JAN ORIGINAL RESEARCH

Impact of hospital nursing care on 30-day mortality for acute medical patients

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Abstract

Title. Impact of hospital nursing care on 30-day mortality for acute medical patients

Aim. This paper reports on structures and processes of hospital care influencing 30-day mortality for acute medical patients.

Background. Wide variation in risk-adjusted 30-day hospital mortality rates for acute medical patients indicates that hospital structures and processes of care affect patient death. Because nurses provide the majority of care to hospitalized patients, we propose that structures and processes of nursing care have an impact on patient death or survival.

Method. A model hypothesizing the impact of nursing-related hospital care structures and processes on 30-day mortality was tested. Patient data from the Ontario, Canada Discharge Abstract Database 2002–2003, nurse data from the Ontario Nurse Survey 2003, and hospital staffing data from the Ontario Hospital Reporting System 2002–2003 files were used to develop indicators for variables hypothesized to impact 30-day mortality. Two multiple regression models were implemented to test the model. First, all variables were forced to enter the model simultaneously. Second, backward regression was implemented.

Findings. Using backward regression, 45% of variance in risk-adjusted 30-day mortality rates was explained by eight predictors. Lower 30-day mortality rates were associated with hospitals that had a higher percentage of Registered Nurse staff, a higher percentage of baccalaureate-prepared nurses, a lower dose or amount of all categories of nursing staff per weighted patient case, higher nurse-reported adequacy of staffing and resources, higher use of care maps or protocols to guide patient care, higher nurse-reported care quality, lower nurse-reported adequacy of manager ability and support, and higher nurse burnout.

Conclusion. Just as hospitals and clinicians caring for patients focus carefully on completing accurate diagnosis and appropriate and effective interventions, so too should hospitals carefully plan and manage structures and processes of care such as the proportion of Registered Nurses in the staff mix, percentage of baccalaureate-prepared nurses, and routine use of care maps to minimize unnecessary patient death.

Keywords: care maps, care protocols, hospital structures, mortality rates, nurse staffing, quality of care, questionnaire survey, secondary data analysis

Introduction

Wide variation in risk and case mix adjusted hospital mortality rates for homogeneous patient populations indicates that some hospitals are able to provide patient care in such a way as to avoid unnecessary patient death (Tourangeau & Tu 2003). There are three known sources of variation in outcomes such as mortality: patients' own characteristics, structures and processes of care, and random variation (Silber *et al.* 1995). Of these, patients' own characteristics have been shown to have the greatest impact (Silber & Rosenbaum 1997). Once the impact of patients' own characteristics have been controlled using effective risk adjustment strategies, the impact of hospital structures and processes of care on patient death can be examined. In this paper, we report on those structures and processes of hospital care found to impact 30-day mortality rates for acute medical patients. Our findings may be useful globally to develop strategies that manage nursing care structures and processes to minimize unnecessary patient death for acute medical patients.

Background

An electronic search using MEDLINE and CINAHL databases between 1986 and 2004 was conducted to retrieve literature related to the impact of nursing structures and processes of hospital care on patient mortality. Detailed results of this search are documented elsewhere (Tourangeau *et al.* 2006a). One additional study report published in 2005 was added to our integrated review. A synthesis of 16 published research reports exploring nursing-related correlates of mortality after acute care hospitalization yielded five categories of correlates: nurse staffing, nurse–physician relationships, nurse characteristics, clinical nursing support, and the nursing practice environment (Tourangeau *et al.* 2006a).

The most consistently explored nursing-related determinant of hospital mortality rates was nurse staffing, both staff mix and nurse staffing dose (total amount of all categories of nursing personnel per some patient output measure). Some studies included indicators of both. However, moderately strong relationships have been found between indicators of nursing staff mix and nursing staff dose (Tourangeau *et al.* 2002). Since 1989, there has been strong evidence that a nursing staff mix richer with Registered Nurses is related to lower hospital mortality rates (Hartz *et al.* 1989, Farley & Ozminkowski 1992, Manheim *et al.* 1992, Schultz 1997, Aiken *et al.* 2002, Needleman *et al.* 2002, Tourangeau *et al.* 2002, Estabrooks *et al.* 2005). Shortell and Hughes (1988) and Shortell *et al.* (1994) did not find evidence of this relationship. There is less evidence supporting a relationship between nurse staffing dose and hospital mortality rates. Blegen *et al.* (1998) found a positive relationship between the total amount of nurse staffing and hospital mortality, indicating that as the total amount of nursing staff increased so did mortality rates. Sasichay-Akkadechanunt *et al.* (2003) found a negative relationship between the total amount of nursing staff and mortality in 17 medical and surgical units in Thailand.

One of the earliest studied nursing-related categories of factors impacting hospital mortality rates was that of nurse–physician relationships. An association has been reported between nurse-reported adequacy of relationships with physicians and hospital mortality rates in three North American studies (Knaus *et al.* 1986, Mitchell *et al.* 1989, Estabrooks *et al.* 2005).

