University of Alberta

The Effects of Nursing-Related Hospital Factors on 30-Day Medical Mortality

by

Ann Elizabeth Tourangeau ©

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Abstract

The purpose of this study is to increase our understanding of the effects of nursing-related hospital variables on 30-day patient mortality. A '30-Day Mortality Model' is hypothesized, tested, and refined to explain relationships of the predictor variables with 30-day mortality. Predictor variables include: dose of nursing staff, nursing skill mix, amount of professional role support for nurses, nurse experience, nurse capacity to work, condition of the nursing practice environment, physician expertise, and hospital type / location. Data sources include the Discharge Abstract Database 1998-99 from the Ontario Ministry of Health and Long-Term Care, the Ontario Hospital Reporting System 1998-99, the Ontario Registered Nurse Survey of Hospital Characteristics, the Ontario Registered Persons Database, and Statistics Canada Census 1996 Population Files.

The unit of analysis is the hospital. The study employs a retrospective design. The dependent variable, a weighted and risk-adjusted 30-day mortality rate, is developed for each hospital using the general formula of observed hospital deaths divided by predicted hospital deaths. Hospital deaths are predicted through a series of logistic regression models. A total of 46,941 discharged patients from 75 Ontario hospitals are included in the study. Only patients with a 'most responsible diagnosis' of acute myocardial infarction, stroke, pneumonia, or septicemia are included. Hospital data from the Ontario Hospital Reporting System 1998-99 and 3988 registered nurse survey responses are used to develop nursing-related hospital predictors.

Multiple regression models are used to test the hypothesized relationships of the predictor variables with hospital 30-day mortality. The final multiple regression model explains 32 percent of variance among risk-adjusted mortality rates in sample hospitals. The results provide evidence of an association between a richer nurse skill mix and lower 30-day mortality rates in sample hospitals. Evidence is also found to support a relationship between more years of registered nurse experience and lower 30-day mortality rates. One surprising finding is that reduced nurse capacity to work (higher numbers of reported missed shifts) is associated with lower 30-day mortality. None of the other 30-day mortality model predictors added to the explanation of variation in risk-adjusted 30-day mortality rates among sample hospitals.

Dedication

There are a number of people to whom I would like to dedicate this thesis. Each of them helped me complete my doctoral studies in their own way.

To Susan Duncan who always shared both the hilarious and serious sides of important situations.

To my family who kept me grounded and encouraged my progress throughout my studies.

To Dr. Phyllis Giovannetti for her unwavering faith in my abilities.

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Chapter One

Introduction

This study has been motivated by my experiences both as a hospital nurse administrator and as a student in the nursing doctoral program at the University of Alberta. As an administrator, I have focussed much effort on plans and decisions related to the most effective amount (e.g., hours) of registered nurses, the best skill mix of various kinds of nursing staff, the amount and kind of professional role support for nurses, and the development of a nursing practice environment conducive to good patient outcomes. As a doctoral student, I have had the opportunity to work with an international and interdisciplinary team of scientists who have been empirically developing knowledge of the relationships among the employment of nurses within hospitals and global hospital outcomes such as rates of mortality, failure-to-rescue, and readmission. This evidence is important to build theory that should be used to guide the development of health policy as well as hospital policies that relate to the organisation of nursing staff in hospitals, nursing education curriculum content, and further research on the effectiveness of nursing care. I have always believed that nursing-related hospital factors like the amount of nursing care provided, the experience and skill mix of nurses, the amount and kind of nursing role support, and the environment in which nurses work all affect patient health outcomes. However, there is only beginning theory and supporting empirical evidence demonstrating these relationships and effects. This research contributes to the developing body of knowledge on the effects of the characteristics of some hospital nursing variables on the global hospital clinical outcome of 30-day medical mortality rates.

The Research Problem and Its Significance

The problem addressed in this study is the need for empirical evidence to develop theory describing the relationship between the hospital outcome '30-day medical mortality' and nursing-related hospital characteristics. Nursing-related hospital characteristics include the amount or dose of nursing staff, nurse characteristics such as experience and capacity to work, skill mix of nursing staff, availability of professional role support for nursing staff, continuity of nursing care provided to patients, and the condition of the environment in which nursing care is provided. Theory developed in this study may be used when making policy and practical decisions about the organisation of nursing in hospitals, including nurse staffing and the condition of nursing practice environments. These decisions have large cost and quality outcome implications for hospitals and patients.

There is a growing literature on cost evaluation of different patterns of nurse staffing (Besner, 1985; Bostrom & Zimmerman, 1993; Eastaugh, 1990; Garfink, Kirby, Bachman, & Starck, 1991; Krapohl & Larson, 1996; Lengacher & Mabe, 1993; O'Brien-Pallas, Irvine, Peereboom, & Murray, 1997; Pfefferkorn & Rovetta, 1940; Tourangeau, White, Scott, McAllister, & Giles, 1999). There also is a growing literature examining some patient quality outcomes (Aiken, Sloane, & Sochalski, 1998; Aiken, Smith, & Lake, 1994; Aydelotte, 1962; Blegen, Goode, & Reed, 1998; Blegen & Vaughn, 1998; Bostrom & Zimmerman, 1993; Brooten & Naylor, 1995; French, 1997; Heinemann, Lengacher, VanCott, Mabe, & Swymer, 1996; Kitson, 1997; Maas, Johnson, & Moorhead S., 1996; Mitchell, Ferketich, & Jennings, 1998; Neidlinger, Bostrom, Stricker, Hild, & Zhang, 1993; Pierce, 1997; Tourangeau et al., 1999; van Servellen & Schultz, 1999; Wan & Shukla, 1987). Nurse researchers and nurse leaders have struggled over the past several decades to identify those patient outcomes that are sensitive to nursing care. Despite the growth in knowledge of outcomes that are sensitive to particular nursing interventions, research has generally not focussed on the study of relationships among hospital nursing variables such as nurse staffing and their relationship with global hospital outcomes such as mortality. Hospital care is for the most acutely ill and medically unstable patients who are primarily hospitalised because of their need for nursing care. It is therefore reasonable to believe that the study of hospital mortality may be even more important now and in the future (Aiken, Sochalski, & Lake, 1997; van Servellen & Schultz, 1999). Others believe that global hospital outcomes such as mortality are not sensitive to nursing-related hospital organisation variables because it is thought that these global outcomes are almost exclusively influenced by patient characteristics (Mitchell & Shortell, 1997). Apart from the effects of patient characteristics on mortality, there is a relatively common assumption that physician expertise or competence affect patient mortality.

Historically, decisions related to nurse staffing have not generally been made with consideration of both cost and patient quality outcomes. Before and even during the 1960s, nurse staffing pattern decisions were based largely on traditional approaches such as a fixed number of nursing care hours per day and the authority of the nursing leadership within the hospital (O'Brien-Pallas, Giovannetti, Peereboom, & Marton, 1995; Williams & Murphy, 1979). However, in the 1960s and 1970s, there was growing recognition that some patients required different amounts and types of nursing care than did others. Indeed, nursing workload measurement systems were developed to more objectively assess the amount and type of care needed by each hospitalised patient. The development of nursing workload measurement systems enabled nurse staffing pattern decisions to be made, at least in part, with consideration of patients' needs for nursing care as assessed through a particular nursing workload measurement system (Edwardson & Giovannetti, 1994; Giovannetti, 1979).

By the 1980s, there was widespread recognition that spending on health care in North America was increasing at an alarming and unsustainable rate (Angus, Auer, Cloutier, & Albert, 1995). Also, by the 1980s, medical case mix classification systems were being developed, refined, and accepted within the American health care system as well as in parts of the Canadian health care system. In the United States, case mix classification systems were being used as a basis for prospective hospital payment. In Canada, these systems were being considered for use in formulae to develop base hospital budgets. Both the rising concern for fiscal accountability and the use of case mix classification systems for hospital funding encouraged heightened emphasis on the study of exact costs of nursing care for individual patients within and among hospitals. It was recognised that nursing services in hospitals accounted for one of the single highest operating expense. Consequently, nursing services became an obvious target in hospital cost-cutting activities beginning in the 1980s and continuing well into the 1990s (Aiken et al., 1997; Aiken, Sochalski, & Anderson, 1996; O'Brien-Pallas et al., 1995). With little evidence about the effects of the amount of nurse staffing hours, the skill mix of nursing personnel, and the amount of professional role support on outcomes such as mortality, there was little defence to counteract the calls for decreasing the supply of registered nurses, weakening the skill mix of hospital nursing staff, and decreasing the amount of professional role support for hospital nurses. In the late 1980s, with the aim of decreasing total hospital expenditures, hospitals began embarking on changing the amount of registered nurse hours available to provide care, the skill mix of nursing care providers, and the amount of professional role support provided (Brooten & Naylor, 1995; Fagin & Gordon, 1996). In many hospital environments, more commonly in unionized hospitals, this often resulted in the movement of registered nurses from one clinical area to another regardless of knowledge, skill, or experience but rather on the basis of seniority within a hospital. Changes in the amount of registered nurse hours and in the skill mix of nursing staff usually have resulted in the segmentation or parcelling out of patient care to a variety of nursing staff prepared at different levels. These changes in how patient care is delivered and by whom constituted a shift in the nursing practice environment. There has been speculation of the lack of wisdom shown when untested nursing care delivery models that involved decreasing the amount of registered nurse hours and weakening the skill mix of nursing staff were implemented across health care systems. These untested care delivery models were designed primarily for the purpose of hospital restructuring and re-engineering and usually involved changing both the amount of registered nurse hours of care delivered and the skill mix of those providing nursing care (Aiken & Fagin, 1997; Sochalski, Aiken, & Fagin, 1997). However, little is known about the effects of these changes in models of nursing care delivery. Little attention has been given to exploring the relationship between the organisation of nursing in hospitals and patient outcomes (Aiken et al., 1994). In this study, I examine the relationships among hospital nursing-related variables and 30-day post-admission mortality.

Chapter Two

Review of the Related Literature

The objectives of this review are to describe the literature used to develop the proposed study and to explicate the current state of knowledge related to nursing-related hospital factors and their relationships with 30-day mortality rates. As well, the review will highlight gaps in the research literature and will culminate in a description of how this study will address one gap in our knowledge of how hospital nursing structures and processes are related to 30-day mortality rates.

Scope of the Literature Review

The literature review began by searching nursing and health services database literature indexed in CINAHL, MEDLINE, and HEALTHSTAR from 1980 to March 2001, using the key words 'nurse staffing', 'nurse', 'staffing', 'mortality', and 'hospital environment'. As well, equally valuable sources of literature were found within the references in key publications. This review focuses on the research that examines both nursing-related acute care hospital factors and the outcome of mortality.

The format of this literature review is an 'integrative research review'. An integrative literature review summarises past research by drawing overall conclusions from many separate studies that address the topic area with the aims of not only describing the present state of knowledge, but also highlights important issues that past research has left unsolved (Cooper, 1982; Cooper, 1989). This review begins with an overview of the historical context of the study of nurse staffing of hospitals and the evolution of the foci in this area of research. This is followed by a review of the nursing research literature on the condition of nursing practice environments within acute care hospitals. This literature was largely developed through a series of studies on magnet hospitals and has laid the foundation for the exploration of hospital organisation characteristics as being important influences on both nurse and patient outcomes. Following this, the research literature examining the relationships among nursing-related hospital variables and mortality is reviewed.

The Historical Context of the Study of Nurse Staffing in Hospitals

The study of nurse staffing of hospitals has kept close pace with the study of quality of care in hospitals. According to Donabedian, quality of care has three major dimensions: structure, process, and outcomes (Donabedian, 1980). The study of hospital quality of care began by first examining structural components of care, then evolved to the examination of process and outcomes components of care, and then finally to the study of outcomes of care as they interact with the structure and processes of hospital care. The study of nurse staffing of hospitals is evolving in a similar manner beginning with the study of hospital nursing structures and processes and evolving toward the study of the outcomes of nursing care as they interact with various nurse staffing structural and process components. It is the relationships among structures, processes, and outcomes of care that define quality (Jennings & Staggers, 1998). Quality is one indicator of effectiveness and outcomes are but one measure of quality of care (Jeffs, 1998; Mark, 1995).

The study of nurse staffing of hospitals has spanned many decades dating at least as early as 1940. The beginning focus was on the study of the structural and process components of nurse staffing in hospitals. As cited in O'Brien-Pallas et al (O'Brien-Pallas et al., 1995), Pfefferkorn and Rovetta completed a descriptive study of hospital requirements and use of nursing personnel in 1940 (Pfefferkorn & Rovetta, 1940). This landmark study of hospitalised medical-surgical patients set the standard methodology of assigning hours of nursing care to a patient day. The assumption was that, on average, patients in an occupied bed required a similar amount of nursing care; set as 3.2 hours of direct nursing care hours in 1940. This methodology, as well as the standard, remained an acceptable practice in hospitals across North America well into the 1980s (O'Brien-Pallas et al., 1995).

