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Nursing-Related Determinants of 30-Day Mortality for Hospitalized Patients

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La présente étude visait à préciser l'incidence de variables liées aux soins infirmiers sur le taux de mortalité sur trente jours chez les hospitalisés. On a effectué une analyse rétrospective dans le but de tester le *30-Day Mortality Model* [Modèle de mortalité sur trente jours]. L'échantillon comprenait 75 hôpitaux de soins actifs situés dans la province de l'Ontario, au Canada. Les taux de mortalité hospitalière ont été établis à partir de 46 941 malades sortants qui avaient reçu un diagnostic confirmé d'infarctus aigu du myocarde, d'accident vasculaire cérébral, de pneumonie ou de septicémie. Des variables indépendantes relativement aux soins infirmiers en hôpital ont été élaborées à partir de 3998 réponses obtenues par le biais du *Ontario Registered Nurse Survey of Hospital Characteristics* [Questionnaire sur les caractéristiques des hôpitaux de l'Association des infirmières autorisées de l'Ontario]. Les résultats confirment l'existence d'un lien entre le taux de mortalité sur trente jours et trois variables indépendantes : l'éventail des compétences en matière de soins infirmiers, le nombre d'années d'expérience au sein d'un service donné et le nombre de quarts de travail manqués. Ces conclusions pourraient servir à prévoir l'incidence des changements effectués en matière de compétences et d'années d'expérience des infirmières autorisées dans les hôpitaux sur le taux de mortalité hospitalière.

The purpose of this study was to further our understanding of the effects of nursing-related hospital variables on 30-day mortality rates for hospitalized patients. A retrospective design was used to test the proposed 30-Day Mortality Model. The sample consisted of 75 acute-care hospitals in the province of Ontario, Canada. To develop hospital mortality rates, 46,941 patients discharged from these hospitals who had a most responsible diagnosis of acute myocardial infarction, stroke, pneumonia, or septicemia were included. To develop hospital-level nursing predictor variables, 3,998 responses to the Ontario Registered Nurse Survey of Hospital Characteristics were also included.

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The findings support a relationship between lower 30-day mortality and 3 predictors: a richer registered nurse skill mix, more years of experience on the clinical unit, and reported larger number of shifts missed. These findings can be used to predict the effects of hospital changes in nursing skill mix and years of RN experience on patient mortality.

Hospital mortality rates are important indicators of the quality of hospital care, yet little is known about relationships between nursing-related hospital variables and mortality rates. It has been suggested that mortality is not sensitive to nursing-related hospital variables (Mitchell & Shortell, 1997). However, it has also been suggested that determination of the relationships between patient mortality and nursing care is an essential mandate of nurse researchers, as hospital care is reserved for the most critically ill and unstable patients, who are hospitalized primarily because of their need for nursing care (Aiken, Sochalski, & Lake, 1997).

As health-care spending across North America was increasing at unsustainable rates throughout the 1980s, health-care leaders searched for strategies to decrease total hospital spending. Nursing services, as the single largest hospital operating expense, became a vulnerable target (Aiken, Sochalski, & Anderson, 1996; O'Brien-Pallas, Giovannetti, Peereboom, & Marton, 1995). There was little evidence to use in understanding or predicting the effects of changing the number of nursing-care hours, the skill mix of nursing staff, or the clinical resources available to support hospital nurses, and thus to use in counteracting such cost-cutting strategies. These strategies, sometimes veiled as quality improvement initiatives, involved changes in the nature and condition of nursing practice environments; displacement of nursing staff from existing as well as closed units; decreases in the number of registered nurse (RN) patient-care hours; weakening of the skill mix of nursing staff by eliminating or substituting RN patient-care hours; and elimination of clinical resources such as clinical nurse specialists, nurse educators, and nurse managers. The potential effects of these strategies on patient outcomes such as mortality were unknown.

Literature Review

This review will briefly describe hospital variables identified in the research literature as being associated with patient mortality. Our understanding of the condition of hospital nursing practice environments has come largely from magnet hospital research. In 1982, a task force of the American Academy of Nursing Fellows was struck to explore why some hospitals, termed magnets, were more successful than others in retaining and recruiting RNs during a period of nursing shortages. In this initial descriptive study, the following characteristics were found in a sample of 41 American magnet hospitals: visionary nurse leaders who supported nursing staff development, decentralized administrative structures, employment of clinical experts, and RNs who had autonomy and control over their practice settings as well as collaborative relationships with physicians (McClure, Poulin, Sovie, & Wandelt, 1983).

