, and hospital location based on Metropolitan Statistical Area. A dummy variable was also constructed to indicate the State. We captured condition-specific hospital volume of the elderly patients.

We captured hospital demographic composition with several measures: hospital average number of Elixhauser comorbid condition for each condition, proportion of patients having a history of hospitalization for both the same and other condition with the index admission for each condition.

3. Analytic approach

Because of the hierarchical structure of the data, with patients nested within hospitals, we used hierarchical generalized linear modeling, a multilevel logistic regression model, to measure the relationship between process quality inpatient care and PPR.

Our final model included patient level predictors and hospital level predictors.

$$\log((p_{ij}/1-p_{ij}))=\beta_{oj}+\gamma_{po}X_{\pi j} \quad \text{(eq.1)}$$

$$\beta_{oj}=\gamma_{oo}+\gamma_{oq}Z_{qj}+u_{oj} \quad \text{(eq.2)}$$

$$\log((p_{ij}/1-p_{ij}))=\gamma_{oo}+\gamma_{po}X_{\pi j}+\gamma_{oq}Z_{qj}+u_{oj} \quad \text{(eq.3)}$$

where X_{pij} are p explanatory variable at the patient level and Z_{pj} are q explanatory variable at the hospital level. While the intercept was allowed to be random, all independent variables at both patient and hospital level were estimated as fixed effects. This model allows us to examine whether the hospital-level explanatory variables, such as process quality of inpatient care, are associated with the hospital-level estimate of the proportion of patients who were readmitted for potentially preventable reasons (i.e., the PPR rate in each hospital).

In the fixed-effects part, we calculated odds ratios (OR) and their 95% confidence intervals (95% CI). In the random-effects part, we obtained the variance and their 95% confidence intervals (95% CI) at the hospital level. Our outcome variable is a binary measure of whether a patient readmitted for potentially preventable reasons (Initial Admission, coded 0) or not (Only Admission, coded 1). While most patients in the cohorts of acute myocardial infarction and pneumonia had 1 candidate discharge record of either Initial Admission or Only Admission within a 1-year period, multiple candidate discharges were frequent in the patient cohort of heart failure. We randomly selected 1 discharge if the multiple candidate discharges records were observed within a 1-year period. As mentioned earlier, we excluded patients who died during index hospitalization because they are not eligible for readmissions. We lack of data on post-discharge patient mortality. We were not able to track process measure-specific 30-day PPR that match specific quality measures because we lack of patient-level data on the eligible population and those who received the indicated care.

The associations between process quality measures and condition-specific PPR were modeled separately. This work performed all statistical analyses using STATA 13(StataCorp, College Station, TX). A p-value of less than .05 was considered statistically significant.

