



HEALTH SYSTEMS

Evaluation of a Patient Care Delivery Model: Patient Outcomes in Acute Cardiac Care

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Abstract

Purpose: To evaluate the influence of nurse staffing and work environment variables on patient outcomes by testing a conceptual model.

Design: A prospective, correlational design with cross-sectional and longitudinal components was conducted in Canadian cardiac and cardiovascular care inpatient units.

Methods: Data were collected from multiple sources. Hierarchical linear modeling was used to examine relationships among variables.

Conclusions: The findings indicate that patient outcomes are influenced not only by patient and nurse characteristics, but also by organizational staffing practices. Organizations that manage the complexity of work conditions and target staffing utilization levels between 80% and 88% at the unit level can optimize patient outcomes.

Clinical Relevance: Empirical validation of the model provides evidence to inform management decisions about hospital nurse staffing.

As health systems evolve, the need to improve health-care service outcomes through the management of organizational factors that influence nurses' working conditions and work lives remains salient (Rafferty, Maben, West, & Robinson, 2005). Work environment factors and nurse staffing are closely linked to outcomes for patients, nurses, and organizations (Lankshear, Sheldon, & Maynard, 2005). A greater understanding of the complexity of work conditions and the effects of hospital nurse staffing at the unit level are essential to meet increased demand for cost and quality accountability in health care.

Guided by the Patient Care Delivery Model (PCDM), interrelationships between variables theorized to influence patient outcomes were examined. As part of a larger study by O'Brien-Pallas, Thomson, et al. (2004), this paper identifies key work factors related to patients, nurses, and units that influenced patient outcomes and provides

evidence-based standards for adjusted ranges of nurse staffing utilization levels for patients receiving cardiac and cardiovascular care in tertiary care hospitals. Patient outcomes included adverse medical consequences (e.g., fall with injury, mortality), physical and mental health, and patients' knowledge, behavior, and status. The findings will assist health system and nurse managers in developing staffing and work environment strategies to optimize productivity returns and minimize staffing costs, while ensuring quality outcomes.

Conceptual Model

The PCDM is based on Open System Theory, and its development and testing in hospital (O'Brien-Pallas, Irvine, Peereboom, & Murray, 1997) and community (O'Brien-Pallas et al., 2001, 2002) settings has been detailed

elsewhere (O'Brien-Pallas, Meyer, & Thomson, 2004). The overall purpose of the PCDM is to understand the relationships between outcomes and factors known to influence variability in nursing work; namely, the characteristics of patients and of nursing teams, as well as factors related to the care delivery environment (O'Brien-Pallas et al., 1997). In the PCDM, the hospital is conceptualized as an open system. Patients are nested hierarchically within and across nurses and units, and nurses are nested within units. The model emphasizes that inputs from the care delivery system (e.g., characteristics of patients, nurses, and the system, as well as system behaviors) and throughput factors (e.g., communication and coordination, environmental complexity, and nursing activities) cross the patient care subsystem boundaries. A transformation occurs as a consequence of interactions and processes among system substructures that result in outputs for the system and provide feedback for the entire system. A key intermediate output is the staffing utilization level of the unit, which represents the relationship between workload hours and worked hours. Typically, utilization levels do not exceed design capacity and effective capacity. Design capacity is the maximum output that can be attained under ideal conditions; this usually constitutes an unrealistic goal in real-life employment settings (Stevenson, 2009). Effective capacity is the maximum possible output given the patient mix, scheduling difficulties and breaks, technology in use, and quality factors (Stevenson). Effective capacity is expected to be less than design capacity because of the realities of the workplace, which may include changing patient mix, educational needs of staff, tech-

nology maintenance, scheduling limitations related to union contracts, and staff availability as well as balancing of operations. Distal outputs in the PCDM include patient, nurse, and system outcomes. **Figure 1** depicts the PCDM as it was conceptualized in this study to investigate patient outcomes.

The PCDM highlights that patient, nurse, work environment, and system factors interact interdependently and dynamically to influence outputs. A review of the research supporting these relationships is summarized elsewhere (Pearson et al., 2006). Patients enter the healthcare system with characteristics that contribute to their own outcomes. Variability in patient outcomes has been associated with demographic characteristics such as age (Estabrooks, Midodzi, Cummings, Ricker, & Giovannetti, 2005; Hu, Chow, Dao, Errett & Keith, 2006; Titler et al., 2006), education (Hu et al.), family support (Titler et al.), and income or employment levels (Allareddy & Konety, 2006; Hu et al.), as well as patients' pre-existing health characteristics, including increased comorbidity or severity of illness (Allareddy & Konety) and poor mental health status (de Jonge et al., 2001).