By the 1960s, there was some recognition that not all hospitalised patients required similar amounts of nursing care. Instead, industrial engineering approaches were being developed that involved the study of nurses at work, including time and task completion (Connor, 1961; Dudek & Gailani, 1960). These studies pioneered the way for the research and development of nursing workload measurement or patient acuity systems that still continue into the present. The first two generations of nursing workload measurement were developed to identify and quantify patient care needs for the purpose of estimating the required nursing staff for each patient. However, the third and fourth generation systems currently being developed serve the purposes of not only estimating the need for nursing resources for patient care requirements but also are being used to assess patient and hospital outcomes in relation to nursing resource inputs (Malloch & Conovaloff, 1999). There are several approaches to nursing workload measurement that differ in how patient conditions are measured. Each approach is designed to estimate the total amount of nursing care hours (both direct and indirect) required for patient care. Little was known about the equivalence of the hours of care estimated by the various approaches to nursing workload measurement until O'Brien-Pallas (O'Brien-Pallas, 1987) tested the workload estimates of three different systems on 206 patients from two medical case mix groups. Although she found that the projected estimates for nursing care were highly correlated among all three nursing workload measurement systems, she also found statistically significant differences in estimates among all three systems (O'Brien-Pallas, Leatt, Deber, & Till, 1989; O'Brien-Pallas, 1987). Further study to compare hours of care estimates by five frequently used nursing workload measurement systems was undertaken to determine the equivalence of estimates in a sample of 256 patients. Again, all five systems produced significantly different hours of care estimates (O'Brien-Pallas, Cockerill, & Leatt, 1991; O'Brien-Pallas, Cockerill, & Leatt, 1992). This evidence has lead to criticisms of the credibility of nursing workload measurement systems for being non-equivalent, and thus, unreliable measures of patient requirements for nursing care. In general, the study of nurse staffing throughout this period was still largely related simply to the determination of the requirements for nursing care by hospitalised patients rather than examination of nurse staffing in relation to specific patient or organisational outcomes. There was, however, one notable exception found. In 1962, Aydelotte reported on an experimental study conducted to determine whether increasing the amount of nurse staffing, without lowering the average nursing skill level, produced improvements in patient welfare. Patient welfare was conceptualised as clinical measures (e.g., hospital days, fever days, and doses of analgesics and sedatives), scaled measures (e.g., mobility, skin condition), and patient sampling measures (e.g., percentage of time spent in bed, percentage of time spent up). An increase in nurse staffing was not found to result in improvements in patient welfare (Aydelotte, 1962). Unfortunately, data analysis procedures were not reported. Some of the discussion about why 'no effects' were found focussed on the potential inadequacies of the instruments used to measure patient welfare. Nonetheless, this study was a beginning effort to empirically seek evidence of relationships between the amount of nurse staffing and patient outcomes.

Until the 1980's when there was beginning recognition of the alarming increases in health care expenditures, the specific costs of nursing care for different hospitalised patients were generally not known. This lack of knowledge prevailed even though there was recognition that nursing services in a hospital accounted for the single highest human resource expense. This growing emphasis on cost containment in the 1980's shifted the focus of study of hospital nurse staffing to the determination of costs associated with different nurse staffing patterns (Bostrom & Zimmerman, 1993; Eastaugh, 1990; Garfink et al., 1991; Krapohl & Larson, 1996; Lengacher & Mabe, 1993; Powers, Dickey, & Ford, 1990; Tourangeau et al., 1999).

As case mix classification systems were being used more consistently within both the American and Canadian health care systems to develop prospective payment systems or to develop hospital base budgets, concerns were being raised about the adequacy of these grouping systems to accurately predict nursing resource use. Both the rising concern for fiscal accountability and the use of case mix classification systems for hospital funding encouraged heightened study of the exact costs of nursing care for individual patients within and among hospitals (Ballard, Gray, Knauf, & Uppal, 1993). However, the determination of nursing costs for individual patient episodes was impeded because patient-specific requirements for nursing care, as measured by nursing workload measurement systems, were not retained in the patient care record, nor were records usually kept of the actual allocation of the different categories of nursing staff assigned to each patient. Though medical case mix groupings were designed to group patients who consumed similar amounts of hospital resources, a number of researchers found that these groupings were not sensitive measures of variations in nursing resource use within hospitals. These researchers suggested that the inclusion of classifications of severity of illness within a case mix group improved the ability of case mix groupings to predict nursing resource use (Besner, 1985; MacKenzie, Giovannetti, Gerlach, & Slobodan, 1992; O'Brien-Pallas et al., 1997).

Though efforts to study the costs of hospital services, including nursing services, were prevalent throughout the 1980s and 1990s, there was also growing recognition that examining the costs of nursing service in isolation from other quality outcomes presented an incomplete picture of the effectiveness of nursing services in hospital patient care (Jennings & Staggers, 1998). In fact, cost is but one part of the definition of quality (Donabedian, 1993). One of the challenges in this more recent period has been the identification of nursing-sensitive patient and organisational outcomes. A nursing-sensitive outcome is a state, behaviour, or perception that is responsive to nursing intervention (Irvine, Sidani, & McGillis Hall, 1998; Maas, Johnson, & Moorhead S., 1996). One major issue in the search for nursing-sensitive outcomes is theoretical in nature. There is the need for intervention theory that identifies "factors related to the intervention, the intervener, the clients, and the setting that influence the clients' response to the intervention and on determining the impact of these factors on outcome achievement" (Sidani & Braden, 1998) (p. vii). Much work has been completed over the past decade to develop classification schemes that identify nursing-sensitive outcomes as well as the related nursing interventions and patient problems (Bowles & Naylor, 1996; Henry, Holzemer, Randell, Hsieh, & Miller, 1997; Maas et al., 1996; Micek et al., 1996; Nielsen & Mortensen, 1997; Nielsen & Mortensen, 1998). These classification schemes are largely developed using empirical evidence linking specific patient problems, specific nursing interventions, and patient outcomes.

In the past, patterns of nurse staffing have not usually been conceptualised as a category of nursing interventions that affect patient outcomes, with the exception of the study of costs of nursing services as an outcome. Recently, there have been more studies examining various patterns of nurse staffing, both the amount and skill mix, and the relationship of these staffing patterns with adverse clinical patient outcomes such as medication errors, patient falls, cardiopulmonary arrests, pressure ulcers, pneumonia, urinary tract or other infections, post-operative infections, and intravenous complications (Blegen, Goode, & Reed, 1998; Blegen & Vaughn, 1998; Heinemann et al., 1996; Krapohl & Larson, 1996; Lichtig, Knauf, & Milholland, 1999; Tourangeau et al., 1999; Wan & Shukla, 1987) and to studying other clinical indicators such as length of stay and patient satisfaction (Behner, Fogg, Fournier, Frankenbach, & Robertson, 1990; Bostrom & Zimmerman, 1993; Bryan et al., 1998; Czaplinski & Diers, 1998; Heinemann et al., 1996; Lichtig et al., 1999; Neidlinger et al., 1993; Tourangeau et al., 1999).

There are a number of issues related to the study of nurse staffing in hospitals. Perhaps the issue that most impedes such research is the lack of visibility of nursing and nurses' work in current health databases (Giovannetti, Smith, & Broad, 1999; Giovannetti & O'Brien-Pallas, 1998). Because of recognition of this deficit in data availability as far back as the early 1960s, there have been calls for the development of a nursing minimum data set (Werley, 1988). According to Werley (p. 7), a nursing minimum data set consists of "a minimum set of information with uniform definitions and categories concerning the specific dimension of professional nursing, which meets the information needs of multiple data users in the health care system." Several of the areas deemed essential components of a nursing minimum data set are data for each hospitalised patient on nursing intensity use (O'Brien-Pallas & Giovannetti, 1993), nursing interventions implemented (Giovannetti et al., 1999; McCloskey & Bulechek, 1993) and the outcomes of nursing care (Giovannetti et al., 1999; Marek & Lang, 1993). Much work has been done over the past two decades in Canada to establish mechanisms that make the work of nursing more visible in health care databases (Canadian Nurses Association, 1993). In 1985, the 'Guidelines for Management Information Systems in Canadian Health Care Facilities', commonly referred to as the 'MIS Guidelines' were published and tested. These guidelines were developed to improve both the timeliness and comparability of data collected within Canadian health care facilities by providing standards related to data gathering, data processing, data integration, and reporting of financial, statistical, and clinical information (Peacock, 1993). Implementation of the

MIS guidelines involved the use of nursing workload measurement systems within hospitals to determine the units of service provided to specific patients throughout their stay in hospital. The implementation of patient-specific nursing workload measurement systems represent a significant gain in estimating patient-specific costs but still do not assist in explaining variations in resource utilisation nor in identifying specific nurse-initiated activities or interventions. Full implementation of the MIS guidelines has yet to be achieved across Canadian hospitals. Though agreement in principle has been reached with such agencies as the Canadian Institute for Health Information about the importance of nursing minimum data sets (Giovannetti & O'Brien-Pallas, 1998), there still is limited movement toward the routine collection of such patient and nurse-specific data.

The Condition of the Nursing Practice Environment

Our understanding of the constituents of a professional nursing practice environment has been furthered largely through research related to magnet hospitals. Many hospitals in the United States experienced a critical shortage of registered nurses in the early 1980s. Despite the under-supply of registered nurses, there were a number of hospitals that successfully recruited and retained registered nurses throughout this period of shortage. Because of the ability of these hospitals to successfully attract and retain registered nurses, these hospitals were called 'magnets'. A task force consisting of a group of nurse fellows from the American Academy of Nursing was struck in 1982 to study what nurses found satisfying about their practice and practice environments in American magnet hospitals (Havens & Aiken, 1999; Scott, Sochalski, & Aiken, 1999). It was expected that understanding the characteristics or conditions of the nursing practice environments of these magnet hospitals would enable other hospitals to develop similar environmental conditions. The initial study carried out by the task force was a descriptive study of 41 magnet hospitals (McClure, Poulin, Sovie, & Wandelt, 1983). The sampling procedure used to select magnet hospitals began with a nomination process in which a group of nurse fellows of the American Academy of Nursing were invited to nominate American hospitals if a hospital met the following criteria:

- had a reputation for quality nursing care
- had a reputation for being a good place to work
- was located in an area where there was some regional competition for registered nurse services
- met criteria with respect to registered nurse retention and turnover rates
- met requirements for proportion of registered nurses of all nursing staff
- met requirements for ratio of nurses to patients.

In all, 165 hospitals were nominated and 155 of these hospitals agreed to participate in the study. Four members of the task force reviewed the nominations, and ranked them based on the submissions of hospital data with respect to retention, turnover rates, proportions of registered nurse staffing, and nurse-patient ratios. One hundred nine of the nominated hospitals were eliminated. Of the 46 nominated hospitals that qualified as 'magnets', the final sample consisted of 41 hospitals that agreed to participate in the study (Havens & Aiken, 1999; Kramer & Schmalenberg, 1988a; Scott et al., 1999). The sampling procedure used was never intended to identify all American magnet hospitals but rather was intended to identify a non-probability sample of magnet hospitals (Buchan, 1999). Investigators wanted to describe the characteristics of these magnet hospitals. Chief nurse executives and one staff nurse from each of the 41 magnet hospitals participated in regional group interviews.

The findings from the initial group of magnet hospitals were grouped into the following areas: leadership / administration, professional practice / registered nurse attributes, and professional development. Magnet hospital nursing leaders were reported as having the following distinct attributes: being visionary, having supportive and participatory management styles, being well educated, having high standards and expectations of nursing staff, valuing professional development and on-going education of nursing staff, maintaining positions of both power and status within the hospital, maintaining open lines of communication, and being actively involved in professional nursing organisations. Magnet hospitals had nursing administration structures and processes that were decentralised, employed clinical experts, and facilitated flexible working schedules. These hospitals were reported as: having professional practice models of care delivery such as primary nursing, being supportive of and expecting nurse autonomy and responsibility, and emphasising the teaching responsibilities of nurses. Magnet hospitals had planned and structured orientation of new registered nurse staff, highly valued and supported continuing education, and supported competency-based career or clinical ladders. Registered nurses working in these magnet hospitals reported the following: being able to establish and maintain therapeutic relationships with patients, having autonomy and control over their work, and having collaborative and mutually respectful relationships with physicians at the level of the patient care unit (Buchan, 1999; Havens & Aiken, 1999; Scott et al., 1999). The overall ratio of registered nurses to licensed practical nurses was 10 to 1 and the registered nurse to nursing aide (unlicensed assistive personnel) ratio was 12 to 1 (Kramer & Schmalenberg, 1987a).

This original magnet hospital study resulted in the description of the reported similarities of characteristics of the nursing practice environments among the 41 designated sample hospitals. No attempt was made to compare these findings with those of non-magnet hospitals. Nor was any attempt made to study the products or outcomes of the magnet hospitals' nursing care (Kramer & Schmalenberg, 1988a). Because of the non-probability sampling plan used to select magnet hospitals in this original study, generalisation of the findings to all 'magnet-like' hospitals is not possible. However, this study laid the foundation that enabled continued research into organisational attributes of hospitals and their relationships to patient, nurse, and organisational outcomes.