<Table 1> Hospital Characteristics

	Heart Failure				Acute Myocardial Infarction				Pneumonia			
	Low (n=143)	Medium (n=142)	High (n=142)	P Value	Low (n=127)	Medium (n=127)	High (n=126)	P Value	Low (n=142)	Medium (n=142)	High (n=142)	P Value
Crude 30-day PPR Rate	12.31%	16.66%	24.69%		7.79%	15.47%	26.72%		6.84%	11.9%	19.77%	
Ownership				0.017				0.043				0.343
Public	21 (15)	16 (11)	32 (23)		24 (19)	13 (10)	21 (15)		26 (18)	18 (13)	25 (18)	
Private not-for-profit	83 (58)	86 (61)	61 (43)		74 (58)	76 (60)	59 (47)		76 (54)	85 (60)	69 (48)	
Private for-profit	39 (27)	40 (28)	49 (34)		29 (23)	38 (30)	46 (36)		40 (28)	39 (27)	48 (34)	
Cardiac Catherization				0.008				0.000				0.000
No	41 (29)	30 (21)	54 (38)		25 (20)	15 (12)	44 (35)		35 (25)	27 (19)	62 (44)	
Yes	102 (71)	112 (79)	88 (62)		102 (80)	112 (88)	82 (65)		107 (75)	115 (81)	80 (56)	
Teaching intensity (Resident-to-bed ratio)				0.422				0.823				0.678
0 (non-teaching)	110 (77)	102 (72)	95 (67)		86 (68)	90 (71)	89 (70)		107 (75)	98 (69)	101 (71)	
0-0.05 (low intensity)	11 (8)	20 (14)	19 (13)		15 (12)	17 (13)	16 (13)		12 (9)	17 (12)	21 (15)	
0.05-0.6 (medium intensity)	15 (10)	12 (8)	17 (12)		18 (14)	14 (11)	11 (9)		14 (10)	17 (12)	13 (9)	
>0.6 (high intensity)	7 (5)	8 (6)	11 (8)		8 (6)	6 (5)	10 (8)		9 (6)	10 (7)	7 (5)	
Magnet hospitals				0.671				0.461				0.017
Non-Magnet	135 (94)	134 (94)	137 (96)		119 (94)	119 (94)	122 (97)		130 (92)	135 (95)	140 (99)	
Magnet	8 (6)	8 (6)	5 (3.52)		8 (6)	8 (6)	4 (3)		12 (8)	7 (5)	2 (1)	
Volume				0.066				0.000				0.071
1st quartile (smallest)	41 (29)	26 (18)	42 (30)		30 (24)	20 (16)	48 (38)		35 (25)	24 (17)	48 (34)	
2nd quartile	32 (22)	37 (26)	36 (25)		32 (25)	21 (17)	41 (32)		35 (25)	37 (26)	34 (24)	
3rd quartile	36 (25)	33 (23)	39 (27)		37 (29)	32 (25)	25 (20)		37 (26)	39 (27)	31 (22)	
4th quartile (largest)	34 (24)	46 (33)	25 (18)		28 (22)	54 (42)	12 (10)		35 (25)	42 (30)	29 (20)	
System affiliation				0.111				0.859				0.462
System hospital	46 (32)	30 (21)	38 (27)		33 (26)	31 (24)	29 (23)		36 (25)	34 (24)	43 (30)	
Non-system hospital	97 (68)	112 (79)	104 (73)		94 (74)	96 (76)	97 (77)		106 (75)	108 (76)	99 (70)	
Metropolitan Statistical Area				0.001				0.022				0.001
Rural	9 (6)	6 (4)	14 (10)		2 (2)	5 (4)	13 (10)		8 (6)	11 (8)	11 (8)	
Micro/Division	39 (27)	53 (37)	68 (48)		51 (40)	46 (36)	52 (41)		43 (30)	44 (31)	73 (51)	
Metro	95 (67)	83 (59)	60 (42)		74 (58)	76 (60)	61 (48)		91 (64)	87 (61)	58 (41)	
State				0.853				0.008				0.000
California	89 (62)	91 (64)	93 (65)		91 (72)	67 (53)	79 (63)		80 (56)	81 (57)	112 (79)	
Florida	54 (38)	51 (36)	49 (35)		36 (28)	60 (47)	47 (37)		62 (44)	61 (43)	30 (21)	
DSH Index				0.048				0.301				0.049
1st thirtiles (low)	50 (35)	45 (32)	48 (34)		50 (39)	41 (32)	36 (29)		53 (37)	41 (29)	48 (34)	
2nd thirtiles	53 (37)	54 (38)	35 (25)		43 (34)	42 (33)	42 (33)		46 (33)	59 (41)	37 (26)	
3rd thirtiles (high)	40 (28)	43 (30)	59 (41)		34 (27)	44 (35)	48 (38)		43 (30)	42 (30)	57 (40)	
Number of comorbidity				0.249				0.262				0.096
1st thirtiles (low)	55 (38)	43 (30)	45 (32)		50 (39)	38 (30)	39 (31)		50 (35)	38 (27)	54 (38)	
2nd thirtiles	43 (30)	56 (40)	43 (30)		41 (32)	48 (38)	38 (30)		51 (36)	54 (38)	37 (26)	
3rd thirtiles (high)	45 (32)	43 (30)	54 (38)		36 (28)	41 (32)	49 (39)		41 (29)	50 (35)	51 (36)	
Proportion of patients with prior hospitalization for both HF and other conditions				0.538				0.000				0.000
1st thirtiles (low)	51 (36)	49 (34)	43 (30)		46 (36)	28 (22)	53 (42)		62 (44)	51 (36)	29 (20)	
2nd thirtiles	46 (32)	52 (37)	45 (32)		42 (33)	61 (48)	24 (19)		47 (33)	54 (38)	41 (29)	
3rd thirtiles (high)	46 (32)	41 (29)	54 (38)		39 (31)	38 (30)	49 (39)		33 (23)	37 (26)	72 (51)	

IV. RESULTS

1. Hospital Characteristics

The characteristics of the hospitals are summarized in Table 1. Overall, 427 hospitals were included in the analysis of heart failure, 380 in acute myocardial infarction, and 426 in pneumonia. The numbers of hospitals were different by conditions as the number of hospitals which reported performance for process quality measures were different by conditions. As noted, for descriptive purposes, this study divided hospitals into three groups according to their condition-specific, crude 30-day PPR

<Table 2> Summary of Hospital Performance for Condition-Specific Process Quality Measures

