

# Influence of Hospital and Nursing Home Quality on Hospital Readmissions

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For Medicare patients 65 years and older, about 20% of all hospitalizations are followed by a rehospitalization within 30 days.<sup>1</sup> The passage of the Affordable Care Act (ACA) changed the accountability of hospitals for patients' outcomes after discharge. As of October 2012, Medicare began financially penalizing hospitals for "excess" readmissions as part of the ACA. Specifically, hospitals are penalized for all-cause 30-day rehospitalization in excess of the "expected" risk-adjusted rate for individuals initially admitted with congestive heart failure (CHF), heart attack, or pneumonia.<sup>2</sup>

In 2010, approximately 1.7 million Medicare fee-for-service beneficiaries used short-term skilled nursing care in nursing homes (NHs) primarily for daily rehabilitation services following a hospital stay.<sup>3</sup> The goal of this care is to prepare patients for discharge back to the community at close to pre-morbid functioning at costs lower than would have been the case had they remained in the hospital. However, recent reports indicate that nearly one-fourth of Medicare skilled nursing patients are readmitted to the hospital within 30 days, costing Medicare \$4.3 billion in 2006 alone.<sup>4,5</sup> Mor and colleagues (2010) found that the rate of rehospitalization from NHs had been increasing over the last several years and was higher than the overall rate of rehospitalization of all Medicare patients. These hospitalizations are known to be frequent,<sup>6</sup> costly,<sup>7</sup> and often preventable.<sup>8,9</sup>

Research suggests that a number of NH characteristics (eg, nurse staffing levels, size, and ownership) are related to hospitalization and rehospitalization of NH residents.<sup>6,10-13</sup> However, the literature on hospital characteristics associated with rehospitalization is quite limited. Furthermore, there is no research, to our knowledge, that considers the contribution of both the hospital and NH to rehospitalization. Prior literature generally examines one or the other, and a more comprehensive view is sorely needed. Therefore, we sought to determine whether the contribution of the quality of the hospital and the quality of the NH to which a patient was discharged were related to the likelihood of rehospitalization.

## ABSTRACT

### Objectives

To determine whether the quality of the hospital and of the nursing home (NH) to which a patient was discharged were related to the likelihood of rehospitalization.

### Study Design

Retrospective cohort study of 1,382,477 individual hospitalizations discharged to 15,356 NHs from 3683 hospitals between 2006 and 2008.

### Methods

Data come from Medicare claims and enrollment records, Minimum Data Set, Online Survey Certification and Reporting Dataset, Hospital Compare, and the American Hospital Association Database. Cross-classified random effects models were used to test the association of hospital and NH quality measures and the likelihood of 30-day rehospitalization.

### Results

Patients discharged from higher-quality hospitals (as indicated by higher scores on their accountability process measures and high nurse staffing levels) and patients who received care in higher-quality NHs (as indicated by high nurse staffing levels and lower deficiency scores) were less likely to be rehospitalized within 30 days.

### Conclusions

The passage of the Affordable Care Act changed the accountability of hospitals for patients' outcomes after discharge. This study highlights the joint accountability of hospitals and NHs for rehospitalization of patients.

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### Take-Away Points

The underlying reasons for the high rates of nursing home (NH) rehospitalization are numerous and complicated, but our initial results suggest that patients discharged from higher-quality hospitals to higher-quality NHs experience significantly lower 30-day readmission rates.

- These findings offer an important first step toward understanding the relative influence of both players, hospitals and NHs, in rehospitalization rates, and the importance of adequate risk adjustment.

- Furthermore, our findings set the stage for additional, more sophisticated analyses required to better understand which entity is ultimately “more” accountable.

This analysis is among the first to examine the potential joint influence of hospitals and NHs on the likelihood of hospitalization. Despite the dearth of background literature, we hypothesize that:

Patients discharged from a hospital to an NH are less likely to be rehospitalized within 30 days if their discharge was to an NH with better quality, all other factors being equal (including the discharge hospital's reported quality).

Patients discharged from a hospital to an NH are less likely to be rehospitalized within 30 days if their discharge is from a hospital with better quality, all other factors being equal (including the admitting NH's reported quality).