Nurse characteristics are also known to influence patient outcomes. For example, nurse experience and education have been positively related to clinical outcomes (McGillis Hall, Doran, & Pink, 2004; O'Brien-Pallas et al., 2002) and reduced 30-day mortality (Aiken, Clarke, Cheung, Sloane & Silber, 2003; Estabrooks et al., 2005; Tourangeau et al., 2007). Casual and temporary employment has also been associated with patient mortality (Estabrooks et al.).

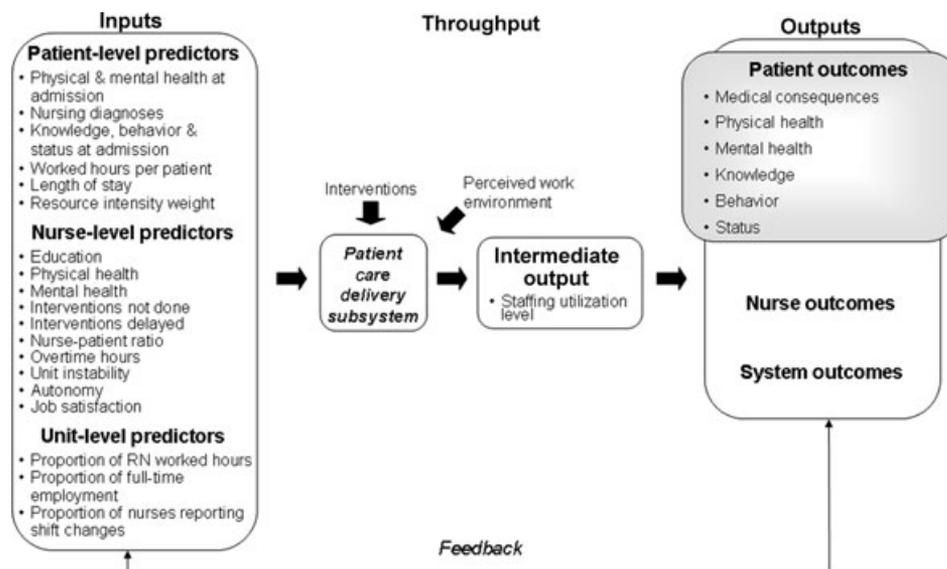


Figure 1. Patient Care Delivery Model.

Table 1. Key Measures and Data Sources

Measure	When administered	Source
SF-12 Health Status Survey ^a (physical and mental health status)	Admission or in preoperative clinic, discharge	Patient self-report
NANDA Nursing Diagnoses ^b and Omaha Problem Rating Scale ^c	Admission, discharge, daily to identify new or resolved diagnoses	Data collector from patient chart/kardex and nurse
Patient data form	Once over patient stay	Data collector from patient chart/kardex/interview
Resource intensity weight	After discharge	Electronic file submitted by Health Records Department
Nurse survey	Once at beginning of data collection	Nurse self-report
Daily unit staffing form	Daily	Data collector from unit assignment sheet and ward clerk (e.g., workload)

^aWare, Kosinski, and Keller (2000); ^bKim, McFarland, and McLane (1991); ^cMartin and Scheet (1992).

Patient outcomes may also be related to organizational characteristics and behaviors. Hospital-level analyses of work environment characteristics such as leadership, quality management, and collegial relationships have been associated with lower rates of patient mortality and failure to rescue (Aiken, Clarke, Sloane, Lake, & Cheney, 2008; Estabrooks et al., 2005; Kazanjian, Green, Wong, & Reid, 2005). Reviews of nurse staffing studies in the acute sector have found mixed support for the associations between indicators of staffing levels (e.g., hours per patient day, nurse-patient ratios, full-time equivalents) and patient outcomes such as mortality, failure to rescue, urinary tract infection, and patient satisfaction (Lang, Hodge, Olson, Romano, & Kravitz, 2004; Lankshear et al., 2005). However, most studies examine staffing indicators at the hospital level. Investigations of unit-level associations are needed to increase the accuracy of these estimates and to inform nursing service delivery at the point of care.

Understanding the factors that influence patient outcomes is important because of rising healthcare costs and the commitment to quality, timely, and safe care. The objectives of this study were to determine work environment and nurse staffing variables that influence patient outcomes and to identify the appropriate staffing levels for achieving positive patient outcomes.

Methodology

Design, Sites, and Participants

A prospective, correlational design with cross-sectional and longitudinal components was used to collect data (Table 1). Of six participating Canadian hospitals in Ontario and New Brunswick that met the inclusion criteria (i.e., high volumes of patients in the cardiac case mix

groups of interest), four were teaching hospitals. Cross-sectional data were collected either at the beginning of the study or when patients were discharged; repeated data, either daily or at two time points between admission and discharge, were collected during a 6-month data collection period between February and December 2002. Ethical approval was received from the University of Toronto and hospital sites. Patient and nurse consents were obtained on site.

