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Relationship between Nurse Staffing and Changes in *Pain Level*, *Infection Severity*, and *Tissue Integrity: Skin and Mucous Membranes**

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Purpose: The study assessed whether nurse staffing was associated with 3 nursing sensitive outcomes used in intensive care unit (ICU) nursing care plans. **Methods:** This study was a retrospective and descriptive study using clinical data extracted from the data warehouse of a large acute care hospital in the Midwest. One-way analysis of variance was used to analyze the records of 578 ICU patients admitted from March 25 to May 31, 2010. **Results:** 79 Nursing Outcomes Classification (NOC) outcomes were used in the nursing care plans. The 3 most commonly used NOC outcomes (*Pain Level*, *Infection Severity*, and *Tissue Integrity: Skin and Mucous Membranes*) were analyzed to determine their relationship to nurse staffing. As a nurse staffing ratio, the skill mix of nursing caregivers ranged from 0.74 to 1 with an average of 0.90. This skill mix of nursing caregivers significantly differed among the changes in *Infection Severity* scores. However, the mean difference was only 0.02. **Conclusion:** The results did not support that greater nurse staffing was associated with better outcomes. More research is still needed to determine the usefulness of *Pain Level*, *Infection Severity*, and *Tissue Integrity: Skin and Mucous Membranes* in evaluating the impact of nurse staffing.

Key words : Nursing staff, Pain, Infection, Tissue

INTRODUCTION

Background and Significance

Nurses working in intensive care units (ICUs) need to have specialized knowledge, skills, and experience to provide appropriate and timely care to critically ill patients with complex care problems (Stone & Gershon, 2006). These nurses provide vital comprehensive nursing care including skilled and timely reduction of sedation, weaning from ventilation, physical rehabilitation, and psychological support. Early rehabilitation care, in particular -- provided by critical care nurses -- is considered a essential part of ICU patient care, which is due mainly to the fact early rehabilitation contributes to improving long-term patient outcomes (Hu, Hsu, Yip, Jeng, & Wang, 2010; National Institute for Health and Clinical Excellence, 2009). However, reduced nurse staffing often results in missing these specific parts of nursing care (Kalisch, Tschannen, & Lee, 2011).

Furthermore, the variations in nursing resource consumption in ICU settings are disregarded in current diagnosis related groups (DRGs), reimbursements, and the per diem hospital charging systems (Sullivan, Carey, & Saunders, 1988). In particular, in the current fixed charge system based on the type of room, hospital administrators often reduce the level of ICU nurse staffing as a method of cost reduction.

주요어 : 간호인력, 통증, 감염, 조직
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With this concern related to nurse staffing, research about the impact of nursing resources on the ICU patient outcome is important to provide evidence about the appropriate levels of nurse staffing in ICU settings. There are several literature studies to examine the relationship between nurse staffing and patient outcomes, such as ICU/hospital length of stay, mortality, nosocominal infections (Amaravadi, Dimick, Pronovost, & Lipsett, 2000; Dang, Johantgen, Pronovost, Jenckes, & Bass, 2002; Hickey, Gauvreau, Connor, Sporing, & Jenkins, 2010; Hugonnet, Uckay, & Pittet, 2007; Pronovost et al., 1999; West, Mays, Rafferty, Rowan, & Sanderson, 2009). These studies showed that fewer nurses on duty increased ICU patients' hospital length of stay (LOS), complications after surgery, or the rates of hospital acquired infections (Amaravadi et al., 2000; Dang et al., 2002; Hickey et al., 2010; Hugonnet et al., 2007; Pronovost et al., 1999). These outcomes studies were valuable for making decisions at the staff nurse level. However, the weakness of this research is that it did not show the unique contribution of nursing care to individual ICU patients' well-being because the outcomes are not directly linked to nursing interventions and are focused on unit level incidence or prevalence rates.

Hegyvary (1991) stresses the influence of a profession's perspective regarding outcome assessment. The perspective of the nurse drives individual clinical practice and may have an impact on the implications of nursing's domain and measurement of outcomes. Therefore, in order to identify the individual and collective contributions of nurses to patient care, nursing sensitive outcomes based on nurses' scope and domain of practice are needed (Moorhead, Johnson, Mass, & Swanson, 2008).

