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Résumé

Évaluation d'un modèle de prestation des soins : résultats systémiques en soins cardiaques actifs

Linda O'Brien-Pallas, X. Mingyang Li, Sping Wang, Raquel M. Meyer, Donna Thomson

Nous avons recouru à la modélisation linéaire hiérarchique afin d'évaluer, à partir de données recueillies auprès de services hospitaliers de cardiologie, l'incidence sur les résultats systémiques de la dotation en personnel infirmier, du milieu de travail et de variables relatives aux infirmières et aux patients. Une utilisation inférieure à 80 % de l'effectif du service et un moindre recours aux heures supplémentaires accroissent au maximum la perception de la qualité des soins et l'exécution des interventions thérapeutiques. Un ratio infirmière/patients peu élevé améliore la perception de la qualité des soins tout en réduisant les séjours prolongés imprévus. Une dotation jugée adéquate par le personnel infirmier est associée à une diminution de l'absentéisme et du nombre d'interventions infirmières inachevées ou remises à plus tard. Les résultats systémiques sont également tributaires des caractéristiques de la clientèle (état de santé, éducation préopératoire, diagnostics infirmiers), des caractéristiques du personnel infirmier (expérience, expertise, état de santé, déséquilibre effort-récompense) et des facteurs associés au milieu de travail (autonomie, instabilité au sein du service).

Mots clés : dotation en personnel infirmier, milieu de travail, qualité des soins, absentéisme, interventions infirmières

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

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Hierarchical linear modelling was used to evaluate the influence of nurse staffing, work environment, and nurse and patient variables on system outcomes based on data collected in Canadian cardiac and cardiovascular inpatient units. Staffing utilization levels below 80% at the unit level and less overtime optimized perceived care quality and the completion of therapeutic interventions. Fewer patients per nurse improved perceived care quality and reduced longer-than-expected length of stay. Nurse reports of greater resource adequacy were associated with less absenteeism and fewer uncompleted or delayed nursing interventions. System outcomes were also influenced by patient characteristics (health, pre-operative education, nursing diagnoses); nurse characteristics (experience, expertise, health, effort-reward imbalance); and work-environment factors (autonomy, unit instability).

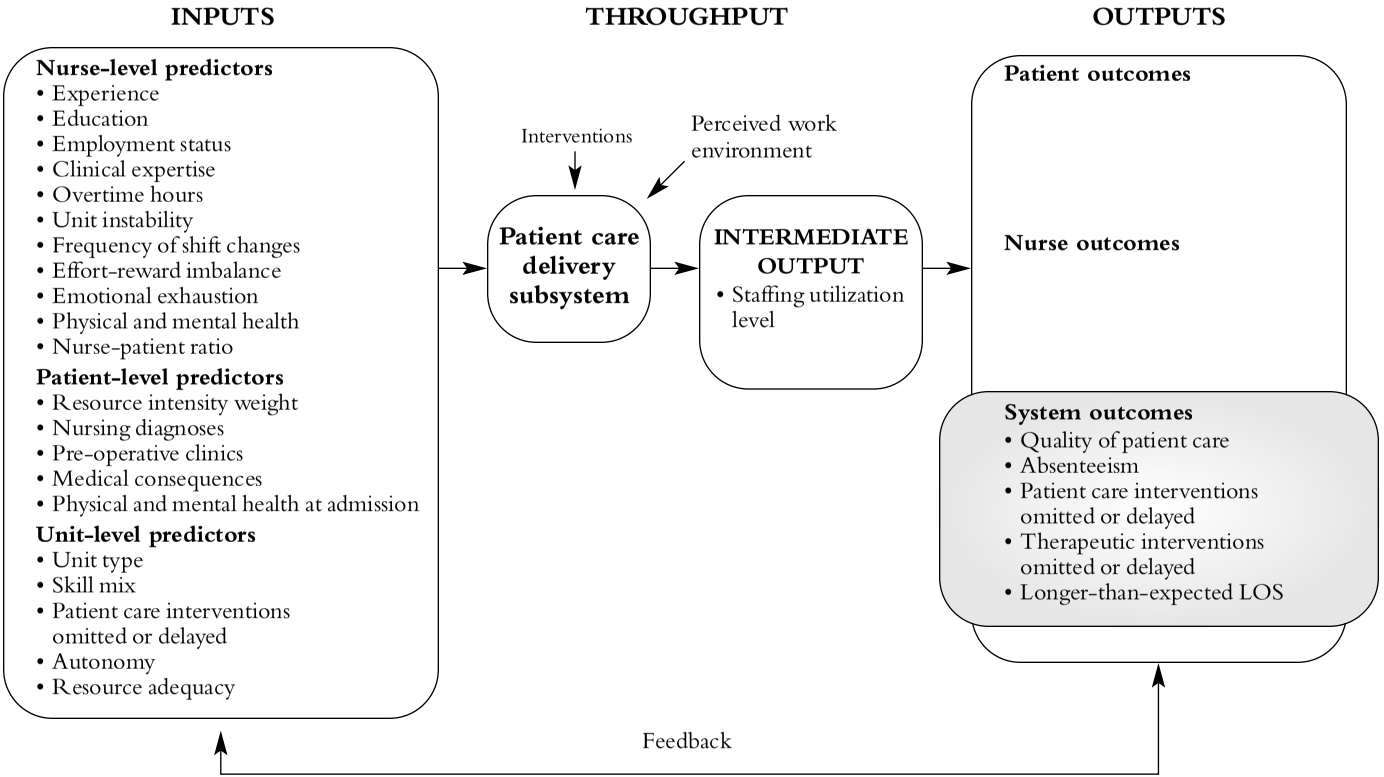
Keywords: nurse staffing, work environments, quality of care, absenteeism, nursing interventions, length of stay

Introduction

The management of organizational factors is key not only to establishing effective working conditions and worklives for nurses, but also to improving health-care outcomes (Rafferty, Maben, West, & Robinson, 2005). Work-environment factors and nurse staffing are closely linked to outcomes for patients, nurses, and the system (Lankshear, Sheldon, & Maynard, 2005). A better understanding of complex relationships among these factors is essential to meet the increased demand for cost and quality accountability in health care.

