The Impact of Nurse Staffing on Hospital Costs and Patient Length of Stay: A Systematic Review

Petsunee Thungjaroenkul, RN, MS (APPLIED STATISTICS); Greta G. Cummings, PhD, RN; Amanda Embleton, BNSc, RN

Introduction

In an era of restricted health care funding and rising health care costs, hospitals have been compelled to restructure work environments, attempting to deliver health services at lower costs without decreasing the quality of care (Heinz, 2004). As a result of restructuring and increasing attention to costs, many hospitals have chosen to decrease their overall labor pool, including the number of full-time nursing positions (Kunen, 1996; Norrish & Rundall, 2001), leading to documented significant negative effects to nurses' health, well-being, and ability to provide quality nursing care (Cummings & Estabrooks, 2003). Efforts to enhance operational efficiency have led to changes in nurse staffing patterns, decreasing the number of registered nurses (RNs) and replacing them with unlicensed assistive personnel (Barkell, Killinger, & Schultz, 2002). Whether the size and skill of the current health care workforce can adequately meet patient needs has become a question of growing concern (Norrish & Rundall, 2001). Increased caregiver workload and declining numbers of RNs threaten the quality of patient care and safety (Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2003).

Nurse staffing patterns are the subject of much discussion in the professional research literature. Several authors examining the effects of reducing RN positions on patient outcomes report increased patient mortality (Estabrooks, Midodzi, Cummings, Ricker, & Gio vannetti, 2005; Needleman, Buer haus, Mattke, Stewart, & Zelevin sky, 2002; Tourangeau, Giovan netti, Tu, & Wood, 2002); increased rates of failure to rescue (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002); and increased incidence of nosocomial infections, pressure sores, medical errors, and pa tient falls (Cho, Ketefian, Barkauskas, & Smith, 2003; Kovner, Mezey, & Harrington, 2002). Furthermore, findings suggest that increased numbers of RNs increases patient satisfaction (McGillis Hall, Doran, & Pink, 2004).

The availability of RNs and their professional nursing skills may also influence patient length of stay (LOS) and hospital costs. Several researchers analyzed the relationship between nurse staffing and LOS. By increasing the number of RNs and providing more RN hours per patient day, patient LOS decreased (Flood & Diers, 1988; Needleman et al., 2002; Schultz, Van Servellen, Chang, McNeese-Smith, & Waxenberg, 1998).

Lange, Hodge, Olson, Romano, and Kravitz (2004) conducted a systematic review of the effect of nurse staffing on patient outcomes including LOS and costs, reviewing studies published between 1980 and 2003. However, they did not report the process and search strategy used. Few studies in the Lange and colleagues' review examined the relationship between nurse staffing, LOS, and hospital costs. Of nine studies showing an effect of nurse staffing on costs, eight were published between the 1980s and early 1990s. No clear recommendations were reported concerning the research design of included studies, or cost and LOS measures, both of which are important for decision making in health care organizations.

The systematic review reported in this article builds on Lange and colleagues' review in two ways: (a) it includes studies published be tween 1990 and 2006, and (b) it provides a detailed search strategy for the review process and results from the research literature examining the relationship between RN staffing levels, patient LOS, and hospital costs. We also present recommendations for effective staff ing and further research in this area.

Methods

The search strategy was guided by the following research questions: (a) Does RN staffing affect the cost of care delivered to patients in acute hospital settings? and (b) Does RN staffing affect patient LOS? The data search included five electronic databases (Medline, CINAHL, Health star, Cochrane, ABI/Inform), and manual searching from reference lists of key articles. The search strategy and search terms are provided in Table 1 .

Studies relevant to the research questions were included if they met the following six criteria: published between 1990 and 2006; focused on nurse staffing and length of stay or costs; relevant to care of all patients; peer-reviewed; use of correlational, experimental, retrospective or ob servation method ologies allowing for a degree of generalizability; and description of the designs and method of data collection to test the relationship between registered nurse staffing, length of stay, and hospital costs. Studies in nursing homes or that examined other health workforce characteristics, such as medical staff ratios or partnership between nurses and staff in other disciplines, were excluded.