Nursing Outcomes Classification (NOC), which is a standardized terminology for nursing-sensitive outcomes, can be used to assess the effectiveness of nursing care because the outcomes try to identify influences from nursing and are comprehensive enough to assess all aspects of nursing practice (Moorhead et al., 2008). Particularly, in effectiveness research, the change of NOC outcome ratings at certain points can be used to capture the results of nursing interventions. However, there is still a lack of nursing effectiveness studies using clinical data with the NOC outcomes. Moreover, no studies have thus far been conducted to identify the precise impact of ICU nurse staffing on nursing sensitive outcomes to provide sufficient evidence to determine the appropriate nurse staffing levels for comprehensive ICU patient care.

Purpose of Study

The purpose of this study was to examine the association between nurse staffing and the change of frequently selected NOC outcome scores in actual nursing care plans.

Specific aims were as follows:

- To identify nursing staffing ratios and characteristics of patients admitted to ICUs within the study period
- To identify the association between nurse staffing and the change of *Pain Level*, *Infection Severity*, and *Tissue Integrity: Skin and Mucous Membranes* scores.

METHODS

Design

This study was a retrospective and descriptive study using large clinical data sets. The data was extracted from elements of an electronic health information system in a large tertiary-care hospital. The electronic health information system of this hospital has a nursing component that contains NANDA- International, Nursing Outcomes Classification (NOC), and Nursing Interventions Classification (NIC).

Setting

The hospital selected for this study is a 680-bed academic medical center in the Midwest with three adult intensive care units: the Cardiovascular Intensive Care Unit (CVICU, 12 beds), the Surgical Intensive Care Unit (SICU, 34 beds), and the Medical Intensive Care Unit (MICU, 14 beds). The nursing staff consists of over 1,671 registered nurses. In 2004, the Department of Nursing Services and Patient Care at this hospital received Magnet designation for excellence in nursing service from the American Nurses Credentialing Association. It was the first hospital in Iowa to receive the Magnet designation. This hospital has been a test site for the clinical testing of NIC since the development of NIC (Daly, Button, Prophet, Clarke, & Androwich, 1997).

Samples

The study sample consisted of administrative data (patient demographics and nursing unit characteristics) and nursing documentation, including NANDA-I, NOC, and NIC, of all patients admitted to three adult intensive care units of the hospital for a period of two months. Inclusion criteria for subjects in this study were: 1) Patients admitted to the CVICU, the SICU, and the MICU between March 25, 2010 and May 31, 2010, and 2) Patients 18 years old and older. The study focused on the care provided by nurses while they were patients in these units and did not follow patients when patients were transferred to outside of the ICU environment. Therefore, 1) Patients who didn't have nursing care plans during ICU stay, 2) Patients whose NOC outcomes were not rated during ICU stay, and 3) Patients who moved from one type of ICU to another ICU in the hospital were excluded from the study.

Measures

- Nurse Staffing

Skill mix of nursing caregivers is defined as the average number of registered nurses (RNs) divided by the average number of all nursing direct caregivers (RNs, Licensed Practical Nurses (LPNs), and Others) during a specific period of time as a continuous variable (Titler et al.,2006). It explains the proportion of hours of care provided by RNs to the total hours of care.

- Nursing Outcomes Classification (NOC)

A nursing outcome is defined as "an individual, family, or community state, behavior, or perception that is measured along a continuum in response to nursing intervention (s)" (Moorhead et al., 2008). Each NOC outcome is composed of a label, a set of indicators, and a measurement scale. Focus group reviews by master's-prepared nurse clinicians from various specialties and settings and questionnaire surveys from experts in specialty areas in nursing practice were conducted to establish content analysis and validation of NOC outcomes (Caldwell, Wasson, Anderson, Brighton, & Dixon, 2005; Head, Maas, & Johnson, 2003; Head et al., 2004; Keenan et al., 2003). The initial reliability, validity, sensitivity, and usefulness of 190 NOC outcomes were clinically evaluated at 10 field sites (Johnson, Moorhead, Maas, & Reed, 2003; Maas, Johnson, Moorhead, Reed, & Sweeney, 2003; Moorhead, Johnson, Maas, & Reed, 2003). The NOC measurement focuses on a 5-point Likert-type scale from 1 (least desirable) to 5 (most desirable) (Moorhead et al., 2008). In addition, the change in the NOC outcome scores was calculated as the difference between a baseline rating of the outcome and a post intervention rating of the outcome or the outcome ratings at discharge from the ICUs (the last outcome score rated). This score was split into three categories: Improved (rating increased), Declined (rating decreased), and No change (rating stayed the same).