To achieve a significance level of .001 and a moderate combined effect size, an estimated sample of 145 patients within each of the selected cardiac and cardiovascular Case Mix Groups was required to examine proposed relationships with high power (90%). Multiple data sources included hospital records, nurse surveys, daily unit data, and a patient data form filled out by nurses or data collectors. The Short Form Health Survey (SF-12) health status was reported by patients at admission or in the preoperative clinic and at discharge. Hospital size ranged from 121 to 1060 beds. In total, 1230 patients and 727 nurses from 24 units completed the data forms. Inter-rater reliability of all measures remained at 90% during orientation and throughout the study.

Measures

As shown in Table 1, patient variables were collected through the patient data form, patient self-report survey, patient interview, and medical chart. Nurse variables were collected through a one-time nurse survey. Unit-level data were collected through unit profiles (e.g., unit type, number of beds) or daily staffing forms. To measure the atmosphere or morale of a unit, some of the individual nurse measurements were aggregated to the unit level. Operational definitions of the variables are presented in Table 2.

Table 2. Operational Definitions of Predictors and Outcomes

Variable	Measure
A. Predictors	
Patient characteristics	
Gender	Male, female
Employment status	Employed, not employed, or retired
Education	High school diploma or less, postsecondary
Health service utilization	Family physician caregiver at home, referrals to homecare, attendance at preoperative or postoperative clinics
Medical diagnosis	Medical diagnosis responsible for the largest proportion of the length of stay (assigned at discharge using Case Mix Groups(tm) methodology; CMG) ^a
Age	Years
Knowledge	Ability of the patient to remember and interpret information for each nursing diagnosis on 5-point Omaha Problem Rating Scale ^b
Behavior	Observable responses, actions, or activities of the patient fitting the occasion or purpose for each nursing diagnosis on 5-point Omaha Problem Rating Scale ^b
Status	Condition of the patient in relation to signs and symptoms for each nursing diagnosis on 5-point Omaha Problem Rating Scale ^b
Physical and mental health	Medical Outcomes Study Form 12 ^{®c} ; a 12-item scale of physical functioning, vitality, role functioning, physical problems, social functioning, bodily pain, mental health, and general health perceptions
Nursing diagnoses	Number of North American Nursing Diagnoses Association (NANDA) ^d diagnoses
Worked hours per patient	Average of the unit daily worked hours of all staff divided by the midnight patient census over the patient's length of stay
Length of stay	Number of days hospitalized
Resource intensity weight	Relative values describing the expected resource consumption of the "average" patient within case mix, complexity, and age groups that were used to control for patient acuity levels
Nurse characteristics	
Education	Highest nursing educational credential
Employment status	Full-time, part-time, or casual status
Job instability	Any report of forced change to unit in past year, anticipated forced change of units in next year, or expected job loss within next year (yes vs. no)
Shift change	Report of more than one shift change in the past 2 weeks (vs. none)
Age	Years
Experience	Years worked
Physical and mental health	Medical Outcomes Study Form 12 ^{®c} ; a 12-item scale of physical functioning, vitality, role functioning, physical problems, social functioning, bodily pain, mental health, and general health perceptions
Nurse-patient ratio	Average daily number of patients cared for by a nurse on day shifts over the data collection period as recorded on a Daily Patient Assignment Form
Overtime	Nurse reports of overtime worked
Autonomy	Sum score of six autonomy items on a 4-point scale from the Revised Nursing Work Index (R-NWI) ^e
Job satisfaction	Mean score of five items on a 5-point scale for satisfaction with social contact, present job, interactions with management, amount of responsibility, and being a nurse (dissatisfied ≤ 3.5)
Interventions delayed	Any report of interventions delayed on the last shift for vital signs/medications/dressings, mobilization/turns, response to patient bell, or PRN medication (1 or more vs. none)
Interventions not done	Any report of interventions not done on the last shift for vital signs/medications/dressings, mobilization/turns, patient/family teaching, discharge prep, comforting/talking with patients, documenting nursing care, back rubs/skin care, oral hygiene, or care plan (1 or more vs. none)
Unit characteristics and behaviors	
Skill mix	Proportion of nursing hours contributed by registered nurses
% of full-time nurses	Proportion of nurses employed full-time
% of nurses reporting shift changes	Proportion of nurses reporting more than one change of shift in the previous 2 weeks
Staffing utilization level	At the unit level, workload hours divided by nurse worked hours multiplied by 100. Daily unit workload scores were computed using GRASP [®] , a standard time methodology, or Medicus [®] , a relative value methodology. Worked hours were measured as the daily number of paid hours (including paid breaks) worked by all nursing staff.

Continued.