Screening

The initial electronic search identified 718 titles and study abstracts. Of these, a second re viewer reviewed 80 abstracts to test the initial author decisions regarding inclusion and exclusion criteria. Inter-rater reliability was 99.8% agreement, with consensus reached on one abstract for a published systematic review. This led to the addition of another exclusion criterion: systematic reviews were excluded unless they examined research questions identical to this review study. Of 718 articles, 89 abstracts were selected using the final inclusion and exclusion criteria. Once 41 duplicate abstracts were removed, 48 abstracts re mained for manuscript retrieval and screening.

Forty-six full-text manuscripts were screened as two studies could not be found. Ten of the 46 studies were randomly screened by a second reviewer. Discrepancies in assessments were managed by consensus. Finally, the screening process yielded a total of 17 papers that met the final inclusion criteria.

Quality Assessment and Data Extraction

The 17 studies were evaluated for methodologic quality. A quality assessment tool guided this process and was adapted from an instrument used in several published systematic reviews (Cummings & Estabrooks, 2003; Estabrooks et al., 2001; Meijers et al., 2006). Twelve items were designed to assess five features of each study: research design, variable measures, sample, data collection, and data analysis. Each item was scored dichotomously. A total score for each paper ranged from 0 to 12. Studies with scores less than 4 were considered weak studies. Those with scores of 4 to 8 were considered to have moderate strength and those with scores greater than 8 were considered strong studies. Of the 17 papers, 12 studies were evaluated as moderate and 5 studies as strong. Weaknesses in the research included use of retrospective design, nonrandom sampling, and inadequate management of data collection processes. Strengths of the final group of studies were the use of multiple sites and statistical methods for controlling extraneous factors. The following data were then extracted onto a standardized form: authors, year, country, study objectives, population, sample, research design, variable measures, data analysis, study results, and comments.

Results

A total of 17 articles met the inclusion and exclusion criteria. Characteristics of included studies are summarized in Table 2 .

Characteristics of Included Studies

Thirteen studies were conducted in the United States. Remaining studies were conducted in Australia, Austria, Canada, and Taiwan. Retrospective re search designs were used most frequently. Some studies combined retrospective and prospective de signs, and few studies used pro spective designs which would offer more detailed cost measurement and more flexibility than retrospective designs.

All reviewed studies reported effects of nurse staffing on hospital costs and/or LOS measures. Twelve studies examined the effect of nurse staffing on hospital costs. Of these, three studies used total hospital expenditures obtained from financial reports. Two studies used a cost-to-charge index (expressed as the ratio between total hospital operating cost and hospital revenue) to adjust hospital charges. Two studies estimated costs from LOS, and another two studies used a micro-costing method (measuring most of resources used at the patient level and assigning monetary value to resource utilization). Remaining studies estimated costs from changes in nursing personnel budget and hospital expenditures per patient day. Length of stay referred to the total days of hospitalization per patient from admission to discharge. Various measures of hospital LOS were used including number of calendar days, days at midnight census, total hours, or the relative LOS (ex pressed as ratios of actual and expected LOS).

In addition to the variety of hospital cost and LOS measures, the included studies used different measures for nurse staffing variables. Six studies used a ratio of total nursing staff to patients, nine studies used a ratio of RNs to other nursing staff, and three studies used hours per patient day. Few studies used the proportion of experienced nurses or staff hours to non-experienced staff hours.

Four studies focused on the effect of nurse staffing on hospital costs and length of stay in intensive care units (ICUs) (Amaravadi, Dimick, Pronovost, & Lipsett, 2000; Dimick, Swoboda, Pronovost, & Lipsett, 2001; Lassnigg, Hiesmayr, Bauer, & Haisjackl, 2002; Pronovost et al., 1999). Only one study fo cused on the relationship between RN staffing in the operating room and length of stay (Newhouse, Johantgen, Pronovost, & Johnson, 2005). Multiple regression analysis was the most frequent method for examining and confirming the relationship between variables. To achieve a normal distribution, five studies transformed LOS and/or cost data to a natural logarithm form. Two studies used multi-level regression to analyze data obtained at both patient and hospital levels. Another three studies used comparative statistics to test the difference in costs and LOS between two nurse staffing regimens. One study used sensitivity analysis to evaluate the effect of three options to increase nurse staffing on cost saving.

Summary Impact of Nurse Staffing On Cost and Length of Stay

Analysis of the findings from the included studies are presented in Tables 3 and 4. Table 3 presents summary data of the impact of nurse staffing on hospital costs and Table 4 presents summary data of the impact of nurse staffing on patient length of stay.