Procedure

The data of this study were collected through two different process:

Patient characteristics (age, gender, and medical diagnoses) and nursing characteristics (the number of RNs, LPNs, and Other staff) were extracted from the data warehouse of the hospital by the Health Care Information System (HCIS) staff. Individuals' nursing care plans were collected by a PI from individual electronic health records.

- Human Subject Approval

This study was approved by the University of Iowa's Institutional Review Board (IRB) (IRB ID #: 201007725). In particular, due to the change of data extraction process, the study was submitted twice to approve the Mikyung Moon (PI)'s access to the electronic information system.

Data Analysis

Statistical Package of Social Study (SPSS), version 19.0 (SPSS Inc, Chicago, Illinois) was used for data analysis. A one-way analysis of variance (ANOVA) was used to evaluate the association between the change of NOC outcome scores and nurse staffing.

RESULTS

Description of Sample Data

A total of 578 patient records were used for data analysis, and Table 1 describes the characteristics of the patients: 57.6% (n=333) of the patients was male, while 42.4% (n=245) were

Table 1. Description of Patient Characteristics

Variables		Frequency	Percent	Cum. %*	
Gender	Female	245	42.4	42.4	
	Male	333	57.6	100	
	Total	578	100	100	
ICD category name					
Diseases of the circulatory system		180	31.1	31.1	
Injury and poisoning		112	19.4	50.5	
Diseases of the digestive system		65	11.2	61.7	
Neoplasms		49	8.5	70.2	
Diseases of the respiratory system		42	7.3	77.5	
		Mean	SD	Min.†	Max.‡
Age (Years)		56.52	17.19	18	96
Nursing staff to patient ratio		1.37	0.13	0.92	1.7
Skill mix of nursing caregivers		0.90	0.04	0.74	1

*Cumulative Percent; † Minimum; ‡ Maximum.

female. The mean age of the patients was 56.52 (SD=17.19), and their ages ranged from 18 to 96 years. The primary medical diagnoses for the patients were sorted by ICD-9-CM Diseases and Injuries Categories (Buck & American, 2010). The top 5 categories for the patient's primary medical diagnoses in this study were Diseases of the circulatory system (n=180, 31.1%), Injury and poisoning (n=112, 19.4%), Diseases of the digestive system (n=65, 11.2%), Neoplasm (n=49, 8.5%), and Diseases of the respiratory system (n=42, 7.3%). These 5 ICD-9-CM categories accounted for 77.5 % of the patients medical diagnoses in the ICU units. The average nursing staff to patient ratio was 1:1.37 with a range of 0.92 - 1.70. The skill mix of nursing caregivers, which is the ratio of registered nurses to other nursing caregivers, ranged from 0.74 to 1 with an average of 0.90.

A total of 79 different NOC outcomes were used at least once in ICU nursing care plans. These NOC outcomes were used a total 2345 times. The five most common NOC outcomes were: Pain Level (n=276, 11.8%); Respiratory Status: Gas Exchange (n=172, 7.3%); Respiratory Status: Airway Patency (n=157, 6.7%); Infection Severity (n=147, 6.7%); Tissue Integrity: Skin and Mucous Membranes (n=134, 5.7%). In order to examine the association between the change of NOC outcome scores and nurse staffing, *Pain Level*, *Infection Severity*, and *Tissue Integrity: Skin and Mucous Membranes* were used for the analysis as dependent variables. The concept of these three NOC outcomes are similar to the nursing sensitive outcomes that are commonly referred to as key nursing sensitive outcomes (Bloodstream infection, ventilator-associated pneumonia, pressure ulcers, and pain) to evaluate the quality of nursing care in ICU settings (Whitman, Kim, Davidson, Wolf, & Wang, 2002).

