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The Unique Contribution of the Nursing Intervention Pain Management on Length of Stay in Older Patients Undergoing Hip Procedures

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Introduction

According to the 2004 National Hospital Discharge Survey (DeFrances & Podgornik, 2006), hip replacement procedures for adults 65 years of age and older rose 38% from 1995 through 2004, from a rate of 27.1 per 10,000 population in 1995 to 37.3 in 2004. There has been remarkable technological progress in recent years in hip prosthetic devices. The result has been earlier patient mobility leading to a lower incidence of complications and better outcomes, which has in turn spurred an increase in the numbers of these procedures performed (Bernstein et al., 2003).

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In 2004, over 329,000 patients were admitted to U.S. hospitals with hip fracture, often being treated with hip replacement procedures (DeFrances & Podgornik, 2006). Due to the anticipated increase in the elderly population, the number of hip fractures is expected to surpass 500,000 by the year 2040 (Cooper, Campion, & Melton, 1992). Both hip replacement surgery (Todaro & Schott-Baer, 2001) and hip fracture (Phy et al., 2005) are considered high volume, high cost medical problems.

In company with this trend of increasing numbers of hip procedures is the continuing concern over the economical utilization of resources in acute care settings. Length of stay (LOS) has become a significant quality of care indicator, and is a common outcome variable used to compare hospital performance (Agency for Healthcare Research & Quality [AHRQ], 2006). The pressure to lower costs by discharging patients as soon as possible after surgery and the anticipated increase in the number of hip procedure patients, make it critical to determine what factors are related to acute care LOS in the population of patients undergoing hip procedures.

Postoperative pain following hip surgery results in patient distress, as well as slowing of recovery and discharge from the hospital (Chelly, Ben-David, Williams, & Kentor, 2003). The management of pain has been recognized as a major factor in the improvement of functional recovery, and therefore its contribution to shorter LOS after outpatient orthopedic procedures (Pavlin et al., 1998; Pavlin, Chen, Penaloza, Polissar, & Buckley, 2002). Numerous studies demonstrate a link between medical management of pain, including use of various blocks, patient-controlled analgesia, type of analgesic used, and LOS (Chelly, Gebhard, Coupe, Greger, & Khan, 2001; Ilfeld, Morey, & Enneking, 2002; Ilfeld, Morey, Wang, & Enneking, 2002). Neitzel, Miller, Shepherd, and Belgrade (1999) had similar results with hip and knee replacement inpatients, demonstrating significantly decreased LOS after implementation of evidence-based postoperative pain management practices, including education of physician and nurse providers and system changes at the point of care. However, little is known concerning the *unique contribution* of nursing interventions to LOS following hip procedures.

This lack of research in the area of LOS and nursing care can be attributed to the fact that nursing interventions are not routinely documented in a format that is retrievable in large electronic data sets (Titler et al, 2006). Through the use of the Nursing Interventions Classification (NIC), a standardized classification of nursing interventions, it is now possible to electronically document the contribution of nursing care to patient outcomes. The NIC, developed at The University of Iowa College of Nursing, describes over 514 interventions performed by nurses in various settings (Dochterman & Bulechek, 2004). Standardized nursing language is being incorporated into electronic documentation systems at an increasing rate, yet the literature is void of studies using electronic clinical data sets and standardized nursing language to investigate the contribution of nursing interventions to LOS in hip procedure patients.

The focal purpose of this study was to investigate the contribution of the nursing intervention Pain Management on LOS in older patients admitted to the hospital for a hip procedure. Pain Management is defined in the NIC as “alleviation of pain or a reduction in pain to a level of comfort that is acceptable to the patient” (Dochterman & Bulechek, 2004, p. 529). The intervention consists of various nursing activities that are selected by the nurse based on their appropriateness for the individual patient or family. Examples of the 43 implementation activities comprising Pain Management are listed below:

- perform a comprehensive assessment of pain;
- ensure that patient receives attentive analgesic care;
- consider cultural influences on pain response;

- explore with patient factors that relieve/worsen pain; and
- control environmental factors that may influence the patient's response to discomfort (e.g., room temperature, lighting, noise) (Dochterman & Bulechek, 2004, p. 529).

Research Questions

The primary research question posited in this study was:

- 1 What is the unique contribution of the nursing intervention Pain Management to LOS for older patients hospitalized for a hip procedure?

A secondary research question was:

- 2 What other factors, such as severity of illness, medical procedures, pharmacy interventions, nursing interventions, and context of care variables, are associated with LOS in this population?

Methods

Data extracted from electronic data repositories for the parent study, "Nursing interventions and outcomes in 3 older populations," funded by the National Institute of Nursing Research (Titler, 2000), were used for this study. The data were obtained from a large academic medical center in the Midwest that uses the NIC to document, in an electronic patient record, the nursing care delivered. Four years of data were extracted for the larger study from nine administrative and clinical data repositories and built into a relational database. Study approval was acquired from the facility's Institutional Review Board (Dochterman, et al., 2005).