Guided by the Patient Care Delivery Model (PCDM), O'Brien-Pallas, Thomson, et al. (2004) examined the interrelationships between variables theorized to influence system outcomes. In this article we identify key patient and nurse characteristics. We also identify nursing-unit factors that influenced system outcomes and provide evidence-based optimal nurse staffing utilization levels for better outcomes of cardiac and cardiovascular care in tertiary-care hospitals. System outcomes included quality of patient care, nurse absenteeism, patient care and therapeutic interventions omitted (or not completed) or delayed, and length of stay (LOS).

Figure 1 *Conceptual Framework*



Conceptual Model

The PCDM is based on Open System Theory. Its development (Meyer & O'Brien-Pallas, 2010; O'Brien, Meyer, Hayes, & Wang, in press) and testing in hospital (Meyer, Wang, Li, Thomson, & O'Brien-Pallas, 2009; O'Brien-Pallas, Irvine, Peereboom, & Murray, 1997; O'Brien-Pallas, Meyer, & Thomson., 2004) and community (O'Brien-Pallas et al., 2001, 2002) settings are detailed elsewhere. In the PCDM, the hospital is conceptualized as an open system and inputs to the care-delivery system (i.e., characteristics of patients, nursing teams, and the system as well as system behaviours) and throughput factors (e.g., nursing interventions, work environment, and environmental complexity) cross the boundaries of the patient care subsystem to influence distal outputs (i.e., patient, nurse, and system outcomes). The inputs are transformed through nursing work processes and structures at the unit level, which in turn generates outputs and provide feedback for the entire system. A key intermediate output in the PCDM is the staffing utilization level of the unit, which indicates how well a unit is staffed relative to patient needs for nursing care. Figure 1 depicts the conceptual framework that guided this study of system outcomes.

In the PCDM, patient, nurse, work-environment, and system factors interact interdependently and dynamically to influence system outputs such as the quality of patient care, nurse absenteeism, nursing interventions, and LOS. Empirical and theoretical reviews of these relationships are detailed elsewhere (Davey, Cummings, Newburn-Cook, & Lo, 2009; O'Brien-Pallas et al., in press; Pearson et al., 2006). In terms of patient characteristics, age, gender, and education have been associated with system outcomes such as quality of patient care, nurse absenteeism, and nursing interventions (Ganova-Iolovska, Kalinov, & Geraedts, 2009; Gellatly, 1995; Palnum et al., 2009); however, these relationships have been inconsistent (Thoroddsen & Thorsteinsson, 2002; Vinson et al., 2007). Patient health conditions also affect system outcomes. Increased patient acuity has been associated with suboptimal care (Massey, Aitken, & Chaboyer, 2009). Nursing diagnoses remain a strong predictor of LOS in hospital and in intensive care units as well as of costs (Thoroddsen & Thorsteinsson, 2002; Welton & Halloran, 2005).

System outcomes also vary in relation to nurse characteristics. The quality of patient care has been associated with nurse education (Tomey, 2009; Wu & Lee, 2006), employment status (Estabrooks, Midodzi, Cummings, Ricker, & Giovannetti, 2005; Wu & Lee, 2006), and age (Wu & Lee, 2006). Relationships have been observed between nurse absenteeism and lower job satisfaction, longer shifts, working in acute care, and

working full time (Zboril-Benson, 2002) as well as between shorter LOS and higher nursing education (Kutney-Lee & Aiken, 2008).

Organizational characteristics and behaviours in acute-care settings may also influence system outcomes. Labour and material resources are conceptualized as influencing missed care (Kalisch, Landstrom, & Williams, 2009). Absenteeism and care quality have also been associated with throughput factors reflective of nursing work environments, including leadership, management style, communication, autonomy, and role ambiguity (Kalisch et al., 2009; Nyathi & Jooste, 2008; Tomey, 2009). Objective staffing indicators (e.g., hours per patient day, nurse-patient ratios) have been associated with system outcomes such as absenteeism (Nyathi & Jooste, 2008; Unruh, Joseph, & Strickland, 2007), quality of patient care (Aiken, Clarke, & Sloane, 2002; Tomey, 2009), LOS (Padilha, de Sousa, Queijo, Mendes, & Reis Miranda, 2008), and cost (Thungjaroenkul, Cummings, & Embleton, 2007). However, the predominance of analyses at the hospital level rather than at the nursing-unit level have limited researchers' understanding of optimal staffing practices at the unit level and have restricted administrators' ability to modify inputs and throughputs to improve nursing at the point of care. In our study, staffing utilization levels were used as an alternative staffing indicator to measure how well a nursing unit was staffed (i.e., worked hours) relative to patient needs for nursing care (i.e., workload hours). Inadequate staffing utilization levels have been associated with poor patient outcomes, including decline in physical health, as well as inpatient knowledge, behaviour, and symptoms related to nursing diagnoses (Meyer et al., 2009). In this article we report on the relationships between staffing utilization levels and system outcomes.

An understanding of the factors that influence system outcomes is essential in the face of rising health-care costs and accountability for care quality. The objectives of the study were to (1) determine the work environment and nurse staffing variables at the nursing-unit level that influence system outcomes, and (2) identify optimal staffing levels for achieving positive system outcomes.