Pain Level

For the NOC outcome, *Pain Level*, 275 patients were used for the analysis. The total sample was 56.9% male and 44.1% female with a mean age of 56.99 years (SD=16.96, Range= 18-96). Average ICU length of stay(LOS) for this group of patients was 62.25 hours (SD=72.82), and 76.4% of the patients were admitted to the SICU. Table 2 displays the results of ANOVA analysis of the variable related to the change of *Pain Level*'s score. *Pain Level* improved in 28.7% patients and declined in 16.0% patients over the ICU stay. The skill mix of nursing caregivers ranged from 0.74 to 1 with an average of 0.88. However, there were no significant differences

Table 2. Association between Changes in *Pain Level* Scores and Nurse staffing

	The change of *Pain Level* score				
	Declined	No change	Improved	Total	
Nursing Caregiver Skill Mix					
Mean (SD)	0.89 (0.31)	0.88 (0.41)	0.88 (0.41)	0.88 (0.04)	F=0.66
[Range]	[0.83-0.86]	[0.74-1]	[0.74-1]	[0.74-1]	*p*=.518
Total (n, %)	44 (16.0%)	152 (55.3%)	79 (28.7%)	275 (100.0%)	

in the nursing caregiver skill mix (F=0.66, p=.518) among the three categories with the change of *Pain Level*'s score (α<.05).

Infection Severity

A total of 147 patients with the NOC outcome *Infection Severity* were used for the analysis. The patient sample included 92 males (62.6%) and 55 females (37.4%) with a mean age of 57.24 years (SD=17.19, Range=18-89). The mean of ICU length of stay for patients with this outcome was 75.72 hours (SD=94.68, Range=7.70-682.73) and 66% of the patients were admitted to the SICU. The *Infection Severity* scores of 18.4% of the patients declined over their ICU stay, while the scores of 27.2% of patients improved. The nursing caregiver skill mix (F=3.50, *p*=.033) significantly differ among the three categories with the change of *Infection Severity* score at the .05 alpha level (Table 3). The rate of nursing caregiver skill mix was lower in the "No change" group for this outcome. However, the result was not clinically meaningful because the rates were nearly identical with only 0.02 difference.

Tissue Integrity: Skin and Mucous Membranes

For this outcome 133 patients were used for the analysis. The mean age of the patients was 59.22 years (SD=16.3), and 61.2% of the patients were male. The mean of ICU length of stay was 86.03 hours (SD=111.36), and 79.9% of the patients were admitted to SICU. For the change of *Tissue Integrity: Skin and Mucous Membranes* score, 18.4% of patients were in the category of 'Declined'; 54.4% in 'No change'; and 27.2% in 'Improved'. Table 4 shows the change of *Tissue Integrity: Skin and Mucous Membranes* scores by the study variable. The skill mix of nursing caregivers ranged from 0.79 to 0.97 with an average of 0.88. However, there were no significant differences in the nursing caregiver skill mix (F=0.38, *p*=.683) among the three categories with the change of *Tissue Integrity: Skin and Mucous Membranes* score (α<.05).

DISCUSSION

This study examined the relationship between nurse staffing rates (nursing caregiver skill mix) and three common NOC outcomes used in actual ICU nursing care plans. The information can be useful for deciding appropriate nurse staffing levels to provide prompt and skilled interventions as well as to prevent complications leading to permanent disabilities. First of all, this study showed the potential for clinical data extracted from electronic documentation with NOC outcomes in nursing research. This study supported the idea that this clinical data could be in fact used for various purposes such as nursing effectiveness studies.

The concepts of the most common NOC outcomes identified in this study were similar to the concepts of the key nursing sensitive outcomes used in ICU settings: Blood stream infection, ventilator - associated pneumonia, falls, pressure ulcers, pain, and education (Whitman et al., 2002). The NOC outcomes could be particularly more valuable than other

Table 3. Association between Changes in *Infection Severity* Scores and Nurse Staffing

	The change of *Infection Severity* score				
	Declined	No change	Improved	Total	
Nursing Caregiver Skill Mix					
Mean (SD)	0.90 (0.03)	0.88 (0.04)	0.90 (0.04)	0.89 (0.04)	F=3.50
[Range]	[0.83-0.97]	[0.75-0.97]	[0.80-0.97]	[0.75-0.97]	*p*=.033
Total (n, %)	27 (18.4%)	80 (54.4%)	40 (27.2%)	147 (100%)	

Table 4. Association between Changes in *Tissue Integrity: Skin and Mucous Membranes* Scores and Nurse Staffing

	The change of *Tissue Integrity: Skin and Mucous Membranes* score				
	Declined	No change	Improved	Total	
Nursing Caregiver Skill Mix					
Mean (SD)	0.88 (0.03)	0.88 (0.03)	0.88 (0.03)	0.88 (0.03)	F=3.38
[Range]	[0.80-0.94]	[0.79-0.97]	[0.79-0.95]	[0.79-0.97]	*p*=.683
Total (n, %)	27 (18.4%)	78 (54.4%)	28 (27.2%)	133 (100%)	

nursing sensitive outcomes because the NOC outcomes were more focused on the status of individual patients who received care while the outcomes used in previous studies were used as the incidence rates or prevalence rates of all patients or units.