More recently, researchers have hypothesized that nurse characteristics such as clinical experience and educational preparation are related to hospital mortality rates. Two reports have included indicators of nurse experience in their analytic models. Tourangeau *et al.* (2002) found that more years experience on current clinical units by Registered Nurses was associated with lower mortality rates across Ontario, Canada hospitals. However, Sasichay-Akkadechanunt *et al.* (2003) did not find a relationship between overall years of nurse experience and patient mortality. A second nurse characteristic hypothesized as a correlate of mortality rates is that of Registered Nurse educational preparation. Three studies have included indicators of nurse baccalaureate preparation, with conflicting results. Both Aiken *et al.* (2003) and Estabrooks *et al.* (2005) reported finding an inverse relationship between baccalaureate preparation of nursing staff and mortality rates. The higher the proportion of baccalaureate-prepared nurses, the lower were hospital mortality rates. Sasichay-Akkadechanunt *et al.* (2003) did not find evidence to support this relationship.

In two studies, it was hypothesized that the amount or quality of clinical support for nurses providing direct care was related to hospital mortality rates. Knaus *et al.* (1986) reported that intensive care units in American hospitals with the lowest mortality rates had comprehensive nursing educational systems such as clinical nurse specialists, and that those with the highest mortality rates did not have such clinical support systems. Tourangeau *et al.* (2002) found no evidence of a relationship between the amount of nurse-reported clinical support and mortality rates in Ontario hospitals.

In two studies, hypotheses were tested of relationships between various aspects of nursing work environments and hospital mortality. Examples of indicators of nursing work environments included: nurse autonomy, nurse control over the practice setting, and nurse manager ability and support. Conflicting results were found. Aiken *et al.* (1994) found that magnet hospitals characterized by having stronger professional nursing practice environments had lower mortality rates. Tourangeau *et al.* (2002) did not find a relationship between the condition of the nursing practice environment and mortality rates in Ontario hospitals.

A number of studies also examined the impact of physician characteristics, particularly physician expertise. Three of five studies retrieved found an inverse relationship between physician expertise, commonly measured as the percentage of board-certified physicians, and hospital mortality rates (Hartz *et al.* 1989, Farley & Ozminkowski 1992, Manheim *et al.* 1992). No evidence of a relationship between physician expertise and hospital mortality rates was found in two studies (Schultz 1997, Tourangeau *et al.* 2002).

Increasing attention has been focused in the research literature over the past two decades on the impact of nursing care on hospitalized patient mortality and survival. However, the relatively small number of studies has yielded inconsistent and incomplete knowledge of the impact of hospital structures and processes on patient mortality.

Conceptual model

The Determinants of Mortality Model, illustrated in Figure 1, guided this study (Tourangeau *et al.* 2002, Tourangeau 2003, 2005). Underlying this model is the assumption that each hospital has a unique mix of structures and processes that affect patient mortality and that an important subset of these hospital characteristics reflects nursing care delivery structures and processes. Because the need for nursing care is usually the most important reason for hospitalization, how nursing care is structured and delivered affects patient survival or death. Because of their unique structures and processes, some hospitals are better at preventing unnecessary patient death through prompt detection and effective treatment of serious patient complications that could lead to death. It is the structures and processes of nursing care that contribute to a hospital's overall success in detecting and treating serious patient complications that could lead to death, if not appropriately managed. The presence and actions of professional nurses at the bedside, with their critical thinking and judgement skills, facilitates early detection and prompt intervention for serious patient complications. A supportive and appropriately structured nursing

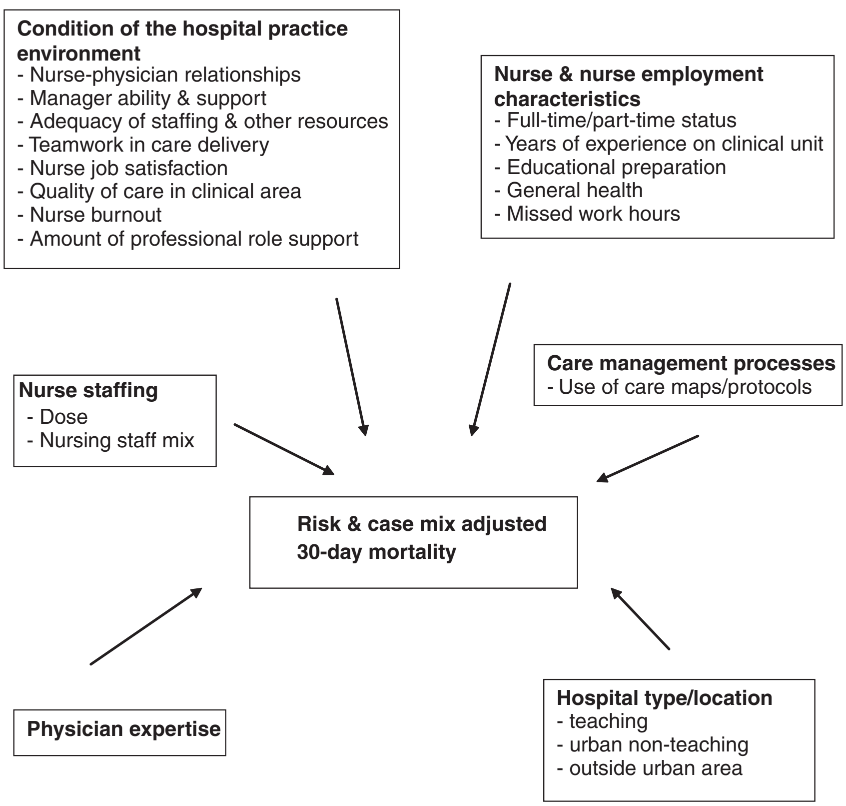

Figure 1 Determinants of 30-day mortality model.

work environment leads to prevention of unnecessary patient death. In this model, we hypothesized that the following categories of hospital organizational characteristics have an impact on hospital mortality rates: nurse staffing, condition of the hospital nursing practice environment, nurse and nurse employment characteristics, hospital type and location, and physician expertise. Indicator variables for each model concept were included in this study.