## METHODS

### Data

The analyses rely on individual-level, hospital-level, and NH-level data. Individual-level data come from the 2006-2008 Medicare Claims and Enrollment records and the 2006-2008 NH Minimum Data Set (MDS) resident assessments completed after admission to NH. The MDS includes data on over 400 assessment items that measure the clinical, functional, behavioral, and social needs of residents. In this study, we used data from the closest MDS assessment completed following hospital discharge: 55% were admission assessments and 44% were those required for Medicare reimbursement.

Hospital-level data came from the 2007 American Hospital Association (AHA) Annual Survey and 2007 Hospital Compare. The AHA survey includes information on organizational structure, facilities and services, utilization, community orientation indicators, physician arrangements, managed care relationships, expenses, and staffing. Hospital Compare is a consumer-oriented website created and maintained by CMS that provides information on how well hospitals provide recommended care to their patients (<http://www.hospitalcompare.hhs.gov/>). The clinical measures focus on acute myocardial infarction (AMI), congestive heart failure (CHF), and pneumonia,

and indicate how often hospitals give recommended treatments known to achieve superior results for patients with certain medical conditions. Information about these treatments was taken from the patients' medical records and converted into a percentage.

NH-level data came from the CMS 2007 Online Survey Certification and Reporting (OSCAR) data. OSCAR is a national dataset of all NH data elements collected by state survey agencies during the required annual onsite Medicare and Medicaid Certification inspection. OSCAR provides information on facility characteristics, resident census, conditions of residents, and deficiency measurements.

### Sample

We used the Residential History File methodology<sup>14</sup> to identify a cohort of fee-for-service Medicare patients who were discharged to a NH during 2007 directly following an acute hospital stay, with no more than a day between hospital discharge and nursing home admission, and had not been in an NH any time in the 120 days preceding the index hospitalization (1,514,690 patients). Therefore, these were considered new, post acute admissions. We restricted the population to individuals that were able to be matched to MDS, OSCAR, AHA, and Hospital Compare, resulting in a final sample of 1,382,477 individual hospitalizations discharged to 15,356 NHs from 3683 hospitals.

### Variables

**Outcome variable.** We used the National Quality Forum's readmission measure (NQF; <http://www.qualitynet.org/>) and defined rehospitalization as returning to any acute general hospital within 30 days of the date of discharge to NH from a hospital, compared with not being rehospitalized or dying during that time period. To be sensitive to the possible bias of competing risk, we undertook a sensitivity analysis excluding residents who died within 30 days of discharge. Results from this model can be found in the [eAppendix](#) (available at [www.ajmc.com](http://www.ajmc.com)).

**Patient-level control variables.** We included patient characteristics to control for the risk of rehospitalization when these characteristics could be confounded with either NH or hospital quality. Characteristics included age (both a linear and a quadratic form of age), race, and sex,<sup>15</sup> taken from the enrollment data; and intensive care unit (ICU) use while in the hospital, length of stay in the hospital, and comorbidity, constructed using the Elixhauser

index<sup>16</sup> from the Medicare claims. We also controlled for characteristics derived from MDS assessments including cognitive status, functional impairment, Resource Utilization Groups (RUGs) III case-mix reimbursement classification index, and presence of an advanced directive (Do Not Resuscitate and/or Do Not Hospitalize). Cognitive status was measured using the Cognitive Performance Scale, ranging from 0 (intact) to 6 (very severe impairment).<sup>17</sup> Functional impairment in activities of daily living (ADL) was measured using the ADL scale scored between 0 (totally independent in all of 7 of the ADLs) to 28 (totally dependent in 7 ADLs).<sup>18</sup> We used the hierarchical classification of the RUGs-III system, where the groups are assigned values based on severity from 1 to 7, with 1 indicating reduced physical functions and 7 indicating extensive services required.