Early rehabilitation care initiated in ICU settings is crucial to prevent and to treat ICU - acquired weakness due to bed rest and immobility (Rochester, 2009). Assessing *pain level*, *infection severity*, and wound/pressure ulcers is a basic step of the early rehabilitation care provided to ICU patients. Uncontrolled pain or infection may contribute to immobility and may make recovery difficult (Hu et al., 2010; Rochester, 2009). In addition, mal-treated wound/pressure ulcers may create permanent damage and deformities to the skin and tissues. Therefore, the three NOC outcomes (*Pain Level*, *Infection Severity*, and *Tissue Integrity: Skin and Mucous Membranes*) of this study could also be important outcomes related to the early rehabilitation care.

Prior studies have shown hat richer nursing staffing or a higher proportion of RN caregivers resulted in improved patient outcomes such as lower mortality rate, pressure ulcer rate and infection rate (Amaravadi et al., 2000; Dang et al., 2002; Hickey et al., 2010; Hugonnet et al., 2007). Particularly, the effect of nursing staffing on patient outcomes was highlighted even more in ICU settings because critical care nurses should detect the change in patient status early and provide nursing interventions promptly to critically ill patients (Dang et al., 2002). However, this study did not show the significant effect of skill mix of nursing caregivers on the change in three NOC outcome scores. In previous studies, above a 1:2 nursing staff to patient ratio was a predictor of poor patient outcomes. However, the overall nursing staffing of this hospital was richer than the ratio of nursing staff to patients in other studies. In this study, the nursing staff to patient ratio of the ICUs was below 1:2 and the proportion of RN hours in skill mix of nursing care givers was almost above 0.9. Therefore, the result didn't show a significant effect of nursing staffing on the NOC outcomes.

The patient factors profoundly influence the effect of the treatment or nursing care on patient outcomes. These factors are defined as risk factors and these risk factors should be adjusted before making presumptions about the effectiveness of care on patient outcomes (Iezzoni, 2003). Without considering these factors, the evaluations for the effectiveness of care are biased. Therefore, identifying the factors influencing the NOC outcomes would be useful in order to reveal the unique effect of nurse staffing on the nursing sensitive outcomes. Further research to identify risk factors on the change of NOC outcome scores could be conducted to identify the unique effectiveness of nurse staffing on NOC outcomes with additional data for other patient factors.

Limitation of this study

The ability to accurately rate NOC outcomes influences the psychometrics of NOC outcome measure. The reliability of NOC outcome measures is crucial to interpret and score labels and indicators in a reasonably consistent manner because ICU patients often move from general units to ICUs or from ICUs to other units. Several studies have tested the validity, reliability, and sensitivity of the NOC outcomes in several clinical settings: Adult care nurse practitioner (Keenan et al., 2003); community level (Head et al., 2004), tertiary care settings (Behrenbeck et al., 2005), and nursing homes (Schneider, Barkauskas, & Keenan, 2008). Moreover, few studies tested the psychometrics of several NOC outcomes used in ICU settings (Moorhead et al., 2004). However, there is still a lack of studies testing the reliability of common NOC outcomes used in ICU settings.

CONCLUSION

This study examined how nurse staffing (nursing caregiver skill mix) were associated with the 3 most common NOC outcomes used in ICU nursing care plans to provide useful information for the allocation of nursing staff and resources. These three NOC outcomes are useful for evaluating the early rehabilitation care in ICU. The results did not support that greater nurse staffing was associated with better patient outcomes in ICUs. However, the study was meaningful because the findings support the usefulness of a large clinical dataset including NOC outcomes in order to assess the effectiveness of nursing care. Further studies are needed to better understand the unique contribution of nurse staffing to the change of NOC scores in ICU units.

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