Table 2. Continued

Variable	Measure
B. Outcomes	
Knowledge, behavior, and status change scores	Difference scores between admission/onset and discharge/resolution (improved over hospital stay versus no change or deteriorated)
Physical and mental health change scores	Difference scores between admission and discharge (improved at discharge vs. no change or deteriorated)
Medical consequences	Any report of death, medical errors with consequences, urinary tract infections, wound infections, pneumonia, falls with injury, bed sores, or thrombosis during hospital stay (1 or more vs. none)

^aCanadian Institute for Health Information (2008); ^bMartin and Scheet (1992); ^cWare, Kosinski, and Keller (2002); ^dKim, McFarland, and McLane (1991);

^eAiken and Patrician (2000).

As measured in this study, staffing utilization levels provide an index of how well the unit was staffed relative to patient needs for nursing care. The design capacity of a nursing unit was 100% (i.e., workload hours were equivalent to worked hours). Effective capacity was design capacity minus breaks and unanticipated events. In this study, 7% of the shifts consisted of paid mandatory breaks. Thus, the effective capacity value was 93%. Under ideal conditions, with no unanticipated events related to either the supply of nurses or the demand for care, staffing utilization levels of 93% would meet patient needs. However, under real conditions, both supply and demand conditions can change quickly. In this study, staffing utilization levels below 93% allowed sufficient flexibility to respond to changing situations and to deliver required care.

Analysis

Descriptive data were analyzed using SPSS version 15. Hierarchical linear modeling was conducted using MLwiN beta version 2.0 (Center for Multilevel Modelling, University of Bristol, Bristol, UK). Subscale scores were generated after exploratory factor analyses were performed and if alpha reliabilities for the subscales reached acceptable criteria (greater than 0.7). Because the data were hierarchical in nature, with patients mostly nested within units, and units nested within hospitals, hierarchical linear modeling was conducted to better account for the possible clustering of effects within units because survey responses from patients within units were likely to be affected by factors that are “fixed” for all staff in that unit (e.g., size and type of unit); that is, patients share a treatment environment. But some patients were cross-classified by nurses and units; that is, patients could be cared for by multiple nurses in the same unit or patients could change units during their hospital stay. To handle patients cared for by multiple nurses, the characteristics

of all care-giving nurses for each patient were disaggregated to the patient level as part of patient variables by weighting the nurse variables based on the number of days they provided care to the patient. To handle patients belonging to multiple units, the proportion of days in the unit out of their total length of stay was assigned as weights to each unit of their stay. Hospital could not be treated as a separate level in the modeling due to the small number of study hospitals ($N=6$). The predictors for the six patient outcomes were modeled with two-level hierarchical logistic regressions: patient and unit levels.

The effects of the PCDM variables that were theoretically important to the outcomes were assumed to be additive and were tested in hierarchical linear regression models. Patient characteristics (e.g., comorbidity, mental health status on admission) were included to control for the acuity or baseline status of patients. Revised Nursing Work Index subscales and unit variables aggregated from individual nurses were included in the final models if they were significantly associated with the outcome variables. Variables of importance in the PCDM were removed from the final model if found to be not significant in the preliminary analysis across patient models. Missing values were imputed using either regression imputation, cell mean imputation, or mean of nearby points (for daily data). In the end, 1198 of 1230 patients were included in the modeling.

The relationships between staffing utilization levels and patient outcomes were hypothesized to be nonlinear, with positive outcomes observed when unit staffing is adequate relative to patient needs for nursing care, but turning negative when units are understaffed. We hypothesized that as units become increasingly understaffed, nurses do not have adequate time to provide the nursing care patients require, thereby compromising patient outcomes. Several modeling strategies were used to examine the nonlinear relationship and to determine the staffing utilization levels at which patient outcomes begin

to deteriorate, including a curvilinear relationship and piece-wise regression.

Results

Sample Description

Sample characteristics are given in **Table 3**. Patients were housed in 24 cardiac and cardiovascular care units. Of these units, 11 were critical care, 2 were step-down units, 2 were day surgery units, and 9 were inpatient units; 20 were pure cardiology and 4 were either mixed units or intensive care units. Across units, the overall average staffing utilization level was 90% ($SD=27.1\%$) for the study period. On 60.4% of study days, staffing utilization levels reached 85%. On 46.2% of study days, the staffing utilization levels exceeded 93%, indicating that patient needs for nursing care exceeded the hours worked by nurses (i.e., effective capacity was surpassed). The proportion of full-time staff was 62% ($SD=18\%$), and 97% of nursing worked hours were contributed RNs.