A few years later, Kramer and Schmalenberg (1988a, 1988b) studied a sample of 16 of the original 41 hospitals to determine whether magnet hospitals shared the characteristics of innovative and "excellent" companies. They concluded that the 16 magnet hospitals had almost all of the characteristics of excellent companies. Concurrently, Kramer (1990) conducted telephone interviews with the chief nursing officers of the 16 hospitals. She reported that they continued to move towards richer RN skill mixes, experienced almost no nursing shortages, and fostered greater RN autonomy. Kramer and Schmalenberg (1991a, 1991b) also surveyed nurses from known magnet hospitals and nurses-at-large to explore influences on nurse job satisfaction. The nurses from magnet hospitals reported more job satisfaction, better staffing in their hospitals, and more discretionary power within their clinical units.

Until the 1990s, magnet hospital research focused on understanding the concept of magnetism in hospitals. The first study examining patient outcomes in magnet versus non-magnet hospitals looked at differences in 30-day mortality rates with a sample of 234 American hospitals, 39 magnet and 195 non-magnet (Aiken, Smith, & Lake, 1994). Magnet hospitals were found to have five fewer patient deaths per 1,000 Medicare patients discharged than non-magnet hospitals.

We located only 10 additional studies examining some aspect of nursing-related hospital factors and patient mortality. Knaus, Draper, Wagner, and Zimmerman (1986) found evidence of a relationship between low patient mortality and high levels of both nurse-physician collaboration and workplace nursing educational support. Three years later, Mitchell, Armstrong, Simpson, and Lentz (1989) found relationships among high nurse-physician collaboration, high levels of nurse expertise, and low mortality rates. However, several years later, Shortell et al. (1994) found no evidence of a relationship between nurse-physician collaboration and risk-adjusted mortality.

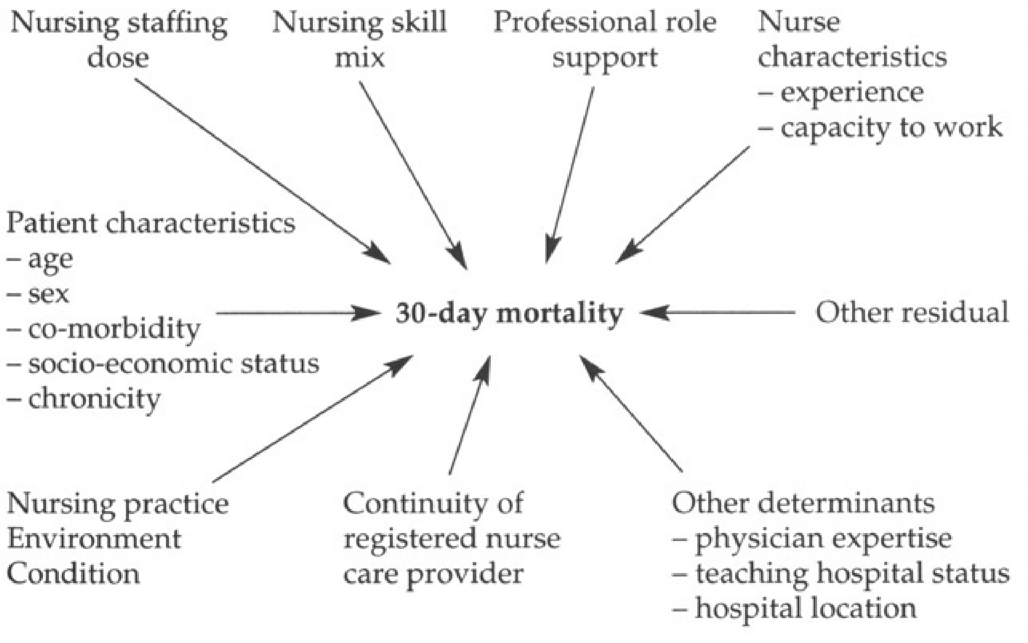
The research literature yields mixed findings on the relationship between nurse dose (number of nursing-care hours) and mortality rates and between nursing skill mix (number of RNs proportionate to other nursing staff) and mortality rates. Shortell and Hughes (1988) found no statistically significant relationship between number of RNs proportionate to other nursing staff and mortality rates. One year later, Hartz et al. (1989) found a high proportion of RNs to be strongly associated with lower adjusted mortality rates. Farley and Ozminkowski (1992), in a study of changes in the volume of diagnostic groups over time, found the ratio of full-time-equivalent RNs to inpatient day to be inversely and significantly associated with adjusted mortality rates. At around the same time, Manheim, Feinglass, Shortell, and Hughes (1992) found a higher number of RNs per adjusted patient admission to be a negative predictor of Medicare 30-day post-admission mortality. Schultz (1997) reported similar findings of an inverse relationship between RNs per patient day and risk-adjusted hospital mortality rates for acute myocardial infarction patients in a sample of California hospitals. Yet Shortell et al. (1994) found no statistically significant association between nursing skill mix and risk-adjusted mortality. Similarly, Blegen, Goode, and Reed (1998) reported that although they found a high proportion of RNs (up to 87.5% of all nursing staff) to be associated with low mortality, this finding was directional and not statistically significant. More recently, Lake (1999) explored relationships, in 42 American hospitals, between 30-day mortality rates and nursing skill mix, nurse-patient ratios, and six nursing environment constructs developed from the revised Nursing Work Index (e.g., adequacy of staff and support services, collaboration between physicians and nurses). Lake found evidence to support bivariate relationships between 30-day mortality and both nurse-patient ratios and several of the nursing environment constructs. However, in the final multiple regression models, which included all nursing and hospital predictors, none of the nursing-related variables were found to be significant predictors of 30-day mortality.

