Published in final edited form as:
Med Care. 2013 January ; 51(1): 52–59. doi:10.1097/MLR.0b013e3182763284.

Hospital Nursing and 30-Day Readmissions among Medicare Patients with Heart Failure, Acute Myocardial Infarction, and Pneumonia

Matthew D. McHugh, PhD, JD, MPH, RN and
Center for Health Outcomes and Policy Research, University of Pennsylvania, Claire M. Fagin Hall, Room 379, 418 Curie Boulevard, Philadelphia, PA 19104-4217, Phone - 215-746-0205, Fax - 215-573-2062

Chenjuan Ma, MS, RN
Center for Health Outcomes and Policy Research, University of Pennsylvania, Claire M. Fagin Hall, 418 Curie Boulevard, Philadelphia, PA 19104-4217, Phone - 215-746-0205, Fax - 215-573-2062

Matthew D. McHugh: mchughm@nursing.upenn.edu; Chenjuan Ma: chenjuan@nursing.upenn.edu

Abstract

Background—Provisions of the Affordable Care Act that increase hospitals' financial accountability for preventable readmissions have heightened interest in identifying system-level interventions to reduce readmissions.

Objectives—To determine the relationship between hospital nursing; i.e. nurse work environment, nurse staffing levels, and nurse education, and 30-day readmissions among Medicare patients with heart failure, acute myocardial infarction, and pneumonia.

Method and Design—Analysis of linked data from California, New Jersey, and Pennsylvania that included information on the organization of hospital nursing (i.e., work environment, patient-to-nurse ratios, and proportion of nurses holding a BSN degree) from a survey of nurses, as well as patient discharge data, and American Hospital Association Annual Survey data. Robust logistic regression was used to estimate the relationship between nursing factors and 30-day readmission.

Results—Nearly one-quarter of heart failure index admissions (23.3% [n=39,954]); 19.1% (n=12,131) of myocardial infarction admissions; and 17.8% (n=25,169) of pneumonia admissions were readmitted within 30-days. Each additional patient per nurse in the average nurse's workload was associated with a 7% higher odds of readmission for heart failure (OR=1.07, [1.05–1.09]), 6% for pneumonia patients (OR=1.06, [1.03–1.09]), and 9% for myocardial infarction patients (OR=1.09, [1.05–1.13]). Care in a hospital with a good versus poor work environment was associated with odds of readmission that were 7% lower for heart failure (OR = 0.93, [0.89–0.97]); 6% lower for myocardial infarction (OR = 0.94, [0.88–0.98]); and 10% lower for pneumonia (OR = 0.90, [0.85–0.96]) patients.

Conclusions—Improving nurses' work environments and staffing may be effective interventions for preventing readmissions.

Corresponding Author Information: Matthew D. McHugh, PhD, JD, MPH, RN, Center for Health Outcomes and Policy Research, University of Pennsylvania School of, Nursing 418 Curie Blvd, Philadelphia, PA 19104-4217, Phone: 215-726-0205; Fax: 215-573-2062, mchughm@nursing.upenn.edu.

Keywords

nursing; readmissions; quality of health care; work environment; organizational culture

Preventable hospital readmissions are a source of unnecessary costs to Medicare—over $15 billion annually.[1–2] Readmissions jeopardize the health of the frail elderly who are particularly vulnerable to loss of function, hospital-acquired infections, and other poor outcomes when hospitalized.[3] Many interventions aimed at reducing hospital readmissions target transitional care, care-coordination, or post-discharge care services for select populations.[4–6] Evidence on the effectiveness of these interventions, which can be costly and require scarce human resources, is promising but mixed.[7–8] Little work has focused on how the organization of inpatient nursing services—which all patients are exposed to—is associated with readmissions.

Our work is grounded in Donabedian's structure–process–outcomes framework, which suggests that structural factors affect outcomes through their impact on care processes. We are informed by organizational sociology which differentiates stable structural factors (e.g., hospital size, ownership) from dynamic organizational elements (e.g., work environment, workforce composition, leadership, communication) that can be changed by administrators and policymakers. This framework suggests that hospitals organized as better places for nurses to work—those that value nurses' autonomy, excel in frontline manager supervisory ability, invest in staff development, support good nurse-physician relations, have high proportions of educated staff, and staff for manageable workloads—empower nurses to provide high quality care resulting in better patient outcomes.[9] The majority of evidence shows that hospitals with these features have better patient outcomes.[10–16]

There has been less research on the relationship between hospital nursing and readmissions.[17–18] We expect that hospitals with better nurse work environments, better staffing levels, and a more educated nursing workforce create the context for nurses to provide optimal care that would translate into, not only reduced risk for mortality and other adverse events, but reduced readmission risk.

Readmission prevention begins the moment the patient enters the hospital. Nurses' round-the-clock presence at decisive moments allows them to prepare patients and families for discharge throughout the hospitalization. This preparation and teaching supports seamless transitions to other settings. Bedside nurses also act as sentinels—identifying early warning signs and addressing complications and adverse events in the acute care setting that increase patients' risk of readmission.[19–20] Nurses are the frontline for providing many of the core processes of care aimed at preventing readmissions—knowledge assessment, patient education, discharge preparation, and care-coordination. These processes, however, can be disrupted when nurses have little autonomy, poor interdisciplinary relationships, minimal managerial support, overwhelming workload, inadequate resources, and poor integration throughout the institution's decision making structure.