Methodology

Design, Data, and Measures

A prospective, correlational design with cross-sectional and longitudinal components was used to collect data. Of six participating hospitals in the Canadian provinces of Ontario and New Brunswick that met the inclusion criteria (i.e., high patient volumes in the cardiac Case Mix Group of interest), four were teaching hospitals. Cardiac and cardiovascular units that group patients with similar diagnoses were targeted in order to opti-

mize sample size and homogeneity. Hospital size ranged from 121 to 1,060 beds. The multiple data sources included hospital records, unit profiles, nurse surveys, daily unit data, and a patient-data form filled out by nurses or data collectors. Nurse survey data were collected at the beginning of the study. Repeated data, either daily or at two time points between admission and discharge, were collected during a 6-month period in 2002. In total, 1,230 patients and 727 staff nurses from 24 units completed the data forms; of these, only 1,198 patients and 555 nurses were included in the final modelling because of missing values. The study was approved by university and hospital ethics review boards.

In addition, some individual nurse measurements were aggregated to the unit level to measure the atmosphere or morale of a unit. This included the Revised Nursing Work Index (R-NWI) resource adequacy subscale, which provides a subjective measure of nurse staffing based on the aggregate score of nurses' ratings of resources present in the workplace. Operational definitions of the variables are presented in Table 1.

Analysis

Because the data were hierarchical in nature, with patients and nurses mostly nested within units and units nested within hospitals, hierarchical linear modelling was conducted at two levels (patient/nurse and unit), using MLwin version 2.11, to better account for the possible clustering of effects within units.

The effects of the PCDM variables that were theoretically important to the outcomes were assumed to be additive. For patient-level outcomes, patient characteristics (e.g., resource intensity weight, nursing diagnoses, medical consequences, health status on admission) were included to control for patient acuity or baseline status. For nurse-level outcomes, nurse characteristics (e.g., education, employment status, health status) were included as control variables. Only the statistically significant R-NWI subscales and unit variables aggregated from individual nurses were retained in the final models. The characteristics of patients (e.g., resource intensity weight, nursing diagnoses) cared for by each nurse were aggregated and treated as nurse-level variables to control for the work environment relative to patients assigned to each nurse. Variables of importance in the PCDM but not statistically significant in the preliminary analysis were not used in the final models.

The staffing utilization level was calculated daily at the unit level as the total GRASP/Medicus workload hours divided by the total worked hours, multiplied by 100 to obtain a percent value. The higher the percent value, the more the unit was understaffed relative to patient needs for nursing care (i.e., the fewer the worked hours relative to workload

Table 1 *Operational Definitions of Predictors and Outcomes*

Predictors	Variable	Measure [*Source*]
Patient Level	Health-service utilization	Attendance at pre-operative or post-operative clinics and so on [*patient interview*]
	Physical and mental health	Medical Outcomes Study Form 12,®[a] a 12-item scale of physical functioning, vitality, role functioning, physical problems, social functioning, bodily pain, mental health and general health perceptions [*patient interview*]
	Nursing diagnoses	Number of North American Nursing Diagnoses Association[b] diagnoses [*patient chart, Kardex, or nurse*]
	Resource intensity weight	Relative values describing the expected resource consumption of the "average" patient within Case Mix,[c] complexity, and age groups that were used to control for patient acuity levels [*Health Records Department*]
	Medical consequences	Report of death, medical errors with consequences, urinary tract infections, wound infections, pneumonia, falls with injury, bed sores or thrombosis during hospital stay (one or more vs. none) [*patient data form*]
Nurse Level	Experience	Years worked as a nurse [*nurse survey*]
	Education	Highest nursing credential (degree vs. diploma) [*nurse survey*]
	Employment status	Full-time versus part-time or casual status [*nurse survey*]

	Clinical expertise	Being a preceptor for another nurse, providing clinical advice [*nurse survey*]
	Overtime	Number of overtime hours worked per week, whether voluntary/involuntary, paid/unpaid [*nurse survey*]
	Unit instability	Any report of forced change to unit in past year, anticipated forced change of units in next year or expected job less within next year (yes vs. no) [*nurse survey*]
	Shift change	Report of more than one shift change in the past 2 weeks (vs. none) [*nurse survey*]
	Effort-reward imbalance	Effort-Reward Imbalance Scale,[d] a 17-item scale identifying the imbalance between high effort spent and low reward received at work; dichotomized as > 1 at risk versus ≤ 1 not at risk [*nurse survey*]
	Emotional exhaustion	Maslach Burnout Inventory,[e] a 25-item scale measuring emotional exhaustion, depersonalization, and personal accomplishment. Only the emotional exhaustion scores for nurses were included; dichotomized as at risk (score > 27) versus not at risk (score ≤ 27). [*nurse survey*]
	Physical and mental health	SF12[a] [*nurse survey*]
	Nurse-patient ratio	Average number of patients cared for daily by a nurse on day shift over the data-collection period [*Daily Patient Assignment Form*]

Continued on next page

Table 1 *(cont'd)*

Predictors	Variable	Measure [*Source*]
Unit Level	Unit type	Step down versus other unit types (inpatient, day surgery, CCU) [*data collector*]
	Skill mix	Proportion of nursing hours contributed by RN [*Daily Unit Staffing Form*]
	Patient care interventions omitted or delayed	Average number of patient care interventions (vital signs/medications/ dressings, mobilization or turns, PRN pain medications, back rubs and skin care, oral hygiene) omitted or delayed in the last shift at the unit level [*nurse survey*]
	Autonomy and resource adequacy	Autonomy is the sum score of six autonomy items and resource adequacy is the sum score of four resource items from the R-NWI.[f] The unit average score was used as a unit-level predictor. [*nurse survey*]
	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 [PRN Daily Workload and Grasp Patient Care Hours]. Worked hours was measured as the daily number of paid hours (including paid breaks) worked by all nursing staff. [*Daily Unit Staffing Form*]