Kramer and Schmalenberg (Kramer & Schmalenberg, 1988a; Kramer & Schmalenberg, 1988b) completed a descriptive study of a subset of 16 of the original group of 41 magnet hospitals and compared these hospitals with the characteristics of excellent organisations described in the publication "In Search of Excellence" (Peters & Waterman, 1982). They asked the following question: to what extent are the eight attributes that emerged as characteristics of excellent and innovative companies (as per Peters and Waterman) also found to be operative in magnet hospitals? Though not a probability sample, Kramer described the sample of 16 magnet hospitals as a nationally representative subset of the original 41 magnet hospitals. Individual and group interviews were conducted with more than 800 staff registered nurses, clinical nurse specialists, staff development instructors, nursing directors, and chief nurse executives of the sample magnet hospitals. As well as interviews, observations of nurses carrying out nursing work were completed on all shifts in each study hospital. Hospital data were collected for the following variables: number of beds, number of fulltime equivalents for all categories of nursing staff, percentage of fulltime to part-time registered nurses, percentage of nursing staff that were registered nurses, level of educational preparation of nursing staff, average years of registered nurse experience, average years of registered nurse employment at that hospital, average number of registered nurse positions currently filled, number of registered nurses per occupied bed, number of registered nurse resignations over the past year, and average number of supplemental or agency registered nurse fulltime equivalents used each month.

Turnover rates were low in all but one of the 16 magnet hospitals. When compared to the original magnet hospital study in 1982, almost all of the magnet hospitals reported a growing percentage of registered nurses and indicated that they were moving toward an all-registered nurse staffing pattern. These hospitals were even more successful in recruiting and retaining registered nurse staff then they had been in 1982. In 1986, sample hospitals reported having a mean of 1.4 registered nurses per occupied bed – an increase from the ratio of 1.1 registered nurses per occupied bed in 1982. As well, the median registered nurse to licensed practical nurse ratio increased slightly from 10 to1 in 1982 up to 11 to 1 in 1986. The registered nurse to nursing aide ratio decreased from 12 to 1 in 1982 to 8 to 1 in 1986 (Kramer & Schmalenberg, 1987a; Kramer & Schmalenberg, 1987b). The dominant nursing care delivery model was no longer reported to be primary nursing but instead was reported to be total patient care by a registered nurse over a particular shift. As well, there was virtually no use of agency or supplemental staffing in these magnet hospitals. These findings support the conclusion that magnet hospitals were moving toward a higher mix of registered nurses to deliver nursing care. Kramer and Schmalenberg concluded that seven of the eight characteristics of excellent and innovative companies (Peters & Waterman, 1982) were also generally present in this sample of magnet hospitals:

- proclivity to act or try things out
- a strong, pervasive focus on quality of care and excellence (staying close to the customer), as well as a focus on education and professional development
- an environment that supports nurse autonomy and entrepreneurship
- a hospital organisation that demonstrates respect for the individual
- nursing leadership that was both hands-on and value-driven
- hospitals administrative structures that were flat, lean, and decentralised
- simultaneous loose-tight organisations that consist of firm central direction, lots of individual autonomy, flexible organisation structures, copious feedback, and being informal.

The findings of this descriptive study confirmed and supported the findings of the original magnet hospital research. However, some of the same limitations were present in this study as were in the original study. The sample used was a non-probability sample of the original non-probability sample of 41 selected 'magnet hospitals'. Generalisation of these findings to other hospitals considered 'magnets' is limited. As well, because no comparisons were made with non-magnet hospitals, it was unclear whether many of these attributes might be present or absent in other magnet or non-magnet hospitals. An alternate explanation for the findings might be that these characteristics are similar in both magnet and non-magnet hospitals.

Kramer and Schmalenberg continued their program of study of magnet hospitals. In 1989-90, they conducted a survey of American nurses to explore what influences nurse job satisfaction. In this descriptive comparative study, the findings of magnet hospital nurses from 14 of the 16 magnet hospitals studied in their previous research were compared to the findings from nurses-at-large. A total of 1444 surveys were sent to magnet hospital nurses and 939 completed surveys were returned (response rate of 69 percent). The 'panel' of nurses-at-large was drawn from a systematic sample of 5000 subscribers to the journal "Nursing 89". A total of 1543 completed surveys were returned by 'panel' nurses (response rate of 30 percent) (Kramer & Schmalenberg, 1991a; Kramer & Schmalenberg, 1991b).

Neither the survey nor its properties were described in detail in the study report though the authors described how nurses were asked questions about five common aspects of job satisfaction: organisational structure, professional practice, management style, quality of leadership, and professional development. Nurses were asked to rate how important each of the identified aspects of job satisfaction were to them and then asked to rate how satisfied they were with these aspects in the hospitals in which they worked. Unfortunately, no evidence or discussion of the reliability and validity of the questionnaire was presented as part of the study report.

Kramer and Schmalenberg found that in 1989-90, there were 1.5 registered nurses per occupied bed in magnet hospitals compared to the American national average ratio of 1.2 registered nurses per occupied bed. Nurses from magnet hospitals reported being more satisfied with their jobs than did nurses from the control or 'panel' group ($p > 0.001$). Furthermore, magnet hospital nurses reported perceiving better staffing in their hospitals than did 'panel' nurses ($p > 0.001$). They found that magnet hospital nurses reported having more discretionary power at the unit level than did 'panel' nurses, had higher levels of self esteem than 'panel' nurses, and had both higher opinions of and were more satisfied with their leaders than were 'panel' nurses. They concluded that more magnet hospital nurses reported their hospitals as possessing the attributes of magnetism and that these attributes were positively correlated with nurse job satisfaction and nurse self esteem. However, the bases for these conclusions were not clearly evident in the findings presented.

This study extended the previous magnet hospital research by introducing a comparison group to determine if there were differences in perceived job satisfaction and nurse staffing in magnet and non-magnet hospitals. However, this study had many limitations, particularly related to the non-probability and potentially non-representative sample for the magnet and panel hospital nurses, as well as the lack of evidence of credibility for the survey instrument employed. The study did offer evidence of a relationship between nurse job satisfaction and nurse staffing of hospitals. Further research could build on this study to link these two variables with patient and hospital outcomes to determine what differences nurse staffing and nurse job satisfaction have on patient and hospital outcomes.

In 1989, in tandem with the study that explored nurse job satisfaction, Kramer further extended the study of the 16 magnet hospitals examined in 1986 by completing telephone interviews with 14 of the 16 chief nursing executives and collecting hospital-specific demographic data (Kramer, 1990). In this descriptive study, she found that certain trends had continued in these hospitals: further flattening of nursing administration, further movement toward an all-registered nurse staff, an increase in the median percentage of registered nurse fulltime equivalents out of all nursing staff positions from 76 percent in 1986 to 81 percent in 1989), and greater autonomy and decision making expectations for registered nurses. Chief nurse executives officers were asked in an open ended question to describe what were the most important new things that had taken place in their nursing departments and hospitals over the last three years. They most frequently cited the following activities: 1) redesigning or developing new care delivery systems (n = 13), 2) designing, expanding or differentiating nurse roles (n = 12), 3) developing programs and activities to enable or empower staff (n = 12), 4) strengthening collaborative practice (n = 11), 5) flattening the organisational structure (n = 10), and 6) strengthening computerisation programs, particularly related to documentation (n = 5). Kramer concluded that these hospitals continued to enjoy very limited or no nursing shortage and were engaged in a variety of innovative programs. She considered them to be hospitals that displayed cultures of excellence and leadership; they continued to maintain magnet qualities. With no comparisons made to other magnet or non-magnet hospitals, nor without evidence of the relationships of these attributes found in this group of magnet hospitals to patient or hospital outcomes, few generalisations, if any, can be made to other hospitals. Nor can conclusions be made about the effectiveness of magnet hospitals.

In 1997, approximately 15 years after the original magnet hospital research and after significant hospital restructuring had already been undertaken in most North American hospitals, Buchan (Buchan, 1999) studied 14 magnet hospitals to determine whether the characteristics of excellence found in the original magnet hospitals had been retained. This more recent study of magnet hospitals explored the stability of 'magnet' characteristics of hospitals over a period of instability within hospitals. Hospital restructuring activities in the late 1980s and into the 1990s changed how some hospital work is done, by whom work is done, and had also changed the environment in which work is done. Ten of the original group of magnet hospitals and four newly designated hospitals accredited with magnet hospital status through the American Nurses Credentialling Center were included in this descriptive case study. Structured interviews with managers from each hospital were used to gather data.

Overall, Buchan found that almost all of the hospitals studied had experienced nursing skill mix changes, usually in the form of dilution of the registered nurses 'dose' through substitution of registered nurses by unlicensed assistive personnel or by licensed practical nurses. Furthermore, he found, as did Kramer and Schmalenberg (1988), that primary nursing was no longer the standard model of nursing care delivery in these hospitals and that instead, primary nursing had been replaced with registered nurse-led teams consisting of unlicensed assistive personnel and / or licensed practical nurses. Buchan found that magnet hospitals remained decentralised and had even further reduced their layers of management since the original magnet hospital study in the early 1980s. This finding was consistent with the decrease in nursing administrators in magnet hospitals found by Kramer in 1990 (Kramer, 1990). He noted that the one striking finding in almost all of these study hospitals was that each hospital had opted for managing the process of hospital restructuring internally rather than relying on external consultants. Buchan found that of the core magnet hospital characteristics determined in the original research, those attributes that remained in magnet hospitals were, on a scale from 'in place in all hospitals' to 'in place in some hospitals':

- decentralised organisation structure (all sample hospitals)
- flexible work practices
- clinical career ladder
- participatory management style
- professional autonomy

- continuing professional education
- registered nurse-rich skill mix
- nurse executive at the board level (some hospitals).

He concluded that some of the original magnet hospitals had retained much of their key magnet characteristics, while others no longer possessed some of the major attributes of magnetism.

There are a number of limitations with this study. Generalisation of these findings is restricted because of the non-probability sampling procedures used as well as the procedures for data acquisition. Only managers were selected as informants and they alone may not be the most appropriate sample of hospital employees to accurately describe their organisations. More importantly, the presence or absence of magnet characteristics in hospitals is insufficient to draw conclusions about the impact of magnetism, or its lack, on patient and hospital outcomes. Clearly further research would be needed to explore the relationships between the strength or dose of magnet attributes of hospitals and hospital patient outcomes.

In 1994, Aiken, Smith and Lake published the results of a retrospective comparative study that examined differences in 30-day mortality between magnet and non-magnet hospitals using a sample of Medicare patients (65 years of age and older) in 234 American hospitals. The objective of the study was to determine whether hospitals known to be good places for nurses to practice (magnet hospitals) had lower Medicare mortality than otherwise similar hospitals that were not especially known for their good nursing care nor as being good places to practice (Aiken, Smith, & Lake, 1994). Until this study, no other studies could be located that examined differences in patient outcomes between magnet and non-magnet hospitals.

Thirty-nine of the 41 original magnet hospitals identified in the early 1980's were included in the sample. Hospital 30-day mortality data from the Health Care Financing Administration (HCFA) file were not available for the other 2 original magnet hospitals and thus both were excluded from this study. The sampling procedure for the non-magnet control hospitals was a complex process of identifying a matched control sample from a total population of 5033 non-magnet hospitals in the HCFA hospital mortality file. A process of multivariate matched sampling was used to control for organisational differences between hospitals by adjusting for confounding variables and reducing bias due to observed co-variates. Each of the 39 magnet hospitals was matched with five control hospitals that were not known as magnet hospitals but were comparable with respect to other hospital attributes thought to be correlated with hospital mortality (e.g., hospital bed capacity, setting / urban-ness, medical staff expertise, and so on). A total of 195 non-magnet control hospitals were identified through this sampling procedure. Despite the use of matching techniques, there were differences that persisted between magnet and control hospitals. First, as expected, magnet hospitals employed more registered nurses both relative to patients (registered nurses per average daily census) and as a proportion of all nurses (registered nurses to total nursing personnel). Second, magnet hospitals had lower rates of predicted mortality. Predicted mortality was the indicator used as a proxy variable to control for differences in patient characteristics. To be included in the study, each hospital had to have reported at least 100 Medicare discharges during that year. Data about organisational structure, facilities and services, beds and utilisation, finance, personnel by occupation, and medical staff were acquired through the 1988 American Hospital Association annual survey of hospitals.