Impact of Nurse Staffing on Hospital Costs

Results of studies that estimated the relationship be tween nurse staffing and cost were mixed. Ten studies reported an association between nurse staffing and costs while two studies reported no statistical significance (Barkell et al., 2002; Bloom, Alexander, & Nuchols, 1997). As seen in Table 3 , three studies reported that higher registered nurse-to-patient ratios reduced hospital costs. One study encouraged reducing costs by increasing the number of experienced RNs (Bloom et al., 1997). The review of recent studies suggests that the proportion of RNs to other nursing staff (or skill mix) is inversely related to costs. However, no significant relationship between skill mix and costs was reported in two studies when the researchers estimated costs by using total hospital expenditure (Barkell et al., 2002; Bloom et al., 1997). Two studies encouraged reducing costs by increasing RN hours (Behner, Fogg, Fournier, Frankenbach, & Robertson, 1990; Cho et al., 2003). Nevertheless, conflicting results were found as studies used *total hospital expenditures* and the *nursing*

personnel budget as indicators of costs (Lee, Yeh, Chen, & Lien, 2004; McCue, Mark, & Harless, 2003; Pratt, Burr, Leelarthaepin, Blizard, & Walsh, 1993).

Impact of nurse staffing on patient length of stay. The effect of nurse staffing on patient length of stay was examined in 11 studies. Eight studies showed that the level of RN staffing was related to LOS while three studies did not (Lichtig, Knauf, & Millholland, 1999; Newhouse et al., 2005; Pratt et al., 1993). In Table 4 , 10 studies showed that the registered nurse-to-patient ratios, hours per patient day and skill mix were significantly related to patient LOS. In ter est ingly, no studies evaluated the effect of RN staff experience and RN staff education on LOS.

Research Design

The predominate use of retrospective designs may be due to the sources of data for nurse staffing, cost, and length of stay variables ex isting in hospital and national administrative databases. Using existing databases, especially national cost accounting, billing, and other hospital information systems, allows investigators to study a larger sample size and a broader geographic area than when investigators must depend on funding for their study (Woods & Catanzaro, 1988). How ever, the quality and reliability of retrospective studies depend on the accuracy and availability of the original data recording system (for example, medical records, cost accounting, or billing systems) (Gyldmark, 1995). Thus, investigators contemplating using retrospective designs and administrative databases initially developed for other purposes should consider two important issues (Hannan, Racz, Jollis, & Peterson, 1997; Lawthers et al., 2000). First, the definition of terms that investigators propose may be inconsistent with the technical definitions employed by the personnel who initially designed the database. Second, investigators must accept the existing database and the potentially unknown quality of the database with no option to re design the data collection strategy. These issues must be weighed carefully before using a retrospective design on administrative databases. In some instances, consideration of the disparity between the preferred and existing databases may lead researchers to reject using the existing database and select prospective designs to obtain new data, such as those employed by Pratt et al. (1993) and Lassnigg et al. (2002). Whatever method is used, careful consideration should be given to measure components of total cost accurately.

Cost Measure

Many studies chose total hospital expenditures to reflect costs of services; however, with this cost measure, patient-specific resource use is not reflected in detail. Two studies determined costs per patient by transforming hospital charges into patient costs using a cost-to-charge ratio. This method assumed that hospital charges would exceed current expenses because of the need for replacement of equipment and facilities over and above these expenses and because some payers would not pay full charges (they take a discount). The charges are converted to costs by using a constant ratio of cost-to-charge, which is estimated by dividing total hospital operation expenditure with hospital revenue. The main concern of using this method was that a constant cost-to-charge ratio was an inappropriate assumption. Drug A costs $10 to produce and can be sold for $11 while drug B costs $10 to produce and can be sold for $10.50. If a cost to charge ratio is 10%, it could reflect the actual costs of drug A but would fail to show the actual costs of drug B.

This false assumption may lead to overestimation of cost of care as shown in three studies (Amaravadi et al., 2000; Cho et al., 2003; Dimick et al., 2001). Con sideration of the inappropriate assumption may lead researchers to reject using this cost finding method. Three studies (Lee et al., 2004; McGillis Hall et al., 2004; Pratt et al., 1993) used micro-costing method in order to increase the precision of cost estimation. Thus, the micro-costing method may be a credible al ternative for cost estimation.