This study evaluates how variation in the organization of hospital nursing services, i.e., nurse work environment, nurse staffing levels, and nurse education, is associated with 30-day all-cause readmissions among Medicare patients over age 65 with heart failure, acute myocardial infarction, and pneumonia. Readmissions for these conditions are common, costly, and often preventable.[1–2, 4–5] Under the Affordable Care Act, the Centers for Medicare and Medicaid Services (CMS) will reduce payments to hospitals with higher than expected readmissions rates for these conditions. Understanding how the nursing care environment affects readmissions can inform the development of system and policy level

interventions, which have the potential for considerable effects while increasing the effectiveness of established clinical interventions targeting readmissions.

Methods

Sample and Data

Hospitals—Measures of hospital work environment, nurse staffing levels, and nurse educational attainment, were taken from a cross-sectional (2005–2006) survey of registered nurses in California, Pennsylvania, and New Jersey. The sampling approach has been detailed previously.[16, 21] The sampling frame was state licensure lists from the three states. Random samples of all licensed nurses (California 40%; Pennsylvania 40%, and New Jersey, 50%) were surveyed by mail at their homes regardless of work setting. Direct care hospital nurses gave the name of their employer, allowing us to aggregate responses by hospital. This approach allowed us to avoid hospital-level response bias but amounted to surveying more than 200,000 nurses, making repeated follow-ups and monetary incentives impossible. The initial response rate of nurses was 39%. Using extensive follow-ups and incentives[22–23] in a second survey of 1300 non-responder nurses, we obtained a very high response rate (91%), and the information indicated that on all of the variables related to nursing organization and the quality of nursing care, non-responders did not differ from responders.[24]

Data describing structural characteristics of hospitals were obtained from the American Hospital Association (AHA) Annual Survey. Analyses were limited to adult, non-federal acute care hospitals with at least 50 annual discharges for each condition and at least 10 direct care nurse respondents.[12] The analytic sample of hospitals for this secondary analysis was 412 hospitals: California, 210; Pennsylvania, 134; and New Jersey, 68.

Patients—Data on the index admissions and readmissions were obtained from state discharge abstract databases from the three states for 2005–2006. We identified index admissions based on CMS's validated Risk-Standardized Readmission Measures[25–27] modified for use with the state databases. All patients with Medicare as the primary payer; between the ages of 65–89; and who were discharged from an adult, non-federal acute care hospital with heart failure, acute myocardial infarction, or pneumonia as primary diagnosis (see Table, Supplemental Digital Content 1, for *International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] codes) were considered potential index admissions to assess 30-day all-cause readmission (separately by condition). Admissions for the same condition more than 30-days from the last discharge could be considered another index admission but readmissions within 30-days were excluded to avoid double counting an admission as both an index admission and readmission. Patients aged 90 and older, that died during hospitalization, transferred out to acute care facilities, were discharged the same or next-day, or discharged against medical advice were excluded.

Variables

Nurse staffing—Nurses provided the number of patients and nurses on their last shift which allowed us to calculate an average hospital patient-to-nurse ratio.[16] Evidence suggests that direct survey measures of staffing are better than other sources (e.g., administrative data) for predicting patient outcomes.[10–12, 28]

Nurse education—Nurses provided detailed educational background information which we used to create a hospital-level measure of the percentage of nurses with a bachelor of science in nursing (BSN) degree.[11]

Nurse work environment—We measured the nurse work environment with the National Quality Forum-endorsed Practice Environment Scale of the Revised Nursing Work Index (PES-NWI).[29] Nurses indicated the degree to which various organizational features were present in their practice setting. Hospital-level measures were created by aggregating nurses' responses to items comprising the five subscales including nursing foundations for quality care; staffing and resource adequacy; nurse participation in hospital affairs; nurse manager ability, leadership, and support; and nurse-physician relations.[29] We used a categorical measure with good predictive validity where hospitals above the median on 4 or 5 subscales were classified as having "good" work environments; hospitals above the median on 2 or 3 subscales were classified as having "mixed" work environments; and hospitals above the median on only 1 or no subscales were classified as having "poor" work environments.[10]

Covariates—Models included covariates characterizing structural and descriptive attributes of hospitals that may be associated with quality of care outcomes.[30–33] Size was defined by the number of staffed hospital beds within the facility. Teaching status was categorized as none (no residents or fellows), minor (0.01 ≤resident/fellow-to-bed ratio ≤0.25), and major (resident/fellow-to-bed ratio > 0.25). High technology hospitals had open-heart surgery capabilities, organ transplant capabilities, or both. Ownership was defined as not-for-profit or for-profit. We used dummy variables to indicate the category based on population size of the hospital's geographic location. The volume of cases was measured by taking the average of the total number of cases for the hospital by condition for years 2005–2006.[34] We created a hospital-level variable categorizing volume into quartiles. We also linked Medicare cost report data to calculate a measure of total operating margin—the ratio of a hospital's total revenues related to direct patient care and total operating expenses.