In analysis, variance component models were used to pool the data for the five matched control hospitals related to each magnet hospital and to adjust for uncontrolled patient composition. Patient composition was operationalised by the proxy variable 'predicted mortality'. They found that magnet hospitals had five fewer deaths per 1000 Medicare discharges ($p = 0.026$ and a 95% confidence interval of 0.9 - 9.4 fewer deaths per 1000) than did the matched non-magnet control hospitals. The authors concluded that magnet hospitals had a five-percent reduction in excess mortality compared to the non-magnet sample hospitals. One of the core attributes that had persisted within magnet hospitals was the higher level of skill mix or registered nurse to total nursing personnel than all American hospitals on average. To test whether this ratio of registered nurse to total nursing personnel provided the full explanation for the observed mortality effect, further analysis was completed using terms for within-block and compositional differences in both the nurse-to-patient ratios and the ratio of registered nurses to total nursing personnel. No evidence was found that either registered nurse-patient ratios or nursing skill mix (registered nurses to total nursing personnel) significantly affected mortality. The inclusion of these two variables in the model did not explain any further variance in magnet hospital mortality, nor did including these variables significantly alter the estimate of the treatment effect. It was concluded that the greater proportion of registered nurses was not the sole explanation for lower mortality in magnet hospitals. It was also concluded that the mortality effects were derived from other nursing-related organisational attributes which were commonly found in magnet hospitals but not in the control hospitals: higher registered nurse status, more nurse autonomy, and more nurse control over their own practice settings. Aiken, Smith and Lake realistically described a number of study limitations as well as possible alternate explanations for the findings. They acknowledged that unknown variables which had been omitted from the study and that were correlated with the set of nursing-related variables in the magnet hospitals could explain the lower mortality found in magnet hospitals. Generalisation of these findings is limited because of the non-probability sample of magnet hospitals studied. As well, the use of Medicare mortality limits the sample of patient mortality to those who are 65 years of age and older. However, this landmark study provides beginning evidence of a relationship between Medicare 30-day post-admission mortality and differences in nursing-related hospital characteristics in magnet and non-magnet control hospitals.

This group of studies examining the nature and condition of the nursing practice environment for registered nurses provides compelling evidence that 'magnet' or magnet-like hospitals possess core organisational attributes consisting of: valuing nurse autonomy and nurse control over the practice setting, valuing professional role support for the registered nurse role, nurses having collaborative and mutually respectful relationships with physicians, and providing a higher skill mix ratio of registered nurse care hours to patients and a larger ratio of registered nurses to occupied bed. Aiken, Smith, and Lake provided further evidence of the credibility of the concept and existence of 'magnet' hospitals by empirically demonstrating that hospitals considered to have 'magnet' attributes also had significantly lower Medicare mortality rates than did non-magnet control hospitals that did not possess 'magnet' characteristics.

Mortality and Nursing-Related Hospital Factors

Mortality rates are among the most common measures used to compare and rank hospital quality (Silber & Rosenbaum, 1997; Silber, Schwartz, Rosenbaum, Ross, & Williams, 1993; van Servellen & Schultz, 1999). Variation in mortality rates among hospitals is considered to arise from three major sources: patient characteristics, quality of care, and random variation (Mitchell & Shortell, 1997; Smith, 1994). A fourth source of variation is believed to arise from community or contextual factors (Al-Haider & Wan, 1991). Valid comparisons of mortality rates among hospitals must include adjustment for patient characteristics including case mix, disease severity, and co-morbidity. These adjustments control for pre-existing clinical factors that could affect patients' likelihood of death (Iezzoni et al., 1996). Differences that persist after these adjustments are made are usually assumed to reflect differences in hospital quality (Silber, Williams, Krakauer, & Schwartz, 1992). Study of the associations and effects of nursing-related hospital variables on mortality rates should utilise sound methods to adjust for patient characteristics so that the nursing-related hospital variable effects can be identified.

Apart from the study of mortality rates in magnet and non-magnet hospitals (Aiken et al., 1994), only ten other studies were located that examined some aspect of nursing-related hospital factors and their relationships with hospital mortality (Blegen et al., 1998; Farley & Ozminkowski, 1992; Hartz et al., 1989; Knaus, Draper, Wagner, & Zimmerman, 1986; Lake, 1999; Manheim, Feinglass, Shortell, & Hughes, 1992; Mitchell, Armstrong, Simpson, & Lentz, 1989; Schultz, 1997; Shortell & Hughes, 1988; Shortell et al., 1994). Of these ten studies, only four studies focussed on nursing-related hospital determinants of mortality as a central objective (Blegen et al., 1998; Lake, 1999; Mitchell et al., 1989; Schultz, 1997). The remaining six studies had objectives that were related to the exploration of medical and general hospital organisation attributes to explain mortality rather than the examination of nursing-related determinants of mortality as a central objective. Five of these six studies examined the variables 'registered nurse hours per patient day' or 'registered nurses as a percentage of all nursing personnel' as determinants of mortality (Farley & Ozminkowski, 1992; Hartz et al., 1989; Manheim et al., 1992; Shortell & Hughes, 1988; Shortell et al., 1994) and the sixth investigated the interaction and collaboration between nurses and physicians as an influence on hospital mortality (Knaus et al., 1986). Each of these studies is reviewed from earliest to most recent to elucidate the current state of knowledge of nursing-related determinants of mortality.

The earliest reported study that investigated the relationship between mortality and nursing-related hospital characteristics was a descriptive prospective study that examined and compared standard mortality rates among intensive care units in 13 self-selected American hospitals (Knaus et al., 1986). Patient data, survey data, and on-site observation comprised the study data. Non-probability quota sampling of patient cases was used to gather patient mortality data. Mortality was calculated as the ratio of actual to predicted deaths. The mean mortality ratio for sample intensive care units was considered the standard. Predicted death rates were calculated using the 'Acute Physiology and Chronic Health Evaluation' (APACHE II) severity classification system scores. The 'Daily Therapeutic Intervention Score' was used to measure intensity and type of medical treatment. Questionnaires were completed by each unit's medical director and nursing director with items being related to staffing, organisational structure of the unit and hospital, policies and procedures, educational affiliation, the extent of the participation of various personnel in patient care, and relationships among physicians and nurses.

In analysis, hospitals were ranked according to their mortality ratio performance (a ratio of 1.00 indicating performance approximating the average of all 13 hospitals and a ratio of less than 1.00 indicating an above average mortality ratio compared to all 13 hospitals). The findings of interest to this literature review relate to the associations found between hospitals with lower than average mortality rates and characteristics of the intensive care units in these hospitals. Knaus et al (1986) found that hospitals with the lowest mortality ratios had the following two characteristics: 1) a comprehensive nursing educational support system such as a master's prepared clinical nurse specialist who focussed on nursing staff education and development as well as targeted educational programs, and 2) excellent communication between physicians and nursing staff, including the nursing and medical directors of the units. They found that hospitals with the highest mortality rates did not possess either of these characteristics. They concluded that the highest quality of care appears to require a commitment to the education and development of nursing staff, a high degree of interaction and communication among dedicated physicians and nurses, as well as a high degree of effective co-ordination of medical and nursing staff.

The authors acknowledged that any number of confounding variables that were not studied could explain the findings such as poor estimation of death rates using APACHE II scores, the influence of average length of stay of patients in the intensive care units on mortality rates, and patient selection biases. They discussed the possible but unmeasured effects that both the volume of patients and teaching-ness of the hospital might have had on mortality rates. The contribution that this study makes to the development of knowledge of the determinants of mortality is beginning understanding that 1) collaboration and interaction between physicians and nurses, and 2) nursing professional support systems such as clinical nurse specialists and educational programs may both be related to lower mortality outcomes.

Shortell and Hughes (Shortell & Hughes, 1988) examined the influences of environmental factors such as hospital competition and regulatory constraints as well as institutional factors such as type of ownership and affiliation with multi-hospital systems on in-hospital mortality rates in 981 American hospitals between July 1, 1983 and June 30, 1984. They included 214,839 patients with one of sixteen clinical conditions. This sample of patients represented forty percent of the Medicare discharged patient files found in Health Care Financing Administration (HCFA) MedPar files for these 981 hospitals. To control for differences in patient characteristics among hospitals, the following variables were included as co-variates in the analysis: patient age, sex, length of stay, presence / absence of co-morbid conditions, the 1984 hospital case mix index determined by the HCFA, and the percentage of hospital days spent in intensive care units. Included in the analysis was the percentage of employees within each hospital who were registered nurses. This variable was included as a measure of a hospital's clinical skill level. It was hypothesised that hospitals that employed higher percentages of registered nurses would have lower mortality rates when controlling for differences in case mix. There was no other explanation or discussion of this variable included in the study report, likely because examination of this nursing-related hospital variable was not central to the study.

Hierarchical ordinary least square regression was used to analyse their model of the determinants of in-patient mortality. This model explained only eleven percent of the variance found in mortality rates among the 981 study hospitals. The presence of co-morbid conditions, length of stay, age, sex, and total days spent in the ICU were all significantly associated with mortality. The authors concluded that a higher percentage of registered nurses among employees was associated with lower in-hospital mortality rates but that the relationship was not statistically significant. This finding could have occurred by chance alone. The most serious limitation cited in the study report was the lack of use of a refined measure of patient severity. It was speculated that a more refined measure of patient severity would have increased the explanatory power of the model tested.

Hartz, Krakauer, Kuhn et al (Hartz et al., 1989) studied the association of hospital mortality rates with a number of hospital structural variables, including nurse staffing variables. Thirty-day mortality rates were calculated from the 1986 HCFA Medicare hospital mortality file and hospital characteristics variables were calculated from the 1986 American Hospital Association annual survey of hospitals. Of the 7,217 hospitals included in the HCFA Medicare mortality database, a sample of 3,100 hospitals was selected by including hospitals that were not psychiatric or rehabilitation hospitals, were not owned by the military or Veteran's Administration, had an emergency department, had predicted mortality rates between 0.5 and 0.20, and who had no missing information on hospital characteristics in the American Hospital Association 1986 annual survey of hospitals.

Hospital structure or characteristic variables included in the study were financial status (measured by the proxy variables of occupancy and payroll expenditures), hospital ownership, medical staff training (measured by number of board-certified specialists per average daily census), technological sophistication, and hospital bed size. The nursing variables included in the study were the number of registered nurses in the hospital per average daily census and the percentage of nurses in the hospital who were registered nurses (skill mix). In the final analysis, only the nursing skill mix variable was included to avoid confounding among predictors. Hospital 30-day mortality rates were taken directly from the HCFA file but were adjusted using the following five severity indicators: the predicted mortality rate calculated by the HCFA, the number of annual visits to the emergency department per average daily census, the percentage of hospital days spent in intensive care units, the percentage of black patients, and the percentage of admitted Medicare patients.

Analysis included weighted least square regression to estimate the association between the hospital characteristics and the adjusted 30-day mortality rates. The dependent variable in the regression was the observed mortality rate for each hospital. The regressors consisted of the hospital characteristic variables for each hospital, the predicted HCFA mortality rate, and the five severity indicators. After adjustment, the hospital factors or characteristics most strongly associated with lower mortality rates were: 1) higher percentage of board-certified physicians ($p < 0.0001$), 2) teaching hospital status ($p < 0.0001$), 3) kind of ownership ($p < 0.0001$), 4) higher percentage of nurses who were registered nurses ($p < 0.01$), 5) higher occupancy rate ($p < 0.01$), 6) higher level of technological sophistication ($p < 0.01$), and 7) larger hospital bed size ($p < 0.05$). The actual values of the regression coefficients were not reported. However, it was reported that 54 percent of the variance among hospital 30-day mortality rates was explained.

The authors concluded that the hospital characteristics most closely associated with adjusted hospital mortality rates were related to the training and preparation of medical and nursing staff - the percentage of board certified physicians and the percentage of registered nurses of all nursing personnel. Hartz et al discussed a number of study limitations, including the reliability of the adjusted mortality rates. They acknowledged potential sources of measurement error as well as the possible need for more clinical and socio-economic information for adequate risk adjustment of the mortality rates. Limitations in generalisability of the findings were acknowledged, particularly as Medicare mortality includes only those patients who are 65 years of age and older. The results may be have been different had mortality rates for the larger proportion of the population been included. However, results of this study strongly suggest that there is indeed a relationship between the skill mix of nursing staff and the outcome of 30-day mortality.

Mitchell, Armstrong, Simpson, and Lentz (Mitchell et al., 1989) completed a descriptive case study in two critical care units of a medium sized community hospital in greater metropolitan Seattle. They asked the following question: to what degree do the organisational elements of decentralised administration, participatory management, critical care certification of registered nurse staff, and nurse-physician collaboration, as well as the organisational and clinical outcomes of nurse satisfaction, mortality, new complications, and patient satisfaction exist in two critical care units? Based on the review of the literature, the investigators wished to compare the presence of organisational elements in the two critical care units to what they considered to be desirable characteristics (specialisation, critical care expertise, decentralisation, all-registered nurse staff, high physician-nurse collaboration, and formalised critical care standards and policies) with desirable organisational and clinical outcomes (low mortality, no new complications, high nurse satisfaction, and high patient satisfaction).