In summary, there is conflicting research evidence concerning the relationship between nursing-related hospital characteristics and hospital mortality rates. Furthermore, the trustworthiness of some of the findings is compromised by failure to use adequate risk-adjustment methods that account for differences arising from variations in patient characteristics across hospitals. The objective of this study was to empirically determine the effects of nursing-related hospital variables on risk-adjusted 30-day post-admission mortality rates in a sample of acute-care hospitals in the province of Ontario.

Theoretical Model

The theoretical framework guiding this study was the 30-Day Mortality Model (see Figure 1). This model was developed from the mortality

Figure 1 *30-Day Mortality Model*



research literature, including the work of a group of researchers at the University of Pennsylvania (Aiken et al., 1997; Havens & Aiken, 1999). We hypothesized that hospital mortality is a sensitive measure of quality of care and that some hospitals are better able than others to prevent unnecessary patient deaths because they can more promptly detect and intervene with serious patient complications that could lead to death. Because of their continuous presence with hospitalized patients, RNs with the appropriate knowledge and skills are vital to both early detection and effective intervention with serious patient complications. Within this model, we hypothesized that the following hospital variables are related to lower mortality rates because each one increases a hospital's ability to prevent unnecessary patient deaths:

- higher dose of nurse staffing (greater number of nursing-care hours)
- richer RN skill mix
- more availability of professional role support resources for nursing staff
- more years of RN experience on the clinical unit
- fewer shifts missed by RNs (increased nurse capacity to work)
- higher reported levels of professional nursing practice environment
- increased opportunities for continuity of care (higher proportion of full-time RNs)

Because the research literature shows evidence of a relationship between 30-day mortality and physician expertise, hospital teaching status, and hospital location (Aiken et al., 1994; Farley & Ozminkowski, 1992; Hartz et al., 1989; Manheim et al., 1992), these concepts were included as predictors in the 30-Day Mortality Model. The research question addressed was: *How well do the predictor variables in the 30-Day Mortality Model explain differences in 30-day medical mortality rates among Ontario acute-care hospitals?*

Methods

Design and Sample

A retrospective design was used. The unit of analysis was the hospital, and the sample consisted of 75 acute-care teaching and community hospitals operating in Ontario during the 1998–99 fiscal year. To enhance homogeneity, small hospitals were excluded. The sample consisted of 10 teaching and 65 community hospitals.