Outcome

30-day readmission—We identified all-cause readmissions to any adult, non-federal, acute care hospital within 30-days of discharge from an index hospitalization for heart failure, acute myocardial infarction, and pneumonia (separately) based on CMS's validated Risk-Standardized Readmission Measures.[25–27] A binary variable was created to indicate readmission within 30-days of index hospitalization for a given individual. For acute myocardial infarction patients, there are readmissions that might be considered planned and within the course of quality care and thus should not be counted as readmissions. These included follow-up revascularization procedures or coronary artery bypass graft surgery.

Risk-adjustment—Using Elixhauser's approach, we identified 27 comorbidities (excluding fluid and electrolyte disorders and coagulopathy) to account for comorbid illnesses.[35–37] We also included sex, age, and for acute myocardial infarction models, we included dummy variables indicating the anatomic location of the infarction (ICD-9-CM codes: anterior 410.00–410.19, inferolateral 410.20–410.69, subendocardial 410.7x, other 410.80–410.99). We also created a summary measure for socioeconomic position based on zipcode-level data linked to each beneficiary's zipcode.[38–39] We used Census data on 6 factors including median household income, percentage of adults who have completed high school, percentage of persons employed in predominantly working class occupations, percentage of owner occupied homes worth >400% of the median value of owned homes, and percentage of unemployed persons to create the index. A zipcode-level z-score was estimated for each variable and the scores were then summed to obtain a socioeconomic position measure for each zipcode which were applied to individuals living in those zip codes. Our c-statistics, 0.61 for heart failure and 0.59 for both myocardial infarction and pneumonia, were similar to other reportss.[25, 27, 30]

Analysis

We have provided descriptive statistics to characterize the patients, nurses who provided information on hospitals, and the hospitals in our sample. We estimated robust logistic regression models separately for each condition to determine the relationship between the work environment, patient-to-nurse ratios, proportion of BSN-educated nurses, and the risk-adjusted odds of readmission. The key predictor variables—nurse work environment, nurse staffing, and nurse education—were hospital-level measures. We also include stable hospital structural characteristics. The outcome—30-day readmission—was measured at the patient level along with detailed patient characteristics for risk adjustment. To account for clustering patients within hospitals, we estimated robust standard errors and significance levels that were corrected for heteroscedasticity and accounted for hospital-level clustering.[40] Using our model results, we estimated the probability of readmission given particular work environment and staffing characteristics. All analyses were conducted using Stata v.11.

Results

Table 1 describes patient characteristics. There were 171,883 (46%) heart failure index admissions (134,695 unique patients); 62,394 (16%) acute myocardial infarction index admissions (60,837 unique patients); and 141,404 (38%) pneumonia index admissions (128,510 unique patients). Nearly one-quarter of the heart failure index admissions (23.3% [n=39,954)); 19.1% (n=12,131) of acute myocardial infarction index admissions; and 17.8% (n=25,169) of pneumonia index admissions were readmitted within 30-days. These rates are similar to national rates for Medicare beneficiaries reported in the Hospital Compare database between July 1, 2006 and June 30, 2009, (heart failure, 24.7%; acute myocardial infarction, 19.9%; and pneumonia,18.3%).

The most common reason for readmission among heart failure patients was a subsequent heart failure admission (32%). Heart failure was also the most common cause of readmission (15%) among acute myocardial infarction patients. Patients with pneumonia were most frequently readmitted for subsequent pneumonia (21%).

Hospitals, and the numbers and percentages of patients and nurses in them, are described in Table 2. Nearly one-third of the hospitals had good work environments (n=120; 29%) and nearly another third had poor work environments (n=118; 29%). The remainder had mixed work environments (n=174; 42%). The average hospital patients-to-nurse ratio was 4.95 (SD = 1.1). The average proportion of BSN-prepared nurses was 39%. On average, hospitals with the best work environments had lower patient-to-nurse ratios and higher proportions of nurses with a BSN compared to other hospitals.

Logistic regression models (Table 3) showed that, accounting for patient and hospital characteristics, care in a hospital with a good versus poor work environment was associated with 7% lower odds of 30-day readmission for heart failure patients (OR = 0.93, 95% CI [0.89–0.97]), 6% lower odds for acute myocardial infarction patients (OR = 0.94, 95% CI [0.88–0.98]), and 10% (OR = 0.90, 95% CI [0.85–0.96]) lower odds for pneumonia patients. The odds of readmission was 4% lower for heart failure (OR = 0.96, 95% CI [0.94–0.98]); 3% lower for acute myocardial infarction (OR = 0.97, 95% CI [0.94–0.99]); and 6% lower for pneumonia (OR = 0.95, 95% CI [0.92–0.98]) patients cared for in a hospital with a mixed versus poor work environment.

Nurse educational attainment was not statistically significantly associated with readmission among patients with heart failure or acute myocardial infarction. Among patients with pneumonia, each additional 10% in the proportion of hospital nurses with a BSN-level

education was associated with 3% lower odds of 30-day readmission (OR = 0.97, 95% CI [0.95–0.99]).