	Hospital, No	Overall [Mean (SD)]	Hospitals in the top 25% (4th quartile) [Mean (SD)]	Hospitals in the middle 50% (2nd & 3rd quartile) [Mean (SD)]	Hospitals in the low 25% (1st quartile) [Mean (SD)]
Heart Failure					
ACE Inhibitor or ARB for LVSD[d]	396	87.27 (9.80)	97.94 (1.51)	89.47 (3.70)	74.58 (8.15)
Evaluation of LVS Function[d]	425	70.31 (23.90)	95.62 (3.25)	74.71 (8.33)	36.88 (17.95)
Discharge Instructions[d]	426	91.10 (14.16)	99.40 (0.49)	95.28 (2.20)	75.79 (21.05)
– HF Discharge Composite score[d]	427	82.17 (15.46)	95.99 (2.17)	85.57 (4.36)	61.66 (16.67)
Acute Myocardial Infarction					
ACE Inhibitor or ARB for LVSD[d]	222	89.36 (8.75)	99.59 (0.76)	91.50 (3.63)	78.11 (6.29)
Aspirin at Arrival[a]	379	96.39 (4.11)	99.21 (0.87) †	96.56 (0.49) ‡	91.31 (4.32)
Aspirin at Discharge[d]	339	93.91 (8.02)	100 (0)	96.62 (1.85)	83.31 (9.61)
Beta Blocker at Arrival[a]	369	92.78 (7.15)	99.64 (0.48)	94.91 (2.24)	83.20 (7.20)
Beta Blocker at Discharge[d]	343	94.39 (7.36)	100 (0)	96.95 (1.56)	86.19 (9.21)
PCI Within 90m of Arrival[a]	168	66.05 (19.53)	87.89 (4.59)	70.01 (8.23)	38.43 (12.00)
– AMI Admission Composite score[a]	380	93.27 (5.36)	98.57 (1.04)	94.16 (1.91)	86.22 (5.20)
– AMI Discharge Composite score[d]	345	93.63 (7.37)	99.42 (0.57)	95.48 (1.76)	84.25 (9.04)
– AMI Composite score	370	93.83 (5.28)	98.74 (0.81)	94.81 (1.65)	87.04 (5.77)
Pneumonia					
Assessed and Given Influenza Vaccination[d]	411	70.13 (23.31)	94.05 (3.49)	75.36 (8.56)	37.98 (18.43)
Assessed and Given Pneumococcal Vaccination[d]	424	75.22 (20.59)	94.74 (2.62)	80.53 (6.74)	46.77 (18.79)
Initial Antibiotic(s) within 6h After Arrival[a]	394	92.49 (7.20)	99.22 (0.88)	94.45 (1.98)	84.01 (7.65)
Oxygenation Assessment[a]	426	99.72 (1.60)	–	–	–
The Most Appropriate Initial Antibiotic(s)[a]	422	88.00 (8.12)	95.69 (1.69)	89.60 (2.39)	78.35 (8.90)
Initial ER Blood Culture Performed prior to First Hospital Dose of Antibiotics[a]	415	88.89 (6.95)	96.20 (1.35)	90.78 (2.23)	80.04 (6.03)
– PN Admission Composite score[a]	426	93.37 (3.75)	97.15 (1.02)	93.94 (1.16)	88.48 (3.69)
– PN Discharge Composite score[d]	424	73.72 (20.78)	93.55 (3.25)	78.37 (6.93)	44.61 (18.35)
– PN Composite score	425	87.71 (7.97)	95.41 (1.65)	89.23 (2.44)	77.08 (7.86)

To ensure the stability of the measures, hospitals with fewer than 15 patients in the denominator of a measure are excluded. A composite score for a condition is calculated only if that hospital treated at least 15 patients for one of the process measures for that condition. If a hospital did not treat at least 15 patients in any one indicator, then no composite score was calculated. For that reason, the number of hospitals' composite measures do not equal to the number of individual measure.

† : hospitals in the 3rd and 4th quartiles;

‡ : hospitals in the 2nd quartile

rates. The mean crude 30-day PPR rates are 16.63% for heart failure, 17.11% for acute myocardial infarction, and 11.50% for pneumonia, respectively. Among hospitals with low crude 30-day PPR rates for heart failure, a larger proportion of hospitals were private non-profit, had cardiac catherization capabilities, were located in urban areas, and had a low DSH index. Among hospitals with low crude 30-day PPR rates for pneumonia, a larger proportion of hospitals had cardiac catherization capabilities, had Magnet status, were located in urban, were located in California, had a low DSH index, and cared for less severe patients (measured by proportion of patients with history of prior hospitalization for both pneumonia and other conditions). Among hospitals with low crude 30-day PPR rates for acute myocardial infarction, a larger proportion of hospitals were private non-profit, had cardiac catherization capabilities, had Magnet status, were located in urban, were located in California, had a low DSH index, and cared for less severe patients (measured by proportion of patients with prior hospitalization for both acute myocardial infarction and other conditions). Hospitals with high condition-specific patient volume, with cardiac catherization capabilities, and with urban location had low crude 30-day PPR rates across all three conditions.