Some studies used micro-costing methods to estimate costs. Micro-costing methods have higher accuracy for costing purposes than total hospital expenditures and the cost to charge method (Edbrooke, Stevens, Hibbert,

Mann, & Wilson, 1997). Micro-costing methods estimate the cost of services by summing all resource utilization at the cost-object level and multiplying units of resource use by the unit price. This method has the advantage of increasing the precision of cost estimation and preserving information about the variability that is inherent in individualized medical treatments. However, this approach is complex, and expensive to perform.

Length of Stay Measure

The number of calendar days (LOS calendar) was most frequently used to determine length of stay. While these data are easy to obtain from existing documents, this method can lead to overestimation (Marik & Hedman, 2000). Marik and Hedman suggest estimating LOS from the number of midnight bed occupancy days or total hours.

Nurse Staffing Measure

Nurse staffing variables measured in the included studies were the ratio of RNs to patients, hours per patient day, staff hours, the ratio of RNs to other nursing staff, and RN qualification. These variables are commonly found in the research literature examining the impact of nurse staffing on patient mortality, pa tient falls, medical errors, or other patient outcomes (Aiken et al., 2002; Kovner et al., 2002; Mark, Harless, McCue, & Xu, 2004). Each of these variables provides different information about how nurses are assigned to care for their patients and work with each another. Using RN-to-patient ratios, hours per patient day and staff hours provides information about the appropriate utilization of nurse staffing in terms of the number of nursing staff per patient day. Skill mix (expressed in the ratio of RNs to other nursing staff) provides information about the appropriate utilization of nurse staffing in terms of workload shared between RNs and non-licensed nurses. RN qualification (expressed in the ratio of total number of RN years of experience to the total number of staff) indicates the efficiency of using RNs with more years of nursing experience. Theoretically, RNs with more years of nursing experience are expected to provide higher quality care and thus positively affect patient outcomes.

Scope of Study

The effect of nurse staffing on LOS and cost of care was reported in each study. Results suggest that higher proportions of RNs optimize quality of care, and decrease LOS and cost of care. However, most studies examining the relationship between nurse staffing, cost, and LOS were limited to patients admitted to general wards. Few studies examined ICUs and operating rooms, highly specialized areas of the hospital and widely different then general wards. Therefore, further research is needed to validate results and study a variety of clinical areas.

Data Analysis

Data analysis that examines the effect of nurse staffing on costs and LOS is complex. The majority of studies used multiple regression analysis. This helped control extraneous variables such as hospital size, location, and patient characteristics. Furthermore, the distribution of costs and LOS measures were reported as skewed. Therefore, some researchers transformed raw LOS and cost data to natural logarithmic values before completing multiple regression analysis. The growing complexity of data analysis methods in these studies was noted. Several studies collected data at patient and hospital levels and used multi-level regression to separately analyze the data at each level. Using multi-level regression, the investigators could control extraneous variables of patient characteristics and other contextual variables such as hospital size and location. More importantly, increasingly sophisticated ways of adjusting extraneous variables generated greater confidence in the interpretation of results.

Impact of Nurse Staffing on Hospital Cost

Previous studies demonstrated that significant cost reductions were possible through effective staff management. Increasing the proportion of hours provided by RNs would yield cost savings resulting from avoiding death and reduced LOS (Needleman, Buerhaus, Stewart, Zelevinsky, & Mattke, 2006). Many studies encouraged reducing costs by increasing the caring activities of RNs (Amaravadi et al., 2000; Cho et al., 2003; Dimick et al., 2001; McGillis Hall et al., 2004). Al though increasing the number of RNs was positively related to increasing hospital expenditures, it did not affect hospital profit significantly. In contrast, greater non-registered nurse hours led not only to higher hospital expenditures but also lower profits (McCue et al., 2003).

An interaction effect among nurse staffing, cost of care, and efficiency of nursing care was noted. Three studies (Behner et al., 1990; Cho et al., 2003; Schultz et al., 1998) suggested that cost reductions were possible by increasing RN nursing hours. They stressed that higher RN nursing hours would contribute to improved patient outcomes, especially nosocomial infection, pneumonia, and other medical complications, while in turn decreasing costs of patient care. The results of these studies reflected the fact that higher RN nursing hours contributed to the improvement of patient safety and efficiency, thereby reducing the LOS and the cost of care in the long term.