An odds ratio of 1.07 (95% CI [1.05–1.09]) suggested that the odds of readmission was 7% higher for heart failure patients for each additional patient per nurse in the average nurse's workload. The findings were similar for patients with acute myocardial infarction and pneumonia—each additional patient per nurse was associated with 9% (OR = 1.09, 95% CI [1.05–1.13]) and 6% (OR = 1.06, 95% CI [1.03–1.09]) higher odds of readmission respectively.

We found that the interaction between staffing and the work environment was not significant. Based on the additive models, Table 4 shows the average estimated probabilities of 30-day readmission in our sample if the patients were treated in hospitals with different staffing and work environment characteristics. The average probability of readmission within 30-days was 0.24 for heart failure patients treated in hospitals with poor work environments, 0.232 in mixed environments, and 0.226 in good work environments. The average probability of readmission for heart failure patients in hospitals with an average workload of seven patients per nurse was 0.256, considerably higher than if patients were treated in hospitals with five patients per nurse (0.232) or three patients per nurse (0.209). In all cases, the probability of readmission would be decidedly lower if both the workloads were less and nurses' work environment was better.

On average, only about half (52%) of hospital staff nurses surveyed were confident that their patients were able to manage their own care when they were discharged. This varied, however, by work environment and staffing level. For example, 56% of nurses working in better staffed hospitals (fewer than 4 patients per nurse on average) and 59% of nurses working in hospitals with good work environments were confident, compared to less than half (48%) in hospitals with 6 or more patients per nurse and in hospitals with poor work environments (45%).

Discussion

Our results suggest that improving nurses' work environment and reducing nurses' workload are organization-wide reforms that could result in fewer readmissions for Medicare beneficiaries with common medical conditions. This is consistent with the evidence showing significant associations between the nurse work environment, staffing, and other patient outcomes.[10, 12–15]

The relationship between the organization of hospital nursing services and readmissions presents an opportunity for hospital administrators interested in system-based interventions to improve care. The need for interventions within the immediate control of the hospital is intensifying as payers increasingly shift accountability for outcomes onto hospitals. Intensive, often nurse-led, coordinated care management and transitional care models are currently in practice and hold promise for reducing readmissions.[4–6] Although these targeted programs for managing patients in the hospital and through their transition from the hospital to home are vital, the financial and human resources for such services is limited compared to their demand. Additionally, these interventions alone inconsistently prevent readmissions and decrease costs.[7–8] The nursing care environment is an attractive target for organizational intervention because all hospitalized patients are exposed to bedside nursing throughout their hospital stay. Combining targeted transitional care interventions with high quality inpatient hospital nursing care may yield optimal outcomes for all patients.

Hospitals with good work environments and sufficient nurse staffing formalize an organizational culture that expects and establishes the necessary conditions for nurses to

effectively influence transitions throughout the hospital stay while continually preparing patients for discharge. Research has shown that nurses working in hospitals with better nurse staffing levels are better able to provide discharge teaching and get their patients prepared for discharge—factors associated with readmissions.[17] Our data are consistent with these reports: a larger percentage of nurses practicing in better staffed hospitals with good work environments were confident in their patients' ability to manage their care upon discharge.

The clinical significance of the effects of staffing and work environment on readmission could be considerable. Based on our estimates, the average difference in heart failure readmission rates between hospitals with poor versus good work environments is 1.4%, which, based on Hospital Compare data, nearly equals the standard deviation in the readmission rate for these patients (1.9%). If a hospital with a poor work environment could improve to a good environment, we would expect its readmission rate to decline from roughly the 84th to 50th percentile or the 50th to the 16th percentile in this distribution of hospitals. A hospital that could change its work environment from poor to good and reduce nurse workloads from 6 to 4 patients per nurse would, all else being equal, see their readmission rates reduced from 25% to 21%.

An example of an organizational intervention aimed at improving the work environment is the American Nurses Credentialing Center's (ANCC) Magnet Recognition Program. Evidence suggests that hospitals that have achieved Magnet recognition fit the good work environment category as we have measured it [41–42] and achieve better patient outcomes.[43–44] Short of achieving Magnet recognition, changing the work environment in ways that provide more administrative support for nursing, promote better nurse-physician relationships, and empower nurses to have a stronger role in the decision-making process would all contribute to producing better patient outcomes, including fewer readmissions.

Increasing staffing levels inherently raises concerns regarding costs given the labor costs of nursing for hospitals.[45] Hospitals, however, may be able to make up for some of these costs with the increased productivity, reduced costs lost to turnover and retraining, improved patient outcomes, and reductions in post-discharge service utilization and readmission costs.[46–49] Weiss and colleagues[17] showed that postdischarge utilization costs could be significantly reduced by investing in better nurse staffing. The costs of improving work environments and staffing will likely be increasingly offset as new models of care and pay for performance financing increase hospitals' incentives to achieve good outcomes. For example, the Hospital Readmissions Reduction program under the Affordable Care Act will result in reduced Medicare payments to hospitals with excessive readmissions.

The proportion of BSN nurses had a significant effect on readmissions for pneumonia but not the other two conditions. A broader set of patient types should be considered to address the question of why having more nurses with BSNs affects readmissions for some patients and not others. Conditional effects of organizational factors and targeted programmatic interventions, e.g., the differential effect of intensive discharge planning programs in hospitals with different proportion of BSN nurses, may be an important avenue for research.