System Outcomes	LOS	Longer than expected [*Health Records Department*][c]
	Patient care interventions omitted or delayed	At least one patient care intervention (vital signs/medications/ dressings,mobilization or turns, PRN pain medications, back rubs and skin care, oral hygiene) omitted or delayed in the last shift [*nurse survey*]
	Therapeutic interventions omitted or delayed	At least one therapeutic intervention (teaching patients and families, preparing patient and family for discharge, comforting/talking with patients, documenting nursing care) omitted or delayed in the last shift [*nurse survey*]
	Nurse absenteeism	Number of missed-work occasions due to illness and disability in the past year; dichotomized as one or more sick leaves versus none [*nurse survey*]
	Quality of patient care	Quality of patient care in the unit in the past year; dichotomized as improvement versus others [*nurse survey*]

[a] Ware, Kosinski, and Keller (2002).
[b] Kim, McFarland, and McLane (1991).
[c] Canadian Institute for Health Information (2009).
[d] Siegrist (1996).
[e] Maslach and Jackson (1982).
[f] Aiken and Patrician (2000).

hours). Generally, utilization levels should not exceed design capacity and effective capacity. Design capacity is the maximum output that can be attained under ideal conditions with workload hours equivalent to worked hours (i.e., 100%); this usually constitutes an unrealistic goal in actual work settings (Stevenson, 2009). Effective capacity is expected to be less than design capacity and is the maximum possible output given the patient mix, scheduling difficulties and breaks, technology in use, and quality factors (Stevenson, 2009). In our study, effective capacity was 93%, to account for paid mandatory breaks (7% of the shift duration), which were embedded in worked hours. It was hypothesized that the relationships between staffing utilization levels and system outcomes were non-linear (where positive outcomes are observed when unit staffing is adequate relative to patient needs for nursing care, but these turn negative when units are understaffed — that is, as units become increasingly understaffed, nurses do not have adequate time to provide the care that patients require, thereby compromising system outcomes). Several modelling strategies were used to examine the non-linear relationship and to determine the cut-off point — the staffing utilization level at which system outcomes begin to deteriorate, including a curvilinear relationship, piece-wise regression, and indicators at predetermined cut-off points.

Results

Sample

Of the 24 cardiac and cardiovascular care units, 11 were critical care, 9 were inpatient, and the remainder were step-down or day-surgery units; 20 were pure cardiology and 4 were either mixed units or intensive care units. Nearly 60% of nurses were employed full time, with registered nurses (RNs) contributing 97% of nursing worked hours (Table 2). Across units, the overall daily average staffing utilization level was 90% (*SD* = 27.1%) for the study period. On 60% of study days, staffing utilization levels reached 85%. On 46% of study days, staffing utilization levels exceeded 93%, indicating that patient needs for nursing care exceeded the hours worked by nurses (i.e., effective capacity was surpassed).

Patients were elderly and mostly male. The average LOS was 6.4 days and 26.6% of patients stayed longer than expected. The number of nursing diagnoses, which averaged 4.5, was highest on critical-care units. Patient health at admission was poor, with 87% and 49.2% of patients scoring below the US population averages for physical and mental health, respectively.

Table 2 *Characteristics of Sample*

Predictors in Hierarchical Linear Models	**%**	***Mean***	***SD***
***Patient Level* (*N* = 1,230)**			
Surgical patients attended pre-operative clinic	33		
Physical health at admission (range = 4.04–76.36, % above US general population/*mean*/*SD*)	13	35.2	11.2
Mental health at admission (range = -3.41–79.48, % above US general population/*mean*/*SD*)	50.8	48.2	11
Number of nursing diagnoses (range = 1–18)		4.5	2.37
Resource intensity weight		2.8	2.66
Medical consequences	6.1		
***Nurse Level* (*N* = 727)**			
Years of work experience in nursing		16.5	8.78
Education: university degree	42.3		
Employment: full time	59.8		
Clinical expertise (range = 1–4)		2.9	0.61
Overtime hours per week		2.8	6.11
Unit instability (forced/anticipated unit change or lose job)	20.9		
Change shift more than once in a 2-week period	32.4		
Effort-reward imbalance (range = 0.5–2)		0.7	0.25
Emotional exhaustion (range = 9–54)		22.6	10.27
Physical health (range = 4.04–76.36; % above US female population/*mean*/*SD*)	65.2	50.1	8.5
Mental health (range = -3.41–79.48; % above US female population/*mean*/*SD*)	50.8	47.3	10.4
Nurse-patient ratio		2.3	1.43

Continued on next page

Table 2 *(cont'd)*

Predictors in Hierarchical Linear Models	**%**	***Mean***	***SD***
***Unit Level* (N = 24)**			
Unit type: step-down unit	8.33		
Skill mix (% of RN worked hours)		96.9	7.9
Average number of patient care interventions omitted or delayed		1.6	0.66
Average autonomy score (range = 6–24)		16.1	1.4
Average resource adequacy score (range = 4–16)		9.54	1.54
Staffing utilization level (%)		86.6	16.78
System Outcomes			
***Patient Level* (n = 1,198)**			
Longer-than-expected LOS	26.6		
***Nurse Level* (n = 555)**			
Quality of patient care (excellent/good vs. fair/poor)	60.4		
Nurse absenteeism (one or more sick leave vs. none)	79.8		
Patient care interventions omitted or delayed (at least one vs. none)	68.8		
Therapeutic interventions omitted or delayed (at least one vs. none)	58.5		