2. Hospital performance on process quality measures

Hospital performance for individual process quality measures and the composite measures are summarized in Table 2. In general, there was little variation in the measures of process quality of inpatient care for all conditions across hospitals. In the case of five out of six individual measures for acute myocardial infarction, hospitals performing in the top 25th percentile adhered to the recommended care more than 99% of the time. For the measures of heart failure, hospitals performing

<Table 3> Summary of Association between Process Quality Measures and Heart Failure PPR using Hierarchical Logistic Regression†

Process Quality Measures	Heart Failure 30-day PPR rates			
	Coefficient	Standard Error	P-value	Odd Ratio
Discharge Composite Score n: level-1 (patients) = 42051 n: level-2 (hospitals) = 427	-0.000	0.002	0.776	1.000
ACE Inhibitor or ARB for LVSD n: level-1 (patients) = 41323 n: level-2 (hospitals) = 396	0.001	0.002	0.571	1.001
Evaluation of LVS Function n: level-1 (patients) = 42038 n: level-2 (hospitals) = 425	-0.000	0.001	0.650	1.000
Discharge Instructions n: level-1 (patients) = 42044 n: level-2 (hospitals) = 426	0.001	0.002	0.741	1.001

† : Multivariable analysis adjusted for 1) patient level variables (level 1), including age, sex, race/ethnicity, discharge destination, severity measured by prior hospitalization, and Elixhauser comorbid conditions, and 2) hospital level variables (level 2), including hospital ownership status, whether a hospital perform cardiac catherization, Magnet status, system affiliation, teaching intensity, and mean number of comorbid conditions, proportion of patients with prior history of hospitalization for both HF and other conditions, condition-specific hospital volume, DSH index, and State.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

in the top 25th percentile adhered to the recommended care more than 95% of the time for all three individual measures. For the measures of pneumonia, hospitals performing in the top 25th percentile adhered to the recommended care more than 94% of the time for all six individual measures. There were relatively more variations among lower-performing hospitals compared to the higher-performing counterparts. In general, there were relatively more variations in the following measures: evaluation of LVS function for heart failure patients, PCI within 90m of arrival for acute myocardial infarction patients, and assessed and given influenza vaccination and pneumococcal vaccination for pneumonia patients.

<Table 4> Summary of Association between Process Quality Measures and Acute Myocardial Infarction PPR using Hierarchical Logistic Regression†

Process Quality Measures	Acute Myocardial Infarction 30-day PPR rates			
	Coefficient	Standard Error	P-value	Odd Ratio
Admission Composite Score n: level-1 (patients) = 21635 n: level-2 (hospitals) = 380	-0.010~	0.006	0.085	0.990~
Discharge Composite Score n: level-1 (patients) = 21367 n: level-2 (hospitals) = 346	-0.004	0.005	0.464	0.996
Global Composite Score n: level-1 (patients) = 21580 n: level-2 (hospitals) = 371	-0.008	0.006	0.204	0.992
ACE Inhibitor or ARB for LVSD n: level-1 (patients) = 19086 n: level-2 (hospitals) = 222	-0.001	0.003	0.726	0.999
Aspirin at Arrival n: level-1 (patients) = 21628 n: level-2 (hospitals) = 379	-0.010	0.008	0.202	0.990
Aspirin at Discharge n: level-1 (patients) = 21301 n: level-2 (hospitals) = 340	-0.003	0.005	0.533	0.997
Beta Blocker at Arrival n: level-1 (patients) = 21548 n: level-2 (hospitals) = 369	-0.001	0.004	0.725	0.999
Beta Blocker at Discharge n: level-1 (patients) = 21328 n: level-2 (hospitals) = 344	-0.003	0.005	0.533	0.997
PCI Within 90m of Arrival n: level-1 (patients) = 16654 n: level-2 (hospitals) = 168	-0.004**	0.001	0.012	0.996**

† : Multivariable analysis adjusted for 1) patient level variables (level 1), including age, sex, race/ethnicity, discharge destination, severity measured by prior hospitalization, and Elixhauser comorbid conditions, and 2) hospital level variables (level 2), including hospital ownership status, whether a hospital perform cardiac catherization, Magnet status, system affiliation, teaching intensity, and mean number of comorbid conditions, proportion of patients with prior history of hospitalization for both AMI and other conditions, AMI location condition-specific hospital volume, DSH index, and State.