This investigation is the largest analysis of the relationship between the nurse work environment, staffing, and readmissions. The chief limitation is that the cross-sectional design limits us to identifying associations rather than causal inferences about the relationship between the organization of nursing and readmissions. Longitudinal designs should be employed to evaluate the associations we found. There are no perfect measures of nurse staffing and other measures of staffing might have yielded different results. When we estimated models substituting our staffing variable with a staffing variable from another data source (registered nurse hours per patient day from the AHA), our findings do not

substantively change. There are also other ways to define readmissions. We used the CMS approach which allowed subsequent index admissions from the same patient so long as that admission was outside of 30-days (thus no admission could also be counted as a readmission). When we limited our definition to only a single first index admission per unique patient, the sample was smaller but the results were virtually identical (see Table, Supplemental Digital Content 2). Finally, there are unmeasured factors that likely contribute to readmissions. These factors may also account for the relatively low c-statistics here and reported elsewhere.[25, 27, 30] Access to and utilization of primary care is an example, although the research is not clear whether increased primary care access would necessarily reduce readmissions.[1, 50]

Conclusion

Preventing readmissions is an ongoing process that includes helping patients fend off functional decline; preventing, identifying, and mobilizing a team response to complications; providing effective discharge teaching and planning; and advocating for discharge at the appropriate time and with the appropriate coordinated post-discharge resources in place. These fundamental nursing processes of care can make the difference between good and bad outcomes. In order to do this work effectively, nurses must practice in an environment that reinforces their professional role and autonomy, provides adequate resources, demonstrates consistent and high-quality managerial support and leadership, and includes nursing in institutional decision making. The challenge of readmissions will require a range of interventions. One potentially effective means of reducing overall readmissions may come through improving the organization and delivery of hospital nursing services.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding for this study was provided by the National Institute on Aging (R01AG041099 -01, McHugh), National Institute of Nursing Research (R01-NR-004513, P30-NR-005043; Aiken), Robert Wood Johnson Foundation Health and Society Research and Training special projects grant (McHugh), Penn Institute on Urban Research, Elder Friendly Urban Environment (Sullivan-Marx), Frank Morgan Jones Fund (McHugh), and Robert Wood Johnson Foundation Nurse Faculty Scholars program (McHugh).

References

1. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med. 2009; 360:1418–1428. [PubMed: 19339721]
2. Medicare Payment Advisory Commission [MEDPAC]. Report to the Congress: Promoting greater efficiency in Medicare. Washington, D.C: Medicare Payment Advisory Commission; 2007. Payment policy for inpatient readmissions; p. 103-120.
3. Creditor M. Hazards of hospitalization of the elderly. Ann Intern Med. 1993; 118:219–223. [PubMed: 8417639]
4. Naylor MD, Brooten D, Campbell R, et al. Comprehensive discharge planning and home follow-up of hospitalized elders: a randomized clinical trial. JAMA. 1999; 281:613–620. [PubMed: 10029122]
5. Coleman EA, Parry C, Chalmers S, et al. The care transitions intervention: results of a randomized controlled trial. Arch Intern Med. 2006; 166:1822. [PubMed: 17000937]
6. Jack BW, Chetty VK, Anthony D, et al. A reengineered hospital discharge program to decrease rehospitalization. Ann Intern Med. 2009; 150:178–187. [PubMed: 19189907]