In business fields, more experienced staff increase organizational labor expenditures. However, in health care, significant reductions in overall costs by increasing the number of experienced nurses was reported by Bloom and colleagues (1997). The lower costs were explained in part by the higher efficiency of experienced staff. The investigators noted that hospitals with more experienced nursing staff had lower non-personnel costs. This may be due to experienced nursing staff providing more efficient and effective health services as well as lower consumption of resources.

Impact of Nurse Staffing on Length of Stay

Seven studies found that *higher RN-to-patient ratios* reduced length of hospital stay and ICU length of stay (Amaravadi et al., 2000; Cho et al., 2003; Lassnigg et al., 2002; Lichtig et al., 1999; Needleman et al., 2002; Pronovost et al., 1999; Schultz et al., 1998). This may explain why adequate RN staffing reduced adverse events and decreased LOS. Adequate RN staffing provided better patient monitoring and surveillance as nurses were prepared to detect and treat complications (Amaravadi et al., 2000; Pronovost et al., 1999; Schultz et al., 1998). In addition, RNs were more effective in preventing adverse events such as nosocomial infections and pressure sores than other nursing staff. Adequate RN staffing produced quality infection control practices, permitting them to adhere to aseptic techniques and high standards of care as these principles and techniques require a higher knowledge and skills level (Cho et al., 2003).

Many studies found the impact of nurse staffing on hospital LOS. Few studies examined the impact on ICU LOS (Amaravadi et al., 2000; Pronovost et al., 1999). These studies contribute to the growing evidence supporting that ICUs or general wards can benefit greatly from using the full potential of RNs. The more positive outcomes of sufficient numbers of RNs may be related to the immediate availability of a RN to evaluate and care for patients.

Four studies found that higher ratios of RNs to other nursing staff were associated with reduced LOS. These studies had sufficient data for multiple regression analysis, and research designs to control extraneous factors. One study used nonparametric statistics to test for differences in LOS between two nurse staffing regimens although controlling extraneous factors was difficult due to their small sample size. From these results, one can infer that RNs are more productive than non-RNs because they can perform the entire range of nursing tasks without supervision (Barkell et al., 2002; Lichtig et al., 1990).

Recommendations

Based on data synthesis, the following recommendations for hospital administration, nursing administration, and ongoing re search are provided to advance our understanding of the impact of staffing on cost and LOS.

Hospital Administration

In view of increasing attention to costs, hospital policy has resulted in reorganized nurse staffing, including few er RNs and the replacement of professional nurses with unlicensed assistive personnel. Hospital ad ministrators ex pected that this strategy would re duce hospital expenditures (Kunen, 1996; Norrish & Rundall, 2001). However, the evidence evaluated here suggests that reducing RNs may significantly de crease quality of care and in crease hospital costs and LOS. Decisions about nurse staffing levels should be based on sound evidence to en sure that appropriate numbers of skilled nursing staff are available to achieve safety standards and optimum patient outcomes.

Nursing Administration

Nurse administrators are responsible for allocating nursing staff to meet quality of care standards and hospital budget requirements. On the surface it may appear that a staff mix with a higher level of RNs would be more costly. However, studies reported that the sufficient numbers of skilled RNs may actually reduce LOS and costs. A nurse staffing model with a lower number of RNs may ineffectively prevent adverse patient events resulting in patients having to stay longer than necessary. Furthermore, this may increase nursing turnover costs, and additional costs incurred from poor retention and use of overtime. The evidence suggests that replacing professional nurses with unlicensed assistive personnel is inappropriate to achieve cost-containment objectives. Rather than decreasing the number of RNs, hospitals should consider increasing the proportion of RNs as higher levels of knowledge and skills can reduce patient mortality (Aiken et al. 2002; Estabrooks et al., 2005) as well as lower patient resource consumption.

Further research on the impact of nurse staffing should address the following.

1. The evidence evaluated here suggests that costs and LOS are influenced by RN staffing levels. The few inconsistent findings may be explained by the various nurse staffing variables, cost measures, and LOS measures. Further research would be enhanced by standardizing measures of cost and LOS. Rather than measuring length of stay by using days of admission, LOS should be determined by using reliable methods such as number of days at midnight census or total hours. Using hospital expenditures as cost measures is a poor method to reflect variation of resource consumption among patients. Calculating costs using the micro-costing method is more reliable than using total hospital expenditures.