Convenience samples consisted of 42 registered nurses (82 percent response rate), 23 physicians (85 percent response rate), and 192 patient admissions (42 percent of all admissions). Data were collected through interview, observation, survey, and chart review on 16 different variables using 24 different indicators. The following variables of interest to this literature review are described: mortality, nurse expertise, and nurse-physician collaboration. Mortality was measured as the ratio of actual mortality to predicted mortality. Predicted mortality was calculated using the 'APACHE II' severity index. A mortality ratio greater than 1.0 is interpreted as excess mortality. In this sample, all nurses were registered nurses and registered nurse expertise was measured as the percentage of registered nurses holding the certification of critical care registered nurse. Nurse-physician collaboration was measured using the unit process item related to nurse-physician collaboration item in the 'Charns Organisational Diagnosis Survey' (CODS). The psychometric properties of the data collection tools used in the study were clearly summarised, including evidence of acceptable levels of reliability and validity, for all data collection tools except for the CODS. No psychometric data were available to report on prior use of this tool. The authors reported a low alpha coefficient of 0.53 for the CODS but justified this low internal consistency as arising from low variability in the responses.

Mitchell et al found a standard mortality ratio of 0.51 for sample patients from both critical care units (chi-square = 7.905, 1 degree of freedom, p. < 0.005). Thirty-nine percent of all registered nurses employed in these two units held certifications as critical care registered nurse compared with the standard of 10 percent certification in other comparable hospitals. When nurses were asked to rate whether the 'degree of nurse-physician collaboration was high' on a seven point likert scale with '1' being 'strongly disagree' and '7' being 'strongly agree', the mean response was 6.1 with a standard deviation of 0.63. Physicians were asked the same question using a five point likert scale with '1' being 'strongly disagree' and '5' being 'strongly agree' and responded with a mean response of 4.4 and a standard deviation of 0.58. Mitchell et al concluded that desirable outcomes such as low mortality existed in these two critical care units that were characterised by high reported levels of nurse-physician collaboration and higher than standard levels of nurse expertise. However, the results of this study lack external validity even to other critical care units because of the convenience sample used as well as the lack of comparisons or control. These results do provide beginning evidence of associations among the variables of low mortality ratios, high nurse-physician collaboration, and high registered nurse expertise. Causal inferences about the relative importance of nurse-physician and nurse expertise on the clinical outcome of mortality cannot be made. At best, these findings point the direction at key variables such as nurse-physician relationships and nurse expertise as factors that influence patient mortality.

Manheim, Feinglass, Shortell, and Hughes (Manheim et al., 1992) studied the extent to which hospital resources and structures, patient severity, and regional environmental variables were significant predictors of risk-adjusted Medicare 30-day post-admission mortality. They included 3,796 American hospitals in their study and used 1987 HCFA hospital data. The ratio of registered nurses per adjusted admission was included as a hospital resource variable. Unfortunately, no further information was provided about the exact method used to calculate the variable 'registered nurses per adjusted admission'. The authors hypothesised that hospitals with more registered nurse staff would have lower mortality rates because of the direct involvement of registered nurses in patient clinical care. Patient severity was controlled for using the HCFA expected mortality rate for each hospital.

Using regression analysis with the individual hospital as the unit of analysis, the following statistically significant predictors of thirty-day post-admission mortality were found: expected deaths ($p < 0.0001$), various hospital regions ($p < 0.0001$), percentage of ICU beds ($p < 0.05$), number of emergency department visits per hospital ($p < 0.0001$), average per capita income in the hospital region ($p < 0.001$), rural location ($p < 0.0001$), percentage of board certified physicians ($p < 0.05$), technology index ($p < 0.001$), public ownership ($p < 0.0001$), and the number of registered nurses per adjusted admission ($p < 0.001$). Fifty-four percent of the variance in 30-day mortality rates among hospitals was explained using this regression model. It was concluded that the strongest predictors of mortality were the availability of high technology equipment, a greater number of registered nurses per adjusted admission, and a higher percentage of board certified sub-speciality physicians.

Farley and Ozminkowski (Farley & Ozminkowski, 1992) examined whether or not and to what degree the outcome of inpatient mortality is affected when there are changes in the volume of diagnosis groups over time. This question was related to the debate about whether inpatient services should be regionalised. It was hypothesised that regionalisation would promote increased volumes of patients with the same or similar diagnoses in a hospital and that those increased volumes may or may not lead to improved quality.

The sample consisted of 500 American community hospitals over an eight-year period. Patient and hospital data spanning the years 1980 to 1987 were accessed for these sample hospitals. The dependent variable was an adjusted mortality rate consisting of the actual mortality rate corrected for case severity by subtracting the hospitals' expected mortality rate. The four groups of explanatory variables included in the regression analyses were 1) patient volume measured by the number of discharges for a particular diagnosis or procedure, 2) nursing intensity measured by the ratio of fulltime equivalent registered nurses per inpatient day, 3) teaching status measured by being affiliated with a medical school and being a member of the Council of Teaching Hospitals, and 4) physician expertise measured by the proportion of board-certified specialists in the field related to the condition of the patient being studied. In this study report, the regression analyses for the diagnosis group of acute myocardial infarction were reported. Farley and Ozminkowski found that there was a statistically significant negative association between patient volume over time and adjusted mortality rates (coefficient = - 0.84, $p < 0.001$), between registered nurse fulltime equivalents per 100 patient days and adjusted mortality rates (coefficient = - 6.38, $p < 0.001$), and between percentage of board certified physicians and adjusted mortality (coefficient = -1.52, $p < 0.05$). They found that hospital teaching status was not a significant determinant of hospital mortality. In their model, 21 percent of the variance among hospital mortality rates was explained. They concluded that higher patient volumes led to better quality outcomes for certain groups of patients. They suggested that physicians and hospital staff became more effective in providing services by gaining expertise and experience and that this increased effectiveness was reflected in lower mortality. Though the authors did not assess threats to validity, including the reliability and validity of the data sources, these findings add further evidence to support a relationship between the amount and type of nurse staffing in hospitals with patient mortality.

Shortell, Zimmerman, Rousseau, et al (Shortell et al., 1994) examined factors believed to be associated with risk-adjusted mortality in intensive care units. A non-probability sample of 40 American hospitals with at least 200 beds and that had a general medical-surgical intensive care unit were included in the study. In all, data for 17,440 patients were collected with an average of 415 patients included from each intensive care unit. Sample patients included in the study were selected by non-probability methods. Risk-adjusted mortality was calculated based on predicted mortality using APACHE II scores and a number of other variables such as disease category, length of stay in intensive care, location prior to intensive care, and so on. A standard mortality ratio for each intensive care unit was computed as the actual mortality rate divided by the predicted mortality rate. Ratios less than 1.00 indicated that the adjusted mortality rate was lower than expected. The four factors examined in this study were 1) available unit technology measured by the assessment of 39 technology items recommended for intensive care units, 2) diagnostic diversity measured by a simple count of the number of different disease categories seen by each intensive care unit, 3) nurse-to-patient staffing ratios measured by the average number of worked registered nurse hours per patient on each shift over the study period, and 4) caregiver (nurse – physician) interaction. Caregiver interaction was measured using a five-point likert scale questionnaire asking items about unit culture, unit leadership, unit communication, and problem solving or conflict management.

Ordinary least square regression was used to estimate the effects of the independent variables on risk-adjusted mortality. Only two of the predictors were found to be statistically significant: available technology (coefficient = - 0.42, $p. < 0.05$) and diagnostic diversity (coefficient = 0.46, $p. < 0.01$). The amount of variance explained among the risk-adjusted mortality rates or adjusted R-squared was 0.20. Neither nurse-patient ratios nor caregiver interactions were significantly associated with intensive care unit risk-adjusted mortality. The authors suggested that the low variance in nurse-to-patient ratios among study intensive care units might account for this non-significant finding. The authors concluded that the results of this study had strong policy implications related to the importance of the availability of adequate technology in intensive care units and the importance of providing specialised skills to a more concentrated volume of patients. Limited discussion was presented about the adequacy of methods used for risk adjustment of intensive care unit mortality rates. There were clear assessments of the adequacy of data collection methods used for the predictors in the study. Because the sampling plan and the population of interest in the study focused only on intensive care units, the results of this study have limited generalisability. However, the findings do add to the body of knowledge related to the determinants of mortality, particularly with respect to the importance of available technology and diagnostic diversity / homogeneity. The findings related to the non-significant association of nurse-to-patient ratios in intensive care units are inconsistent with those of other studies.

Schultz (1997) investigated the relationships of eight structural and financial hospital variables with inpatient hospital mortality rates in a sample of 373 California acute care hospitals involving only acute myocardial infarction (AMI) patients. The eight hospital predictor variables included: hospital teaching status, percentage of board certified physicians, registered nurse hours per patient day, volume of cases, technological resource availability, hospital location in an urban area with a population greater that 250,000, profit status of hospital, and total operating expenses per patient day. AMI patients discharged between July 1, 1991 and June 30, 1992 were included in study hospitals. Risk-adjusted inpatient mortality rates for sample hospitals were obtained from the California Hospital Outcomes Project (CHOP) and were calculated as the observed number of AMI inpatient deaths divided by the number of patients admitted to that hospital with AMI. It was reported that a logistic regression model was developed to determine the probability of death for each patient and included the following predictors: sex, age, congestive heart failure co-morbidity, chronic liver disease co-morbidity, infarction size, race, source of payment, and source of admission. No evidence such as a c-statistic was provided about the performance of the logistic regression model used for risk-adjustment.

In a multiple regression model involving the eight model predictors and risk-adjusted inpatient mortality as the dependent variable, Schultz was able to explain 12.6 percent of the variance in mortality among hospitals. Three of the eight model predictors had statistically significant parameter estimates. A statistically significant inverse relationship was found between registered nurse hours per patient day and risk-adjusted hospital mortality ($p < 0.001$). Positive statistically significant relationships were found between total operating expenses per patient day and risk-adjusted mortality (($p = 0.004$) and between technological resource availability and risk-adjusted mortality ($p = 0.048$). No relationship was found between any of the other model predictors including hospital teaching status, percentage of board certified physicians, volume of AMI cases, urban density, and profit status of hospitals with risk-adjusted 30-day hospital mortality. These findings add to the body of knowledge of the determinants of hospital mortality suggesting that higher amounts of registered nurse hours of care provided to acute myocardial infarction patients is associated with lower inpatient mortality.

Blegen, Goode, and Reed (Blegen et al., 1998) studied the relationship between nurse staffing and six adverse patient outcomes, including patient mortality. The unit of analysis in this study was the nursing unit. The sample consisted of 42 inpatient nursing care units in one 880 bed US hospital. There were 21,783 discharges and 198,962 patient days of care within these 42 units over a 12-month period between July, 1992 and June 30, 1993. There were 1,074 fulltime equivalent nursing staff, 832 fulltime equivalents being registered nurses. All data were obtained from routinely kept hospital data sources: patient care records and hospital databases.

Patient severity was controlled for using the results of an in-hospital and on-line nursing acuity system that classified patients into an acuity level between '1' and '7', with '7' being those patients who required the most care. The two independent nursing variables included in the study were: 1) All Hours (worked hours by all nursing personnel in that unit per patient day), and 2) RN proportion (worked hours by registered nurses per patient day divided by All Hours). The six adverse patient outcomes measured were: medication errors, patient falls, decubiti, urinary and respiratory tract infections, patient and family complaints, and death rates per 1,000 patient days. Only the results related to the outcome of patient deaths are discussed in this literature review.

Data analyses included descriptive statistics, correlations, and testing of multivariate regression models. The mean number of All Hours of nursing care provided to patients across all 42 units was 10.74 (SD = 4.45, minimum = 6.88, maximum = 26.0). The mean RN proportion hours of nursing care provided (skill mix) was 0.72 (SD = 0.15, minimum = 0.46, maximum = 0.96). The mean death rate per 1,000 patient days was 0.56 (SD = 1.91, minimum = 0.0, maximum = 11). Correlations between unit death rates and All Hours of nurse staffing was 0.640 ($p. < 0.05$) and between death rates and RN proportion was 0.351 ($p. < 0.05$). The correlation between acuity (patient severity index) and All Hours was 0.819 ($p. < 0.05$) and between acuity and RN proportion was 0.559 ($p. < 0.05$). Because examination of the data showed non-linear relationships between RN proportion and mortality, a quadratic term using a dummy variable for RN proportion at the point where the regression line changed (0.875 in this case) was included in the regression analysis. Controlling for patient severity by acuity, the independent variables of nurse staffing, All Hours and RN proportion accounted for 38 percent of the death rate variance. The RN proportion of nursing care was found to be negatively associated with rates of death (- 0.063), though this relationship was not statistically significant. This observed effect was present only up to a staff mix or RN proportion of 87.5 percent. Above this level, death rates also increased. All Hours of nursing care was statistically significant and directly related to death rates (0.491, $p < 0.05$) suggesting that higher levels of nursing staff was related to higher levels of death. This positive relationship was explained by the high correlation between acuity (the patient severity measure) and All Hours per patient day of 0.819.