The study

Aim

The aim of the study was to answer the research question: What are the nursing-related determinants of risk-adjusted 30-day mortality for acute medical patients in hospitals in Ontario, Canada? Listed below are 16 research hypotheses flowing from this research question. Lower 30-day mortality rates will be related to the following hospital characteristics:

- Higher proportion of Registered Nurses in nursing staff mix.
- Lower nurse staffing dose.
- Higher proportion of full-time nursing staff.
- Higher years of nurse experience on current clinical units.
- Higher proportion of baccalaureate-prepared nurses.
- Higher nurse-reported level of health.
- Fewer missed work hours.
- Higher nurse-reported relationships with physicians.
- Higher nurse-reported manager ability and support.
- Higher nurse-reported adequacy of staffing and resources.
- Higher nurse-reported use of teamwork when delivering care.
- Higher nurse-reported job satisfaction.
- Higher nurse-reported quality of care.
- Lower nurse burnout.
- Higher nurse-reported availability of professional role support.
- Higher use of care maps/protocols.

Design

A retrospective design guided this study. Data sources included large clinical and administrative secondary databases and nurse survey data collected specifically for this study. This study occurred in two phases. In phase 1 (year 2003), we surveyed nurses working in medical and combined medical–surgical units in Ontario teaching and community hospitals. In phase 2 (year 2004–2005), we linked nurse survey data with secondary sources of patient and hospital data to test the hypothesized model.

Participants

All Ontario teaching and community hospitals that existed throughout 2002–2003 were included. Small hospitals and specialty hospitals such as paediatric and psychiatric hospitals were excluded. Small hospitals were excluded because they discharge fewer than 100 patients yearly with the acute medical diagnosis categories included in this study. Specialty hospitals were excluded because they did not provide care for adult acute medical patients. In Ontario, acute care hospitals are categorized as teaching, community or small (Baker *et al.* 1999). Teaching hospitals are designated as such by the Ontario Council of Teaching Hospitals because of their affiliation with an Ontario university that provides medical education. Community hospitals discharge at least 3500 weighted patient cases yearly. Small hospitals discharge fewer than 3500 weighted patient cases yearly. 'Weighted cases' is an expression that reflects standardized patient volume based on their relative resource consumption. The final sample consisted of nine teaching and 66 community hospitals.

Study patients were discharged between 1 April 2002 and 31 March 2003 from the sample hospitals with a most responsible diagnosis in one of four diagnostic groups: acute myocardial infarction, stroke, pneumonia, or septicaemia. These patient groups were selected because these conditions are acute in nature, have high volumes, and have high crude death rates. Patients also had to be Ontario residents and 20 years of age or older. Those with a pre-existing diagnosis of cancer or HIV were excluded. The final sample consisted of 46,993 patients. For each of the four diagnostic groups, Table 1 lists the number of study patients, mean patient age, sex, and crude mortality rate.

All nurses employed in Ontario teaching and community acute care hospitals who worked in medical and combined medical–surgical clinical areas were surveyed ($n = 5980$) between February and May 2003.

Data collection

Four data sources were used to calculate risk and case mix adjusted hospital 30-day mortality rates: the Ontario Discharge Abstract Database 2002–2003 (DAD) to select patients and their health information, Statistics Canada 2001 Population files to assign each patient one of five socioeconomic level indicators, the Ontario Hospital Insurance Plan database to develop proxy indicators for each patients' general preadmission health status, and the Ontario Registered Persons Database to identify dates of death for patients within 30 days of hospital admission. Databases

Table 1 Description of sample patients

	Acute myocardial infarction	Stroke	Pneumonia	Septicaemia	All sample
Number of cases	19,475	11,160	13,433	2925	46,993
Mean age (SD)	69 (14)	74 (12)	72 (17)	70 (16)	71 (15)
Proportion male (%)	63	50	49	48	55
Crude mortality rate (%)	13	21	16	31	16·9

were accessed at the Institute for Clinical Evaluative Sciences in Ontario. Three sources of data were used to create hospital level variables to address the research question and included the DAD, the Ontario Hospital Reporting System file 2002–2003 (OHRS), and the Ontario Nurse Survey 2003. All data sources, except the Ontario Nurse Survey 2003, were secondary sources of routinely collected data.

Patients discharged from Ontario hospitals each have a record in the DAD that is created through chart abstraction. For each patient, this database contains demographic information as well as codes for most responsible diagnosis and other co-morbidities (Canadian Institute for Health Information 2003a). In the DAD, the International Classification of Diseases-Version 10-Canadian was used to code medical diagnoses (Canadian Institute for Health Information 2003b). The DAD was used to select study patients and to identify their health information.

The OHRS file contains activity and financial information for Ontario hospitals. A subset of this file contains nurse staffing information for specific hospital clinical areas in each Ontario hospital. These data were used to develop nursing dose and Registered Nurse staff mix indicators.

In the Ontario Nurse Survey 2003, respondents were asked to describe: the type of clinical unit they worked within their hospital, their evaluation of patient care quality, their career intentions, their job-related feelings (burnout), the condition of the nursing work environment, their job satisfaction, selected discharge-related care processes, and demographic information. Three commonly used instruments were included in the survey: the McCloskey Mueller Satisfaction Scale, the Revised Nursing Work Index, and the Maslach Burnout Inventory. Data elements from this nurse survey were used to develop many variables to test the proposed model.