**Hospital-level measures.** Hospital quality was assessed using staffing levels and processes of care measures. We used the National Quality Forum measure #0204 for skill mix of nursing staff calculated as the percentage of licensed nurses who were registered nurses (RNs).<sup>19</sup> We also used the condition-specific summary scores of process measures, 1 for each of the 3 clinical areas: AMI, CHF, and pneumonia. We selected Joint Commission on Accreditation of Healthcare Organizations (JCAHO)-endorsed, publicly reported accountability measures from Hospital Compare.<sup>20</sup> Included are process of care measures that are based on a strong foundation of research, capture whether evidence-based care has been delivered, address a process quite proximate to the desired outcome, and have minimal or no unintended adverse consequences. (See [eAppendix B](#) for a list of specific items included in each measure.) The average score for 3 accountability summary scores of the hospitals in our sample were as follows: AMI mean score of 84.4 (SD = 15.6); pneumonia mean score of 88.9 (SD = 7.3); and CHF mean score of 86.3 (SD = 13.8). To classify hospitals into those that perform well or do not do so, and consistent with previous research, we dichotomized the measures to indicate the accountability as either less than 90% or greater than or equal to 90%.<sup>21,22</sup>

We controlled for hospital characteristics that have been shown to be related to hospital mortality and rehospitalization rates.<sup>23,24</sup> As a measure of financial performance, we included hospital occupancy (the average daily census divided by the total number of facility beds set up and staffed during the year). We also controlled for size using a measure of total number of beds, for-profit status, JCAHO accreditation, and membership in the Council of Teaching Hospitals. In addition, we controlled

for whether the hospital was located in an urban area, because that factor is believed to be related to discharge and readmission patterns<sup>25</sup> and is a proxy for unmeasured market characteristics.

**Nursing home-level measures.** NH quality was measured using RN, licensed practical nurse (LPN), and certified nursing assistant (CNA) hours per resident day staffing levels. We also measured quality using the state-adjusted weighted deficiency citations that facilities received during their annual inspection.<sup>26</sup> The annual survey includes a number of possible citations given in 1 of 6 categories: administration, quality of care, resident rights, dietary services, physical environment, and other services (including dental, pharmacy, and specialized rehab).

Because researchers have suggested that NH size, chain affiliation, and profit status may differentiate treatment patterns and NH outcomes,<sup>8</sup> we controlled for chain affiliation and profit status. We also controlled for the facility occupancy rate, total number of beds, resident acuity index, percent of Medicaid residents, the number of admissions per bed, and whether or not the NH was part of a hospital. Presence of a nurse practitioner or physician assistant (NP/PA) was included because it has been shown to be related to hospitalization of NH residents.<sup>6,8,27</sup>

All continuous variables at the hospital and NH level were standardized for ease of interpretation.

## Analyses

This study employs a nonexperimental, retrospective, statistical association-based research design. We used cross-classified random effects models (CCREMs) estimated in SAS Proc Mixed<sup>28-31</sup> to examine the influence of multiple contexts (NHs and hospitals) on rehospitalization, while simultaneously adjusting for the unmeasured variability attributable to each context. Because hospital and NH quality are analyzed simultaneously, results represent each care setting's unique influence on rehospitalization. We performed initial assumption testing and confirmed the variables included in these models do not approach multicollinearity. Although we have a dichotomous outcome, we use a linear probability model for 3 reasons: a) given the size of the data, it is computationally intensive to estimate a logit model; b) linear probability models give interpretable coefficients directly, unlike logit models which require calculating marginal effects; and c) these types of models have been used when estimating hospitalization and rehospitalization.<sup>32-34</sup> Linear probability models treat the zero-one outcomes as continuous, approximating the probability of observing a rehospitalization.<sup>35,36</sup> Additional details about the CCREM used in

this analysis are provided in eAppendix A. Use of these data was approved by the Brown University Institutional Review Board.