Patients were relatively older and mostly male. Length of stay averaged 6.4 days, with a mean resource intensity weight (RIW) of 2.8 (± 2.66) that was higher than the Ontario acute care inpatient average of 1.38 (Ministry of Health and Long-Term Care, 2002). The number of nursing diagnoses averaged 4.5, with the highest values observed in critical care units. Medical consequences occurred infrequently (6.1% of patients). Patient health was poor at admission, with 87% and 49.2% of patients scoring below the U.S. population average for physical and mental health, respectively. However, nearly half of patients had improved physical and mental health scores at discharge. General improvement of patients in Omaha Scale knowledge (55.7%), behavior (43.1%), and status (78%) scores was also observed at discharge.

Nurses in the study were predominantly female (93.9%) and RNs (96.6%); relative to the general nursing workforce in Ontario, they were younger (40.7 ± 8.21) with similar years of experience (16.5 ± 8.87 ; Ontario average of 44 years in age and 17 years of experience in 2002; College of Nurses of Ontario, 2002). Four tenths of nurses held a bachelor's or higher degree and were in relative good health. On average, nurses cared for 2.3 patients a day. The work conditions were stressful, as reflected by overtime hours, anticipated or forced change in their work unit, frequent change of shift, and number of tasks not done or delayed. On average, more than half of nurses were dissatisfied with work, primarily with opportunities to interact with management (45.5%), followed by amount of responsibility (23.6%).

Multivariate Results

Regression coefficient estimates and odds ratios from the hierarchical logistic regression models for the patient outcomes are presented in **Tables 4** and **5**.

Medical Consequences. Medical consequences were more likely to be experienced by acute care cardiac patients with higher numbers of nursing diagnoses and lower mental health scores. Medical consequences were 52% more likely to occur for each additional nursing diagnosis and 13% more likely for each additional hour of care given. For each one unit increase in SF-12 mental health scores at admission, patients were 2% less likely to suffer a medical consequence. Patients with poor health were at increased risk for adverse medical consequences. Increased hours of care may have reflected the time needed to care for patients suffering medical consequences. Staffing variables, including staffing utilization level, were not statistically significant.

Physical health. For every additional nursing diagnosis, the odds of improvement in patient physical health at discharge decreased by 11%. Physical health was also less likely to improve if patients consumed relatively higher resources, that is, among patients with higher acuity levels. As staffing utilization levels exceeded 80%, the odds of improvement in physical health decreased by 45%. The relationship between staffing utilization levels and physical health is illustrated in **Figure 2**. Nurse overtime also negatively impacted physical health. Improvements in physical health at discharge were 7% less likely for each additional hour of nurse overtime.

Mental health. Improvements in patient mental health at discharge were more likely when patients scored higher in physical health status at admission, but were less likely when patients stayed longer in the hospital. Patient mental health was also less likely to improve if patients had better mental status at baseline, suggesting that patients with higher scores at admission were less likely to show improvements at discharge. There was a negative relationship between increased worked hours per patient and improved mental health, probably because patients with deteriorated mental health consumed more hours of nursing care. Staffing variables, including staffing utilization levels, were not statistically significant.

Omaha scale knowledge, behavior, and status. Again, ceiling effects were suggested whereby patients with higher Omaha scores at admission were less likely to show improvements at discharge. After controlling for baseline patient physical and mental health and Omaha scores, patients were more likely to have gained knowledge about their health conditions when cared for by nurses who reported higher autonomy in their jobs.

Table 3. Sample Characteristics

A. Predictors in hierarchical linear models	%	Mean	SD
Patient characteristics (N=1230)			
Gender: male	66.7		
Employment status			
Employed	48.9		
Not employed	11.7		
Retired	39.4		
Postsecondary education	41.9		
Have a family physician	95.2		
With a potential caregiver at home	82.0		
Was a planned admission	44.5		
Most common CMG: percutaneous transluminal coronary angioplasty	13.5		
Surgical patients attended preoperative clinic	33.0		
Surgical patients received postoperative education	57.5		
Age (years)		63.5	13.01
Omaha score at time 1: knowledge (range 1–5)		3.4	0.75
Omaha score at time 1: behavior (range 1–5)		4.0	0.58
Omaha score at time 1: status (range 1–5)		3.3	0.62
Physical health at admission (% above U.S. general population/mean/SD)	13.0	35.2	11.20
Mental health at admission (% above U.S. general population/mean/SD)	50.8	48.2	11.00
Number of nursing diagnoses (range 1–18)		4.5	2.37
Worked hours per patient		9.2	4.18
Length of stay		6.4	7.88
Resource intensity weight		2.8	2.66
Nurse characteristics (N=727)			
Education: Bachelor's degree or higher	42.3		
Employment: full-time	59.8		
Unit instability (forced/anticipated unit change or expected job loss)	20.9		
Change shift more than once in a 2-week period	32.4		
Age (years)		40.7	8.21
Years of working experience in nursing		16.5	8.78
Physical health (% above U.S. female population/mean/SD)	65.2	50.1	8.50
Mental health (% above U.S. female population/mean/SD)	50.8	47.3	10.40
Nurse-patient ratio		2.3	1.43
Overtime hours per week		2.8	6.11
Autonomy (range 8–24)		16.1	3.18
Dissatisfaction with current job	57.5		
No. of intervention tasks not done (range 0–9) % at least one/mean/SD	74.6	2.1	1.84
No. of interventions tasks delayed (range 0–4) % at least one/mean/SD	60.4	1.1	1.13
Unit characteristics (N=24)			
Skill mix (% of RN worked hours)		96.9	7.90
Proportion of full-time nurses		0.62	0.18
Proportion of nurses reporting shift changes		0.58	0.12
Staffing utilization level (%)		86.6	16.78
B. Patient outcomes n=1230			
Improved Omaha scores from admission to discharge			
Knowledge scores	55.7		
Behavior scores	43.1		
Status scores	78.0		
Improved health score from admission to discharge			
Physical health	41.1		
Mental health	42.3		
Medical consequences	6.1		