Sample

The sample for this study consisted of 568 episodes of hospitalization of 523 adult patients, age 60 and older, who were admitted for acute care between July 1998 and June 2002. Inclusion criteria were: a coded Diagnosis Related Group (DRG) category of either 209 (major joint or limb reattachment procedure of the lower extremity), 210 (hip and femur procedure excluding a major joint > 17 years with complications), 211 (hip and femur procedure excluding a major joint, > 17 years without complications), 236 (fracture of the hip and pelvis), or 471 (bilateral or multiple major joint procedures) or one of seven specific International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) (American Medical Association, 2005) primary or secondary diagnosis codes (e.g. 820 fracture of neck of femur) or one of six specific procedure codes (e.g. 8151 total hip replacement). The five DRG categories (209, 210, 211, 236, and 471) are those categorized by the U.S. Office of Technology Assessment (1994) as those in which hospital care for hip fractures typically occur. Hospitalizations of patients with in-hospital fractures, chronic osteomyelitis of the pelvis, pyogenic arthritis, and malignant neoplasm of the pelvis were not included in the dataset of the larger study.

Propensity Score Analysis

Propensity score analysis was performed to determine the unique effect of the NIC intervention Pain Management on LOS after controlling for the associations between other factors and LOS in patients who had undergone hip procedures. The use of propensity scores is a method of analysis that addresses the potential bias in observational studies in which groups are not randomly treated (Rosenbaum & Rubin, 1983; Rubin, 1997). This is in contrast to the traditional randomized clinical trial (RCT) which consists of strict inclusion and exclusion criteria and randomization designed to control for all factors, other than the treatment of interest, that may affect outcomes (Burns & Grove, 2001; Iezzoni, 2003). In non-randomized studies, such as this observational, retrospective study, patients belonging to different treatment groups may be dissimilar in regard to factors such as sex, age, treatments being received, and

other attributes. All of these are likely to be correlated to the outcome of interest and are therefore possible confounders. Propensity score analysis tries to recreate circumstances comparable to randomization (D'Agostino, 1998).

The propensity score is defined as, “the conditional probability of being treated given the individual’s covariates” (D’Agostino, 1998, p. 2265). In this study, Pain Management is the treatment of interest, but patients were not randomly assigned to receive or not receive this treatment. Hence, factors thought to be related to whether a patient received the NIC intervention Pain Management were selected by the researchers (see Table 1), using clinical judgment, to generate a propensity score. This score is the probability (between 0% and 100%) of receiving the Pain Management intervention given these factors. The purpose of the propensity score is to replace a collection of potential confounders, such as patient characteristics and medical conditions thought to be related to receiving the intervention Pain Management, with one summary score (the propensity score). Then, the unique contribution of Pain Management can be investigated after accounting for the propensity score.

Step one of propensity score analysis was to dichotomize the treatment variable and calculate a propensity score (Qin, Titler, Shever, & Kim, 2007). In this study, the propensity score was calculated using a regression model to predict the dichotomous treatment variable of interest: 0 = hospitalization did not receive the Pain Management intervention, and 1 = hospitalization did receive the Pain Management intervention, based on the patient variables outlined in Table 1. Generalized Estimating Equation (GEE) method was used to calculate propensity scores to account for lack of independence due to some patients having more than one episode of hospitalization during the study period (Liang & Zeger, 1986).

In the second step of the propensity score analysis method, the propensity score is entered into a regression (Qin et al., 2007), again using GEE to account for lack of independence, as a single control variable for the measured confounders (listed in Table 1). Using the propensity score in this manner as a continuous control variable is referred to as covariance-adjustment (Qin et al., 2007). The dichotomous treatment variable of Pain Management and other independent variables thought to be related to LOS also entered the regression with the propensity score.

Variables

The dependent variable, LOS, was defined as the sum of days that a patient was in the acute care hospital, based on total hours of hospitalization, and calculated as number of full days and fraction of a day (e.g. 2.75 days). The primary treatment variable of interest, Pain Management, has been described previously. The independent variables associated with the secondary research question are described below.

Severity of illness—Severity of illness was defined as the overall level of illness, as designated by the All Patient Refined Diagnosis-Related Groups (APR DRG) software system. The patient’s primary medical diagnosis, secondary diagnoses, age, and non-operating room procedure data are utilized by the software to calculate a severity of illness score upon discharge (1=minor, 2=moderate, 3=major, 4=severe) (3M Health Information Systems, 1993). The “minor” category was used as the reference category in the statistical analysis.

Context of care—A total of five context of care variables were studied: number of units resided on during hospitalization, time in the ICU, registered nurse (RN) skill mix, average RN-to-patient ratio, and RN-to-patient “dip proportion.” These are described in detail in the following paragraphs.

The number of units resided on during hospitalization was measured as a continuous variable, and included the emergency department, operating room, and recovery room. Time in the ICU

was defined as the amount of time that the patient spent in the ICU during an episode of hospitalization and was measured in days, such that 0.5 means the patient spent 12 hours in the ICU, while 1.0 indicates 24 hours spent in the ICU.