## RESULTS

Twenty percent of our sample was rehospitalized within 30 days of hospital discharge. **Table 1** presents the descriptive characteristics of the patient sample, the NHs, and the hospitals included in these analyses. The average resident in our sample was 80 years old with an average hospital stay of 9 days (median = 6). Most patients were white (87%) and female (65%). The most common diagnoses (either primary or comorbidities) were hypertension (55%), followed by fluid and electrolyte disorders (30%), and chronic pulmonary disease (22%). These patients had a low average *cognitive performance scale* score (mean = 1) indicating that they were, on average, cognitively intact, and had an average *activities of daily living* score of 16 (moderate impairment). Patients in our sample were discharged from 3683 hospitals, with 43%, 48%, and 46% having a 90th percentile score on their AMI, pneumonia, and CHF accountability measures, respectively. The patients in our sample were admitted to 15,356 NHs. The average proportion of nursing staff that were RNs was 86%. The average RN, LPN, and CNA staffing levels in the NHs were 0.40, 0.85, and 2.28 hours per resident day (HPRD), respectively, and the average weighted deficiency score was 76.5.

Approximately 5% of patients were discharged from higher-quality hospitals (those with AMI, CHF, and pneumonia scores greater than 90% and whose ratio of RNs to licensed nurses were greater than the mean) to higher-quality NHs (those with staffing ratios greater than the mean and weighted deficiency scores less than the mean). Approximately 59% of patients were discharged from lower-quality hospitals (those with AMI, CHF, and pneumonia scores less than 90% and whose ratio of RNs to licensed nurses were below the mean) to lower-quality NHs (those with staffing ratios less than the mean and weighted deficiency scores greater than the mean).

### Relative Effects of Hospital Quality Versus Nursing Home Quality

Independent variables associated with hospital quality were significantly associated with 30-day rehospitalization rates. Specifically, a process score for AMI below 90% was associated with a statistically significant absolute increase of 0.37 percentage points in the likelihood of rehospitalization, representing a 2% relative increase over the unadjusted mean (20%). Residents discharged from hospitals

■ **Table 1.** Descriptive Characteristics of Sample

	Mean (SD) or %
<b>Patient Characteristics (N = 1,382,477)</b>	
Length of stay in hospital (days)	9 (12)
Age (years)	80 (10)
White	87%
Female	65%
ICU use in hospital	33%
Do Not Resuscitate order	28%
Do Not Hospitalize order	1%
ADL score <sup>a</sup>	16 (6)
CPS score <sup>b</sup>	1 (2)
RUGs category	4 (2)
Congestive heart failure	21%
Valvular disease	11%
Pulmonary circulation disease	3%
Peripheral vascular disease	5%
Hypertension	55%
Paralysis	4%
Other neurological disorders	13%
Chronic pulmonary disease	22%
Diabetes without chronic complications	17%
Diabetes with chronic complications	4%
Hypothyroidism	12%
Renal failure	15%
Liver disease	1%
Peptic ulcer disease	<1%
Acquired immunodeficiency syndrome	<1%
Lymphoma	<1%
Metastatic cancer	3%
Solid tumor without metastasis	2%
Rheumatoid arthritis/collagen vascular diseases	3%
Coagulopathy	4%
Obesity	3%
Weight loss	5%
Fluid and electrolyte disorders	30%
Chronic blood loss anemia	2%
Deficiency anemias	14%
Alcohol abuse	2%
Drug abuse	<1%
	(Continued)

**Table 1. Descriptive Characteristics of Sample**  
(continued)

	Mean (SD) or %
Psychoses	3%
Depression	7%
<b>Hospital Characteristics (N = 3683)</b>	
High AMI accountability score	43%
High pneumonia accountability score	48%
High CHF accountability score	46%
Proportion of RNs to nurses	86% (12%)
Total beds	178 (189)
Occupancy rate	57% (20%)
For profit	82%
JCAHO accreditation	75%
Member of the Council of Teaching Hospitals	7%
Urban area	81%
<b>Nursing Home Characteristics (N = 15,356)</b>	
RN staffing HPRD	0.4 (0.7)
LPN staffing HPRD	0.8 (0.8)
CNA staffing HPRD	2.3 (1.1)
Weighted deficiency score	76.5 (81.2)
Facility is part of a chain	54%
For-profit status	67%
Hospital based	7%
Occupancy rate	84% (15%)
Admissions per bed	2.3 (3.7)
Percent with Medicaid as primary payer	60% (24%)
Acuity index	11.1 (1.5)
Total beds	107 (64)
Any physician extender	30%
ADL indicates activities of daily living; AMI, acute myocardial infarction; CHF, congestive heart failure; CPS, Cognitive Performance Scale; HPRD, hours per resident per day; ICU, intensive care unit; JCAHO, Joint Commission on Accreditation of Healthcare Organizations; RN, registered nurse; RUGs, Resource Utilization Groups. <sup>a</sup> ADL score is on a scale of 1-28. <sup>b</sup> CPS score is on a scale of 0-6.	