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3. Hierarchical Analyses

The results of our 22 separate unconditional models consistently indicate that statistically significant variance in PPR rates exists at the hospital level, underlining the need to look at the hierarchical nature of PPR ($p<0.001$ for 20 models and $p<0.01$ for 2 out of 22 models). Degree of variance in PPR rates between hospitals varies by medical conditions; variance is smaller in cardiovascular conditions than in pneumonia.

Summary of association of condition-specific PPR with individual and composite process quality measures after controlling patient- and hospital-level factors are summarized in Table 3 for heart failure, Table 4 for acute myocardial infarction, and Table 5 for pneumonia, respectively. We found that the existence of inverse association between process quality of inpatient care and 30-day, risk-adjusted PPR rates varies by medical conditions; that is, we observed the hypothesized inverse association between process quality of inpatient care and 30-day, risk-adjusted PPR rates in pneumonia but not generally in two cardiovascular conditions (i.e., heart failure and acute myocardial infarction). For pneumonia, as performance for process quality of inpatient care increases, 30-day, risk-adjusted hospital PPR rates tend to decline after adjusting for patient clinical and demographical characteristics and hospital characteristics (Table 5). There was a significant inverse association between all 3 composite measures (i.e., admission, discharge, and global composite) and 30-day, risk-adjusted PPR rates ($p<0.05$ for each measure). Specifically, for every one point increase in the admission composite score out of 100 possible points, the odds of being readmitted for a potentially preventable reason decreased by 2% ($p<0.01$). For the discharge composite measure, a weaker magnitude of association was observed than admission composite measure; for every one point increase in the discharge composite score out of 100 possible points, the odds of being readmitted within 30 days for a potentially preventable reason decreased by 0.2% decrease in the odds of being readmitted within 30 days for a potentially preventable reason ($p<0.05$). For every one point increase in the global composite score out of 100 possible points, the odds of being readmitted within 30 days for a potentially preventable reason decreased by 0.8% ($p<0.01$).

For the individual pneumonia process quality measure, two out of six individual measures had a statistically significant inverse association with 30-day, risk-adjusted PPR rates ($p<0.05$ for each measure) and other three measures exhibited marginally significant inverse trends ($p<0.10$ for each measure). Specifically, for every one point increase in the "assessed and given influenza vaccination" out of 100 possible points, the odds of being readmitted within 30 days for a potentially preventable reason decreased by 0.3% decrease in the odds of being readmitted within 30 days for a potentially preventable reason ($p<0.05$). "the most appropriate initial antibiotic(s)" turned out to be inversely associated with 30-day, risk-adjusted PPR rates; that is, for every one point increase in the most appropriate initial antibiotic(s) out of 100 possible points, the odds of being readmitted within 30 days for a potentially preventable reason decreased by 3.4%, ($p<0.01$).

The rest of the individual measures for pneumonia exhibited marginal influence on the PPR rates, with the exception of "Initial ER Blood Culture Performed Prior To First Hospital Dose of Antibiotic". Specifically, for every one-point increase in "Assessed and Given Pneumococcal Vaccination" the odds of being readmitted within 30 days for a potentially preventable reason decreased by 0.2% ($p=0.08$). For every one-point increase in "Initial Antibiotic(s) within 6h After

Arrival" the odds of being readmitted within 30 days for a potentially preventable reason decreased by 0.7% (p=0.05). Lastly every one point increase in "Oxygenation Assessment" the odds of being readmitted within 30 days for a potentially preventable reason decreased by 3.3% (p=0.05).

Contrary to the pneumonia, the quality scores for the two cardiovascular conditions were generally found to be unrelated to 30-day, risk-adjusted PPR rates after adjusting for patient clinical and demographical characteristics and hospital characteristics. For acute myocardial infarction, neither composite nor individual measures had a statistically significant relation to 30-day, risk-adjusted PPR rate,

<Table 5> Summary of Association between Pneumonia PPR and Process Quality Measures using Hierarchical Logistic Regression†