Table 4. Results of Hierarchical Linear Models for Medical Consequences and for Physical and Mental Health

Predictor	Medical consequences		Physical health		Mental health	
	Regression coefficient	Odds ratio	Regression coefficient	Odds ratio	Regression coefficient	Odds ratio
Patient level						
Patient characteristics						
Physical health at admission	-0.01	0.99	-0.13*	0.88*	0.01*	1.01*
Mental health at admission	-0.03*	0.98*	0.00	1.00	-0.09*	0.92*
Number of nursing diagnoses	0.42*	1.52*	-0.12*	0.89*	-0.06	0.94
Worked hours per patient	0.10*	1.11*	0.00	1.00	-0.06*	0.94*
Length of stay	0.02	1.02	0.01	1.01	-0.04*	0.96*
Resource intensity weight	0.03	1.03	-0.10*	0.90*	-0.01	0.99
Nurse characteristics						
Education (ref: diploma)	0.22	1.25	0.11	1.11	0.05	1.05
Physical health	0.03	1.03	-0.01	1.00	0.01	1.01
Mental health	-0.05	0.95	-0.01	0.99	0.01	1.01
Interventions not done	-0.54	0.58	0.08	1.08	0.27	1.32
Interventions delayed	-0.73	0.48	-0.02	0.98	-0.10	0.91
Nurse-patient ratio	0.30	1.35	0.05	1.05	-0.14	0.87
Overtime hours	-0.02	0.98	-0.08*	0.93*	0.04	1.04
Unit level						
Proportion of RN worked hours ^a	4.69	1.60	-0.94	0.91	0.53	1.05
Staffing utilization levels (beyond 80%) ^{b,c}			-0.60*	0.55*		
Staffing utilization levels (beyond 85%) ^{b,c}	-0.48	0.62			0.30	1.35
Staffing utilization levels (beyond 88%) ^{b,c}						

Note. * $p \leq .05$. ^aOdds ratios based on a 10% increase. ^bUsed proportion to model. ^cA curvilinear relationship was tested by including both linear and quadratic terms for staffing utilization levels. If both terms were significant at 5% level, the effect of staffing utilization levels on the outcome variable reversed after reaching the cut point. If the U-shape effect was not supported, piecewise linear regression was modeled next using a linear term and dummy variable with a predetermined cut-off point value (e.g., 80%, 85%). A statistically significant dummy term indicated that the direction of the relationship between staffing utilization levels and the patient outcome changed and the term was therefore retained in the final model. If both strategies failed, a dichotomized staffing utilization level at various cut points was tested. If all these failed, a dichotomized staffing utilization level at 85% was included in the model. We tested the statistical significance of dichotomized staffing utilization levels at 80%, 85%, or 88% for three respective models presented in this table.

Several other unit attributes were significantly associated with patient knowledge. Improved Omaha Scale knowledge scores at discharge were 74% more likely for every 10% increase in RN worked hours on the unit and 24% more likely for every 10% increase in full-time nurses on the unit. Knowledge scores were 44% less likely to improve for every 10% increase in nurses on the unit with more than one shift change in the past 2 weeks. Improvements in patient Omaha Scale behavior scores at discharge related to their nursing diagnoses were positively related to nurses' job satisfaction and job security. Patients were 176% more likely to have improved behavior scores when nurses were satisfied with their work. Patients were 53% less likely to exhibit improved behavior when nurses experienced or anticipated a forced change in work units.

Relationships were also observed between staffing utilization levels and the Omaha Scale outcomes. In piecewise regression, the linear relationship between staffing

utilization levels and improved Omaha Scale knowledge and status changed direction at a value of 88%. A curvilinear relationship with a cut-point of 88% was also observed between staffing utilization levels and Omaha Scale behavior scores. These results indicated that patient knowledge, status, and behavior scores were more likely to decrease as staffing utilization levels exceeded 88%.