with a lower proportion of total nurses who were RNs had an absolute increase of 0.59 percentage points in the likelihood of rehospitalization, representing a 3% relative increase over the unadjusted mean. In addition, patients that were discharged from an urban, nonprofit, non-JCAHO-accredited teaching hospital with a higher occupancy rate were at an increased likelihood of being rehospitalized within 30 days.

A number of NH characteristics were related to the likelihood of rehospitalization. Patients discharged to NHs with lower RN staffing levels, low occupancy levels, and a higher weighted deficiency score were at an increased risk of rehospitalization. Specifically, patients discharged to an NH with lower RN staffing levels and a higher weighted deficiency score experienced an absolute increase of rehospitalization of 0.19 percentage points and 0.16 percentage points, respectively. Being discharged to an NH with low occupancy rates was associated with a 0.55 percentage point increase in the likelihood of rehospitalization, representing a 3% relative increase over the unadjusted mean likelihood of rehospitalization. Patients who were discharged to freestanding, for-profit NHs with a higher proportion of Medicaid residents and a higher number of admissions per bed were associated with an increased likelihood of rehospitalization.

### Variability in Rehospitalization

Our model also allows us to assess the variation in rehospitalization attributable to patient characteristics, hospital characteristics, and nursing home characteristics. Most variation in rehospitalization is explained by the patient characteristics included in the model (32.4%). Of those patient characteristics, 16.5% of the variation was attributable to the characteristics that are controlled for in the NQF measure of rehospitalization (age, gender, and comorbidities). Hospital quality measures explained an additional 1.7% of the variation in rehospitalization rates and NH quality measures contributed to an additional 1.3% of the variation.

## DISCUSSION

This is among the first studies, to our knowledge, that examines the relative influence of hospital quality and NH quality on rehospitalizations for patients discharged to an NH. The underlying reasons for the high rates of NH rehospitalization are numerous and complicated, but our initial results suggest that patients discharged from higher-quality hospitals (as measured by a high RN-to-total-nurse ratio and a high score on the AMI process summary measure) to higher-quality NHs (as measured by higher RN staffing levels and a lower weighted deficiency score) experience significantly lower 30-day readmission rates. Our results build on previous research and confirm our hypotheses that both hospital and NH quality are related to rehospitalizations within 30 days of an acute hospital stay. These findings offer an important first step toward understanding the relative influence of both play-

ers, hospitals and nursing homes, in rehospitalization rates. Furthermore, our findings set the stage for additional, more sophisticated analyses required to better understand which entity is ultimately “more” accountable.

Our findings echo the perspective of others,<sup>37</sup> in that much of what drives hospital readmission rates are patient-level factors that are well outside the hospital’s control. Specifically, most of the variation in rehospitalization in our model is attributable to patient characteristics, while NH quality and hospital quality account for only 2.8% of the explained variation. In the new healthcare environment, where quality and outcomes are increasingly linked to reimbursement and public reporting initiatives, it is important that rehospitalization rates be adequately adjusted for patients’ underlying risks of rehospitalization. The Hospital Readmissions Reduction Program accounts for age, gender, comorbidities, and selected medical history when risk-adjusting these rates.<sup>38</sup> However, as our results show, there are many additional patient-level factors that contribute to a hospital’s readmission rate from an NH, including patients’ demographic characteristics, functional impairment, cognitive functioning, and even preferences as indicated by the strength of the variables indicating whether the patient had an advanced directive. It is important that these characteristics are taken into account when risk-adjusting rehospitalization, particularly for patients who are discharged to an NH.