The Ontario Nurse Survey 2003 was mailed to 5980 nurses working in medical and combined medical–surgical clinical areas in Ontario teaching and community hospitals. All Registered Nurse and Registered Practical Nurse registrants with the Ontario College of Nurses who reported on their 2003 registration renewal form that they worked in a medical or combined medical–surgical clinical area in an Ontario teaching or community hospital were mailed the questionnaire to their homes. A reminder card was mailed 10 days after the initial questionnaire was mailed. A second complete questionnaire was mailed to non-responders 4 weeks after the initial questionnaire was mailed and was followed 10 days later by a reminder card. A total of 3886 nurses (65% of surveyed nurses) completed the questionnaire.

Validity and reliability of variables

Nineteen variables were included as indicators for predictors of 30-day mortality. Table 2 contains a description of each variable, including operational definitions and data sources. Three frequently used and well-validated instruments were included in this survey. First, the McCloskey Mueller Satisfaction Scale (MMSS), a 31-item instrument with 5-point response options ranging from very dissatisfied (value = 1) to very satisfied (value = 5), was used to measure global nurse job satisfaction. Alpha reliability for this scale in our study was 0·91. To facilitate interpretation, this scale was standardized to give scores out of 100. Documentation of the psychometric properties and scoring procedures for the MMSS are presented elsewhere (McCloskey 1974, McCloskey & McCain 1987, Mueller & McCloskey 1990, Tourangeau *et al.* 2006b).

Second, the Revised Nursing Work Index (NWI) was used to calculate three study variables measuring hospital work environments. The NWI is a 49-item instrument with 4-point response options ranging from strongly disagree (value = 1) to strongly agree (value = 4). The nurse–physician relationship subscale consisted of three items, the nurse manager ability and support subscale consisted of four items, and the adequacy of staffing and resources subscale consisted of four items (Lake 2002). Alpha reliabilities for these NWI subscales used in our study ranged between 0·84 and 0·90. To facilitate interpretation, scores on these subscales were standardized to be out of 100. Additional evidence of reliability and validity of the NWI subscales as well as scoring procedures are documented elsewhere (Estabrooks *et al.* 2002, Lake 2002).

Table 2 Description of predictor variables

Concept	Operational definition	Source of data
Proportion of Registered Nurses in nursing staff mix (nursing staff mix)	For medical hospital areas, % inpatient RN earned hours/all nursing staff earned hours (RN + RPN + UAP) (for 2002–2003)	OHRS
Nursing staff dose	Total inpatient clinical nursing worked hours (all nurse categories)/sum of weighted patient cases* discharged per hospital (for 2002–2003)	OHRS/DAD
Proportion of full-time nursing staff	For medical hospital areas, % RN full-time earned hours/all RN earned hours (fulltime + part-time + casual) (for 2002–2003)	OHRS
Years nurse experience on current clinical unit	Mean hospital nurse-reported years experience on current medical unit	Nurse Survey 2003
Proportion of baccalaureate-prepared nurses	For medical hospital areas, % nurses in hospital reporting having a baccalaureate degree or higher educational preparation	Nurse Survey 2003
Overall nurse level of health	Hospital mean medical nurse response on survey item asking about level of health on 5-point scale [1 (poor) to 5 (excellent)]	Nurse Survey 2003
Missed work hours	Mean hospital response for medical nurses to item asking how many 8/10/12 hours shifts missed from work in previous 3 months (calculated into hours)	Nurse Survey 2003
Nurse–physician relationships	Mean hospital response for medical nurses on 3-item subscale of NWI asking nurses to rate work relationships with physicians on 4-point scale (higher score = higher rating)	Nurse Survey 2003
Manager ability and support	Mean hospital response for medical nurses on 4-item subscale of NWI asking nurses to rate their manager ability and support on 4-point scale (higher score = higher rating)	Nurse Survey 2003
Adequacy of staffing and other resources	Mean hospital response for medical nurses on 4-item subscale of NWI asking nurses to rate adequacy of staffing and access to other patient care resources on 4-point scale (higher score = higher rating)	Nurse Survey 2003
Teamwork in care delivery	Dichotomous variable reflecting care delivery pattern (value = 0 if majority of nurses described providing patient care as a team; value = 1 when majority of nurses report using total patient care)	Nurse Survey 2003
Overall nurse job satisfaction	Mean hospital response on global job satisfaction scale consisting of 31-item MMSS on 5-point scale (higher score = higher rating)	Nurse Survey 2003
Nurse reported quality of care on unit	Percentage of medical nurses in hospital rating quality of care on unit as good or very good on 4-point scale	Nurse Survey 2003
Nurse burnout	Mean hospital score for medical nurses on 9-item emotional subscale of MBI	Nurse Survey 2003
Amount of professional role support	Mean hospital score on medical nurse agreement with item about availability of clinical nurse specialists or other experts on 4-point scale, standardized out of 100 (higher score = more availability)	Nurse Survey 2003
Use of care maps/protocols to guide patient care	Mean hospital score of nurse-reported routine use of care maps/ protocols to assist with patient care management on 5-point scale, standardized to be out of 100 (higher score = more routine use)	Nurse Survey 2003
Physician expertise	Percentage of study patients in each hospital with a specialist identified as most responsible physician for most responsible diagnosis	DAD
Outside urban area hospital	Dichotomous variable identifying hospitals located outside urban areas with populations >100,000 (0, no; 1, yes)	Statistics Canada 2001 Population files
Urban non teaching hospital	Dichotomous variable identifying non-teaching hospitals located in urban areas with populations greater 100,000 (0, no; 1, yes)	Statistics Canada 2001 Population files
Teaching hospital (left out of models as reference group)	Dichotomous variable identifying hospital as teaching hospital designated by Ontario Council of Teaching Hospitals (0, no; 1, yes)	–