Discussion

This study tested the PCDM using additive regression models. Consistent with previous research (McGillis Hall et al., 2004), patient characteristics influenced nursing care requirements and the extent to which positive clinical outcomes were achieved. In our study, patients' pre-existing levels of physical and mental health and their nursing complexity (as reflected by nursing diagnoses) influenced the extent to which medical consequences were experienced and physical and mental health were

Table 5. Results of Hierarchical Linear Models for Knowledge, Behavior, and Status

Predictor	Omaha knowledge		Omaha behavior		Omaha status	
	Regression coefficient	Odds ratio	Regression coefficient	Odds ratio	Regression coefficient	Odds ratio
Patient level						
Patient characteristics						
Physical health at admission	0.01	1.01	0.01	1.01	0.01	1.01
Mental health at admission	0.00	1.00	0.00	1.00	0.00	1.00
Number of nursing diagnoses	0.05	1.05	0.06	1.07	0.08	1.08
Knowledge at admission	-1.33*	0.26*				
Behavior at admission			-2.14*	0.12*		
Status at admission					-1.48*	0.23*
Worked hours per patient	0.04	1.04	-0.02	0.98	0.00	1.00
Length of stay	0.01	1.01	-0.01	0.99	0.00	1.00
Resource intensity weight	0.01	1.01	0.08	1.08	0.05	1.05
Nurse characteristics						
Education (ref: diploma)	-0.29	0.75	-0.08	0.92	0.10	1.10
Physical health	-0.02	0.98	-0.01	0.99	-0.02	0.98
Mental health	-0.01	0.99	-0.01	0.99	0.02	1.02
Interventions not done	-0.47	0.62	0.03	1.03	-0.27	0.76
Interventions delayed	0.10	1.11	-0.01	0.99	-0.42	0.66
Nurse-patient ratio	0.11	1.11	-0.03	0.97	0.16	1.17
Overtime hours	0.02	1.02	-0.03	0.97	0.02	1.02
Unit instability			-0.75*	0.47*		
Autonomy	0.17*	1.19*				
Satisfaction with current job (ref: dissatisfied)			1.02*	2.76*		
Unit level						
Proportion of RN worked hours ^a	5.55*	1.74*	0.42	1.04	2.06	1.23
Proportion of full-time employment ^a	2.13*	1.24*				
Proportion of nurses reporting shift changes ^a	-5.75*	0.56*				
Staffing utilization levels ^b	7.40* ^c	n/a*	17.83* ^d	n/a*	4.94* ^c	n/a*
Staffing utilization levels (Quadratic) ^b			-10.11* ^d	n/a*		
Staffing utilization levels (beyond 88%) ^b	-1.49* ^c	n/a*			-.80* ^c	n/a*

Note. * $p \leq .05$. ^aOdds ratios based on a 10% increase. ^bUsed proportion to model and same modeling strategies as outlined in notes in Table 4. ^cPiecewise regression was modeled for Omaha Knowledge and Status models (with both linear and dummy terms). ^dA curvilinear relationship was tested for Omaha Behavior model by including both linear and quadratic staffing utilization level terms. Cut point was 88.2%.

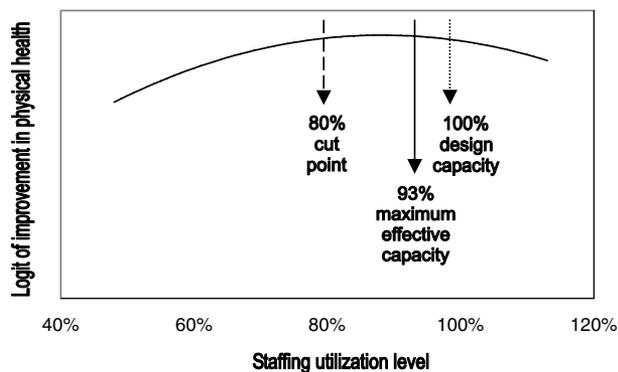


Figure 2. Example of curvilinear relationship between staffing utilization levels and physical health.

improved at discharge. Although hospitals have limited control over the characteristics and health needs of admitted patients, administrators are able to address staffing issues that are associated with clinical outcomes. For example, given that medical consequences required additional hours of nursing care, organizations that invest in structures and staffing to minimize adverse events may not only improve patient safety, but may also decrease costs (Thungjaroenkul, Cummings, & Embleton, 2007).