Registered nurse skill mix was defined as the proportion of RNs to all nursing direct caregivers for a specified time period. Operationally, this number was obtained by dividing the RN hours for a specified one-hour period by the total caregiver hours (RN + LPN + others) for that same one-hour period. The hourly values for a single episode of hospitalization were then averaged, resulting in the registered nurse skill mix metric for the hospitalization. Post-hoc analysis was done in terms of 0.1 units, or 10% incremental changes in proportion of RNs to all other caregivers, to make the results more meaningful.

The average RN-to-patient ratio was calculated by dividing the total number of RNs for all hours of care by the total number of patient care hours for the whole hospitalization (Budreau, Balakrishnan, Titler, & Hafner, 1999). Once calculated, the results were then divided into quartiles of staffing levels, with the lowest quartile serving as the reference category: 1–25% (worse staffing), 26–50%, 51–75%, and 76–100% (best staffing). The quartiles permitted improved analysis of nonlinearity, and made it possible to use average RN-to-patient ratio concurrently with the RN-to-patient dip proportion variable which follows.

The RN-to-patient dip proportion variable was created to signify the variability in the amount of RN care available, specifically the extent to which the amount of available RN care drops (dips) below the average amount of RN care on a nursing unit for the hospitalization. This figure was obtained by subtracting the average of the three lowest hourly values of the hourly RN-to-patient ratio (three of the lowest hourly values were averaged, rather than using only the lowest value to increase the validity for the actual degree of low staffing) from the average of the hourly RN-to-patient ratio over the entire hospitalization, and dividing this figure by the average RN-to-patient ratio for the hospitalization. This resulted in a range of 0 to 1 for this variable, with post-hoc analysis done in increments of 0.2 (20%), similar to that described previously for RN skill mix analysis.

Procedures/interventions—The number of medical procedures was defined as the sum of ICD-9-CM procedure codes (Public Health Service and Health Care Financing Administration, 1994) for any one hospitalization, as recorded in the medical record abstract. The number of unique medications was a variable created by the count, per hospitalization, of unique medications administered at least once during a hospital visit.

In the study setting, nursing interventions are documented electronically using the NIC (Dochterman & Bulechek, 2004). Nurses choose the interventions they want from a pre-selected list, or add others, as appropriate. For this sample, a total of 94 unique interventions were administered. The nursing interventions were examined in two ways, in addition to the analysis of Pain Management described previously. First of all, the sum of unique types of interventions provided during the hospitalization was analyzed (Number of Unique Nursing Interventions). The second method was to analyze each type of delivered NIC intervention individually (e.g. Blood Product Administration, Fall Prevention, etc.).

The small sample size was considered when analyzing types of NIC interventions. For variable reduction, to accommodate the small sample size, and to make certain that each intervention type had enough variability, interventions used by more than 90% of the sample were not included. Also, to ensure that each intervention had enough observations to allow for analysis, nursing treatments received by less than 2% of the sample were not used.

Each type of NIC treatment was analyzed by one of two methods which incorporated the percent of hospitalizations in which the intervention was used and its use rate (average number of times the intervention was used per day): (a) if the intervention was used in 5% or more of the hospitalizations, the use rate was separated into thirds (1–33% [lowest use], 34–67%, 68–100% [most use]) and 0=no use (reference category), and (b) if the intervention was used in greater than 2% and less than 5% of the sample, it was coded dichotomously as received or did not receive the intervention.

Results

The average patient age for the 568 hospitalizations was 74.5 years (SD=8.9). Sixty-two percent were female, 42% suffered non-traumatic joint disorders, 33% had fractures, and 18% complications of device. Only 7% of the sample was in the severe category of severity of illness, while 48% were moderate, 29% major, and 16% categorized as mildly ill. The mean LOS was 8.02 days (SD=6.19) and median LOS was 6.19 days. Thirty-eight percent of the sample received the Pain Management intervention at least once during their hospitalization, delivered an average of 3.9 times per day for those hospitalizations in which it was delivered.

Primary Research Question

Table 2 presents the results of the propensity score-adjusted analysis using GEE to address the primary research question. An additive model was used which indicates that the estimate also serves as the change (positive or negative) in the dependent variable given a one-unit change in the independent variable. Pain Management was shown to be significantly related to LOS ($p<.05$). The estimate of 0.78 indicates that, on average, LOS of the group of patients receiving the Pain Management intervention at least once during their hospitalization was increased by 0.78 day compared to those who did not receive it. Since the propensity score method took into account the non-randomized assigning of the Pain Management intervention, the estimate reflects the unique contribution of the intervention's effect on LOS.

Secondary Research Question

Several context of care variables, addressed in research question number two, were shown to be significantly associated with LOS, including the number of units resided on during hospitalization, time in the ICU, the average RN-to-patient ratio, and the RN-to-patient dip proportion. The registered skill mix variable was not significant in the analysis.

The positive association between LOS and number of units resided on during hospitalization indicate that as the total number of units resided on increased by one, the LOS also increased, on average, by approximately a half day (estimate=0.46). The same was true of time in ICU: as the total number of days in the ICU increased by one, LOS increased by 0.44 day.