RN, Registered Nurse; RPN, Registered Practical Nurse; UAP, Unlicensed Assistive Personnel; OHRS, Ontario Hospital Reporting System; DAD, Discharge Abstract Database; NWI, Nursing Work Index; MMSS, McCloskey Mueller Satisfaction Scale; MBI, Maslach Burnout Inventory.

*Weighted patient cases is an expression that reflects standardized patient volume based on their relative resource consumption. This term acknowledges that all patients do not consume the same amount of hospital resources relative to each other. A weighted patient case value expresses the amount of resource consumption one patient consumes during hospitalization relative to other patients.

Nurse burnout was measured using the 9-item emotional exhaustion subscale of the Maslach Burnout Inventory (MBI). The MBI is a 22-item instrument with 7-point response options ranging from never (value = 0) to everyday (value = 6). Burnout is conceptualized as high scores on emotional exhaustion. Scores of 16 or less indicate low burnout, scores between 17 and 26 indicate moderate burnout, and scores 27 or higher indicate high burnout. The alpha reliability for this subscale used in our study was 0·91. Additional evidence of reliability and validity of the MBI as well as scoring procedure information are documented elsewhere (Maslach *et al.* 1996).

The DAD, a secondary source of data, was used to develop the dependent variable, risk and case mix adjusted 30-day mortality. There is evidence of varying reliability of data elements in the DAD and our findings are only as credible as the data used to produce these results. A study by the Canadian Institute for Health Information explored levels of agreement between patient data collected in the DAD with re-abstractions of these data elements from patient records. They found 87% agreement in most responsible diagnosis coding, 75·5% agreement with presence or absence of co-morbid conditions, and 83% agreement with typing of co-morbid conditions (Canadian Institute for Health Information 2003a). Other studies of data quality in the DAD have consistently found under-coding of co-morbidities (Quan *et al.* 2002, Austin *et al.* 2005, Lee *et al.* 2005).

An indirect standardization method was used to develop risk and case mix adjusted 30-day mortality rates for each hospital using the formula: actual number of deaths divided by expected number of deaths. The numerator, actual number of deaths, was calculated by linking patient cases in the DAD with patient dates of death in the Ontario Registered Persons Database (RPDB). The RPDB contains dates of birth and death for all Ontario residents. The number of sample patients who died within 30 days of admission was summed for each diagnostic group in each hospital. To calculate the denominator, four logistic regression models, one for each of the four diagnostic groups, were completed to determine the expected probability of 30-day death for each patient. To calculate each patient's probability of death, 28 indicators of patient health-related characteristics existing before hospitalization were entered into logistic regression models. C-statistics for the four models ranged between 0·72 and 0·78. C-statistics range from zero to one and provide a measure of logistic regression model ability to discriminate between those patients who experience the outcome of interest (death) and those who do not. C-statistics $>0{\cdot}70$, such as those found in this study, indicated that our models had good discrimination between patients who died or were alive 30 days after admission (Hosmer & Lemeshow 2000). Weighted standard mortality rates were calculated for each hospital to eliminate confounding effects that patient mix had on outcome rates. This weighted calculation is necessary because mortality rates vary by diagnostic group and because patient mix within the four diagnostic categories varied across hospitals. Details of this risk-adjustment methodology are documented elsewhere (Tourangeau & Tu 2003, Tourangeau 2006).

Ethical considerations

Approval for the study was obtained from the University of Toronto Health Sciences Ethics Committee in November 2002 and was renewed yearly until November 2005. For survey participants, each nurse received an information letter about the study with the questionnaire. This letter explained the study purpose, procedure, risks and benefits, and assured anonymity and confidentiality. Return of a completed questionnaire was taken as consent to participate. Ethical approval was also received to link nurse survey data with secondary sources of patient and hospital data.

Data analysis

Analyses were completed using SAS®, version 9.1 (Cary, NC, USA). The unit of analysis was the acute care hospital. Descriptive statistics were generated to summarize hospital level predictors and the outcome variable. To answer the research question, two multiple regression analysis methods were implemented: simultaneous and backward regression. Regression diagnostics were performed to ensure that the model met assumptions for ordinary least squares regression (Fox 1991). In the first regression model, all variables were entered into analysis simultaneously and a single equation was developed that included regression coefficients for each independent variable (Polit & Beck 2004). In the second backward (statistical) regression model, all predictors were entered into the model and each one was removed to determine whether the R^2 dropped significantly. Only those predictors that contributed significantly to the regression model were retained in the final backward regression equation (Munro 2005).