Nurses were predominantly female (93.9%) and RNs (96.6%). They were in relatively good health. Four tenths of nurses held a university degree. On average, nurses cared for 2.3 patients a day. About one in seven nurses (13.4%) rated the nursing quality as fair/poor and four in ten (41.9%) indicated that the quality of patient care had deteriorated over the past year. When faced with insufficient time, nurses generally omitted nursing interventions (as opposed to physician-dependent interventions). Interventions that were omitted (or not completed) or delayed included, for patient care, vital signs/medications/dressings (37.3%), back/skin care (31.4%), mobilization/turns (30.5%), oral hygiene (28.7%), and PRN pain medications (16.6%); for therapeutic care, comforting/talking (38.6%), patient/family teaching (23.3%), documentation (22.6%), and preparing patients and families for discharge (11.4%). In total, nurses missed 1,768 work occasions in the past year, with each occasion averaging 2.4 shifts. Although 16.4% of nurses were never absent, frequency of missed occasions ranged from one to two (42.9%), three to four (25.2%), and greater than four (15.5%). Physical health (71.4%) was the major reason for nurse absenteeism; mental health (5.4%) and injury (4.8%) were minor reasons.

Multivariate Results

Regression coefficient estimates and odds ratios from the hierarchical logistic regression models for the system outcomes are presented in Table 3.

Quality of patient care over the past year. Nurses who rated themselves as expert clinicians or who reported more overtime hours were less likely to perceive improved patient care. Improvement in the quality of care was 64% less likely when staffing utilization levels exceeded 79%, 22% less likely for each additional patient cared for by nurses, 70% less likely for every additional patient care intervention omitted or delayed per nurse on the unit, and 50% less likely when nurses experienced effort-reward imbalances. Improved care was more likely to be reported by experienced nurses and was 43% more likely for every one-point increase in the average unit autonomy rating.

Nurse absenteeism. Full-time nurses were nearly twice as likely as part-time and casual nurses to miss work. Absenteeism was 2% less likely when nurses scored one point higher on physical health status, 22% less likely when nurses reported unit instability, and 23% less likely for every one-point increase in the average resource adequacy score on the unit.

Patient care interventions omitted or delayed at the last shift. Full-time nurses were 60% more likely than part-time and casual nurses to report patient care interventions omitted or delayed. The likelihood of omitted or delayed patient care interventions declined by 3% for every additional

Table 3 *Results of Hierarchical Linear Models for Quality of Patient Care, Nurse Absenteeism, Interventions Omitted or Delayed, and Longer-Than-Expected LOS*

	Good/ Excellent Quality of Patient Care		Absenteeism		Patient Care Interventions Omitted or Delayed		Therapeutic Interventions Omitted or Delayed		Longer-Than-Expected LOS	
Predictor	**Co-efficient**	**Odds Ratio**	**Co-efficient**	**Odds Ratio**	**Co-efficient**	**Odds Ratio**	**Co-efficient**	**Odds Ratio**	**Co-efficient**	**Odds Ratio**
Nurse Level										
Years of work experience in nursing	0.026★	1.03★	-0.01	0.99	-0.03★	1★	0.018	0		
Education (ref: diploma)	0.094	1.1	0.022	1.02	0.112	1.1	0.179	1.2	-0.312	0.73
Full-time employment (ref: part-time/casual)	-0.38	0.68	0.989★	2.69★	0.473★	1.6★	0.217	1.2		
Clinical expertise	-0.41★	0.67★	-0.04	0.96	-0.07	0.9	-0.05	1	0.322	1.38
Overtime hours	-0.04★	0.96★	0.011	1.01	0.029	1	0.029★	1★		
Unit instability	0.181	1.2	-0.25★	0.78★	-0.1	0.9	-0.14	0.9		
Shift change	-0.35	0.71	0.218	1.24	0.016	1	-0.12	0.9		
Effort-reward imbalance	-0.86★	0.42★	-0.06	0.94	0.613	1.9	0.943★	2.6★		
Emotional exhaustion	-0.03	0.97	-0.13	0.88	0.021	1	0.062	1.1		
Physical health	0.007	1.01	-0.05★	0.95★	-0.01	1	-0.03★	1★	0.017	1.02
Mental health	0.022	1.02	-0.02	0.98	-0.04★	1★	-0.03★	1★	-0.019	0.98
Nurse-patient ratio	-0.25★	0.78★	-0.09	0.91	-0.03	1	0.173	1.2	0.303★	1.35★

Patient Level										
Resource intensity weight	0.015	1.02	0.017	1.02	0.031	1	0.021	1	0.273★	1.31★
Number of nursing diagnoses	0.105	1.11	0.077	1.08	-0	1	-0.04	1	0.119★	1.13★
Pre-operative clinics									-0.907★	0.4★
Medical consequences									0.726★	2.07★
Physical health at admission									-0.017★	0.98★
Mental health at admission									-0.009	0.99
Unit Level										
Step-down unit (ref: other types)	0.805	2.24	-1.01	0.36	-1.16	0.3	-0.7	0.5		
Skill mix (proportion of RN worked hours)[a]	-1.98	0.82	-0.95	0.91	-0.1	1	-1.32	0.9	1.193	1.13
Average number of patient care interventions omitted or delayed	-1.2★	0.3★								
Average autonomy score	0.36★	1.43★								
Average resource adequacy score			-0.26★	0.77★	-0.48★	0.6★	-0.44★	0.6★		
Staffing utilization (beyond 85%)[b, c]			0.188	1.21	0.02	1			0.159	1.17
Staffing utilization (beyond 79%)[b, c]	-1.02★	0.36★								
Staffing utilization (beyond 76%)[b, c]							0.688★	2★		

[a] Odds ratios based on a 10% increase.
[b] Used proportion to model.
[c] A dichotomized staffing utilization level at various cut-off points was tested. If all of these failed, a dichotomized staffing level at 85% was included in the model.
★ $p \leq 0.05$. All outcome measures were dichotomized.

year of nursing experience, by 4% for every one-point increase in nurse mental health score, and by 38% for every one-point increase in average unit resource adequacy scores.