7. Peikes D, Chen A, Schore J, et al. Effects of care coordination on hospitalization, quality of care, and health care expenditures among Medicare beneficiaries: 15 randomized trials. JAMA. 2009; 301:603–618. [PubMed: 19211468]
8. Sochalski J, Jaarsma T, Krumholz HM, et al. What works in chronic care management: the case of heart failure. Health Aff. 2009; 28:179–189.
9. Aiken LH, Sochalski J, Lake ET. Studying outcomes of organizational change in health services. Med Care. 1997; 35:NS6–18. [PubMed: 9366875]
10. Aiken LH, Clarke SP, Sloane DM, et al. Effects of hospital care environment on patient mortality and nurse outcomes. J Nurs Adm. 2008; 38:223–229. [PubMed: 18469615]
11. Aiken LH, Clarke SP, Cheung RB, et al. Educational levels of hospital nurses and surgical patient mortality. JAMA. 2003; 290:1617–1623. [PubMed: 14506121]
12. Aiken LH, Clarke SP, Sloane DM, et al. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. JAMA. 2002; 288:1987–1993. [PubMed: 12387650]
13. Needleman J, Buerhaus P, Mattke S, et al. Nurse-staffing levels and the quality of care in hospitals. N Engl J Med. 2002; 346:1715–1722. [PubMed: 12037152]
14. Kane, RL.; Shamliyan, T.; Mueller, C., et al. Nursing Staffing and Quality of Patient Care. Rockville, MD: Agency for Healthcare Research and Quality; 2007.
15. Estabrooks CA, Midodzi WK, Cummings GG, et al. The impact of hospital nursing characteristics on 30-day mortality. Nurs Res. 2005; 54:74–84. [PubMed: 15778649]
16. Aiken LH, Cimiotti JP, Sloane DM, et al. Effects of nurse staffing and nurse education on patient deaths in hospitals with different nurse work environments. Med Care. 2011; 49:1047–1053. [PubMed: 21945978]
17. Weiss ME, Yakusheva O, Bobay KL. Quality and cost analysis of nurse staffing, discharge preparation, and postdischarge utilization. Health Serv Res. 2011; 46:1473–1494. [PubMed: 21517836]
18. Diya L, Van den Heede K, Sermeus W, et al. The relationship between in-hospital mortality, readmission into the intensive care nursing unit and/or operating theatre and nurse staffing levels. J Adv Nurs. 2011
19. Friedman B, Encinosa W, Jiang HJ, et al. Do patient safety events increase readmissions? Med Care. 2009; 47:583–590. [PubMed: 19318996]
20. Kandilov, A.; McCall, N.; Dalton, K., et al. Readmissions Due to Hospital-Acquired Conditions (HACs): Final Report. Research Triangle Park, NC: RTI International; 2012.
21. Aiken LH, Sloane DM, Cimiotti JP, et al. Implications of the California nurse staffing mandate for other states. Health Serv Res. 2010; 45:904–921. [PubMed: 20403061]
22. Hansen M, Hurwitz W. The problem of non-response in sample surveys. J Am Stat Assoc. 1946; 41:517–529. [PubMed: 20279350]
23. Johnson TP, Wislar JS. Response rates and nonresponse errors in surveys. JAMA. 2012; 307:1805–1806. [PubMed: 22550194]
24. Smith, HL. Population Studies Center Working Paper Series. Philadelphia, PA: University of Pennsylvania, Population Studies Center; 2009. A Double Sample to Minimize Bias Due to Non-response in a Mail Survey.
25. Keenan PS, Normand SL, Lin Z, et al. An administrative claims measure suitable for profiling hospital performance on the basis of 30-day all-cause readmission rates among patients with heart failure. Circ Cardiovasc Qual Outcomes. 2008; 1:29–37. [PubMed: 20031785]
26. Lindenauer PK, Bernheim SM, Grady JN, et al. The performance of US hospitals as reflected in risk-standardized 30-day mortality and readmission rates for medicare beneficiaries with pneumonia. J Hosp Med. 2010; 5:E12–18. [PubMed: 20665626]
27. Krumholz HM, Merrill AR, Schone EM, et al. Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission. Circ Cardiovasc Qual Outcomes. 2009; 2:407–413. [PubMed: 20031870]
28. Harless DW, Mark BA. Nurse staffing and quality of care with direct measurement of inpatient staffing. Med Care. 2010; 48:659–663. [PubMed: 20548254]

29. Lake ET. Development of the practice environment scale of the Nursing Work Index. Res Nurs Health. 2002; 25:176–188. [PubMed: 12015780]
30. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race and site of care. JAMA. 2011; 305:675. [PubMed: 21325183]
31. Hartz AJ, Krakauer H, Kuhn EM, et al. Hospital characteristics and mortality rates. N Engl J Med. 1989; 321:1720–1725. [PubMed: 2594031]
32. Brennan TA, Hebert LE, Laird NM, et al. Hospital characteristics associated with adverse events and substandard care. JAMA. 1991; 265:3265–3269. [PubMed: 2046108]
33. Landon BE, Normand SL, Lessler A, et al. Quality of care for the treatment of acute medical conditions in US hospitals. Arch Intern Med. 2006; 166:2511–2517. [PubMed: 17159018]
34. Joynt KE, Orav EJ, Jha AK. The association between hospital volume and processes, outcomes, and costs of care for congestive heart failure. Ann Intern Med. 2011; 154:94–102. [PubMed: 21242366]
35. Elixhauser A, Steiner C, Harris DR, et al. Comorbidity measures for use with administrative data. Med Care. 1998; 36:8–27. [PubMed: 9431328]
36. Glance LG, Dick AW, Osler TM, et al. Does date stamping ICD-9-CM codes increase the value of clinical information in administrative data? Health Serv Res. 2006; 41:231–251. [PubMed: 16430609]
37. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care. 2005; 43:1130–1139. [PubMed: 16224307]
38. Birkmeyer NJO, Gu N, Baser O, Morris AM, Birkmeyer JD. Socioeconomic status and surgical mortality in the elderly. Med Care. 2008; 46:893–899. [PubMed: 18725842]
39. Bonito, AJ.; Bann, C.; Eicheldinger, C., et al. Final Report, Sub-Task 2. Rockville, MD: Agency for Healthcare Research and Quality; 2008. Creation of New Race-Ethnicity Codes and Socioeconomic Status (SES) Indicators for Medicare Beneficiaries. (Prepared by RTI International for the Centers for Medicare and Medicaid Services through an interagency agreement with the Agency for Healthcare Research and Policy, under Contract No. 500–00–0024, Task No. 21)
40. White H. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica. 1980; 48:817–838.
41. Aiken L. Extending the magnet concept to developing and transition countries. Reflect Nurs Leadersh. 2005; 31:16–18. [PubMed: 15776720]
42. Aiken LH, Havens DS, Sloane DM. The Magnet Nursing Services Recognition Program: A comparison of two groups of Magnet hospitals. Am J Nurs. 2000; 100:26–35. [PubMed: 10738398]
43. Aiken LH, Smith HL, Lake ET. Lower Medicare mortality among a set of hospitals known for good nursing care. Med Care. 1994; 32:771–787. [PubMed: 8057694]
44. Lake ET, Staiger D, Horbar J, et al. Association between hospital recognition for nursing excellence and outcomes of very low-birth-weight infants. JAMA. 2012; 307:1709–1716. [PubMed: 22535856]
45. Li Y-F, Wong ES, Sales AE, et al. Nurse staffing and patient care costs in acute inpatient nursing units. Med Care. 2011; 49:708–715. [PubMed: 21758025]
46. Dall TM, Chen YJ, Seifert RF, et al. The economic value of professional nursing. Med Care. 2009; 47:97–104. [PubMed: 19106737]
47. Rothberg MB, Abraham I, Lindenauer PK, et al. Improving nurse-to-patient staffing ratios as a cost-effective safety intervention. Med Care. 2005; 43:785–791. [PubMed: 16034292]
48. Jones CB. The costs of nurse turnover: part 1: an economic perspective. J Nurs Adm. 2004; 34:562–570. [PubMed: 15632752]
49. McCue M, Mark BA, Harless DW. Nurse staffing, quality, and financial performance. J Health Care Finance. 2003; 29:54–76. [PubMed: 12908654]
50. Weinberger M, Oddone EZ, Henderson WG. Does increased access to primary care reduce hospital readmissions? Veterans Affairs Cooperative Study Group on Primary Care and Hospital Readmission. N Engl J Med. 1996; 334:1441–1447. [PubMed: 8618584]