Blegen et al concluded that the higher the registered nurse proportion or skill mix, up to 87.5 percent, the lower the death rate on patient care units. Though the evidence points in that direction, there were no statistically significant results that supported this conclusion. The strong positive relationships between both All Hours of nursing care and RN proportion of care with acuity suggests that future research should include more effective methods that control for patient differences. Furthermore, the mortality rate results in this study are not useful to compare with those of other hospitals and other study findings as these rates did not control for patient differences such as age, sex, and patient co-morbidities and were calculated as a ratio involving patient days. The authors did acknowledge the lack of external validity with study results as well as the various possible sources of measurement error that may have affected both the reliability and validity of the data. The findings of this study suggest a relationship between nurse staffing variables and death rate, though the nature of the relationship remains unclear suggesting the need for further study.

The most recent study that examined the relationship between the organisation of nursing in hospitals and patient mortality was completed by Lake (Lake, 1999). In a retrospective study, including nurse survey data from two previous studies and the related Medicare patient discharge data, Lake explored relationships between nursing skill mix, nurse-patient ratios, six nursing practice environment constructs from the 65-item Nursing Work Index, and other hospital characteristics with 30-day post-admission mortality. The six nursing practice environment constructs were developed through a factor analysis process of the Nursing Work Index completed by almost 3,000 registered nurses from 42 hospitals in two earlier studies completed in 1986 and 1991. The six derived constructs were believed to reflect critical elements of a professional nursing practice model for hospital organisations and included:

- regard for nursing throughout the hospital
- adequacy of staff and support services
- collaboration between nurses and physicians
- nurse manager ability and leadership
- elements of professional practice, and
- nurse professional development and advancement.

Lake implemented a series of thirteen regression models to explore relationships among the predictor variables and the outcome of 30-day mortality for the period of 1987-1989. To adjust for patient differences among hospitals and nursing units, Lake included Health Care Financing Administration (HCFA) published expected mortality rates in the regression models. To control for differences in case mix among hospitals, Lake used the hospital variable of number of emergency room visits divided by the average daily hospital census. In the beginning models, which included the expected

30-day hospital mortality rates to adjust for patient differences and one other predictor entered at a time, Lake was able to explain between 53 and 70 percent of the variance in 30-day mortality among sample hospitals. In some of these first bivariate regression models, Lake reported that she found that registered nurse ratios, both per patient and as a proportion of all nursing personnel, were associated with lower 30-day Medicare mortality. She also found that hospitals with magnet hospital characteristics or those with higher levels of the six nursing practice environment constructs, were also associated with lower 30-day mortality rates.

However, Lake reported that in the final multiple regression model that included all nursing and hospital predictors, none of the nursing-related variables were found to be significant predictors of 30-day hospital mortality. She reported that most of the variance in 30-day Medicare mortality was explained by patient characteristics. However, she also reported that higher physician qualifications (higher percentage of board-certified physicians) were significantly associated with lower Medicare 30-day mortality. Lake explains the findings of no statistically significant nursing-related predictors of 30-day mortality in the final regression model by arguing that the dimensions on which the organisation of nursing differ across hospitals may act collectively rather than individually to influence hospital mortality. Discussion was not provided about the level of adequacy of the methods used to adjust for differences in patient characteristics and composition, nor about the impact these methods may have had on the study findings. However, Lake did find beginning evidence that supports relationships between both registered nurse ratios and the nursing practice environment with 30-day post-admission mortality.

In summary of the literature examining the nature of relationships between mortality and nursing-related hospital variables, the findings of Knaus et al (Knaus et al., 1986) built the foundation for the notions that collaboration and interaction between physicians and nurses as well as workplace nursing educational support systems are related to patient mortality. The importance of nurse-physician collaboration was supported three years later by Mitchell et al (Mitchell et al., 1989) with the finding of associations among low mortality ratios, high nurse-physician collaboration, and higher levels of registered nurse expertise. Though Shortell and Hughes (Shortell & Hughes, 1988) did not find a statistically significant association between the proportion of registered nurses of all employees and mortality rates, Hartz et al (Hartz et al., 1989) found that the proportion of registered nurses to all nursing personnel (skill mix) was strongly associated with adjusted mortality rates. When Farley and Ozminkowski (Farley & Ozminkowski, 1992) studied the relationship between changes in volume of diagnostic groups over time, they too found that the ratio of fulltime equivalent registered nurses per inpatient was inversely and significantly associated with adjusted mortality. Around the same time, Manheim et al (Manheim et al., 1992) found that higher numbers of registered nurses per adjusted admission was a negative predictor of Medicare thirty-day post-admission mortality. Schultz reported similar findings of an inverse relationship between registered nurse hours per patient day and risk-adjusted hospital mortality (Schultz, 1997). However, Shortell et al (Shortell et al., 1994) found no statistically significant associations between either nurse-to-all nursing staff ratios (skill mix) or caregiver interactions (e.g., nurse-physician collaboration) and risk-adjusted mortality. Shortell explained these findings as a result of low variability in the indicators across hospitals. Similar to Shortell et al, Blegen et al (Blegen et al., 1998) found that higher proportions of registered nurses to all nursing staff, up to 87.5 percent, may be associated with a lower incidence of mortality. However, this finding was directional and not statistically significant. The findings of this study might have been different had more effective methods been used to adjust for patient differences among hospital units. Lake (Lake, 1999) found some evidence supporting bi-variate relationships between registered nurse ratios and 30-day mortality as well as between the nature of the nursing practice environment and 30-day patient mortality.

Conclusions from the Review of the Literature

The magnet hospital research has established evidence that magnet hospitals have nursing practice environments that promote professional nursing practice models of care delivery and that these nursing practice environments may also be associated with improved patient outcomes such as lower mortality. Not only are magnet hospitals better places for nurses to work but they may also produce better patient outcomes

(Aiken et al., 1994). However, the actual notion of what constitutes a magnet hospital and exactly how a magnet hospital is distinguished from a non-magnet hospital is less clear, and in the long run, may not be that important. This study builds on that foundation of research and assumes that hospitals have different characteristics. Different patterns of these hospital characteristics will generally result in different patient and organisational outcomes. Nursing-related factors or characteristics are a subset of each hospital's characteristics and reflect both the structures and processes of the organisation of hospital nursing practice.

There is only beginning and sometimes conflicting knowledge of which nursing-related hospital characteristics contribute to differences in hospital mortality rates. There is some evidence that the amount of nurse staffing hours and the concentration of registered nurse staffing or skill mix are associated with lower mortality rates (Farley & Ozminkowski, 1992; Hartz et al., 1989; Lake, 1999; Manheim et al., 1992; Schultz, 1997). Yet, there is other evidence indicating that the amount of nurse staffing hours as well as skill mix are not associated with hospital mortality. The findings by Knaus et al (Knaus et al., 1986) support the hypothesis of an association between professional role support systems such as clinical nurse specialists, clinical educators, and nursing staff education programs with hospital mortality rates, though these findings were observed in a non-probability sample of intensive care units. There is also some evidence that effective collaboration among nurses and physicians, which constitutes part of the condition of the nursing practice environment in hospitals, is associated with lower mortality rates (Knaus et al., 1986; Mitchell et al., 1989). Less is known about the associations between other elements of the nursing practice environment such as nurse autonomy and nurse control over the practice setting with hospital mortality rates. However, there is evidence that nurses who work in magnet hospitals report higher levels of both autonomy and control over their practice settings than nurses working in non-magnet hospitals (Aiken et al., 1994; Kramer & Schmalenberg, 1988a; Kramer & Schmalenberg, 1988b; Kramer & Schmalenberg, 1991a; Kramer & Schmalenberg, 1991b; McClure et al., 1983). Aiken, Smith, and Lake (Aiken et al., 1994) found that lower Medicare mortality rates exist in magnet hospitals that are known to have higher registered nurse status, more nurse autonomy, and more nurse control over the practice setting. However, these conclusions were based on inferences from previous descriptive research that identified the characteristics of magnet hospitals. Further study is necessary to directly explore relationships between hospital mortality outcomes with nursing-related hospital factors including nurse staffing, nurse characteristics such as experience, role support resources for hospital nurses, continuity of care, and the condition of the nursing practice environment. The findings of this study will narrow the gap in knowledge in this area.

Chapter Three

Theoretical Framework, Research Questions, and Hypotheses

Theoretical Framework

The theoretical framework, 'The 30-Day Mortality Model' guiding this study has been adapted from the work of a group of researchers from the University of Pennsylvania (Aiken et al., 1997; Havens & Aiken, 1999; Silber et al., 1992; Silber, Rosenbaum, Schwartz, Ross, & Williams, 1995; Silber & Rosenbaum, 1995). The 30-Day Mortality Model is illustrated in Figure 1. In this model, it is assumed that hospitals have unique mixes of structural and process characteristics that together affect patient outcomes. A subset of these hospital characteristics reflects the organisational structures and processes associated with the delivery of nursing care to patients. Patients' need for nursing care is one of the most important reasons for hospitalisation. Consequently, it is reasonable to expect that hospital structures and processes of the organisation of nursing care be related to important patient outcomes such as death or survival. The 30-Day Mortality Model addresses the relationships among specific nursing-related hospital structural and process characteristics and the outcome of 30-day mortality. According to this model, 30-day mortality is a sensitive measure of differences in quality of care among hospitals because some hospitals are better able than others to effectively and promptly detect and intervene with serious patient complications. Rapid detection of complications as well as swift and effective treatment of these complications result in the prevention of unnecessary patient death. Because of their continuous care at the bedside, the presence and actions of professional registered nurses with appropriate assessment, critical thinking and judgement skills are vital to both early detection and prompt intervention of serious complications. Early detection of patient complications is vital to rescue patients with serious unstable conditions who are at risk of rapid multi-system failure and possible death. In this model, it is hypothesised that hospitals providing higher amounts of nursing care hours (higher nurse dose) and employing higher proportions of registered nurses to provide patient care (richer skill mix) will have nursing surveillance systems that are better able to detect the early signs of serious complications and then to rapidly initiate and engage in responses that prevent patient death. As well, it is hypothesised that the registered nurse characteristics of number of years of experience in their clinical units of employment and the overall capacity of registered nurses to provide care are both associated with 30-day mortality. Nurses with more experience within their clinical unit develop the knowledge and skills related to patient care in that particular clinical speciality. They are better equipped to assess and recognise serious patient complications quicker and more accurately than nurses with less clinical experience in that clinical area. Increased experience or tenure in a clinical unit also facilitates the development of stable relationships among health team members. As well, hospitals with nurses who have enhanced capacity to work (less number of scheduled shifts of work missed) will experience lower patient mortality. Nurses who feel physically, psychologically, and emotionally capable to attend work on a consistent basis will be prepared to act quickly and effectively to detect patient complications and treat these complications to prevent patient death.

This model also postulates that two other nursing-related process components affect 30-day mortality – the condition of the nursing practice environment in the hospital and the degree to which continuity of care is supported in the hospital. Two key issues when organising work among any group of workers are decision-making control over the work at hand and coordination of the work effort across workers (Flood, 1994). Two ideal types of work arrangement models that address these issues have been described in the literature – the bureaucratic model and the professional practice model (Alexander, 1982). Bureaucratic models of practice are task-oriented and value control through hierarchical authority and the adherence to rules. Bureaucratic organisations are associated with procedural specificity, differentiation of tasks related to patient care, and a strong organisational decision-making hierarchy. On the other hand, professional practice models are goal-oriented, emphasize qualifications and competence of practitioners, use collegial control systems, and value professional autonomy and control. In environments in which the nature of the work is complex and unpredictable, such as patient care units in hospital environments, a professional model of practice is believed to be the more effective model to organize and deliver nursing care to achieve better patient and nurse outcomes (Lake, 1999). The condition of the nursing practice environment in hospitals reflects the degree to which a professional model of nursing care delivery exists in the hospital environment in which registered nurses work. Hospitals that promote and have high amounts of nurse autonomy and nurse control over the practice setting, as well as effective relationships among nurses and physicians are considered to have professional models organizing nursing care. The more these elements exist in a hospital environment, the more 'professional' is the nature of the nursing practice environment. A higher level of a professional nursing practice environment facilitates the effectiveness of the nurse surveillance role in detecting serious patient complications that may result in death. Nurses who work in environments that promote higher levels of nurse autonomy and nurse control over the practice setting are better prepared to use their assessment, critical thinking and judgement skills to promptly and accurately detect and treat complications to prevent patient death. Nurses working in environments that have and expect more positive relationships with physicians are better able to effectively collaborate with physicians to treat complications once detected and thus prevent unnecessary patient death.

In the 30-Day Mortality Model, it is also hypothesised that hospitals with organisational systems that promote continuity or consistency of registered nurse care providers (e.g., higher proportions of fulltime registered nurse staff) have lower mortality rates. A consistent registered nurse team working in the clinical area will have developed enhanced communication and collaborative skills that promote early detection of serious patient complications and the prevention of patient death.

In this model, I propose that one other nursing-related factor is an important determinant of a hospital's ability to prevent unnecessary patient death. I hypothesise that higher amounts of professional role support provided to nurses within a hospital will promote the early detection of serious complications and the prevention of patient death. Professional role support refers to hospital nursing personnel such as clinical nurse specialists and nurse educators whose primary roles are related to assisting nursing staff to develop and implement knowledge, skills, and attitudes that maximise nurse role performance and patient outcomes. Professional role support promotes competence and competence is a necessary precursor to nurse autonomy (Kramer & Schmalenberg, 1993). Registered nurse competence is developed, at least in part, through on-going professional role support from nursing personnel such as clinical nurse specialists and clinical educators. These types of nursing personnel are sometimes referred to as indirect care providers (Scott et al., 1999).