To develop 30-day mortality rates for each hospital, only patients who were at least 20 years of age and had a most responsible diagnosis of acute myocardial infarction, stroke, pneumonia, or septicemia were included. These four medical conditions were chosen because they are acute rather than chronic, have high patient volumes, and have high crude death rates. To promote homogeneity of patients, the most responsible diagnosis had to be the initial reason for hospitalization. To avoid multiple counting of patients, patients transferred from other acute-care hospitals were excluded. Patients with a pre-admission or secondary diagnosis of cancer, palliative care, or immune-deficiency disease were excluded, as the disease trajectories and health goals of these patients may be different from those of patients experiencing acute disease processes. The final sample consisted of 46,941 patients discharged from the 75 sample hospitals; they accounted for 4% of all patients discharged from Ontario acute-care hospitals in the period April 1, 1998, through March 31, 1999.

The responses of 3,988 medical-surgical nurses working in the 75 hospitals who responded to the Ontario Registered Nurse Survey of Hospital Characteristics were used to develop several hospital nursing-related variables. The survey was completed in fall 1998/winter 1999 as part of an international study, Outcomes of Hospital Staffing. A modified random sample of 15,438 RNs working in Ontario acute-care hospitals were sent the survey. The completed survey response rate was 57% (Tibert, 1999). Ethical approval for this study was obtained from the Capital Health Region Ethics Review Panel, Edmonton, Alberta, in January 2000 and was renewed in February 2001.

Study Variables

The 30-day risk-adjusted mortality rate reflects the proportion of patients admitted to hospital who die within 30 days of admission regardless of whether the death occurred in hospital or after discharge. Rates were calculated for each hospital over the period April 1, 1998, through March 31, 1999. The general form of the risk-adjusted 30-day mortality rate was the ratio of observed deaths divided by the expected number of deaths. For between-hospital comparisons to be valid, mortality rates must be adjusted for patient differences among hospitals. Differences in mortality rates that persist after effective risk-adjustment are usually attributed to differences in quality of care among hospitals (Iezzoni, 1997; Shwartz, Ash, & Iezzoni, 1997). Each patient's probability of death was estimated using four logistic regression models (one for each diagnostic group) and summed to calculate a hospital's expected number of deaths. The following risk factors were included as predictors of death in each logistic regression model: age, sex, 14 categories of pre-existing co-morbid conditions, an indicator of socio-economic status, and a chronicity of health indicator. All four logistic regression models performed well in predicting death, with c-statistics ranging from 0.71 to 0.76. A c-statistic between 0.70 and 0.80 is considered evidence of acceptable discrimination power of a logistic regression model (Hosmer & Lemeshow, 2000). A detailed description of the method used to develop risk-adjusted 30-day mortality rates can be found elsewhere (Tourangeau, 2001).

Nurse staffing dose for each hospital was measured as the total inpatient clinical nursing worked hours per Ontario case weight (OCW). Ontario case weight is a measure of relative total resource consumption by patients; it is a refinement of the American-derived resource intensity weights. "Worked hours" are unit-producing hours worked by nursing staff in providing care, excluding benefit hours. The denominator is the sum of OCWs for all patients discharged from each hospital from April 1, 1998, through March 31, 1999.

Nursing skill mix was calculated as RN inpatient earned hours proportionate to other inpatient nursing staff earned hours (RN, registered practical nurse, and unlicensed assistive personnel earned hours).

Availability of professional role support was estimated as the mean hospital score of medical-surgical nurse respondents on the Ontario Nurse Survey to the following item: "In my hospital there is the opportunity for staff nurses to consult with clinical nurse specialists or expert nurse clinicians/educators" (1 = strongly disagree; 4 = strongly agree).

Years of RN experience on the clinical unit was calculated as the mean hospital response by medical-surgical nurses to the Ontario Nurse Survey item on number of years employed on the current clinical unit.

Nurse capacity to work was estimated as the mean hospital response by medical-surgical nurses to the Ontario Nurse Survey item on number of shifts missed in the preceding 3 months.