NHs and hospitals are similar to suppliers and manufacturers: manufacturers are dependent on the supplier for a high-quality product and the suppliers are dependent on the quality and success of manufacturers for business. If an organization and its supplier establish a relationship that benefits both sides, then the relationship will enhance “the ability of both to create value.”<sup>39</sup> With the advent of the Total Quality Management philosophy of doing business, ways to assure quality performance—such as by establishing an atmosphere of trust, teamwork, and cooperation—become more important. Hospitals and NHs (like suppliers and manufacturers) working together as partners is the way both can assure quality products and outcomes. In addition to implementing quality improvement projects within the hospital, hospitals should track and observe trends to identify which NHs frequently readmit patients in an effort to partner with these NHs to identify opportunities for improvement and education, and to provide optimal patient care. Hospitals committed to reducing readmissions from NHs must assess their processes from admission (evaluating risk of readmission), to discharge planning, handoffs, and follow-up. In addition, it is important that hospital discharge planners are

familiar with NHs to ensure that they are adept at matching patients with NHs that can best meet their continuing medical needs.

It is also in NHs’ best interests to work to improve their quality and lower readmission rates. The Medicare Payment Advisory Commission has advised Congress to impose penalties on NHs with high rehospitalization rates as well as to require public reporting of rehospitalization rates to consumers. Results from our study suggest that facilities with lower quality, based on nurse staffing and state survey citations, do indeed have higher rehospitalization rates. Increased attention and efforts to boost the quality of lower-performing NHs may have the added benefit of reducing the rehospitalization rate.

### Limitations

Our study has several limitations worth noting. First, the only hospital quality measures related to the delivery of inpatient care came from the 3 condition-specific measures in Hospital Compare. While we selected items that measure the actual care delivered, have been linked to outcomes, have been endorsed by JCAHO, are used as resources for consumer decision making, and have been used in other studies related to quality, we must consider other processes of care that may be distinctly relevant to this unique population discharged to NHs. These include potentially focusing on frailty, symptom relief, and end-of-life issues. In addition, only 1 process summary measure was related to rehospitalizations. One explanation for this may be the robustness of this measure, as it is composed of 5 individual measures in relation to the other 2 summary measures for CHF and pneumonia (composed of 1 and 2 individual measures, respectively). In regards to our NH quality data, we did not have any measure of care coordination or the process of admitting patients from the hospital. Future research is needed to understand the impact of the relationship between hospitals and NHs on rehospitalizations.

While our analysis is limited in that we use linear probability models as opposed to modeling a multinomial outcome, we believe our use of CCREMS is novel and appropriate. The number of fixed and random effects that were estimated with a sample this large is computationally intensive. If we were to ignore the cross-classification of data, our models’ error terms would be misspecified, potentially resulting in biased estimates of covariate effects and spurious conclusions.<sup>30,31</sup> With the CCREMS we used, we are unable to capture unobserved, omitted variables that could bias the coefficients, such as characteristics of patients who may self select into certain hos-

pitals and NHs. There might be some strong hospital-NH relationships, but in other cases the patient might choose from several NHs that the hospital recommends and may decide on the basis of geographic convenience and/or bed availability. In addition, hospitals may strategically place their patients in NHs and there may be some selection bias in the types of patients that NHs accept. However, we attempted to control for observable characteristics of the patients, NHs, and hospitals that may be related to their likelihood of rehospitalization. More research is needed to understand the choice set and decision processes of patients, discharge planners, and admission coordinators in order to establish a causal relationship.

## CONCLUSIONS

We assume that the current policy emphasis on rehospitalizations encourages both hospital and NH providers to manage the transitions between them to avoid penalties. This study highlights the importance of hospitals' monitoring of the quality of the NHs to which they are discharging patients, and NHs' monitoring of the quality of hospitals from which they are receiving patients. Therefore, as bundled post acute care and payment becomes a reality and forming preferred provider relationships is important, it is in the best interest of both NHs and hospitals to improve the quality of care they provide to their patients. The goal of improved patient care is the rationale behind the decision to impose penalties, as it is behind accountable care