Findings

An average of 52 nurses responded from each of the 75 study hospitals, with the number of respondents from each hospital ranging between 21 and 213. Table 3 contains descriptions of these nurses who cared for study patients in the 75 hospitals,

Table 3 Description of sample nurses

	Teaching hospitals	Community hospitals	All hospitals
Mean age (SD)	41·9 (10·0)	44·3 (9·6)	43·7 (9·8)
Mean years experience as nurse (SD)	15·9 (10·2)	18·5 (10·3)	17·8 (10·3)
Proportion female (%)	94·6	97·3	96·6
Proportion of Registered Nurses (%)	94	69	75

SD, standard deviation.
There were statistically significant differences on all the above nurse characteristics between teaching and community hospital nurses ($P < 0{\cdot}001$). Analysis of variance was used to test for differences in mean age and mean years experience between nurses in teaching and community hospitals. Chi-square test was used to test for differences in proportion of females and Registered Nurses in teaching and community hospitals. Teaching hospital nurses were younger and had less career experience. There were also higher proportions of male nurses and lower proportions of Registered Practical Nurses (vs. Registered Nurses) in teaching hospitals.

Table 4 Descriptive statistics for all variables used in multiple regression analyses

Variable	Mean (SD)	Number/% hospitals	Range
Risk and case mix adjusted 30-day hospital mortality rate	17·4 (3·4)		9·9–28·3
Nursing staff dose	36·2 (9·3)		25·6–106·3
Proportion (%) Registered Nurses in staff mix	66·3 (13·5)		36·1–100·0
Proportion (%) full-time nursing staff	61·1 (12·5)		34·6–92·2
Years nurse experience on current clinical unit	8·1 (2·4)		3·5–14·5
Proportion (%) baccalaureate-prepared nurses	12·6 (10·8)		0·0–61·5
Overall nurse-reported level of health (out of 100)	67·9 (3·8)		60·4–79·2
Missed work hours	15·1 (7·4)		4·9–49·8
Nurse–physician relationships (out of 100)	59·5 (6·3)		39·8–75·6
Manager ability and support (out of 100)	45·3 (9·7)		22·7–62·4
Adequacy of staffing and other resources (out of 100)	40·3 (7·3)		19·3–52·8
Teamwork in care delivery	–	52/69·3%	–
Overall nurse job satisfaction (out of 100)	53·9 (4·2)		44·1–66·4
Nurse reported quality of care on unit	96·3 (4·9)		79·4–100·0
Nurse burnout	23·2 (3·1)		17·2–30·1
Amount of professional role support (out of 100)	47·5 (14·8)		11·6–75·8
Use of care maps/protocols (out of 100)	62·8 (12·1)		29·2–85·1
Physician expertise (% specialists caring for patients)	51·1 (35)		0·0–100·0
Outside urban area hospital		38/50·7%	
Urban non-teaching hospital		28/37·3%	
Teaching hospital (left out of regression models as reference group)		9/12%	

including mean nurse age, mean years experience as a nurse, proportion of female nurses, and proportion of Registered Nurses.

The mean risk-adjusted 30-day mortality rate for hospitals was 17·4 (SD = 3·42) and ranged between 9·9 and 28·3%. The mean crude hospital mortality rate was 17·0 (SD = 3·42) and ranged between 8·33 and 24·32%. Means, standard deviations, and ranges (or numbers and percentage for dichotomous variables) for all hospital level study variables are shown in Table 4. Correlations among predictors were calculated to investigate existence of co-linearity. Linear relationships among independent variables must be very strong (e.g. approaching correlations of 0·9) before co-linearity seriously degrades the precision of estimation (Fox 1991). Correlations among predictors ranged from 0·003 to 0·654 indicating no evidence of strong co-linearity among predictor variables.

In the first regression analysis, when all predictors were forced to enter the regression model, 50% of variance in

30-day mortality rates was explained. The overall *F*-value used to test statistical significance of the R^2-value of 0·50 was 2·94 ($P < 0{\cdot}001$). Table 5 lists the results of this regression model, including regression coefficients, standard errors, *t*-statistics, and *P*-values. Five of the 19 predictors had probabilities < 0·10. Lower 30-day hospital mortality rates for acute medical patients were found to be associated with hospitals that had a higher proportion of Registered Nurses in the staffing mix, a higher proportion of baccalaureate-prepared nurses, higher nurse-reported adequacy of staffing and resources, higher nurse-reported quality of care, and higher use of care maps.

Because the first regression model results indicated that not all variables added to the explanation of differences in 30-day mortality rates, backward regression was implemented to find a more parsimonious explanation. Forty-five per cent of variance in 30-day mortality rates was explained by eight predictors. The *F*-value used to test statistical significance of the R^2-value of 0·45 was 6·73 ($P < 0{\cdot}0001$). Table 6 lists the results of this model, including regression coefficients,

Table 5 Multiple regression results when all variables forced to enter model together

Variable	Regression coefficient	Standard error	*t*-value	*P*-value
Intercept	47·04	19·01	2·47	0·017
Nursing staff dose	0·06	0·05	1·29	0·202
Proportion (%) of Registered Nurses in staff mix	−0·07	0·03	−2·01	0·049
Proportion (%) of full-time nursing staff	0·02	0·04	0·56	0·577
Mean years experience on clinical unit	−0·09	0·17	−0·54	0·594
Proportion (%) of baccalaureate-prepared nurses	−0·10	0·05	−1·94	0·057
Nurse reported level of health	0·03	0·11	0·25	0·802
Missed hours	−0·07	0·05	−1·37	0·178
Nurse–physician relationships	0·06	0·07	0·79	0·430
Manager ability and support	0·08	0·07	1·23	0·224
Adequacy of staffing and other resources	−0·21	0·09	−2·41	0·020
Teamwork in care delivery	−0·28	0·95	−0·29	0·772
Nurse job satisfaction	0·18	0·16	1·15	0·254
Quality of care	−0·24	0·10	−2·44	0·018
Nurse burnout	−0·32	0·20	−1·64	0·107
Amount professional role support	0·02	0·04	0·56	0·579
Use of care maps/protocols	−0·12	0·04	−3·43	0·001
Physician expertise	0·01	0·01	0·59	0·556
Outside urban area hospital	0·82	1·76	0·47	0·642
Urban non-teaching hospital	0·48	1·41	0·34	0·735