Therapeutic interventions omitted or delayed on the last shift. The likelihood of omitted or delayed therapeutic interventions increased by 3% for every 1-hour increment in overtime, by 99% when staffing utilization levels exceeded 76%, and by 157% when nurses were at risk of effort-reward imbalance. The likelihood of omitted or delayed therapeutic interventions decreased by 3% for every one-point increase in nurse mental or physical health scores and by 36% for every one-point increase in the average unit resource adequacy score.

Longer-than-expected LOS. Patients with higher resource intensity weights, reflecting a higher degree of medical acuity, were more likely to have longer-than-expected LOS. Longer-than-expected LOS was 107% more likely when patients experienced medical consequences, 13% more likely for each additional nursing diagnosis, and 35% more likely for each additional patient cared for by nurses. Longer-than-expected LOS was 2% less likely when patients' physical health status scores were one point higher at admission and 60% less likely for patients who had attended a pre-operative clinic.

Discussion

The health-care sector, like many other sectors, is facing budgetary restraints in response to a global recession. When cutbacks occur, nursing services are targeted for cost savings because these large cost centres account for significant expenditures. The findings of this study suggest that when units are staffed inadequately and nurses are over-utilized, system outcomes deteriorate. Cutting nursing budgets may not be the answer. The findings indicate that staffing resources are associated with improved system outcomes. Yet with each round of budget cuts, this downward spiral continues. The purpose of the PCDM is to determine how outcomes vary relative to the delivery of nursing services at the unit level. In this study, inadequate staffing was not effective for patient outcomes (Meyer et al., 2009) or for hospitals. We will now discuss the influence of inputs and throughputs (including staffing) on system outcomes and the implications for the management of nursing services.

The study used both objective and subjective staffing measures and was consistent with previous research linking low staffing with low quality and safety concerns. In terms of objective staffing indicators, as staffing utilization levels exceeded 79% for quality of patient care and 76% for missed therapeutic nursing interventions, system outcomes declined. This suggests that as the study units became increasingly under-

staffed, nurses had inadequate time to ensure good-quality care or were unable to speed up their work to complete necessary nursing interventions. Overtime was also negatively associated with perceived care quality, and, for each additional patient per nurse, good or excellent care was 22% less likely and longer-than-expected LOS was 35% more likely. These findings corroborate previous findings on the association between higher nurse-patient ratios and lower nurse ratings of quality (Al-Kandari & Thomas, 2009; Cho et al., 2009; Sochalski, 2004). Similarly, the participants' subjective perceptions of greater resource adequacy were associated with improved patient care, less missed care, and less absenteeism. The finding of a negative relationship between absenteeism and resource adequacy, which is consistent with the finding reported by Unruh et al. (2007), indicates that low staffing may contribute to unit absenteeism, which further lowers staffing and may create a vicious circle. Policy formulation and planning strategies to address understaffing and the lack of labour and material resources are therefore likely to improve system outcomes.

In addition to the positive impacts of adequate staffing, hospital administrators need to give high priority to providing an environment that fosters nurse autonomy and good health as well as a balance between efforts and rewards. Consistent with other research (Kane, Shamliyan, Mueller, Duval, & Wilt, 2007; Murphy, 2007), the present study found that patient care stands to improve when nurses report more autonomy and less effort-reward imbalance and that nursing interventions may be completed when nurses report higher levels of physical and mental health and are less stressed by inadequate rewards for efforts expended.

Kalisch et al. (2009) warn that the safety of hospitalized patients may be jeopardized by missed nursing care or errors of omission. The present study found that nurse characteristics such as experience, good mental or physical health, and perceived effort-reward balance lower the likelihood of missed patient and therapeutic care. Therefore, retaining experienced nurses, promoting a healthy workforce, and recognizing and rewarding staff excellence are valuable human resource strategies for fostering patient safety; these strategies have also been cited as tenets of magnet hospitals and as central to healthy work environments (Aiken & Patrician, 2000; Laschinger, Almost, & Tuer-Hodes, 2003).

The study also found that full-time nurses were more likely than their part-time and casual counterparts to report omitted/uncompleted or delayed patient care interventions and to be absent from work. Kalisch and Begeny (2005) note that full-time staff take on the burden of ensuring care continuity in the face of shifting team composition. We surmise that, for this reason, full-time nurses in the present study had less time to complete patient care interventions such as vital signs, medications, dress-

ings, mobilization or turns, PRN pain medications, back rubs and skin care, and oral hygiene. In addition, the full-time nurses had much higher rates of absenteeism, similar to Zboril-Benson's (2002) findings. Management strategies sensitive to the coordination burden placed on full-time staff and to the unrelenting pace of full-time schedules may enable full-time staff to participate more effectively in the workplace.

The system outcome of patient LOS has been studied in the context of different organizational settings, with implications for resource use and medical costs in relation to nurse staffing (e.g., Thungjaroenkul et al., 2007). Findings on the relationship between nurse staffing and actual LOS have been mixed, with either an inverse relationship or no relationship reported. In some instances this may be partially explained by the fact that the actual LOS does not evaluate the adequacy of the length of admission — that is, shorter LOS may not result from better care or lead to cost savings. Deviations from an expected LOS based on Case Mix Group and age group (Canadian Institute for Health Information, 2009) used in this study provide a better measure of the relationship between patient days on the unit and other unit characteristics, such as nurse staffing. Tschannen and Kalisch (2009) indicate that higher numbers of nursing staff resulted in patients being discharged sooner than expected based on Diagnosis Related Groups. Similarly, the present study found that a higher nurse-patient ratio may reduce the likelihood of longer-than-expected LOS.