**Table 2. Results of Cross-Classified Random Effects Models: 30-Day Rehospitalization**

	Estimate	SE	P
<b>Hospital-Level Predictors</b>			
High AMI accountability score	-0.0037	0.0015	.015
High pneumonia accountability score	-0.0023	0.0015	.132
High CHF accountability score	-0.0020	0.0015	.180
Proportion of RNs to nurses <sup>a</sup>	-0.0059	0.0012	<.001
Total beds <sup>a</sup>	-0.0002	0.0008	.815
Occupancy rate <sup>a</sup>	0.0027	0.0010	.009
For-profit	-0.0084	0.0021	<.001
JCAHO accreditation	-0.0230	0.0030	<.001
Member of the Council of Teaching Hospitals	0.0143	0.0027	<.001
Urban area	0.0110	0.0020	<.001
<b>NH-Level Predictors</b>			
Weighted deficiency citations <sup>a</sup>	0.0016	0.0006	.013
RN HPPD <sup>a</sup>	-0.0019	0.0009	.030
LPN HPPD <sup>a</sup>	0.0007	0.0009	.469
CNA HPPD <sup>a</sup>	-0.0014	0.0007	.052
Facility is part of a chain	-0.0002	0.0012	.870
For-profit status	0.0075	0.0014	<.001
Hospital based	-0.0082	0.0030	.006
Occupancy <sup>a</sup>	-0.0055	0.0008	<.001
Any physician extender	-0.0022	0.0012	.078
Total beds <sup>a</sup>	-0.0002	0.0006	.726
Percent Medicaid <sup>a</sup>	0.0051	0.0008	<.001
Admissions per bed <sup>a</sup>	0.0058	0.0008	<.001
Acuity Index <sup>a</sup>	-0.0005	0.0007	.491
Intercept	0.1660	0.0111	<.001
Variance at the NH level	0.0010	0.0000	<.001
Variance at the hospital level	0.0007	0.0000	<.001
Residual variance	0.1534	0.0002	<.001
-2LL		937,083	
Pseudo R <sup>2</sup>		36%	

AMI indicates acute myocardial infarction; CHF, congestive heart failure; CNA, certified nursing assistant; HPPD, hours per patient day; JCAHO, Joint Commission on Accreditation of Healthcare Organizations; LPN, licensed practical nurse; NH, nursing home; RN, registered nurse.  
<sup>a</sup>Variables standardized for ease of interpretation.  
 Controls were for the following patient level characteristics: age, race, sex, intensive care unit use while in the hospital, length of stay in the hospital, Elixhauser index, Cognitive Performance Scale score, Activities of Daily Living scale score, Resource Utilization Groups hierarchical score, and Do Not Resuscitate and Do not Hospitalize advanced directives.  
 Note: Pseudo R<sup>2</sup> was calculated by [(τb00 + τc00) unconditional model - (τb00 + τc00) unconditional model].

generally. If NHs and hospitals can utilize information—including data and discussion about the importance of the quality of the discharging hospitals and admitting NHs—to reduce 30-day rehospitalization rates, it will be an important step in achieving that goal.

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## **eAppendix A.** Specification of Cross-Classified Random Effects Models

When patients are cross-classified by nursing homes (NHs) and hospitals, there are 2 Level 2 random factors (ie, NHs and hospitals). Let NHs be indexed by  $j = 1, \dots, J$ ; hospitals be indexed by  $k = 1, \dots, K$ ; and patients be indexed by  $i = 1, \dots, n$  within each combination of NHs and hospitals. In an unconditional model (ie, model without predictors), the Level 1 (ie, patient-level) model is specified as  $Y_{i(jk)} = \pi_{0(jk)} + e_{i(jk)}$  where  $\pi_{0(jk)}$  is the mean rehospitalization for patients who received care in the  $j$ th NH and the  $k$ th hospital, and  $e_{i(jk)}$  is the Level 1, person-level residual. In the Level 2 model, we include 2 sources of error: variance in rehospitalization attributable to NHs ( $\mu_{0j}$ ) and hospitals ( $\nu_{0k}$ ). The mean score  $\pi_{0(jk)}$  is modeled as  $\pi_{0(jk)} = \Upsilon_{00} + \mu_{0j} + \nu_{0k}$  where  $\Upsilon_{00}$  is the grand mean,  $\mu_{0j}$  is the variance component attributable to NH  $j$  and  $\nu_{0k}$  is attributable to hospital  $k$ . The combined model is obtained by substituting the Level 2 model into the Level 1 model, yielding Model 1:

$$Y_{i(jk)} = \Upsilon_{00} + \mu_{0j} + \nu_{0k} + e_{i(jk)}$$

Adding to Model 1, we included patient characteristics, hospital-level predictors of rehospitalization, and NH-level predictors of hospitalization to form our final model. This allowed us to test hypotheses 1 and 2 by examining rehospitalization as a function of both hospital quality and NH quality, while statistically controlling for patients' characteristics.