Model $R^2 = 0{\cdot}50$; *F*-value = 2·94; $P < 0{\cdot}001$. The regression coefficient reflects the number of units that 30-day mortality is predicted to change for each unit change in an independent variable/predictor, when the effects of other predictors are held constant. A statistically significant *t*-value indicates that the regression coefficient is statistically significantly different from zero.

Table 6 Multiple regression results for backward regression model

Variable	Regression coefficient	Standard error	*F*-value	*P*-value
Intercept	52·61	10·28	26·21	< 0·001
Nurse staffing dose	0·08	0·04	5·34	0·024
Proportion (%) of Registered Nurses in staff mix	−0·06	0·03	4·02	0·049
Proportion (%) of baccalaureate-prepared nurses	−0·09	0·04	5·14	0·027
Manager ability and support	0·16	0·05	9·47	0·003
Adequacy of staffing and other resources	−0·17	0·08	4·79	0·032
Quality of care	−0·21	0·08	6·66	0·012
Nurse burnout	−0·32	0·15	4·71	0·034
Use of care maps/protocols	−0·10	0·03	11·88	0·001

Model $R^2 = 0{\cdot}45$; C(p) = 4·1; *F*-value = 6·73; $P < 0{\cdot}0001$. The regression coefficient reflects the number of units that 30-day mortality is predicted to change for each unit change in an independent variable/predictor, when the effects of other predictors are held constant. A significant *F*-value indicates that the regression coefficient is significantly different from zero.

standard errors, F-statistics, and P-values. On average, the mean 30-day hospital mortality rate for acute medical patients was 17·4% and lower 30-day hospital mortality rates were associated with hospitals that had a higher proportion of Registered Nurses in the staffing mix, a higher proportion of baccalaureate-prepared nurses, a lower nurse staffing dose, higher nurse-reported adequacy of staffing and resources, higher use of care maps, higher nurse-reported quality of care, lower nurse-reported adequacy of manager ability and support, and higher nurse burnout.

Discussion

Study limitations

This study has a number of limitations, including weak power for regression models such as those used in this study. Our sample consisted of 75 hospitals and 19 predictors. Although adjusted R^2 provides a conservative estimate of R^2 that takes into account the number of subjects (hospitals in this case) and predictors, a high R^2 such as that found in this study may be an artefact of too few study hospitals (Munro 2005). Furthermore, our small sample size relative to number of predictor variables may have masked the significance of other model predictors that might actually be predictors of hospital mortality.

A second study limitation relates to threats to both internal and external study validity. Measures were undertaken to strengthen internal validity by including a homogeneous group of acute medical patients and incorporating risk adjustment strategies to control for the impact of patients' characteristics on the dependent variable. However, study internal validity may have been weakened because of unknown and unmeasured extraneous variables that influence 30-day mortality. For example, we did not include indicators for hospital characteristics such as use of temporary agency nursing staff or for environmental factors such as availability of community care services to support patient recovery after hospital discharge. The impact of such factors on 30-day mortality may be significant but this was not explored in this study. Furthermore, external validity is threatened by uncertainty about how representative this sample of hospitals, patients in these hospitals, and nurses caring for study patients were of those outside Ontario, Canada.

Discussion of findings

Findings indicated that structures and processes of hospital nursing care had an impact on 30-day mortality for acute medical patients. Both nurse staffing variables (proportion of Registered Nurses in the staff mix and nursing staff dose) were found to be predictors of 30-day mortality. This was an expected finding. As found in other studies (Tourangeau *et al.* 2002), we found a moderate inverse relationship between the total dose of nurse staffing with the proportion of Registered Nurse staff in the mix of nurse staffing ($r = -0{\cdot}33$, $P = 0{\cdot}004$). The explanation for this inverse relationship relates to how hospitals allocate resources to pay for nursing services. Because hospitals have fixed resources, those that employ higher proportions of Registered Nurses in their nurse staffing complement can usually afford fewer total numbers of nursing staff. Registered Nurse staffing is more expensive than other categories of nursing personnel such as practical nurses or unregulated assistive nursing personnel. In our study, a 10% increase in the proportion of Registered Nurses was associated with six fewer deaths for every 1000 discharged patients (based on regression coefficient produced in multiple regression model shown in Table 6). Similar findings of the impact of higher proportions of Registered Nurse staffing and total dose of nurse staffing have been found previously with the same patient population (Tourangeau *et al.* 2002), as well as with other patient populations in American hospitals (Hartz *et al.* 1989, Farley & Ozminkowski 1992, Manheim *et al.* 1992, Schultz 1997, Blegen *et al.* 1998, Aiken *et al.* 2002, Needleman *et al.* 2002).