The findings support the use of pre-operative education, over and above standard care, to reduce longer-than-expected LOS. Cardiac patients who attended a pre-operative clinic were less likely to have longer-than-expected LOS. In contrast to this finding, a systematic review of pre-operative education for hip or knee replacement concluded that LOS is unaffected by pre-operative education (McDonald, Hetrick, & Green, 2004). The difference could be attributable to the fact that longer-than-expected LOS was modelled in the present study, while actual LOS was used in that study. The finding of a significant (60%) reduction in the likelihood of longer-than-expected LOS suggests that pre-operative education may either shorten recovery or expedite the discharge process once patients can be safely sent home.

Conclusion

Several important conclusions emerge from this study. Although hospitals have limited control over patient characteristics and health status, administrators can manage staffing and work-environment factors that impact system outcomes. Adequate nurse staffing and organizational support for nursing are key to improving system outcomes. All system

outcomes in this study were negatively influenced by inadequate nurse staffing, as reflected by either objective (i.e., staffing utilization levels, nurse-patient ratios, overtime) or subjective (i.e., nurse perceptions of resource adequacy) staffing indicators. Understaffing of nursing units ought to be immediately addressed to ensure effective delivery of nursing care and to reduce costly outcomes. Organizational support that attends not only to nurses' health and work autonomy but also to expert and experienced nurses' perceptions of care quality and workflow may be important to designing management interventions to improve care quality, reduce nurse absenteeism, and ensure the completion of nursing interventions. Further studies that assess the influence of workload and other aspects of the work environment on care quality are warranted. This study has demonstrated that system outcomes for cardiac and cardiovascular nursing units are influenced by many interrelated factors and that conceptual models such as the PCDM can be used to evaluate and improve health-system outcomes.

References

Aiken, L. H., Clarke, S. P., & Sloane, D. M. (2002). Hospital staffing, organization, and quality of care: Cross-national findings. *Nursing Outlook, 50*(5), 187–194.

Aiken, L. H., & Patrician, P. (2000). Measuring organizational traits of hospitals: The Revised Nursing Work Index. *Nursing Research, 49*(3), 146–153.

Al-Kandari, F., & Thomas, D. (2009). Perceived adverse patient outcomes correlated to nurses' workload in medical and surgical wards of selected hospitals in Kuwait. *Journal of Clinical Nursing, 18*(4), 581–590.

Canadian Institute for Health Information. (2009). *DAD resource intensity weights and expected length of stay.* Ottawa: Author.

Cho, S., June, K. J., Kim, Y. M., Cho, Y. A., Yoo, C. S., Yun, S., et al. (2009). Nurse staffing, quality of nursing care and nurse job outcomes in intensive care units. *Journal of Clinical Nursing, 18*(12), 1729–1737.

Davey, M. M., Cummings, G., Newburn-Cook, C. V., & Lo, E. A. (2009). Predictors of nurse absenteeism in hospitals: A systematic review. *Journal of Nursing Management, 17*(3), 312–330.

Estabrooks, C. A., Midodzi, W. K., Cummings, G. G., Ricker, K. L., & Giovannetti, P. (2005). The impact of hospital nursing characteristics on 30-day mortality. *Nursing Research, 54*(2), 74–84.

Ganova-Iolovska, M., Kalinov, K., & Geraedts, M. (2009). Quality of care of patients with acute myocardial infarction in Bulgaria: A cross-sectional study. *BMC Health Services Research, 9,* 15.

Gellatly, I. (1995). Individual and group determinants of employee absenteeism: Test of a causal model. *Journal of Organizational Behavior, 16,* 469–485.

Kalisch, B. J., & Begeny, S. M. (2005). Improving nursing unit teamwork. *Journal of Nursing Administration, 35*(12), 550–556.

Kalisch, B. J., Landstrom, G., & Williams, R. A. (2009). Missed nursing care: Errors of omission. *Nursing Outlook, 57*(1), 3–9.

Kane, R. L., Shamliyan, T., Mueller, C., Duval, S., & Wilt, T. (2007). *Nursing staffing and quality of patient care.* Evidence Report/Technology Assessment 151. AHRQ Publication 07-E005. Rockville, MD: Agency for Healthcare Research and Quality.

Kim, M. J., McFarland, G. K., & McLane, A. M. (1991). *Pocket guide to nursing diagnoses* (4th ed.). St. Louis: Mosby.

Kutney-Lee, A., & Aiken, L. H. (2008). Effect of nurse staffing and education on the outcomes of surgical patients with comorbid serious mental illness. *Psychiatric Services, 59*(12), 1466–1469.

Lankshear, A. J., Sheldon, T. A., & Maynard, A. (2005). Nurse staffing and healthcare outcomes: A systematic review of the international research evidence. *Advances in Nursing Science, 28*(2), 163–174.

Laschinger, H. K., Almost, J., & Tuer-Hodes, D. (2003). Workplace empowerment and magnet hospital characteristics: Making the link. *Journal of Nursing Administration, 33*(7–8), 410–422.

Maslach, C., & Jackson, S. E. (1982). Burnout in health professions: A social psychological analysis. In G. S. Snaders & J. Suls (Eds.), *Social psychology of health and illness* (pp. 227–251). Hillsdale, NJ: Lawrence Erlbaum.

Massey, D., Aitken, L. M., & Chaboyer, W. (2009). What factors influence suboptimal ward care in the acutely ill ward patient? *Intensive and Critical Care Nursing, 25*(4), 169–180.

McDonald, S., Hetrick, S., & Green, S. (2004). Pre-operative education for hip or knee replacement. *Cochrane Database of Systematic Reviews, 1*, CD003526.

Meyer, R. M., & O'Brien-Pallas, L. (2010). Nursing Services Delivery Theory: An open system approach. *Journal of Advanced Nursing, 66*(12), 2828–2838.