Condition of nursing practice environment was estimated as the mean hospital score of medical-surgical nurses to the Ontario Nurse Survey on the Canadian Practice Environment Index (CPEI). The CPEI is a 26-item one-factor scale derived from the revised Nursing Work Index (NWI-R) through a process of exploratory principal component analysis. Items with loadings above 0.50 were included (Estabrooks et al., submitted). For each item, respondents were asked to select an answer on a four-point continuum (1 = strongly disagree; 4 = strongly agree). The possible theoretical range of CPEI scores was 26 to 104. The higher the score, the more nurses reported the existence of a professional nursing practice environment in their hospital. There was strong evidence of internal consistency reliability with use of the CPEI in this study (Cronbach's alpha = 0.90). Evidence of criterion-related validity was found for the CPEI, with correlations ranging from 0.58 to 0.85 ($p < 0.0001$) between the CPEI and three other previously used subscales of the NWI-R: nurse autonomy, nurse control over the practice setting, and nurse relationships with physicians.

Continuity of care was estimated for each hospital as the number of *full-time inpatient* RN earned hours proportionate to other RN earned hours (including full-time, part-time, and casual RN earned hours).

Physician expertise for each hospital was measured as the proportion of physicians who were general practitioners rather than specialists and who were the most responsible physician for the most responsible diagnosis of patients in the sample.

Hospital status and location. A dummy indicator variable was created to identify teaching hospitals as designated by the Ontario

Council of Teaching Hospitals. All 10 of the hospitals so identified were located in urban areas (population greater than 100,000). Two dummy indicator variables were created to identify community hospitals as located either in an urban area or outside an urban area; 25 were identified as urban, 40 as non-urban.

Data Sources, Management, and Analysis

Three sources of data were used to develop the 30-day risk-adjusted mortality outcome: the Discharge Abstract Database (DAD) 1998–99 from the Ontario Ministry of Health and Long- Term Care, the Ontario Registered Persons Database (RPDB), and the Statistics Canada 1996 Population Data file containing average-income information. The DAD file describes all patients discharged from Ontario hospitals. The RPDB contains death-date information and was linked with the DAD file using scrambled Ontario health insurance numbers. The Statistics Canada 1996 Population Data information was linked to each discharged patient by postal code to estimate the socio-economic status of sample patients.

Two sources of data were used to develop the independent hospital nursing variables: the Ontario Registered Nurse Survey of Hospital Characteristics and the Ontario Hospital Reporting System (OHRS) 1998–99 file and its appendices. Individual medical-surgical nurse responses were aggregated to the hospital level to develop nursing variables (availability of professional role support, experience on the clinical unit, number of shifts missed, and condition of the nursing practice environment). For each hospital, the OHRS file contains information about the dose of nurse staffing, nursing skill mix, and continuity of RN care provider.

The source of data used to develop the physician expertise variable was the DAD 1998–99 file. The teaching hospital status variable was developed from the list of teaching hospitals identified by the Ontario Council of Teaching Hospitals. The Statistics Canada Census 1996 Population Statistical Profiles of Canadian Communities file was used to develop the indicator for hospital location: within or outside of an urban area.

All data were managed using the UNIX system at the Institute for Clinical Evaluative Sciences in Toronto, Ontario. All analyses were conducted using SAS® Version 8. Multiple regression models were completed to answer the research question.

Results

The mean risk-adjusted mortality rate for the 75 sample hospitals was 15.03 ($SD = 2.28$) and ranged from 10.53 to 21.53. Teaching hospitals on average had the lowest risk-adjusted mortality rate, 14.02 ($SD = 1.29$). Urban community hospitals had a mean risk-adjusted mortality rate of 15.05 ($SD = 2.21$). On average, non-urban community hospitals had the highest risk-adjusted mortality rate, 15.27 ($SD = 2.48$). Table 1 contains descriptive statistics for each of the nursing-related predictor variables for all hospitals and separately for teaching, urban community, and non-urban community hospitals. Table 2 contains a correlation matrix of the nursing-related predictor variables and 30-day mortality rate.