2. Retrospective design is commonly used in studies that examine nurse staffing, costs, and LOS. This design is practical when there is sufficient data recorded in hospital and national administrative databases. However, routinely recorded data related to nurse staffing variables, costs, and LOS must be complete and accurate as errors and missing records may influence the reliability and validity of study outcomes. Prospective designs are an alternative research method, albeit costly, if quality retrospective data are not available.

3. Intensive care units are highly specialized areas of the hospital where critically ill patients are monitored and often treated using complex equipment. Critical care nurses have the ability to promote the quality of clinical practice procedures and decrease ICU length of stay and costs of intensive care. However, studies examining the relationship between nurse staffing, costs of ICU care, and ICU length of stay are limited to patients admitted to surgical ICUs. Thus, further research is needed to validate results and to study patients admitted to a variety of specialty ICUs.

4. Research examining the effect of RN qualifications on hospital costs was limited. Only one study determined that a greater number of experienced RNs led to reduced costs (Bloom et al., 1997). One

difficulty in interpreting this study was that secondary data used for analysis were collected in 1982. These data may not reflect current circumstances. Thus, replication of this study is warranted.

5. While there is evidence to support the relationship between RN experience, RN education, patient length of stay, and the cost of care, there are no studies linking these variables to patient LOS. Thus, further research to confirm the relationship between RN qualifications and LOS is needed to conclude whether the competency of RNs is the most important criteria for achieving cost-effective patient care in hospitals.

A potential limitation is that studies identified in the review may not represent all existing research in the area, since unpublished research was not obtained. A potential reporting bias may exist by including only published studies, which tend to over report positive (in our case negative) findings. We were not able to conduct a meta-analysis due to the variation in outcome variables measured and heterogeneity in this group of studies. However, since we did not pool effect sizes, the risk of inflating effect size was not present. Future research should examine directly the relationship between nurse staffing levels and patient health outcomes as well as LOSand costs.

Conclusion

Research examining the relationships between nurse staffing, hospital costs, and length of stay is varied using a range of methods and definitions. This lack of coherence in definitions and measurement tools for cost and LOS makes it difficult to conclude with certainty the results of nurse staffing on hospital cost and LOS. How ever, the evidence reflected that significant reductions in cost and LOS may be possible with higher ratios of nursing personnel in hospital settings. Sufficient numbers of RNs may prevent patient adverse events that cause patients to stay longer than necessary. Patient costs were also reduced with greater RN staffing as RNs have higher knowledge and skill levels to provide more effective nursing care as well as reduce patient resource consumption. Hospital administrators are encouraged to use higher ratios of RNs to non-licensed personnel to achieve their objectives of quality patient outcomes and cost containment.

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Table 1. Literature Search: Electronic Databases

Database 1990-2006	Search Terms	Number of Abstracts
ABI inform	Nurse staffing and cost Nurse staffing and length of stay Skill mix and cost Skill mix and length of stay Registered nurse and cost Registered nurse and length of stay	275
CINAHL	Nurse staffing and cost Nurse staffing and length of stay Skill mix and cost Skill mix and length of stay Registered nurse and cost Registered nurse and length of stay	204
Cochrane Library (CDSR, ACP, Journal Club, CCTR)	Nurse staffing and cost Nurse staffing and length of stay Skill mix and cost Skill mix and length of stay Registered nurse and cost Registered nurse and length of stay	92
HealthSTAR	Nurse staffing and cost Nurse staffing and length of stay Skill mix and cost Skill mix and length of stay Registered nurse and cost Registered nurse and length of stay	65
Medline	Nurse staffing and cost Nurse staffing and length of stay Skill mix and cost Skill mix and length of stay Registered nurse and cost Registered nurse and length of stay	78
Manual Search	References from key articles	4
Total		718
First selection		89
First selection minus duplicate		48
Second selection		46
Final selection		17