TABLE 1

Patient Characteristics by Condition

Patient Characteristics	*Heart Failure (N =171,883)*		*Myocardial Infarction (N = 62,394)*		*Pneumonia (N = 141,404)*	
	No.	**(%)**	**No.**	**(%)**	**No.**	**(%)**
Readmissions within 30 days	39,954	23.2	12,131	19.1	25,169	17.8
Length of stay (days), median (IQR)	4	3–7	5	3–8	5	3–7
Age (y), median (IQR)	80	74–84	78	72–84	79	74–84
Female	92,884	54	31,350	49	75,440	53
Top reasons for readmission						
Most frequent	Heart failure	12,961 32.4	Heart failure	1,850 15.3	Pneumonia	5,318 21.1
2nd most frequent	Renal failure	1,718 4.3	Coronary atherosclerosis	1,696 14	COPD*	1,966 7.8
3rd most frequent	Cardiac dysrhythmias	1,398 3.5	Acute myocardial infarction	1,000 8.2	Heart failure	1,764 7.0
4th most frequent	Pneumonia	1,330 3.3	Cardiac dysrhythmias	497 4.1	Respiratory failure	1,009 4.0
5th most frequent	COPD	1,223 3.1	Nonspecific chest pain	469 3.9	Septicemia	720 2.9
6th most frequent	Coronary atherosclerosis/heart disease	5,139 3.0	Complications of device or procedure	421 3.5	Urinary tract infection	622 2.5
7th most frequent	Respiratory failure	5,070 2.9	Pneumonia	353 2.9	Cardiac dysrhythmias	564 2.2
8th most frequent	Hypertension with complications	4,366 2.5	Renal failure	308 2.5	Renal failure	521 2.1
9th most frequent	Complications of device or procedure	4,314 2.5	Respiratory failure	285 2.4	Intestinal infection	518 2.1
10th most frequent	Urinary tract infection	3,111 1.8	Gastrointestinal hemorrhage	282 2.3	Fluid/electrolyte disorders	445 1.8

Note: Top reasons for readmission are based on the Agency for Healthcare Research and Quality's Clinical Classification's software.

*COPD, chronic obstructive pulmonary disease

TABLE 2

Numbers and Percentages of Study Hospitals With Different Characteristics, and Numbers and Percentages of Patients and Nurses in Them

	Hospitals *(n=412)*	Patients *(n=375,681)*			Nurses *(n=20,585)*
		Heart Failure *(n=171,883)*	Acute Myocardial Infarction *(n=62,394)*	Pneumonia *(n=141,404)*	
Hospital Characteristic	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**
State					
CA	210 (51)	71,075 (41)	28,482 (45)	69,339 (49)	8,122 (40)
NJ	68 (17)	31,933 (19)	8,992 (14)	24,463 (17)	5,581 (27)
PA	134 (33)	68,875 (40)	25,920 (41)	47,602 (34)	6,882 (33)
Urban	362 (88)	157,219 (91)	58,464 (92)	128,361 (91)	19,162 (93)
Ownership					
For profit	37 (9)	10,027 (6)	3,512 (6)	9,894 (7)	1,029 (5)
Not for profit	375 (91)	161,856 (94)	59,882 (94)	131,510 (93)	19,556 (95)
High technology	183 (44)	97,771 (57)	46,281 (73)	72,633 (51)	12,539 (61)
Hospital size					
Small	41 (10)	7,227 (4)	1,407 (2)	7,886 (6)	680 (3)
Medium	191 (46)	65,022 (38)	19,113 (30)	56,809 (40)	6,363 (31)
Large	180 (44)	99,634 (58)	42,874 (68)	76,709 (54)	13,542 (66)
Teaching Status					
Non-teaching	209 (51)	78,033 (45)	26,111 (41)	70,904 (50)	7,929 (39)
Minor teaching	161 (39)	72,402 (42)	27,162 (43)	57,397 (41)	8,899 (43)
Major teaching	42 (10)	21,448 (12)	10,121 (16)	13,103 (9)	3,757 (18)
Work Environment					
Poor	118 (29)	52,210 (30)	17,050 (27)	39,690 (28)	5,107 (25)
Mixed	174 (42)	72,291 (42)	27,826 (44)	61,358 (43)	8,947 (44)
Good	120 (29)	47,382 (28)	18,518 (29)	40,356 (29)	6,531 (32)
Nurse staffing (patients/nurse)					
Less than 4	85 (21)	28,542 (17)	11,872 (19)	26,505 (19)	4,123 (20)
4-less than 5	148 (36)	64,823 (38)	27,009 (43)	53,449 (38)	7,969 (39)