Process Quality Measures	Pneumonia 30-day PPR rates			
	Coefficient	Standard Error	P-value	Odd Ratio
Admission Composite Score n: level-1 (patients) = 36384 n: level-2 (hospitals) = 426	-0.020**	0.007	0.004	0.980**
Discharge Composite Score n: level-1 (patients) = 36374 n: level-2 (hospitals) = 424	-0.002*	0.001	0.048	0.998*
Global Composite Score n: level-1 (patients) = 36378 n: level-2 (hospitals) = 425	-0.008*	0.003	0.010	0.992*
Assessed and Given Influenza Vaccination n: level-1 (patients) = 35964 n: level-2 (hospitals) = 411	-0.003*	0.001	0.017	0.997*
Assessed and Given Pneumococcal Vaccination n: level-1 (patients) = 36374 n: level-2 (hospitals) = 424	-0.002~	0.001	0.078	0.998
Initial Antibiotic(s) within 6h After Arrival n: level-1 (patients) = 35202 n: level-2 (hospitals) = 394	-0.007~	0.004	0.050	0.993
Oxygenation Assessment n: level-1 (patients) = 36384 n: level-2 (hospitals) = 426	-0.033~	0.017	0.052	0.967
the Most Appropriate Initial Antibiotic(s) n: level-1 (patients) = 36172 n: level-2 (hospitals) = 422	-0.008**	0.003	0.005	0.992**
Initial ER Blood Culture Performed Prior To First Hospital Dose Of Antibiotics n: level-1 (patients) = 36118 n: level-2 (hospitals) = 415	-0.005	0.004	0.134	0.995

†: Multivariable analysis adjusted for 1) patient level variables (level 1), including age, sex, race/ethnicity, discharge destination, severity measured by prior hospitalization, and Elixhauser comorbid conditions, and 2) hospital level variables (level 2), including hospital ownership status, whether a hospital perform cardiac catherization, Magnet status, system affiliation, teaching intensity, and mean number of comorbid conditions, proportion of patients with prior history of hospitalization for both PN and other conditions, condition-specific hospital volume, DSH index, and State.

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

with the exception of "PCI within 90m of arrival" (Table4). There was a relatively larger variation in hospital performance for this measure, "PCI within 90m of arrival", compared to other process quality measures for acute myocardial infarction. For every one point increase in "PCI within 90m of arrival", the odds of being readmitted within 30 days for a potentially preventable reason decreased by 0.4% ($p < 0.01$). The admission composite measure was marginally significant, but had a modest influence on the 30-day, risk-adjusted PPR rates; for every one point increase in admission composite measure, the odds of being readmitted within 30 days for a potentially preventable reason decreased by 1% ($p=0.09$). For other individual and composite measures for acute myocardial infarction, although statistically insignificant, the inverse direction of the association between process measures and PPR rates was consistently observed. As for heart failure, none of the composite and individual measures were statistically associated with 30-day, risk-adjusted PPR rates after adjusting for patient clinical and demographical characteristics and hospital characteristics (Table 3).

V. DISCUSSION

The present work examined the association between process quality of inpatient care and condition-specific risk-adjusted 30-day PPR rates, and found that better performance on the process quality metrics was associated with the better patient outcome (i.e., low PPR rates) in pneumonia, but not generally in two cardiovascular conditions (i.e., heart failure and acute myocardial infarction). Hospitals with better performance for process quality measures had lower condition-specific 30-day PPR rates for pneumonia, even after taking patient risk factors and hospital characteristics into account. These findings are consistent with the results of previous studies that examined the association between quality of inpatient care and mortality rates at hospital level [18,19]. However, we did not find a similar inverse pattern for heart failure and acute myocardial infarction. While we observed, in the case of acute myocardial infarction, a statistically significant inverse association in one individual measure (i.e., PCI within 90m of arrival) and a marginally significant inverse trend in one composite measure (i.e., admission composite measure), none of the process quality measures for heart failure were found to be associated with condition-specific 30-day PPR rates. Our findings of disassociation between heart failure process quality metrics and 30-day PPR rates are consistent with findings from previous OPTIMIZE-HF studies investigating the association between process quality measures for heart failure and cardiovascular readmissions [5,6].

There are possible reasons why the findings in cardiovascular conditions are dissimilar from those in pneumonia. One is that there was not enough variation in the cardiovascular measures of quality of inpatient care across hospitals for the present work to detect their significant associations with 30-day PPR rates. For example, "PCI within 90 minutes of arrival" exhibited the lowest performance score with the largest variation among process quality measures for acute myocardial infarction, and among measures in acute myocardial infarction, it was the only significant measure that was inversely related to 30-day PPR rates. While plausible, this explanation alone may not perfectly explicate the disassociations between process quality metrics and 30-day PPR rates because variations in the process quality measures for pneumonia were not substantially large, compared to those in the process measures for cardiovascular

conditions. In addition to little variations in the cardiovascular process measures, variance between hospitals is relatively smaller in cardiovascular conditions compared to pneumonia. Variance between hospitals in unconditional models for heart failure ranged from 0.029 to 0.030, for acute myocardial infarction ranged from 0.023 to 0.040, and for pneumonia ranged from 0.105 to 0.113.