Table 1 *Nursing-Related Predictor Variables*

Variable	Mean (*SD*): All Hospitals (*N* = 75)	Mean (*SD*): Teaching Hospitals (*N* = 10)	Mean (*SD*): Urban Community Hospitals (*N* = 25)	Mean (*SD*): Non-Urban Community Hospitals (*N* = 40)
Nurse staffing dose: inpatient clinical worked hours per OCW	39.92 (7.5)	41.61 (10.70)	36.36 (5.30)	41.73 (7.10)
Skill mix: proportion of RN staffing	0.75 (0.11)	0.85 (0.09)	0.79 (0.09)	0.71 (0.10)
Availability of professional role support	2.20 (0.53)	2.84 (0.14)	2.39 (0.38)	1.92 (0.48)
Years of RN experience on clinical unit	9.06 (2.0)	7.85 (1.00)	8.89 (1.80)	9.47 (2.20)
RN capacity to work: average number of shifts missed in previous 3 months	1.54 (0.80)	1.81 (0.41)	1.65 (0.70)	1.41 (0.92)
Condition of nursing practice environment: CPEI*	61.90 (4.0)	63.20 (3.30)	61.70 (3.90)	61.80 (4.20)
Continuity of care: proportion of full-time RN earned hours	0.59 (0.10)	0.67 (0.06)	0.62 (0.11)	0.55 (0.08)

* Canadian Practice Environment Index.

Table 2 ***Correlations among Continuous Predictor Variables and 30-Day Mortality with the Associated Probabilities***

	ND	SM	RS	YX	CW	CPEI	CC	PE
ND	1.00							
SM	-0.47 $p<0.0001$	1.00						
RS	-0.41 $p=0.0003$	0.53 $p<0.0001$	1.00					
YX	-0.08 $p=0.47$	-0.12 $p=0.29$	-0.11 $p=0.33$	1.00				
CW	-0.05 $p=0.66$	-0.04 $p=0.75$	0.08 $p=0.50$	-0.25 $p=0.03$	1.00			
CPEI	-0.12 $p=0.32$	0.20 $p=0.08$	0.41 $p=0.0003$	0.06 $p=0.60$	-0.16 $p=0.18$	1.00		
CC	-0.06 $p=0.61$	0.39 $p=0.001$	0.33 $p=0.004$	-0.14 $p=0.24$	0.21 $p=0.07$	-0.10 $p=0.39$	1.00	
PE	0.24 $p=0.04$	-0.51 $p<0.0001$	-0.59 $p<0.0001$	0.28 $p=0.02$	-0.35 $p=0.00$	-0.09 $p=0.45$	-0.45 $p<0.0001$	1.00
30	0.21 $p=0.07$	-0.21 $p=0.07$	-0.18 $p=0.11$	-0.20 $p=0.08$	-0.30 $p=0.01$	-0.08 $p=0.50$	-0.17 $p=0.16$	0.19 $p=0.11$

ND = nursing dose SM = skill mix RS = availability of role support for nurses YX = years of experience on the clinical unit CW = nurse capacity to work CPEI = Canadian Practice Environment Index (condition of nursing practice environment) CC = continuity of registered nurse care provider PE = physician expertise 30 = 30-day mortality rate.

A series of five multiple regression models was completed to answer the research question. Each model builds on the findings of the previous models. Only the results for the fifth and final model are discussed in this paper. Detailed descriptions of these analyses are described elsewhere (Tourangeau, 2001). In all multiple regression models, the predictor "hospital location outside an urban area" was left out of the model as the reference group for hospital type and location.

In the first four models, using either stepwise or forced-entry multiple regression procedures, the following three statistically significant predictors of 30-day mortality were found: years of nurse experience in the clinical unit, nursing skill mix, and nurse capacity to work. No other hypothesized predictor variables in the 30-Day Mortality Model were found to be statistically significant. Interaction terms were included to determine whether the effectiveness of these significant predictors of 30-day mortality was the same across hospital types: teaching, urban community, and non-urban community. In the first four multiple regression models, the effectiveness of only nursing skill mix was the same across hospital types. Therefore, interaction terms were not included in the final multiple regression model for nursing skill mix. The addition of interaction variables in the multiple regression models provides more detailed information on the effectiveness of the predictor of 30-day mortality in various hospital contexts and is a useful strategy for testing and refining theory. The following variables were forced-entered into the final multiple regression model: nursing skill mix, years of nurse experience on the clinical unit in [multiplied by] non-urban community hospitals, years of experience on the clinical unit in [multiplied by] teaching hospitals, years of experience on the clinical unit in [multiplied by] urban community hospitals, nurse capacity to work in [multiplied by] non-urban community hospitals, nurse capacity to work in [multiplied by] teaching hospitals, and nurse capacity to work in [multiplied by] urban community hospitals. Table 3 lists the results of the final multiple regression model: the predictor variables, their parameter estimates, the associated F statistics, and the p values. The proportion of 30-day mortality rate variance explained was 0.32 ($p = 0.0004$). The results of this final model are interpreted as:

- The mean risk-adjusted 30-day mortality rate for all sample hospitals was 15% (150/1,000 patients discharged).
- A 10% increase in the proportion of RNs across all hospital types was associated with five fewer patient deaths for every 1,000 discharged patients.
- In non-urban community hospitals, each additional hospital mean year of nurse experience on the clinical unit was associated with four fewer patient deaths for every 1,000 discharged patients.
- In urban community hospitals, each additional hospital mean year of nurse experience on the clinical unit was associated with six fewer patient deaths for every 1,000 discharged patients.
- In non-urban community hospitals *only*, each additional hospital mean shift missed by nurses (less capacity to work) was associated with 15 fewer patient deaths for every 1,000 discharged patients.

The mean hospital years of experience on the clinical unit was inversely related to 30-day mortality rates in both urban and non-urban community hospitals, though the effect size was larger in the former. For teaching hospitals, the effect size was almost as large as that for urban community hospitals but was not statistically significant because of the

Table 3 ***Final Multiple Regression Results: Statistically Significant Predictors and 4 Related Interaction Terms Forced to Enter Model***

Variable	Parameter Estimate	*F* statistic	*P* value
Nursing skill mix	-0.0489	-1.97	0.04
Years of clinical unit experience for non-urban community hospitals	-0.0035	-2.83	0.01
Years of clinical unit experience for teaching hospitals	-0.0052 *	2.59	0.11
Years of clinical unit experience for urban community hospitals	-0.0061	15.16	0.0002
Capacity to work for non-urban community hospitals	-0.0149	-4.35	< 0.0001
Capacity to work for teaching hospitals	-0.0100 *	0.60	0.44
Capacity to work for urban community hospitals	0.0006 *	0.01	0.91

Note: model R square = 0.32; overall model F value = 4.50; $p = 0.0004$;
* refers to parameter estimate that is not significantly different from 0.00.

small number of teaching hospitals in the sample. Capacity of nurses to work (number of reported missed shifts in the preceding 3 months) was significantly associated with 30-day mortality in non-urban community hospitals *only*.

Discussion

In this study, a richer skill mix of RNs was found to be associated with lower 30-day mortality, while the dose of nurse staffing was not found to be associated with 30-day mortality. Only one of the studies reviewed had found a statistically significant relationship between nursing skill mix and mortality (Hartz et al., 1989). In two of the studies reviewed, it was noted that their measures of nurse staffing dose and nursing skill mix were highly correlated (Blegen et al., 1998; Hartz et al.). We too found a moderate correlation ($r = -0.47$; $p < 0.0001$) between our indicators of nursing skill mix and nurse staffing dose. If correlated variables are included in a regression analysis, one of the correlated variables may be eliminated from the analysis unless a forced-entry procedure is used.

No evidence was found to support a relationship between the amount of professional role support for hospital nursing staff and 30-day mortality, though two earlier studies (Aiken et al., 1994; Knaus et al., 1986) did find such a relationship. This present finding might be a result of the crude proxy variable used to measure the amount of professional role support in sample hospitals.

The average number of years of experience by RNs on their clinical units was significantly and inversely related to 30-day mortality in the majority of hospitals. No other studies could be found that investigated such a relationship. It is reasonable to expect that the more experience nurses have with the patient population on their unit, the more prepared they will be to assess and intervene effectively with serious complications and thus prevent unnecessary deaths. Over the past decade, the re-organization activities undertaken by many hospitals may have disrupted the tenure of or accumulation of experience by RNs on their units. Some re-organization strategies have involved the elimination and reduction of RN positions, substitution of RNs with less qualified nursing personnel, and closure of clinical units. The process of eliminating and substituting RNs has often involved moving them from one unit to another through bumping. Registered nurses may have been moved from a unit in which they had developed clinical expertise to a unit with a patient population of whom they had limited knowledge and experience. Our findings suggest that hospital re-organization activities that resulted in fewer years of RN experience on their clinical unit contributed to excessive or unnecessary patient mortality.