Reducing overtime hours worked by nurses and adequately staffing nursing units are key strategies for improving clinical outcomes. As nurses worked more overtime, patient health was less likely to improve. Our finding is consistent with hospital level studies that have observed the detrimental influence of overtime on

mortality (Berney & Needleman, 2006), infections, decubitus ulcers (Stone et al., 2007), errors and near errors (Rogers et al., 2004), and medical incidents (O'Brien-Pallas, Tomblin Murphy, et al., 2004). Although economists have theorized the effects of overtime on productivity and scheduling, conceptual models are needed to understand how mechanisms such as fatigue link overtime to patient outcomes (Thomson, 2004).

Patients cared for on units that were understaffed relative to patients' needs for nursing care were more likely to experience declines in their physical health and their knowledge, status, and behaviors related to their health condition. Staffing utilization levels of 80% for physical health and 88% for knowledge, status, and health behaviors were below the effective capacity value of 93%. This suggests that nursing units require surge capacity in their staffing levels to intervene in patients' care trajectories and to coach patients in understanding and managing their health conditions. For example, if a cardiac patient exhibited activity intolerance related to insufficient oxygenation for activities of daily living, the nurse would assist the patient in modifying his behaviors to progress an activity gradually, to engage in energy conservation methods, and to stop an activity if fatigue or signs of cardiac hypoxia were present. As our study units became increasingly understaffed, nurses had inadequate time for this type of care or were unable to speed up their work and still maintain the effectiveness of nursing interventions. This study extends research on hospital level staffing indicators to the unit level and is consistent with previous studies. For instance, higher proportions of regulated nursing staff at the unit level were associated with improved physical functioning of patients (McGillis Hall et al., 2003).

Organizational hiring and staffing practices at the unit level can also influence outcomes. By employing higher proportions of nurses in full-time positions, by reducing the frequency of shift changes, and by increasing the relative proportion of RN worked hours, organizations can improve patients' knowledge about their conditions at discharge. Continuity of the caregiver is posited to enhance clinical outcomes by fostering nurses' knowledge about patients as well as nurses' influence on clinical and workplace decisions (Grinspun, 2002). When more nurses on a unit work full time and change shifts less often, patients may experience greater continuity of care provider and hence more planned and responsive teaching by nurses. Less fatigue and greater opportunity to establish therapeutic relationships with patients may allow nurses to better assess patient readiness for learning and to provide more individualized teaching interventions. Care fragmentation, in the form of patient movement across multiple units, has been associated with re-

duced rates of teaching and discharge planning by nurses (Kanak et al., 2008). Our findings suggest that care fragmentation within units (i.e., lower levels of full-time nurses, frequent shift changes) may also have a detrimental influence on patients' knowledge of their health conditions. Consistent with previous research (Thungjaroenkul et al., 2007), staffing with greater RN worked hours ensured that patients received care skilled in therapeutic relationships and teaching methods.

Inconsistent associations between nurse autonomy and patient outcomes such as reduced mortality, failure to rescue, urinary tract infections, and pressure ulcers have been documented (Boyle, 2004; Kazanjian et al., 2005). Our study showed that enhancing nurses' job autonomy can improve clinical outcomes related to patient knowledge of their medical and nursing conditions. Better conceptualization of the clinical, organizational, and professional dimensions of nurse autonomy is needed to theorize the associated influences on patient outcomes (Tranmer, 2004) and to reconcile conflicting findings.

Offering secure employment and managerial support are strategies employers can consider to foster improved clinical outcomes. Although job insecurity and insufficient supervisory support have been frequently linked to poor nurse outcomes (e.g., Hall, 2007; Verhaeghe, Vlerick, Gemmel, Van Maele, & De Backer, 2006), this study extends the association to clinical outcomes. Improvement in patient health behaviors was less likely when nurses were preoccupied with forced or anticipated changes in work group membership or when nurses were dissatisfied with their job, primarily because of inadequate interaction with managers. Health workers who perceive unstable work environments have reported higher exhaustion and lower job satisfaction and work engagement (Mauno, Kinnunen, Makikangas, & Natti, 2005). We surmise that when unit stability was threatened or job dissatisfaction was high, nurses in this study may have become less engaged in their work.

Conclusions

This study adds to a growing body of evidence that improvements in patient outcomes are influenced by multiple and interrelated staffing and work environment factors. The results of this study suggest that nurses' work performance is enhanced when staffing practices related to job security and satisfaction, nurse autonomy, overtime, shift changes, and RN and full-time staffing complements are appropriate. Further, adequate staffing of units to achieve staffing utilization levels of 80% to 88% also leads to better outcomes for cardiac patients. Units staffed at or beyond effective capacity must urgently

address staffing levels to implement acceptable standards. Patient outcomes are a key measure of the effectiveness of nursing care; however, nurses need supportive working conditions to enable high quality patient care.

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Clinical Resources

- The Omaha System. <http://www.omahasystem.org>
- Short Form Health Survey (SF-12). <http://www.sf-36.org/tools/sf12.shtml>

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