The uppermost quartile of average RN-to-patient ratio, with a mean of 6.3 RN hours per patient day (HPPD), was significantly and inversely associated with LOS, on average 1.64 fewer days when compared to the lowest quartile of average RN-to-patient ratio. The remaining quartiles were not significant.

Post hoc analyses of the RN-to-patient dip proportion, done in increments of 0.2, were also significant. For each incremental 20% decrease in RN staffing below the average, LOS increased, on average, by 0.92 day.

The number of medical procedures performed and the number of unique medications delivered per hospitalization were significantly associated with LOS. Both of these treatments had positive associations with LOS, demonstrating that as the total number of procedures or the

total number of medications increased by one, LOS increased by 0.39 and 0.18 days respectively. The number of unique nursing interventions was not significant.

There were a total of ten nursing interventions significantly associated with LOS (in addition to Pain Management): Autotransfusion, Fall Prevention, Infection Protection, Oxygen Therapy, and Respiratory Monitoring were inversely associated. Only one category of use was significant for each of these nursing interventions, for example, Infection Protection was only significant in the low use category. This indicates that when Infection Protection was delivered slightly more than twice a day (2.20 use rate) the LOS was decreased, on average, by 1.48 days compared to the LOS for hospitalizations that did not receive this intervention. The remaining five nursing interventions were positively associated with LOS, indicating an increase in LOS, and included: Blood Product Administration (low use), Nutrition Management, Pressure Ulcer Prevention, Skin Surveillance (high and low use), and Teaching (low use).

Several NIC interventions thought to be related to LOS were not significant (e.g. Hypoglycemia Management, Medication Management, Neurologic Monitoring, etc.). Also, the severity of illness variable was not significantly related to LOS.

Discussion

The finding that the Pain Management nursing intervention contributed to an increased LOS was not in the direction expected. The literature suggests that effective pain management in hip procedure patients is associated with a decreased LOS (Chelly et al., 2003; Neitzel et al., 1999; Pavlin et al., 1998; Pavlin et al., 2002). One explanation for the unexpected finding is that pain may be an indicator of procedural complications or delayed healing. Nurses may not add the Pain Management intervention to the patient care plan in routine, uncomplicated post-operative cases. Perhaps nurses specifically select the Pain Management NIC to add to a patient's care plan primarily in situations of complicated pain management. In these circumstances, use of the NIC intervention Pain Management may be a proxy measure of nursing intensity, thus signifying more complex patients with greater needs requiring a longer LOS.

A second possible explanation for the unexpected direction of the results is that the Pain Management intervention needed to be used as a dichotomous variable for the propensity score analysis; the patient either received the intervention at least once during the hospitalization or did not receive it at all. This sample had a fairly high use rate of the Pain Management intervention, being delivered an average of 3.9 times per day. Dochterman et al. (2005) consider the use rate of nursing interventions as the "dose" of the intervention. However, by dichotomizing the intervention as only received or not received, the "dose" of the intervention remains unknown. Another potential issue in this older population is that research has shown that older patients may not be administered the same amount of analgesics as younger patients with similar pathology, or they may be given smaller doses of analgesics than have been prescribed (Closs, Fairtlough, Tierney, & Currie, 1993; Honari, et al., 1997). This finding is supported by the results of a University of Iowa study (Ardery, Herr, Hannon, & Titler, 2003) in which the records of a group of eight hip fracture patients who were not administered an opioid analgesic during the first three days following their admission to the hospital were examined, and concluded that measures to support the implementation of evidence-based pain management practices are needed to ensure quality of care for this older population. However, neither a dichotomous Pain Management intervention measure, nor a measure of the "dose" of this intervention, would reveal issues related to inadequate amounts of analgesics in this older population, subsequently resulting in minimization of the treatment effect of Pain Management on LOS. In summary, using propensity score analysis methods to account for confounding variables, the unique contribution of the Pain Management intervention on LOS

for this sample of hip procedure patients was to increase it, on average, by 0.78 day compared to patients who did not receive the intervention.

The findings related to context of care variables were expected. As the number of units resided on during hospitalization and the time in the ICU increased, LOS increased as well. Again, this may be indicative of changing patient needs and increasing complexity of care. Also, handoffs and care transitions may result in missed or delayed treatments, medication errors, and lags in communication, thereby resulting in prolonged LOS (Kanak et al., 2008; Streitenberger, Breen-Reid, & Harris, 2006). These results validate the findings of others in terms of the high-risk nature of patient transfer (Miller, 1998; Parker & Coiera, 2000; Patterson, Roth, Woods, Chow, & Gomes, 2004). The increase in LOS for hospitalizations with higher number of units resided on calls attention to the need for the development of mechanisms to improve handoffs in care. Collaboration and communication strategies to enhance the quality of the patient transfer process and reduce gaps that may result in increased LOS are needed. Technological and other innovative approaches to improve the efficiency, safety, and effectiveness of the transfer process are likely a necessary step in managing the LOS of this group of patients. Lastly, the finding that patients with ICU stays had a longer overall LOS is predictable because ICU stays are usually an add-on to a typical LOS. Rarely is a patient able to be discharged directly to home from an ICU.