Three additional hospital-related variables are included in the 30-Day Mortality Model as there is some evidence demonstrating their relationship with hospital mortality. These hospital-related factors have empirically, though not consistently, been shown to affect hospital mortality: physician expertise (Al-Haider & Wan, 1991; Farley & Ozminkowski, 1992; Hartz et al., 1989; Lake, 1999; Manheim et al., 1992), teaching hospital type (Al-Haider & Wan, 1991; Burns & Wholey, 1991; Flood, Scott, & Ewy, 1984; Keeler, Rubenstein, & Kahn, 1992; Rosenthal, Harper, Quinn, & Cooper, 1997), and hospital location or setting (Al-Haider & Wan, 1991; Burns & Wholey, 1991; Keeler et al., 1992; Manheim et al., 1992).

Study Purpose and Objectives

The purpose of this study is to increase our understanding of the effects of nursing-related hospital structural and process variables on the outcome of 30-day post-admission medical mortality. The primary objective of this study is to empirically determine the effects that different hospital nursing structural and process components have on 30-day medical mortality rates among Ontario acute care teaching and community hospitals.

Research Questions

There are two research questions addressed in this study:

1. How well do the predictor variables in the 30-day mortality model (nurse staffing dose, skill mix of nurse staffing, amount of professional role support for nurses, nurse experience, nurse capacity to work, condition of the nursing practice environment, continuity of registered nurse care provider, physician expertise, and hospital type / location) explain differences in the outcome of 30-day medical mortality among a sample of Ontario acute care hospitals?

2. Is there a more parsimonious explanation of nursing-related hospital variables that predict 30-day medical mortality?

Hypotheses

In this study, evidence is being sought to support the following relationships among the variables in the 30-Day Mortality Model using multiple regression modelling:

1. hospitals with a higher amount or dose of nurse staffing will have lower 30-day medical mortality rates
2. hospitals with higher proportions of registered nurses among nursing care providers will have lower 30-day medical mortality rates
3. hospitals with more years of registered nurse experience on their clinical units will have lower 30-day medical mortality rates
4. hospitals with increased nurse capacity (fewer shifts missed by nurses) will have lower 30-day medical mortality rates
5. hospitals in which registered nurses experience higher levels of a professional nursing practice environment will have lower 30-day medical mortality rates
6. hospitals that promote continuity of care by employing higher proportions of fulltime registered nurse staff will have lower 30-day medical mortality rates
7. hospitals that provide more professional role support to nursing staff will have lower 30-day medical mortality rates.

Chapter Four

Methods and Procedures

The Design

This study uses a comparative or retrospective design. A comparative study design is used to test theory rather than an experimental or quasi-experimental design when the independent variable(s) cannot be manipulated. Instead, the dependent variable is examined in already existing groups that differ on the independent variables (Wood & Brink, 1998). In this study, it was not possible to manipulate the independent variables as the nursing-related hospital factors had already occurred within hospitals. The use of a comparative design is strengthened when a theory or a theoretical framework depicts the relationships among the dependent, independent, and intervening variables (LoBiondo-Wood & Haber, 1998; Polit & Hungler, 1987; Wood & Brink, 1998). In this study, the causal effects of the nursing-related independent variables on the dependent variable 30-day medical mortality were theoretically postulated and examined retrospectively.

Serious limitations of a comparative study design are the threats to internal validity that arises because of the lack of random assignment to groups as well as the lack of manipulation of an independent variable. In a comparative study, subjects are in a group because of pre-existing conditions or situations such as the patient being admitted to a particular hospital or a hospital having an existing nurse staffing pattern. The possibility exists that the groups differ on some other important variable that is either unknown or uncontrolled in the study (Wood & Brink, 1998). A strong case might be made for alternative explanations involving unknown or uncontrolled extraneous variables that bring about any observed differences in the dependent variable of 30-day medical mortality.

The Sample

Hospitals

The unit of analysis in this study is the hospital. The population of interest is Canadian acute care hospitals. However, the study sample consisted of 75 Ontario teaching and community hospitals in operation during the fiscal year 1998-99. The

Ontario Joint Policy and Planning Committee, a partnership between the Ontario Ministry of Health & Long-Term Care and the Ontario Hospital Association, categorise acute care hospitals in one of the following three types: teaching, community, or small. Small hospitals are those hospitals that discharge patients totalling less than 3,500 weighted cases (weighted cases being the sum of the resource intensity weights for all discharged patients over the year period), have a referral population of less than 20,000 people, and are the only hospital in the community. Teaching hospitals are those hospitals designated as teaching by the Ontario Council of Teaching Hospitals because of their direct affiliation with an Ontario university that provides medical education. The remaining Ontario acute care hospitals are designated as community hospitals.

To enhance homogeneity of the sample, only teaching and community hospitals are included in this study. Because there are fewer hospital beds and services in small hospitals, nurse staffing patterns are not necessary related to patient care requirements but instead may be related to minimum nurse staffing requirements. Consequently, the practice environment in which nurses work in small hospitals may be substantially different than for other acute care hospitals. As well, community hospitals with a volume of less than 100 discharged patients in the study diagnosis categories were excluded. The final sample consisted of 75 hospitals; 10 being teaching and 65 being community. Four community-designated hospitals were excluded from this study because they did not have a volume of at least 100 discharged patients in the four diagnosis categories. Twenty-five of the community hospitals and all ten teaching hospitals were located in urban areas with a population of at least 100,000. The remaining 40 hospitals were located outside of these larger urban areas. Table 1 contains a description of the 75 sample hospitals. The average number of inpatient patient days, sample patients, discharged patients, total hospital Ontario case weights, and the average weighted case are summarised for the following sample hospital categories: all sample hospitals, teaching hospitals, urban non-teaching hospitals, and outside urban hospitals. The average weighted case for a hospital is the total number of hospital Ontario case weights divided by that hospital's total number of patients discharged.

Patients in Sample Hospitals

In 1998-1999, Ontario acute care hospitals reported discharging a total of 1,187,414 patients. Patients from sample hospitals were included if they had a 'most responsible diagnosis' (MRD) code in one of the four general categories of acute myocardial infarction (AMI), stroke, pneumonia, or septicemia. In Canadian hospitals, the MRD is that diagnosis that describes the most significant patient condition causing the hospitalisation and contributing most to the patient length of stay (Canadian Institute for Health Information, 1995). These four diagnosis categories were included in the study for the following reasons. They 1) are generally considered to be acute rather than chronic conditions, 2) have high patient volumes, and 3) have high crude death rates. Of all patients discharged from Ontario acute care hospitals from April 1, 1998 through March 31, 1999, 66,609 (6 percent) of discharged patients older than 19 years of age were reported to have a MRD in one of these four diagnosis categories. In the 75 sample hospitals, 58,300 patients older than 19 years of age were discharged with a MRD in one of the four study diagnosis categories.

Two inclusion criteria were invoked when selecting patients discharged from each sample hospital. First, patients had to be older than 19 years at the time of admission. Second, the MRD also had to be the initial reason for the hospitalisation. Both these criteria were used to promote sample homogeneity. For discharged patients having more than one admission during the year with the same MRD, only the first admission was included in the study. Two exclusion criteria were used to select patients. To avoid double counting of patients, patients transferred in from another acute care facility were excluded. Patients with a pre-admission or secondary diagnosis of cancer, palliative care, or human immune deficiency disease were excluded from the study as these patients may have had a different trajectory of disease and different health goals than patients who had experienced acute disease. The final sample consisted of 46,941 patients from the 75 sample hospitals. These patients accounted for four percent of discharges from Ontario acute care hospitals from April 1, 1999 through March 31, 1999. For each diagnosis category, Table 2 contains a description of the

ICD-9 codes used to select sample patients, the number of patients, the patient average age, the proportion of patients, and the crude 30-day mortality rate.

Registered Nurses in Sample Hospitals

In fall 1998 and winter 1999, a sample of Ontario registered nurses was surveyed as part of the international study 'Outcomes of Hospital Staffing' led by Dr. Linda Aiken at the University of Pennsylvania (Aiken et al., 2001). In Ontario, sampling of registered nurses was undertaken in two phases starting in October 1998. Nurses were selected from the population of 40,363 registered nurses registered with the College of Nurses of Ontario who had reported their place of employment as an Ontario acute care hospital. In Phase 1 of the sampling procedure, registered nurses from all employment units within a hospital were considered for inclusion in the study. If the College of Nurses of Ontario registrant file included 120 or fewer registered nurses employed with an acute care hospital, all registrants were sent a survey. If more than 120 registrants had identified an acute care hospital as their primary place of employment, then a random sample of 100 registered nurses were selected for inclusion in the study. In Phase 2 of the sampling procedure, only acute care registered nurses that had identified their primary area of responsibility as medicine or surgery in the College of Nurses of Ontario registry were considered for inclusion in the study. A random sample of up to 150 medicine/surgery registered nurses was selected from each Ontario acute care hospital that had more than 150 registered nurses listed in the College of Nurses of Ontario registrant file. For hospitals with less than 150 medicine/surgery nurses, this often resulted in the whole population of medical/surgical nurses being surveyed. In each of the two phases of the sampling procedure, a modified Dillman technique consisting of four mailings was conducted. The first mailing consisted of a 16-page survey including a cover letter and a postage-paid reply envelope. The second mailing was done one week after the initial mailing and consisted of a reminder card. The third mailing consisted of a complete package similar to the first mailing and was sent to all non-respondents five weeks after the initial mailing. The fourth mailing, a reminder card, was sent out to non-respondents one week after the third mailing was completed. In all, 15,438 Ontario registered nurses were sent a survey. Of these, 8,778

(57 percent) completed the survey, 1,057 (7 percent) returned the survey uncompleted, and 6118 (39 percent) did not respond. Of the 8,778 completed surveys, 515 were removed from the data set as the hospitals in which the respondents worked were no longer acute care hospitals or the respondents were not currently employed as staff nurses in their hospitals. The final usable sample of nurse survey responses was 8,263 (Tibert, 1999a; Tibert, 1999b).

In this study, responses from registered nurses in the 75 sample hospitals were included if they had identified medicine and / or surgery as their primary area of responsibility in their acute care hospital. This resulted in a sample size of 3,988 nurse survey responses. On average, there were 53.2 medicine and / or surgery nurse survey responses from each hospital ranging from 11 through 74 survey respondents. For registered nurse survey respondents, Table 3 contains a description of the average age, years of experience as a registered nurse, years of experience in the current hospital, percent fulltime, percent female, and percent with baccalaureate or more education. These descriptors are provided for the whole sample of medical / surgical nurse respondents, as well as separately for nurse survey respondents from teaching, urban non-teaching, and outside urban area hospitals.

Data Sources

Three sources of data were used to develop the 30-day risk-adjusted medical mortality outcome: 1) the Discharge Abstract Database (DAD) 1998-1999 file from the Ontario Ministry of Health and Long-Term Care, 2) the Ontario Registered Persons Database, and 3) the Statistics Canada 1996 Population Data file containing average income information. The DAD file was used to identify discharged patients from Ontario acute care hospitals for inclusion in the study. This file incorporates the International Classification of Diseases 9th Revision (ICD-9) to classify diagnosis codes. A subset of the Statistics Canada 1996 Population file containing average incomes within each Ontario postal code was linked to the DAD file to estimate the socioeconomic status of sample patients. Linkage of these two files was made by postal code. The Ontario Registered Persons Database, a subset of the Ontario Vital Statistics file, identifies birth and death dates in Ontario. To identify patient death that occurred within 30 days from each sample patient's admission to hospital date, a subset of the Registered Persons Database file containing death information was linked with the DAD 1998-99 file by scrambled Ontario Health Insurance Plan number.

Two sources of data were used to develop the independent hospital nursing variables: 1) the Ontario Registered Nurse Survey of Hospital Characteristics 1998-1999 (Ontario Nurse Survey), and 2) the Ontario Hospital Reporting System 1998-1999 files and its supporting operational plan appendices which are usually referred to as the Hospital Management Information or MIS files. The Nurse Survey was completed by a sample of Ontario Registered Nurses as part of the 'International Study of Hospital Organisation and Staffing on Patient Outcomes'. This survey contains almost 300 items asking nurses to describe their job characteristics, hospital environments, job-related feelings, and their personal characteristics. Individual medical – surgical nurse responses on the survey were aggregated to the hospital level to develop hospital-nursing variables. The MIS files contain information about nurse staffing and the skill mix of nursing staff for each Ontario hospital.

Three sources of information were accessed to develop indicators for the other explanatory variables of physician expertise, teaching hospital type, and hospital location. The Discharge Abstract Database (DAD) 1998-1999 file from the Ontario Ministry of Health and Long-Term Care was used to develop the physician expertise variable. The list of Ontario teaching hospitals from the Ontario Council of Teaching Hospitals was used to develop the teaching hospital type variable. The Statistics Canada Census 1996 Population Statistical Profiles of Canadian Communities file was used to develop indicator variables for hospital location inside and outside urban areas.