These findings also support the current movement towards legislating baccalaureate education as minimum requirement for Registered Nurse entry to practice. Hospitals with higher proportions of baccalaureate-prepared nurses tended to have lower 30-day mortality rates. Our findings indicated that a 10% increase in proportion of baccalaureate-prepared nurses was associated with nine fewer deaths for every 1000 discharged patients (based on regression coefficient produced in multiple regression model shown in Table 6). This finding is similar to that of Aiken *et al.* (2003) with a sample of surgical patients discharged from hospitals in the USA.

We found a similar relationship between one indicator of the hospital nursing work environment, adequacy of staffing and resources, and mortality as in previous findings by Aiken *et al.* (1994) with a sample of US magnet hospitals. Similar to the findings of Aiken *et al.*, we found that a 10% increase in nurse-reported adequacy of staffing and resources was associated with 17 fewer deaths for every 1000 discharged patients (based on regression coefficient produced in multiple regression model shown in Table 6).

One finding not previously identified in the research literature prior to this study is the impact that routine use of care maps had on lowering 30-day mortality. We found

What is already known about this topic

- The impact of hospital structures and processes of care on patient death can be examined once the impact of patients' own characteristics have been controlled using effective risk adjustment strategies.
- Wide variation in risk and case mix adjusted hospital 30-day mortality rates for homogeneous groups of patients suggests that structures and processes of patient care have an impact on 30-day mortality rates.

What this study adds

- Eight variables predicted 45% of variance in risk and case mix adjusted 30-day mortality rates.
- Evidence continues to mount about the impact of the structures and processes of patient care on 30-day mortality rates, particularly related to the importance of both the proportion of Registered Nurses and the proportion of baccalaureate-prepared nurses in the hospital nursing staff mix.
- A new and important finding is that higher use of care maps or protocols to guide patient care was associated with lower 30-day patient mortality.
- Suggested strategies that may minimize unnecessary acute medical patient death include maximizing the proportion of Registered Nurses in the nursing staff mix, hiring and retaining baccalaureate-prepared nurses to provide patient care, providing adequate nurse staffing to deliver safe and effective care, and consistently using care maps or protocols to guide patient care.

lower risk-adjusted 30-day mortality rates for hospitals in which nurses reported higher routine use of care maps or protocols. This finding reaffirmed the importance of establishing and maintaining best practice care maps or protocols to guide patient care throughout hospitalization.

Two variables in our model were found to be statistically significant predictors of 30-day mortality in the opposite direction hypothesized. First, lower mortality was associated with lower nurse-reported manager ability and support. Overall, nurses across study hospitals rated their nurse manager support as low. Nurses working in hospitals with lower mortality rates felt less supported by their managers than did nurses working in hospitals with higher mortality rates. Perhaps managers in hospitals with lower mortality rates had wider spans of control that detracted from their ability to provide direct support to nursing staff. Managers in hospitals with lower mortality rates may have focused their energies on enabling other hospital structures and processes, such as securing resources or promoting patient care initiatives that supported lower mortality rather than providing direct support to nursing staff. Second, lower mortality was associated with hospitals having nurses who reported experiencing higher burnout. On average, nurses across hospitals reported burnout levels within the moderate range of emotional exhaustion. Perhaps higher levels of burnout acted as motivators that enabled nurses to detect and intervene promptly with serious patient complications that could have led to unnecessary patient death if left unattended or detected too late. Further research is needed to understand these counterintuitive findings better.

Conclusion

Our findings contribute to the mounting evidence that structures and processes of hospital nursing care have an impact on patient mortality and survival, and have implications for hospital management, clinical practice, and for future research.

Just as hospitals emphasize and strengthen clinical practices such as diagnostic procedures and clinical interventions to minimize mortality and promote other desirable patient outcomes, so should they also focus on strengthening organizational structures and processes of care to minimize patient death. Based on our findings, we recommend that, if hospitals have goals of minimizing unnecessary patient death for their acute medical patient population, they should maximize the proportion of Registered Nurses in providing direct care, even if this results in lowering total numbers of nursing personnel across all categories. Furthermore, because of the impact that higher proportions of baccalaureate-prepared nursing staff had on lowering hospital mortality rates, we recommend that hospitals aggressively seek to hire and retain baccalaureate-prepared nurses to care for acute medical patients. Acute medical hospitalized patients require the scope and depth of knowledge, skill and judgement attained through baccalaureate education to provide safe quality care to complex acute medical patients.

Because hospitals in which nurses reported higher use of care maps or other protocols to guide patient care also had lower mortality rates, we recommend that hospitals make significant investment in the development, use, and systematic updating of care maps or protocols to guide patient progress throughout hospitalization. Hospitals that use care maps or protocols could share their current tools across the Internet as a source of information to assist other hospitals and nursing staff around the world to develop their own patient- and culturally sensitive care maps or protocols.

Finally, it is important to acknowledge that although a respectable 45% of variance in 30-day risk adjusted hospital mortality rates was explained by eight hospital care structures and processes, 55% of the variance remained unexplained. Clearly, there is much to discover about the determinants of mortality. Further research is required to refine the Determinants of Mortality Model. Future research should include measures of the environment, including access to in-hospital and outside of hospital care as well as further explore the impact of hospital management and leadership on mortality outcomes.

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Author contributions

AT, DD and LMH were responsible for the study conception and design and AT, DD, LMH, LOP, DP, JT and LC were responsible for the drafting of the manuscript. AT performed the data collection and data analysis. AT and DD obtained funding.

AT provided statistical expertise. AT, DD, LMH, LOP, DP, JT and LC made critical revisions to the paper. AT supervised the study.

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