	Hospitals *(n=412)*	Patients *(n=375,681)*			Nurses *(n=20,585)*
		Heart Failure *(n=171,883)*	Acute Myocardial Infarction *(n=62,394)*	Pneumonia *(n=141,404)*	
Hospital Characteristic	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**
5-less than 6	106 (26)	48,774 (28)	16,749 (26)	37,629 (27)	5,540 (27)
6-less than 7	50 (12)	22,764 (13)	6,082 (10)	18,192 (13)	2,341 (11)
7 or more	23 (6)	6,980 (4)	1,682 (3)	5,629 (4)	612 (3)
Nurse education (BSN)					
Less than 20%	25 (6)	7,423 (4)	1,792 (3)	7,379 (5)	628 (3)
20%–29%	89 (22)	35,259 (21)	11,342 (18)	29,236 (21)	3,519 (17)
30%–39%	103 (25)	45,176 (26)	17,951 (28)	36,481 (26)	5,347 (26)
40%–49%	112 (27)	47,594 (28)	18,248 (29)	39,560 (28)	5,954 (29)
50% or more	83 (20)	36,431 (21)	14,061 (22)	28,748 (20)	5,137 (25)

Note: BSN, bachelor of science in nursing

TABLE 3

Effects of nurse work environment, nurse staffing, and nurse education on 30-day readmissions

	Heart Failure			*Myocardial Infarction*			*Pneumonia*		
	OR	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***
Work environment (Poor category as reference)									
Good	0.93	(0.89–0.97)	0.001	0.94	(0.88–0.98)	0.01	0.90	(0.85–0.96)	<0.001
Mixed	0.96	(0.94–0.98)	0.001	0.97	(0.94–0.99)	0.01	0.95	(0.92–0.98)	<0.001
Proportion of BSN nurses *	1.00	(0.98–1.01)	0.82	1.00	(0.98–1.03)	0.98	0.97	(0.96–0.99)	0.006
Patients per nurse	1.07	(1.05–1.09)	<0.001	1.09	(1.05–1.13)	<0.001	1.06	(1.03–1.09)	<0.001

Note:

* BSN, bachelor of science in nursing.

Adjusted models included controls for hospital characteristics (core-based statistical area size of geographic location, hospital size, technological status, ownership, teaching status, total operating margin and percentage of Medicaid discharges) and patient characteristics. Estimates for nurse work environment reflect change in estimate for effect of better versus mixed (or of mixed versus poor) environments. The two estimates for the nurse work environment effect for each of the three patient groups are derived from a single odds ratio that involves a linear effect; e.g., for heart failure, the odds ratio of 0.93 for the contrast of Good:Poor equals the squared odds ratio for Good:Mixed or Mixed:Poor, or 0.96 × 0.96. Estimates for proportion of BSN nurses reflect the change in estimates for the effect of an increase of 10% BSN nurses. Estimates for nurse staffing reflect the change in estimates for the effect of an increase of one patient per nurse.

TABLE 4

Estimated Average Probabilities of Readmission by Nurse Staffing Level and Quality of the Work Environment of the Hospital

	Staffing (Patients per Nurse)					
Environment	**3**	**4**	**5**	**6**	**7**	**Overall**
Heart Failure						
Poor	0.216	0.227	0.239	0.251	0.263	0.239
Mixed	0.209	0.221	0.232	0.244	0.256	0.232
Good	0.204	0.214	0.225	0.237	0.249	0.226
Overall	0.209	0.221	0.232	0.244	0.256	0.232
Acute Myocardial Infarction						
Poor	0.172	0.184	0.197	0.211	0.225	0.195
Mixed	0.168	0.180	0.193	0.207	0.221	0.191
Good	0.165	0.177	0.189	0.203	0.217	0.187
Overall	0.168	0.180	0.193	0.207	0.221	0.191
Pneumonia						
Poor	0.169	0.177	0.186	0.195	0.204	0.185
Mixed	0.162	0.170	0.178	0.187	0.196	0.178
Good	0.155	0.163	0.171	0.179	0.188	0.171
Overall	0.162	0.170	0.178	0.187	0.196	0.178