## **eAppendix B.** Information on Hospital Quality Measures

For acute myocardial infarction (AMI), we included these measures: a) patients given aspirin at arrival, b) patients given aspirin at discharge, c) patients given ACE inhibitor or ARB for left ventricular systolic dysfunction, d) patients given beta blocker at discharge, e) patients given beta blocker at arrival.

For congestive heart failure we included 1 of the 4 heart failure measures reported on Hospital Compare: patients given angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) for left ventricular systolic dysfunction.

For the processes of care for pneumonia patients, we included the following accountability measures: a) patients given the most appropriate initial antibiotic(s), b) patients whose initial emergency department blood culture was performed prior to the administration of the first hospital dose of antibiotics.

We averaged the measures for each condition to create 3 condition-specific cumulative scores that define how often the hospital provides recommended care for each condition.

**eAppendix C. Results From Sensitivity Analyses Modeling Likelihood of Rehospitalization, Excluding Death**

	<i>Estimate</i>	<i>SE</i>	<i>P</i>
<i>Hospital-Level Predictors</i>			
High AMI accountability score	-0.0031	0.0015	.038
High pneumonia accountability score	-0.0019	0.0015	.189
High CHF accountability score	-0.0014	0.0015	.353
Proportion of RNs to nurses <sup>a</sup>	-0.0059	0.0011	<.001
Total beds <sup>a</sup>	-0.0001	0.0008	.935
Occupancy rate <sup>a</sup>	0.0031	0.0010	.003
For-profit status	-0.0089	0.0021	<.001
JCAHO accreditation	-0.0226	0.0025	<.001
Member of the Council of Teaching Hospitals	0.0157	0.0026	<.001
Urban area	0.0083	0.0021	<.001
<i>NH-Level Predictors</i>			
Weighted deficiency citations <sup>a</sup>	0.0018	0.0006	.004
RN HPPD	-0.0011	0.0009	.207
LPN HPPD	0.0005	0.0009	.621
CNA HPPD	-0.0014	0.0007	.043
Facility is part of a chain	-0.0003	0.0012	.814
For-profit status	0.0055	0.0014	<.001
Hospital based	-0.0038	0.0029	.192
Occupancy <sup>a</sup>	-0.0056	0.0008	<.001
Any physician extender	-0.0020	0.0012	.102
Total beds <sup>a</sup>	-0.0004	0.0006	.521
Percent Medicaid <sup>a</sup>	0.0046	0.0008	<.001
Admissions per bed <sup>a</sup>	0.0056	0.0007	<.001
Acuity index <sup>a</sup>	-0.0007	0.0007	.332
Intercept	0.1590	0.0111	<.001

Variance at the NH level	0.0010	0.0000	<.001
Variance at the hospital level	0.0007	0.0000	<.001
Residual variance	0.1447	0.0002	<.001
<i>-2LL</i>		820,797	

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AMI indicates acute myocardial infarction; CHF, congestive heart failure; CNA, certified nursing assistant; HPPD, hours per patient day; JCAHO, Joint Commission on Accreditation of Healthcare Organizations; LPN, licensed practical nurse; NH, nursing home; RN, registered nurse.

<sup>a</sup>Variables standardized for ease of interpretation.

Controls were for the following patient level characteristics: age, race, sex, intensive care unit use while in the hospital, length of stay in the hospital, Elixhauser index, Cognitive Performance Scale score, Activities of Daily Living scale score, Resource Utilization Groups hierarchical score, and Do Not Resuscitate and Do Not Hospitalize advanced directives.