Another explanation is that cardiovascular process quality metrics selected for the present study may indeed not be related with 30-day PPR rates. Cardiovascular process quality metrics employed in this study capture only incomplete information on hospitals' adherence. For example, five out of six AMI individual process quality measures are medication-related, such as beta-blocker, aspirin, and ACE Inhibitor. Information about whether a hospital prescribed a drug (e.g., beta blocker) in aggregate only does not capture other important information about whether the appropriate dose was used, about whether appropriately prescribed a drug considering all of the types of unwanted medication reaction [20], or about whether patients adhered to medication instructions after discharge[21]. Those missing information for which current process metrics cannot capture might have associations with 30-day PPR rates. Similarly, successful completion of discharge planning and smoking cessation counseling are not enough evidence to conclude that process of inpatient care was excellent.

Lastly, it is also possible that 30 days might be too short to observe the association of the medications, particularly beta-blockers, with PPR rates. One systemic review of randomized controlled trials on beta blocker in the treatment for AMI found that short-term use (less than 1 year) of blockade after acute myocardial infarction may not have as large benefits as does long-term use (more than 1 year) [22]. This finding suggests that a longer readmission time-frame would be more suitable to detect link between beta-blockers and PPR rates, but, paradoxically, a longer readmission time-frame (> 90 days) reflects the effectiveness of community-based, monitoring and maintenance systems [23]. This study adopted a readmission time interval of 30-day because hospitals may have greater control over the clinical processes during the hospitalization and the discharge process.

Better adherence to the process quality metrics for cardiovascular conditions currently in use by CMS may not likely lead to low 30-day PPR rates. While we found an inverse association between process quality metrics currently in use by CMS for pneumonia and 30-day PPR rates, that was not the case for cardiovascular conditions. Performance for current clinical process quality metrics for pneumonia might be able to be considered as a potential indicator of 30-day PPR rates, but not for heart failure and acute myocardial infarction. Performance measures should be confined to those clinical process of care for which the evidence is so robust that successful adherence to them increases the likelihood of optimal patient outcomes [24,25]. Policy implications emerge from the present study. First, if a policy objective is to reduce 30-day PPR rates for heart failure and acute myocardial infarction through enhancing hospital performance for process quality of care, more evidence-based process quality metrics closely linked to 30-day PPR rates, particularly for cardiovascular conditions, need to be developed to serve as a guide to reduce PPR rates. Second, one size does not fit all. As evidenced in this study, both the existence of an association and the magnitude of association between process and outcome are different for each condition. Before it is too late, pay-for-performance broadly across all condition, policy makers need to confirm a causative association

between process care metrics and patient outcomes for each condition. Another implication for clinical and managerial staffs in hospitals is that 30-day PPR rates in pneumonia might be reduced by hospitals' efforts to better adhere to the recommended care. This study also has an important implication to future health service research on readmission. While a complex set of factors may contribute to occurrence of preventable readmissions, most theoretical and empirical attention has been paid to the patient-level factors, including demographics, socioeconomic standing, behaviors, and disease states. The future research on PPR might need to account for the quality of inpatient care provided to the patients during index hospitalization as well.

Our findings should be interpreted with caution as this study has several limitations. First, there have been no empirical studies validating the PPR algorithm. In developing PPR logic, clinical panels applied criteria for clinical relevance and preventability. The PPR algorithm needs validation studies assessing reproducibility and reliability of the judgment process. However, as mentioned earlier, the methodologies are being used in 13 state agencies. Second, risk-adjustment method used in this study has an inherent limitation in that it is only able to adjust to the extent that clinical information about the patient is captured by administrative data. Administrative data sets have been criticized as lacking clinical detail, such as diagnostic and prognostic information, required to permit adequate adjustment for each patient's underlying medical condition[26-30]. Although we used a well-validated risk-adjustment model designed for use with administrative data [31,32], the findings should be interpreted with cautions. Third, this work used a hospital discharge dataset that may contain misclassification of the variables due to coding errors in ICD-9-CM codes. Fourth, the findings from this study are limited in the reliance on the cross-sectional observational data which does not allow us to investigate a causal relationship between performance for process quality and 30-day PPR rates. It is possible that the observed association between process quality of inpatient care and 30-day PPR rates is confounded by patient or hospital factors that are not observed in our data. More information about the patients and hospitals is needed to clarify whether the association reflects a causal relationship. Fifth, because sample hospitals are located in California and Florida, our findings may not generalize to other geographic areas. Similarly, as we focused only on three medical conditions, our findings may not be generalized to other medical and surgical conditions. Finally, it is unclear how accurate hospitals' process quality performance is. Hospitals self-report their process quality performance and hence, it is likely that there is a systematic scoring bias in hospitals' incomplete reporting across all measures. That is, hospitals might not report specific performance scores if they poorly performed in the particular measure. If it is the case, the association between process quality of inpatient care and 30-day PPR rates may be weaker.