Two of the nurse staffing variables contributed to LOS: the average RN-to-patient ratio and the RN-to-patient dip proportion. Each decrease in RN staffing, calculated in increments of 20%, added, on average nearly a full day (0.92) to LOS. These findings might suggest that as more nurses are on hand, they are available to implement interventions that contribute to moving a patient toward discharge, including Pain Management. Registered nurse skill mix was not a significant contributor to LOS, an unanticipated finding, since a review of the literature suggests that richer skill mix (especially of RNs) is associated with improved patient outcomes (Lankshear, Sheldon, & Maynard, 2005). However, these findings support those of Unruh (2003), who found that the number of licensed nurses is a stronger predictor of adverse events than the proportion of licensed nurses to total nursing staff. The impact on LOS related to nurse staffing highlights the importance of adequate nursing care to quality (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002; Person, et al., 2004).

The number of medical procedures and number of unique medications were also factors in an increased LOS. It is likely that both are indicative of increased patient complexity and needs, resulting in longer LOS.

The NIC interventions varied in their impact on LOS and at what level of use rate they were significant. For example, Infection Protection contributed to a decreased LOS compared to patients who did not receive the intervention; however, this was significant only at the lowest average use rate of 2.2 times per day. This indicates that providing Infection Protection approximately two times per day decreases LOS compared to when it is not delivered. Perhaps patients needing a lower use rate are not as sick as those requiring a higher use rate. Again, this intervention may be a proxy measure of nursing intensity, as suggested previously. Conversely, the highest use rate (2.9 times per day) of Respiratory Monitoring resulted in a decreased LOS in comparison to no use, while lower use rates did not show a significant effect.

Limitations

Although the sample size was quite large, all the findings are from one health care institution which limits generalization. Another issue related to the sample is that it is secondary data, limiting the analyses to variables existing in the data repositories of the institution. This is

related to a third limitation of the study, which is that LOS could have been related to other factors we did not consider.

Conclusion

The findings related to Pain Management reveal that further study is needed to determine the relationship of Pain Management to LOS. While it can be concluded that Pain Management had a positive relationship to LOS in this study, future research is needed in which the independent variable Pain Management is measured as either a multi-categorical or a continuous “dose” variable to provide more information regarding how Pain Management delivered in differing dosages affects LOS. Also, issues related to the possible minimization of the effect of Pain Management on LOS due to inadequate treatment underscore the need for quality improvement related to pain and the implementation of nursing protocols based on evidence and best practice.

This research also suggests the need for further investigation of the effect of residing on multiple units and nurse staffing on LOS. Innovative approaches are needed for improving the quality of patient transfer processes. Furthermore, if the link between RN staffing and LOS suggested by these results is supported, then the goal of cost savings that underlies staffing reductions may be counteracted by the resultant increases in LOS. Cutbacks in nurse staffing should not be contemplated without consideration of the potential effect on LOS.

The results for NIC interventions and their impact on LOS show that it is important for nurse researchers to continue studying the impact of nursing interventions on patient outcomes. Careful examinations of these NIC interventions and their contribution to LOS are important in understanding how nursing actions influence quality and cost for this population. Research in the area of LOS and nursing care should continue so that the contribution of nursing care to quality indicators can be established. For this to occur, standardized nursing language must be incorporated into electronic documentation systems at an increasing rate. Also, because randomized clinical trials are not always practical, propensity score analysis is a useful tool in demonstrating the unique contributions of nursing interventions to a patient outcome.

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References

- 3M Health Information Systems. All Patient Refined Diagnosis Related Groups (APR DRG). Definitions manual (version 15.0). Author: Wallingford, CT; 1993.
- Agency for Healthcare Research and Quality (AHRQ). National Quality Measures Clearinghouse. . Intensive care: mean length of stay (LOS) for intensive care unit (ICU) by type of unit. Retrieved from <http://www.qualitymeasures.ahrq.gov/> on 11 August 2006.
- Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. JAMA 2002;288:1987–1993. [PubMed: 12387650]
- American Medical Association. American Medical Association Hospital International Classification of Diseases, 9th Revision, Clinical Modification. Chicago: 2005.
- Arderly G, Herr K, Hannon BJ, Titler MG. Lack of opioid administration in older hip fracture patients. Geriatric Nursing 2003;24:353–360. [PubMed: 14694324]
- Bernstein, BB.; Hing, E.; Moss, AJ.; Allen, KF.; Siller, AB.; Tiggle, RB. Health care in America: Trends in utilization. National Center for Health Statistics; Hyattsville, MD: 2003.
- Budreau G, Balakrishnan R, Titler M, Hafner MJ. Caregiver-patient ratio: Capturing census and staffing variability. Nursing Economics 1999;17:317–324. [PubMed: 10711184]