Table 2. Characteristics of Included Studies

First Author, Year, and Journal Name	Countries	Samples	Study Designs	Cost Measures	Length of Stay Measures	Nurse Staffing Measures	Analysis
Amaravadi et al. (2000). *Intensive Care Medicine*, Vol. 26.	USA	One hospital; 336 patients admitted to 35 adult ICUs after esophageal resection.	Retrospective study	Hospital charges adjusted with cost to charge ratio.	Days of admission	Ratio of RNs to patients	Multiple regression with data transformation
Behner et al. (1990). *Healthcare Management Review*, Vol. 15.	USA	One hospital; 132 patients with DRG 215.	Retrospective study	Cost estimation from LOS.	Not identified	Hours per patient day	t-test (2 models of nurse staffing)
Barkell et al. (2002). *Outcomes Management*, Vol. 6.	USA	One hospital; 96 patients with DRG 148 and 149.	Retrospective study	Total hospital expenditures.	Days at midnight census	Ratio of RNs to other nursing staff	t-test (2 models of nurse staffing)
Bloom et al. (1997). *Social Science & Medicine*, Vol. 44.	USA	586 hospitals; all patients admitted to those hospitals in 1982.	Retrospective and prospective study	Total hospital expenditures.		Ratio of RNs to other nursing staff; proportion of experienced nurses	Multiple regression with data transformation
Cho et al. (2003). *Nursing Research*, Vol. 52.	USA	232 hospitals; 124,204 patients in 20 common surgical DRGs.	Retrospective study	Hospital charges adjusted with cost-to-charge ratio.	Days of admission	RN hours per patient day; ratio of RNs to other nursing staff	Multi-level regression with data transformation
Lee et al. (2004). *Journal of Advanced Nursing*, Vol. 51.	Taiwan	A 54-bed GI ward in a general hospital; 25 RNs, 3 LPNs, and 34 patients.	Pre-post quasi-experimental design	Nursing personnel cost.		Ratio of RNs to other nursing staff	t-test (2 models of nurse staffing)
McCue et al. (2003). *Journal of Healthcare Finance*, Vol. 29.	USA	422 hospitals in 11 states.	Retrospective study	Total hospital expenditures.		RN hours-Non-RN hours	Multiple regression with data transformation
Pratt et al. (1993). *Australian Journal of Advanced Nursing*, Vol. 10.	Australia	One hospital; patients in medical and surgical wards.	Prospective study	Cost estimation from micro costing method.	Days of admission	Ratio of RNs to other nursing staff	Chi-square (2 models of nurse staffing)
Needleman et al. (2002). *Health Services Research*, Vol. 38.	USA	799 hospitals; patients admitted to medical and surgical wards.	Retrospective study		Not identified	Ratio of RN hours to all nursing care hours	Multiple regression without data transformation
Needleman et al. (2006). *Health Affairs*, Vol. 25.	USA	799 hospitals; patients admitted to medical and surgical wards.	Retrospective study	Cost estimation from LOS.		Ratio of RN hours to all nursing care hours	Sensitivity analysis with three options to increase the proportion of hours provided by RNs

First Author, Year, and Journal Name	Countries	Samples	Study Designs	Cost Measures	Length of Stay Measures	Nurse Staffing Measures	Analysis
Newhouse et al. (2005). *AORN Journal*, Vol. 81.	USA	32 hospitals; 1,894 records of patients with principal procedure code of abdominal aortic surgery.	Retrospective study		Day of admission with defining prolonged hospital stay as being greater than 7 days	Ratio of RNs to other nursing staff	Logistic regression
Lichtig et al. (1999). *Journal of Nursing Administration*, Vol. 29.	USA	691 hospitals in California and New York; all patients admitted to those hospitals in 1992 and 1994.	Retrospective study		Ratio of actual to expected LOS	Ratio of RNs hours to all nursing care hours; nursing hour per intensity weight	Multiple regression without data transformation
McGillis Hall et al. (2004). *Journal of Nursing Administration*, Vol. 34.	Canada	19 hospitals; 203 patients admitted to 77 adult medical, surgical, and obstetric units.	Retrospective and prospective study	Cost estimation from micro-costing method.		Ratio of RNs to other nursing staff	Multi-level regression with data transformation
Pronovost et al. (1999). *JAMA*, Vol. 281.	USA	All Maryland hospitals; 2,987 ICU patients with principal procedure code of abdominal aortic surgery.	Retrospective and prospective study		Days of admission	Ratio of RNs to patient	Multiple regression with data transformation
Dimick et al. (2001). *American Journal of Critical Care*, Vol. 10.	USA	One hospital; 569 adult ICUs who had hepatic resection, 1994 to 1998.	Retrospective and prospective study	Hospital charges adjusted with cost-to-charge ratio.		RN hours per patient day	Multiple regression with data transformation
Schultz et al. (1998). *Outcomes Management for Nursing Practice*, Vol. 2.	USA	373 hospitals; patients with AMI.	Retrospective study	Hospital expenditures per patient day.	Days of admission	Ratio of RNs to patient	Multiple regression without data transformation
Lassnigg et al. (2002). *Intensive Care Medicine*, Vol. 28.	Austria	Several hospitals in Europe; patients admitted to 21 ICUs and had undergone coronary artery surgery, valvular surgery, heart transplantation, thoracic aortic surgery, or other cardiac intervention.	Prospective study		Total hours from admission to discharge		Cox regression