Meyer, R. M., Wang, S., Li, X., Thomson, D., & O'Brien-Pallas, L. (2009). Evaluation of a patient care delivery model: Patient outcomes in acute cardiac care. *Journal of Nursing Scholarship, 41*(4), 399–410.

Murphy, K. (2007). Nurses' perceptions of quality and the factors that affect quality care for older people living in long-term care settings in Ireland. *Journal of Clinical Nursing, 16*(5), 873–884.

Nyathi, M., & Jooste, K. (2008). Working conditions that contribute to absenteeism among nurses in a provincial hospital in the Limpopo Province. *Curationis, 31*(1), 28–37.

O'Brien-Pallas, L., Doran, D. I., Murray, M., Cockerill, R., Sidani, S., Laurie-Shaw, B., et al. (2001). Evaluation of a client care delivery model. Part 1: Variability in nursing utilization in community home nursing. *Nursing Economics, 19*(6), 267–276.

O'Brien-Pallas, L., Doran, D. I., Murray, M., Cockerill, R., Sidani, S., Laurie-Shaw, B., et al. (2002). Evaluation of a client care delivery model. Part 2: Variability in client outcomes in community home nursing. *Nursing Economics, 20*(1), 13–21.

O'Brien-Pallas, L. L., Irvine, D., Peereboom, E., & Murray, M. (1997). Measuring nursing workload: Understanding variability. *Nursing Economics, 15*(4), 172–182.

O'Brien-Pallas, L., Meyer, R. M., Hayes, L., & Wang, S. (in press). The Patient Care Delivery Model — an open system framework: Conceptualization, literature review and analytical strategy. *Journal of Clinical Nursing.*

O'Brien-Pallas, L., Meyer, R., & Thomson, D. (2004). Workload and productivity. In L. McGillis Hall (Ed.), *Quality work environments for nurse and patient safety* (pp. 105–138). Sudbury, MA: Jones & Bartlett.

O'Brien-Pallas, L., Thomson, D., McGillis Hall, L., Pink, G., Kerr, M., Wang, S., et al. (2004). *Evidence based standards for measuring nurse staffing and performance.* Final report. Toronto: Canadian Health Services Research Foundation.

Padilha, K. G., de Sousa, R. M., Queijo, A. F., Mendes, A. M., & Reis Miranda, D. (2008). Nursing activities score in the intensive care unit: Analysis of the related factors. *Intensive and Critical Care Nursing, 24*(3), 197–204.

Palnum, K. D., Andersen, G., Ingeman, A., Krog, B. R., Bartels, P., & Johnsen, S. P. (2009). Sex-related differences in quality of care and short-term mortality among patients with acute stroke in Denmark: A nationwide follow-up study. *Stroke, 40*(4), 1134–1139.

Pearson, A., O'Brien-Pallas, L., Thomson, D., Doucette, E., Tucker, D., Wiechula, R., et al. (2006). Systematic review of evidence on the impact of nursing workload and staffing on establishing healthy work environments. *International Journal of Evidence-Based Healthcare, 4*(4), 337–384.

Rafferty, A. M., Maben, J., West, E., & Robinson, D. (2005). *What makes a good employer?* Geneva: International Council of Nurses.

Siegrist, J. (1966). Adverse health effects of high-effort/low-rewards conditions. *Journal of Occupational Health Psychology, 1*(1), 27–41.

Sochalski, J. (2004). Is more better? The relationship between nurse staffing and the quality of nursing care in hospitals. *Medical Care, 42*(2 Suppl), II67–II73.

Stevenson, W. J. (2009). *Operations management* (10th ed.). New York: McGraw-Hill/Irwin.

Thoroddsen, A., & Thorsteinsson, H. S. (2002). Nursing diagnosis taxonomy across the Atlantic Ocean: Congruence between nurses' charting and the NANDA taxonomy. *Journal of Advanced Nursing, 37*(4), 372–381.

Thungjaroenkul, P., Cummings, G. G., & Embleton, A. (2007). The impact of nurse staffing on hospital costs and length of stay: A systematic review. *Nursing Economics, 25*(5), 255–265.

Tomey, A. M. (2009). Nursing leadership and management affects work environments. *Journal of Nursing Management, 17*(1), 15–25.

Tschannen, D., & Kalisch, B. J. (2009). The effect of variations in nurse staffing on patient length of stay in the acute care setting. *Western Journal of Nursing Research, 31*(2), 153–170.

Unruh, L., Joseph, L., & Strickland, M. (2007). Nurse absenteeism and workload: Negative effect on restraint use, incident reports and mortality. *Journal of Advanced Nursing, 60*(6), 673–681.

Vinson, D. R., Magid, D. J., Brand, D. W., Masoudi, F. A., Ho, P. M., Lyons, E. E., et al. (2007). Patient sex and quality of ED care for patients with myocardial infarction. *American Journal of Emergency Medicine, 25*(9), 996–1003.

Ware, J. E. Jr., Kosinski, M., & Keller, A. D. (2002). *SF-12®: How to score the SF-12® physical and mental health summary scales* (4th ed.). Lincoln, RI: QualityMetric Incorporated.

Welton, J. M., & Halloran, E. J. (2005). Nursing diagnoses, diagnosis-related group, and hospital outcomes. *Journal of Nursing Administration, 35*(12), 541–549.

Wu, S. H., & Lee, J. L. (2006). A comparison study of nursing care quality in different working status nursing staffs: An example of one local hospital. *Journal of Nursing Research, 14*(3), 181–189.

Zboril-Benson, L. R. (2002). Why nurses are calling in sick: The impact of health-care restructuring. *Canadian Journal of Nursing Research, 33*(4), 89–107.

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