- Burns, N.; Grove, SK. The practice of nursing research: conduct, critique, and utilization. 4. W.B. Saunders; Philadelphia: 2001.
- Chelly JE, Ben-David B, Williams BA, Kentor ML. Anesthesia and postoperative analgesia: Outcomes following orthopedic surgery. *Orthopedics* 2003;26:s865–s871. [PubMed: 12934742]
- Chelly JE, Gebhard R, Coupe K, Greger J, Khan A. Local anesthetic PCA via a femoral catheter for the postoperative pain control of an ACL performed as an outpatient procedure. *American Journal of Anesthesiology* 2001;28:192–194.
- Clinical Classification Software (CCS). 2002. Retrieved from <http://www.ahrq.gov/data/hcup/ccs.htm> on 30 June 2004.
- Closs S, Fairtlough HL, Tierney AJ, Currie CT. Pain in elderly orthopaedic patients. *Journal of Clinical Nursing* 1993;2:41–45.
- Cooper C, Campion G, Melton LJ. Hip fractures in the elderly: a world-wide projection. *Osteoporosis International* 1992;2:285–289. [PubMed: 1421796]
- D'Agostino RB Jr. Tutorial in biostatistics: Propensity scoring methods for bias reduction in the comparison of a treatment to a non-randomized control group. *Statistics in Medicine* 1998;17:2265–3381. [PubMed: 9802183]
- DeFrances, CJ.; Podgornik, MN. 2004 National Hospital Discharge Survey. Advance data from vital and health statistics; no. 371. National Center for Health Statistics; Hyattsville, MD: 2006.
- Dochterman, JM.; Bulechek, GM. Nursing interventions classification (NIC). Mosby; St. Louis, MO: 2004.
- Dochterman J, Titler M, Wang J, Reed D, Pettit D, Mathew-Wilson M, et al. Describing use of nursing interventions for three groups of patients. *Journal of Nursing Scholarship* 2005;37:57–66. [PubMed: 15813588]
- Honari S, Patterson DR, Gibbons J, Martin-Herz SP, Mann R, Gibran NS, et al. Comparison of pain control medication in three age groups of elderly patients. *Journal of Burn Care Rehabilitation* 1997;18:500–504. [PubMed: 9404983]
- Iezzoni, LI. Reasons for risk adjustment. In: Iezzoni, LI., editor. Risk adjustment for measuring healthcare outcomes. 3. Health Administration Press; Chicago: 2003. p. 1-16.
- Ilfeld BM, Morey TE, Enneking FK. Continuous infraclavicular brachial plexus block for postoperative pain control at home: a randomized, double-blinded, placebo-controlled study. *Anesthesiology* 2002;96:1297–1304. [PubMed: 12170039]
- Ilfeld BM, Morey TE, Wang RD, Enneking FK. Continuous popliteal sciatic nerve block for postoperative pain control at home: a randomized, double-blinded, placebo-controlled study. *Anesthesiology* 2002;97:959–965. [PubMed: 12357165]
- Kanak MF, Titler M, Shever L, Fei Q, Dochterman J, Picone DM. The effects of hospitalization on multiple units. *Applied Nursing Research* 2008;20:15–22. [PubMed: 18226759]
- Lankshear AJ, Sheldon TA, Maynard L. Nurse staffing and healthcare outcomes. *Advances in Nursing Science* 2005;28:163–174. [PubMed: 15920362]
- Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika* 1986;73:13–22.
- Miller C. Ensuring continuing care: styles and efficiency of the handover process. *Australian Journal of Advanced Nursing* 1998;16:23–27. [PubMed: 9807281]
- Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K. Nurse-staffing levels and the quality of care in hospitals. *New England Journal of Medicine* 2002;346:1715–1722. [PubMed: 12037152]
- Neitzel JJ, Miller EH, Shepherd MF, Belgrade M. Improving pain management after total joint replacement surgery. *Orthopaedic Nursing* 1999;18(4):37–45. 64. [PubMed: 11052040]
- Parker J, Coiera E. Improving clinical communication: a view from psychology. *Journal of the American Medical Informatics Association* 2000;7:453–461. [PubMed: 10984464]
- Patterson ES, Roth EM, Woods DD, Chow R, Gomes JO. Handoff strategies in settings with high consequences for failure: Lessons for health care operations. *International Journal for Quality in Health Care* 2004;16:125–132. [PubMed: 15051706]
- Pavlin DJ, Rapp SE, Polissar NL, Malmgren JA, Koerschgen M, Keyes H. Factors affecting discharge time in adult outpatients. *Anesthesia & Analgesia* 1998;87:816–826. [PubMed: 9768776]