Table 3. Summary of the Impact of Nurse Staffing on Hospital Costs

Effect of Nurse Staffing on Hospital Costs		Sources	Significant Findings
Nurse Staffing Variables	**Cost Measures**		
Ratio of RNs to patients	Hospital charges adjusted with cost-to-charge ratio Hospital expenditure per patient day	Amaravadi et al. (2000) Dimick et al. (2001) Schultz et al. (1998)	Negative relationship Negative relationship Negative relationship
Ratio of RNs to other nursing staff	Hospital charges adjusted with cost-to-charge ratio Total hospital expenditure Nursing personnel cost Cost estimation from micro-costing method Cost estimation from LOS	Cho et al. (2003) Barkell et al. (2002) Bloom et al. (1997) Lee et al. (2004) Pratt et al. (1993) McGillis Hall et al. (2004) Needleman et al. (2006)	Negative relationship NS NS Positive relationship Positive relationship (medical wards) Negative relationship (surgical wards) Negative relationship Negative relationship
Hours per patient day	Hospital charges adjusted with cost to charge ratio Cost estimation from LOS	Cho et al. (2003) Behner et al. (1990)	Negative relationship Negative relationship
Staff hours	Total hospital expenditure	McCue et al. (2003)	Positive relationship
RNs' qualifications	Total hospital expenditure	Bloom et al. (1997)	Negative relationship

Table 4. Summary of the Impact of Nurse Staffing on Patient Length of Stay

Effect of Nurse Staffing on Hospital Costs		Sources	Significant Findings
Nurse Staffing Variables	Length of Stay Measures		
Ratio of RNs to patients	Days of admission	Amaravadi et al. (2000) Pronovost et al. (1999)	Negative relationship Negative relationship
	Ratio of actual and expected LOS	Lichtig et al. (1999)	NS
	Total hours	Lassnigg et al. (2002)	Negative relationship
Ratio of RNs to other nursing staff	Days of admission	Pratt et al. (1993) Cho et al. (2003)	NS Negative relationship
		Newhouse et al. (2005)	NS
	Days at midnight census	Barkell et al. (2002)	Negative relationship
	Ratio of actual and expected LOS	Lichtig et al. (1999)	Negative relationship
	Not identified	Needleman et al. (2002)	Negative relationship
Hours per patient day	Days of admission	Cho et al. (2003) Schultz et al. (2003)	Negative relationship Negative relationship
	Not identified	Behner et al. (1990)	Negative relationship

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Sidebar: Executive Summary

Research examining the relationships between nurse staffing, hospital costs, and length of stay is varied using a range of methods and definitions.

This lack of coherence in definitions and measurement tools for cost and length of stay makes it difficult to conclude with certainty the results of nurse staffing on hospital cost and length of stay.

However, the evidence reflected that significant reductions in cost and length of stay may be possible with higher ratios of nursing personnel in hospital settings.

Sufficient numbers of RNs may prevent patient adverse events that cause patients to stay longer than necessary.

Patient costs were also reduced with greater RN staffing as RNs have higher knowledge and skill levels to provide more effective nursing care as well as reduce patient resource consumption.

Hospital administrators are encouraged to use higher ratios of RNs to non-licensed personnel to achieve their objectives of quality patient outcomes and cost containment.

Disclaimer

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Petsunee Thungjaroenkul, RN, MS (APPLIED STATISTICS), MEcon, is a Faculty Nursing member, Chiang Mai University, Chiang Mai, Thailand.

Greta G. Cummings, PhD, RN, is an Assistant Professor, Faculty of Nursing, University of Alberta, Edmonton, Alberta, Canada. She is also a Population Health Investigator, Alberta Heritage Foundation for

Medical Research, and a New Investigator, Canadian Institutes for Health Research.

Amanda Embleton, BNSc, RN, is a Master of Nursing Student, and a Faculty Nursing member, University of Alberta, Edmonton, Alberta, Canada.