Greater nurse capacity to work and fewer shifts missed were found to be associated with higher 30-day mortality rates in non-urban community hospitals. When nurses in these hospitals missed more shifts, fewer patients died. This unexpected relationship is difficult to explain. It might be related to other characteristics of nurses and hospitals in non-urban areas. As shown in Table 1, non-urban community hospitals have the least mean number of missed shifts by nurses, the lowest proportion of RNs in their nursing skill mix, the least amount of professional role support resources available to support nursing practice, and the lowest proportion of full-time RN staff. It is possible that these characteristics together exert a direct influence on nurses' capacity to work and the ability of nurses in non-urban community hospitals to coordinate, plan, and communicate patient care. It is possible that nurses cope effectively with workplace pressures by taking non-scheduled time away from work to recuperate and regain the capacity to work. Nurses in non-urban community hospitals may not be taking adequate time to recuperate and regain their capacity to work, possibly resulting in less effective detection and intervention with serious patient complications and contributing to higher 30-day mortality rates.

Though a weak association between the condition of the nursing practice environment and mortality was found in previous studies (Aiken et al., 1994; Lake, 1999), no evidence of an association was found in the present study. This may be because the association is not a direct one. The condition of the nursing environment may be a mediating factor that is itself affected by predictor variables such as nursing skill mix and nurse staffing dose.

Replication and refinement of the model is an important next step in theory development. In the 30-Day Mortality Model, each of the predictors was hypothesized to have a direct effect on the outcome. Some of these variables may exert indirect and reciprocal effects on 30-day mortality. To test total effects of the predictors, rather than direct effects only, we believe that analysis strategies such as structural equation modelling may be more appropriate (Hayduk, 1987).

This study had a number of limitations. When a researcher is unable to manipulate or control study variables in retrospective studies such as this, alternative explanations threaten the validity of claims made about relationships between outcomes and predictor variables. Because the model accounted for only 32% of the variance in 30-day risk-adjusted mortality among hospitals, there clearly were other determinants, unknown and unspecified, of 30-day mortality. Another limitation was the potential introduction of sources of measurement error, particularly associated with the use of secondary data sources. Data may have both systematic and random sources of error that affect both the reliability and validity of the findings. There is evidence of errors, particularly random errors, with patient data extracted from the Discharge Abstract Database (Hawker, Coyte, Wright, Paul, & Bombardier, 1997; Malenka, McLerran, Roos, Fisher, & Wennberg, 1994; Mayo, Danys, Carlton, & Scott, 1993). These errors may inflate standard errors of estimates and ultimately diminish the credibility of the results. Little is known about the reliability of the OHRS files. Similarly, responses in the Ontario Nurse Survey may contain sources of error. No tests of stability were undertaken with the Ontario Nurse Survey and the degree of error in survey responses is unknown.

Caution should be exercised in generalizing these results across different diagnostic groups in Ontario hospitals, as the sample consisted only of patients with acute myocardial infarction, stroke, pneumonia, and septicemia. When other diagnostic groups are studied, not only will the 30-day mortality rate for hospitals change, but the rankings of 30-day mortality rates among hospitals may also change. Further replication research is needed with other diagnostic groups. Generalization outside the province of Ontario should be done with caution. Policies governing the funding and organization of hospitals are a provincial responsibility and may result in different hospital environments outside Ontario.

Hospital administrators, funding organizations, and health policymakers may find the results of this study useful. The findings suggest that at least two aspects of the organization of nursing in acute-care hospitals — nursing skill mix and nurses' years of experience in their clinical units — have a direct effect on 30-day mortality. If hospitals are considering strategies that will change nursing skill mix or years of experience on clinical units, these findings can be used to estimate the effects of the changes on 30-day mortality. The findings also have implications for the decision of hospitals and collective bargaining units to displace nursing staff in times of perceived over-supply, and they shed doubt on the appropriateness of bumping, a common practice in the management of nurses in hospitals.

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