- Pavlin DJ, Chen C, Penaloza DA, Polissar NL, Buckley FP. Pain as a factor complicating recovery and discharge after ambulatory surgery. *Anesthesia & Analgesia* 2002;95:627–634. [PubMed: 12198050]
- Person SD, Allison JJ, Kiefe CI, Weaver MT, Williams OD, Centor RM, et al. Nurse staffing and mortality for Medicare patients with acute myocardial infarction. *Medical Care* 2004;42:4–12. [PubMed: 14713734]
- Phy M, Vanness DJ, Melton LJ, Long KH, Schleck CD, Larson DR, et al. Effects of a hospitalist model on elderly patients with hip fracture. *Archives of Internal Medicine* 2005;165:796–801. [PubMed: 15824300]
- Public Health Service and Health Care Financing Administration. DHHS Pub. No. [PHS] 94–1260. 5. Public Health Service; Washington, DC: 1994. *International Classification of Diseases-9th revision-Clinical Modification*.
- Qin, R.; Titler, M.; Shever, L.; Dochterman, J.; Picone, D.; Kim, T. Estimating effects of nursing interventions via propensity score analysis. 2007. Unpublished manuscript
- Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika* 1983;70:41–55.
- Rubin DB. Estimating causal effects from large data sets using propensity scores. *Annals of Internal Medicine* 1997;127:757–763. [PubMed: 9382394]
- Streitenberger K, Breen-Reid K, Harris C. Hand-offs in care: Can we make them safer? *Pediatric Clinics of North America* 2006;53:1185–1195. [PubMed: 17126690]
- Titler, M. Nursing interventions & outcomes in 3 older populations, 5 RO1 NR05331. National Institute of Nursing Research and the Agency for Health Care Research and Quality; 2000. 07/01/2001–3/31/2005
- Titler M, Dochterman J, Xie XJ, Kanak M, Fei Q, Picone DM, et al. Nursing interventions and other factors associated with discharge disposition in older patients after hip fractures. *Nursing Research* 2006;55:231–242. [PubMed: 16849975]
- Todaro T, Schott-Baer D. Plan faster, healthier recovery after orthopedic surgery. *Nursing Management* 2001;31:24–26. [PubMed: 10818936]
- Unites States Congress, Office of Technology Assessment. Hip fracture outcomes in people age 50 and over (pb94–107653). Unites States Government Printing Office; Washington, D.C: 1994.
- Unruh L. Licensed nurse staffing and adverse events in hospitals. *Medical Care* 2003;41:142–152. [PubMed: 12544551]

Table 1

Variables used to generate propensity score (step one)

	Category	Type
Patient Characteristics	Demographic Data	Sex
		Marital Status
		Site Admitted From
		Age
		Race
		Religion
Clinical Condition	Primary Medical Diagnosis ^a	Non-traumatic Joint Disorders
		Fractures
		Complications
		Other
Procedures/Interventions	Medical Procedures ^b	Arthroplasty
		Blood Transfusion
		Other Therapeutic Procedures
		Morphine
	Pharmacy Interventions ^c	Fentanyl
		Acetaminophen with Codeine
		Meperidine/Demerol
		Hydromorphone/Dilaudid
		Other Opiates
		Opiate Agonists
		Local Anesthetics
		Antipruritics
	Nursing Interventions (NICs) ^d	Analgesic Administration
		Post-Op Care
		Sleep Enhancement
		Exercise Therapy
		Wound Care
		Traction/Immobilization Care
		Positioning
		Vital Signs Monitoring
		Learning Readiness Enhancement
		Surgical Preparation
		Cardiac Care
		Venous Access Device Maintenance
		Exercise Promotion
		Dying Care
		Restraint
		Chest Physiotherapy
		Splinting

Category	Type
	Anxiety Reduction

^aClassified by Clinical Classification Software (CCS, 2002).

^bICD-9-CM procedure codes (Public Health Service and Health Care Financing Administration, 1994). Medical procedures received by < 50% of the sample were not included.

^cAmerican Hospital Formulary Service Pharmacologic-Therapeutic Classification (McEvoy, 2000).

^dNIC interventions received by <2% or >90% of the sample were not included.

Table 2

Propensity score-adjusted analysis using GEE (step two)

Variable	Estimate	SE	95% CI	
			Lower	Upper
Propensity Score	0.40	1.10	-1.76	2.56
Pain Management	0.78*	0.34	0.12	1.44
Severity of Illness				
Severe	0.41	1.11	-1.77	2.59
Major	0.46	0.47	-0.47	1.39
Moderate	-0.11	0.27	-0.64	0.41
Number of Units Resided On	0.46**	0.17	0.14	0.79
Time in ICU	0.44*	0.20	0.05	0.84
Registered Nurse Skill Mix	-3.45 (-0.35 per 0.1 unit) ^a	4.10	-11.84	4.58
Average RN-to-Patient Ratio				
Quartile of (76–100%) Mean HPPD 6.30	-1.63**	0.61	-2.82	-0.44
Quartile of (51–75%) Mean HPPD 4.77	-0.14	0.44	-1.00	0.73
Quartile of (26–50%) Mean HPPD 4.26	0.17	0.39	-0.61	0.94
RN-to-Patient Dip Proportion	4.58** (0.92 per 0.2 unit) ^a	1.58	0.30	1.53
Number of Medical Procedures	0.39**	0.13	0.14	0.64
Number of Unique Meds	0.18**	0.04	0.11	0.26
Number of Unique Nursing Interventions	0.15	0.11	-0.06	0.35
Autotransfusion (29.2)				
Highest Third (68–100%) 2.94 use rate	-1.08*	0.45	-1.96	-0.21
Middle Third (34–67%) 1.49 use rate	-0.58	0.42	-1.39	0.24
Lowest Third (1–33%) 0.65 use rate	-0.99	0.54	-2.05	00.07
Blood Product Administration (41.3)				
Highest Third (68–100%) 4.63 use rate	-0.31	0.36	-1.01	0.40
Middle Third (34–67%) 2.62 use rate	-0.63	0.40	-1.42	0.16
Lowest Third (1–33%) 1.23 use rate	2.34**	0.63	1.10	3.57
Embolus Precautions (9.3)				
Highest Third (68–100%) 2.97 use rate	1.82	1.04	-0.22	3.85
Middle Third (34–67%) 2.59 use rate	0.57	0.91	-1.22	2.36
Lowest Third (1–33%) 1.16 use rate	0.91	1.81	-2.64	4.46
Enteral Tube Feeding (2.3)	2.10	2.31	-2.43	6.64
4.08 use rate				
Fall Prevention (76.6)				
Highest Third (68–100%) 2.46 use rate	-1.24	0.68	-2.57	0.09
Middle Third (34–67%) 0.21 use rate	-1.22*	0.48	-2.15	-0.29
Lowest Third (1–33%) 0.11 use rate	0.78	0.66	-0.50	2.06
Hyperglycemia Management (6.2)				
Highest Third (68–100%) 4.65 use rate	-0.70	0.85	-2.36	0.97