Hospitals have a significant stake in identifying strategies that can reduce occurrences of preventable readmissions. The recently enacted health reform legislation introduces a Hospital Readmissions Reduction Program (Section 3025 of the Patient Protection and Affordable Care Act). For fiscal years beginning on or after October 1, 2012, inpatient payments to hospitals will be reduced if a hospital experiences excessive readmissions within a specified period following discharge for a heart attack, heart failure, or pneumonia [33]. Recent study reported that nearly 80% of U.S. hospitals were subject to payment

penalties in 2014-2015 under this program [34]. The present study revealed the inverse association of process quality of inpatient care with 30-day PPR rates in the case of pneumonia but not cardiovascular conditions. Findings from this study can be served as useful sources to entities that are seeking ways to reduce the occurrences of PPRs.

Starting in November 2016, Health Insurance Review & Assessment Service (HIRA) in South Korea began publicly reporting national- and regional-level all-case risk standardized readmission rates on the HIRA hospital compare website. While HIRA provides hospital-level performance on the readmission measure to each hospital, many hospitals are struggling to identify ways to reduce unnecessary readmission as current HIRA readmission measures focuses only on hospital-wide readmission rate, rather than condition-specific readmission rates. A recent study calculated risk-standardized 30-day readmission rates for 3 condition-specific measures (heart failure, acute myocardial infarction, and pneumonia) and the hospital-wide readmission measure, and examined agreement between the hospital-wide readmission measure and each of the condition-specific measures on hospital performance [35]. The study found poor agreement between the condition-specific risk-standardized 30-day readmission rates for 3 conditions and hospital-wide readmission measure. Each year, CMS publicly report not only hospital-wide all-cause readmission but also condition-specific 30-day risk-standardized unplanned readmission measures including AMI, Chronic Obstructive Pulmonary Disease (COPD), Heart Failure, Pneumonia, Stroke, Coronary Artery Bypass Graft (CABG), total hip arthroplasty (THA) and/or Total Knee Arthroplasty (TKA). If health policy-makers in the Republic of Korea desire to improve quality of care by reducing unnecessary readmissions, substantial efforts should be made to provide condition-specific guidelines to reduce unnecessary readmissions that are most common and costly. Clinical and managerial staffs in hospitals also need to identify clinical and socio-demographic factors associated with unnecessary readmissions with condition-specific approach.

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〈Abstract〉

Does Process Quality of Inpatient Care Serve as a Guide to Reduce Potentially Preventable Readmission (PPR)?

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Objective: The objective of this study is to examine the association between process quality of inpatient care and risk-adjusted, thirty-day potentially preventable hospital readmission (PPR) rates.

Data Sources/Study Setting: This was an observational cross-sectional study of nonfederal acute-care hospitals located in two states California and Florida, discharging Medicare patients with a principal discharge diagnosis of heart failure, acute myocardial infarction, or pneumonia January through December 31, 2007. Data were obtained from the Healthcare Cost and Utilization Project State Inpatient Database of the Agency for Healthcare Research and Quality, Centers for Medicare and Medicaid Services Hospital Compare database, and the American Hospital Association Annual Survey of Hospitals.

Study Design: The dependent variable of this study is condition-specific, risk-adjusted, thirty-day potentially preventable hospital readmission (PPR). 3M's PPR software was utilized to determine whether a readmission was potentially preventable. The independent variable of this study is hospital performance for process quality of inpatient care, measured by hospital adherence to recommended processes of care. We used multivariate hierarchical logistic models, clustered by hospitals, to examine the relationship between condition-specific, risk-adjusted, thirty-day PPR rates and process quality of inpatient care, after taking clinical and socio-demographic characteristics of patients and structural and operational characteristics of hospitals into account.

Findings: Better performance on the process quality metrics was associated with better patient outcome (i.e., low thirty-day PPR rates) in pneumonia, but not generally in two cardiovascular conditions (i.e., heart failure and acute myocardial infarction).

Practical Implication: Adherence to the process quality metrics currently in use by CMS is associated with risk-adjusted, thirty-day PPR rates for patients with pneumonia, but not with cardiovascular conditions. More evidence-based process quality metrics closely linked to 30-day PPR rates, particularly for cardiovascular conditions, need to be developed to serve as a guideline to reduce potentially preventable readmissions.

Keywords: Potentially preventable readmission, process quality of inpatient care, hospitals, hierarchical logistic regression