Variable	Estimate	SE	95% CI	
			Lower	Upper
Middle Third (34–67%) 3.85 use rate	0.12	1.40	−2.62	2.86
Lowest Third (1–33%) 1.48 use rate	3.00	2.61	−2.12	8.13
Hypoglycemia Management (3.0)	0.12	1.05	−1.94	2.17
3.84 use rate				
Infection Protection (88.6)				
Highest Third (68–100%) 3.12 use rate	−0.11	0.65	−1.40	1.17
Middle Third (34–67%) 2.92 use rate	0.28	0.60	−0.90	1.45
Lowest Third (1–33%) 2.20 use rate	−1.48*	0.68	−2.81	−0.15
Medication Management (4.2)	−0.53	0.77	−2.04	0.99
0.53 use rate				
Neurologic Monitoring (7.6)				
Highest Third (68–100%) 5.10 use rate	−0.96	0.89	−2.70	0.78
Middle Third (34–67%) 3.33 use rate	0.01	1.07	−2.09	2.11
Lowest Third (1–33%) 1.04 use rate	0.55	1.46	−2.31	3.41
Nutrition Management (2.8)	4.26*	2.11	0.13	8.38
0.89 use rate				
Oxygen Therapy (78.0)				
Highest Third (68–100%) 3.19 use rate	−0.61	0.45	−1.50	0.28
Middle Third (34–67%) 1.35 use rate	−1.03*	0.45	−1.92	−0.14
Lowest Third (1–33%) 0.49 use rate	−0.15	0.51	−1.14	0.84
Pressure Ulcer Prevention (2.3)	5.79*	2.70	0.49	11.09
3.36 use rate				
Respiratory Monitoring (6.5)				
Highest Third (68–100%) 2.90 use rate	−3.62**	1.18	−5.93	−1.32
Middle Third (34–67%) 1.19 use rate	0.80	1.15	−1.46	3.06
Lowest Third (1–33%) 0.29 use rate	−0.30	0.92	−2.11	1.51
Skin Surveillance (9.3)				
Highest Third (68–100%) 2.93 use rate	2.35*	1.12	0.15	4.54
Middle Third (34–67%) 1.45 use rate	2.35	1.55	−0.69	5.38
Lowest Third (1–33%) 0.45 use rate	2.37*	1.10	0.21	4.53
Teaching (77.7)				
Highest Third (68–100%) 0.51 use rate	−0.52	0.51	−1.52	0.48
Middle Third (34–67%) 0.18 use rate	0.12	0.41	−0.69	0.93
Lowest Third (1–33%) 0.10 use rate	1.58*	0.63	0.34	2.82
Technology Management (5.8)				
Highest Third (68–100%) 2.89 use rate	0.88	1.03	−1.13	2.90
Middle Third (34–67%) 2.15 use rate	0.07	1.57	−3.01	3.15
Lowest Third (1–33%) 0.60 use rate	0.94	1.06	−1.13	3.01
Thrombus Precautions (20.7)				
Highest Third (68–100%) 6.88 use rate	0.12	0.48	−0.81	1.06

Variable	Estimate	SE	95% CI	
			Lower	Upper
Middle Third (34–67%) 2.99 use rate	0.02	0.69	−1.32	1.37
Lowest Third (1–33%) 1.17 use rate	0.16	0.69	−1.18	1.50
Urinary Elimination Management (36.7)				
Highest Third (68–100%) 2.70 use rate	0.05	0.40	−0.74	0.83
Middle Third (34–67%) 1.27 use rate	−0.14	0.37	−0.86	0.59
Lowest Third (1–33%) 0.24 use rate	−0.63	0.48	−1.57	0.30

Note. Variables in boldface are NIC interventions (Dochterman & Bulechek, 2004), and are followed in parentheses by the percent of sample that received the intervention at least once.

^aPost-hoc analysis done in increments, as designated, to facilitate meaningful interpretation.

*
p < .05.

**
p < .01