Study Variables

The Dependent Variable - 30-Day Risk-Adjusted Medical Mortality Rate

Theoretical: The most frequently used hospital quality of care outcome is mortality (Silber et al., 1992). However, for between-hospital comparisons of death rates to be valid, the mortality rate must be risk-adjusted for case mix, disease severity, and co-morbidity (Park et al., 1990; Iezzoni, 1997). After effective risk-adjustment, persistent differences in adjusted mortality rates are usually attributed to differences in quality of care (Dubois, Rogers, Kosecoff, & et al, 1987; Iezzoni, 1997). The 30-day risk-adjusted mortality rate reflects the death rate of patients admitted to hospital who die within 30 days after the admission, regardless of whether the death occurred in hospital or after discharge. Thirty-day post admission mortality is regarded as an outcome able to measure the full impact of hospitalisation without the introduction of too many other competing risks (Jencks, Williams, & Kay, 1988; Silber, Williams, Krakauer, & Schwartz, 1992). The term medical in 30-day medical mortality is used to distinguish that these mortality rates reflect death rates for a particular subset of discharged patients with one of four major medical diagnoses rather than a whole-hospital mortality rate.

Operational: Risk-adjusted 30-day medical mortality is calculated for each sample Ontario hospital over the period of the fiscal year April 1, 1998 through March 31, 1999 using the general form of the ratio of observed hospital deaths divided by the expected number of deaths. A series of four logistic regression models was used to calculate the probability of death for each sample patient within each hospital. To adjust for differences in diagnosis mix across hospitals so that differences in patient mix among hospitals is minimized as a confounding factor, a weighted standard mortality rate (SMR) is calculated for each study hospital (Shwartz, Ash, & Iezzoni, 1997). First, the number of expected 30-day deaths per hospital diagnosis category is calculated by summing the predicted probability of death for each patient within each diagnosis category for that hospital. Similarly, the number of actual or observed 30-day deaths is summed within each hospital diagnosis category. Next, an un-weighted 30-day SMR for each hospital's diagnosis category is constructed as the ratio of the sum of actual deaths in that hospital diagnosis category divided by the sum of the expected number of deaths (sum of the probabilities of death) in that same hospital category. A weighted diagnosis-specific SMR is calculated for each hospital diagnosis category by multiplying the un-weighted diagnosis-specific SMR in each hospital by the proportion of whole sample cases in that category. Finally, the hospital weighted SMR is calculated by summing the weighted SMR in each of the four hospital diagnosis categories. For ease of interpretation, a risk-adjusted hospital mortality rate is calculated by multiplying each hospital's weighted SMR by the crude whole-sample mortality rate.

The Independent Variables

Nurse staffing dose.

Theoretical: Nurse staffing dose is the amount of nurse staffing hours or the average number of hours of nursing care provided to patients for a particular patient-related unit of output. Hours of nursing care refer to care provided by registered nurses, licensed practical nurses, and unlicensed assistive personnel. In this study, the patient-related unit of output is an Ontario case weight. The Ontario case weight system is an estimate of relative resource consumption by patients (Canadian Institute for Health Information, 1996; Chu, 1994; Poole, Robinson, & MacKinnon, 1998; Canadian Institute for Health Information, 1995). After discharge, each patient is assigned an Ontario case weight value that reflects the patient's relative consumption of hospital resources. Algorithms for assigning this weight consider patient diagnoses and case mix, complications and severity, and age. This unit of output was chosen as the numerator in the nurse staffing dose variable because it incorporates at least some acknowledgement that patients consume varying amounts of resources throughout their hospital stays, including nursing resource consumption. However, this unit of output is an imperfect measure for use in this study because it estimates the relative consumption of all hospital resources used, not simply nursing resources as would have been desirable. More traditional units of output such as a patient day do not reflect any differences among patient-related outputs.

Operational: In this study, the dose of nurse staffing is measured as the total inpatient clinical nursing worked hours per Ontario case weight. The numerator, inpatient clinical worked hours, includes all unit producing worked hours for inpatient nursing services in each hospital. Inpatient clinical worked hours do not include worked hours for nursing or program administration, nor any medical resources worked hours. Worked hours refer to those unit-producing hours worked by nursing staff to provide patient care and do not include benefit hours or benefit pay. The denominator is the total sum of Ontario weighted cases assigned to all discharged patients from that hospital over the same period of time. The ratio of inpatient clinical nursing worked hours per Ontario case weight is an estimate of the number of nursing care hours provided to each Ontario case weight. To estimate the total number of nursing worked hours provided to a patient in a hospital, this ratio is multiplied by that patient's assigned Ontario case weight. Two sources of data were used to develop this nurse staffing dose variable: the Ontario Hospital Reporting System 1998-1999 files (MIS files) and the DAD 1998-1999 file from the Ontario Ministry of Health and Long-Term Care. The total number of inpatient clinical nursing worked hours for each sample hospital was extracted from the MIS 1998-99 files. The total number of Ontario case weights discharged from each sample hospital was calculated from the DAD 1998-99 file.

Skill mix of nursing staff.

Theoretical: The skill mix of nursing staff reflects the strength of the 'dosage' of registered nurse staffing in a hospital. To provide nursing care, hospitals may employ a variety of nursing personnel including registered nurses, registered or licensed practical nurses, and unlicensed assistive personnel.

Operational: The proportion of registered nurses to all nursing personnel reflects the skill mix or strength of the registered nurse dose. The skill mix of nursing staff was estimated as the proportion of inpatient earned hours by registered nurse staff divided by the total amount of inpatient nursing staff earned hours within each sample hospital during April 1, 1998 through March 31, 1999. Earned hours include all paid hours to nursing staff, including benefit hours. Ontario hospitals are required to report this information yearly and this information is contained in the operational plan attachment to the MIS 1998-99 files. Ontario hospitals are also required to report earned hours for each inpatient nursing functional centre separately by fulltime, part-time, and casual/relief/agency employment categories for the three skill levels of nursing staff: registered nurse, registered or licensed practical nurse, and unlicensed assistive personnel.

Availability of professional role support.

Theoretical: Professional role support for nurses refers to the availability of in-hospital personnel resources to provide educational, developmental, and role modelling opportunities for nursing staff who provide direct patient care. Hospital personnel such as clinical nurse specialists and clinical nurse educators are nursing personnel who are available to facilitate further development of nurse role knowledge, skills, and attitudes that promote desired patient and organisational outcomes.

Operational: In this study, the availability of professional role support was estimated as the mean hospital response on the Ontario Nurse Survey to item B.19. For this item, registered nurse respondents were asked to indicate their agreement that the following item was present in their current job 'the opportunity for staff nurses to consult with clinical nurse specialists or expert nurse clinicians/educators'. Responses were reverse-coded so that there were four possible response categories ranging from strongly agree (value = 4) to strongly disagree (value = 1). Though the Ontario Hospital Reporting System (MIS) has created categories for reporting dedicated nursing education and nursing research worked and earned hours, only several Ontario hospitals reported hours in these categories. In the absence of this objective data about the amount of professional role support hours for nursing staff, this study relies on the reports or estimates of this type of resource by registered nurses themselves in the Ontario Nurse Survey.

Years of registered nurse experience on the clinical unit.

Theoretical: Experience refers to the amount of time that a Registered Nurse has been employed in their current nursing unit. It is assumed that the longer the period of time a registered nurse has worked on a nursing unit, the more knowledge, skills, and intuition will be amassed by the nurse to care for the kinds of patients usually admitted to that unit.

Operational: For each sample hospital, nurse experience is calculated as the mean number of years of experience on the current unit of employment as reported by nurses in the Ontario Nurse Survey. The data source for the variable nurse experience was item 5.c of the Ontario Nurse Survey in which respondents were asked to identify the number of years they had been employed on their current unit.

Nurse capacity to work.

Theoretical: Capacity to work refers to the availability and choices made by registered nurses to attend work and is related to their general levels of wellness. Capacity to work reflects how nurses experience and deal with their own health as related to their ability to actually provide patient care.

Operational: Nurse capacity was estimated as the mean number of shifts missed in the preceding three months as reported by nurse respondents in the Ontario Nurse Survey. The source of data for the capacity variable was item G.2.b in the Ontario Nurse Survey in which respondents were asked to identify how many shifts they had missed in the past three months.

Nursing practice environment condition: the Canadian practice environment index.

Theoretical: The nature of the environment in which nurses work is believed to affect patient outcomes, nurse outcomes, and organisation outcomes. An environment promoting nurse autonomy, control over the practice setting resources, and effective relationships with other health team members is described as a professional practice environment (Aiken & Fagin, 1997; Aiken et al., 1997; Havens & Aiken, 1999; Aiken & Patrician, 2000; Sochalski, Estabrooks, & Humphrey, 1999).

Operational: The condition of the nursing practice environment was measured as the mean hospital score by nurse respondents on the Canadian Practice Environment Index (CPEI) derived from the Revised Nursing Work Index in the Ontario Nurse Survey. The possible range of the index is 26 through to 104 – a higher score indicates an environment more reflective of a professional practice model work. The CPEI is the single-factor solution found from the Revised Nursing Work Index used in the Nurse Survey (Alberta, British Columbia, and Ontario) as part of the international study of hospitals led by Dr. L. Aiken and supported by the National Institute of Nursing Research, U.S. and the Alberta Heritage Foundation for Medical Research, Alberta. A ingle-factor solution was found when the psychometric properties of the Revised

Nursing Work Index were examined in the Canadian context (Estabrooks et al., under review). The single-factor solution was derived empirically using exploratory principal component analysis and consisted of 26 of the Revised Nursing Work Index items with loadings above 0.50. Registered nurses were asked to rate items on the Revised Nursing Work Index as to the degree to which their work environment supported professional nursing practice components such as autonomy in nursing practice, recognition, support from leadership, collaboration with physicians, and adequacy of resources in the setting. Possible responses were strongly disagree (value=1), somewhat disagree (value=2), somewhat agree (value=3), and strongly agree (value=4). Table 4 lists the items included in the CPEI. The inter-item correlation for the original single-factor 26-item CPEI was 0.92. The authors of the single factor solution concluded that this index is a unified measure of the practice environment or work context of registered nurses that reflect the degree of the presence of attitudes that value professional nursing practice in Canadian hospitals (Estabrooks et al., under review).

In this study, the CPEI was calculated for respondents who had no greater than four missing items of the 26 items in the CPEI. If a respondent had four or less missing items, any missing item was imputed using the hospital mean for that item. A total of 60 survey responses were omitted in the calculation of the CPEI as these surveys had more than four missing items of the 26 CPEI items. With the sample of 3,928 nurse surveys used, Cronbach's alpha, a measure of internal reliability of the CPEI, was 0.90. Evidence of criterion-related validity was found with Pearson's correlations ranging from 0.58 to 0.85 (all with $p < 0.0001$) between the CPEI and three other previously used sub-scales of the Revised Nursing Work Index (nurse autonomy, nurse control over the practice setting, and relationships with physicians). Previous studies have used these three sub-scales of the Revised Nursing Work Index to measure the nature of the hospital practice environment (Aiken et al., 1994; Aiken et al., 1997; Sochalski et al., 1998; Havens & Aiken, 1999; Aiken et al., 1998; Aiken & Sloane, 1997; Aiken & Patrician, 2000; Aiken, Havens, & Sloane, 2000).

Continuity of care: proportion of fulltime registered nurses.

Theoretical: The proportion of fulltime registered nurses reflects a hospital's capacity to provide continuity of care. A higher proportion of fulltime registered nursing staff facilitates the patient receiving nursing care from a nurse already familiar with that patient's nursing care requirements, preferences, progress, goals, and so on.

Operational: For each sample hospital, continuity of care was measured as the proportion of fulltime inpatient registered nurse earned hours divided by all inpatient registered nurse earned hours reported for that hospital. This information is attached to the 1998-99 MIS file.

Other Explanatory Variables

Physician expertise.

Theoretical: Physician expertise refers to the overall hospital level of physician preparation and specialised knowledge and skill providing medical care to sample patients. This concept is similar to the nursing skill mix concept and may be thought of as a physician skill mix indicator. However, for this variable, a lower proportion of general practitioners reflects higher physician expertise, or a richer skill mix of physicians.

Operational: In the individual record for each discharged patient in the DAD file, the patient is assigned a most responsible diagnosis and a medical service code related to that most responsible diagnosis. The most responsible diagnosis is the diagnosis that describes the most significant patient condition causing the hospitalization and contributing most to the patient length of stay (Canadian Institute for Health Information, 1995). The medical service code identifies the category or type of physician most responsible for the medical care related to the most responsible diagnosis. Physician expertise was estimated as the proportion of sample patients in each hospital with a general practitioner identified as the type of medical care provider associated with the patient's most responsible diagnosis. A lower proportion indicates a physician skill mix richer in preparation and specialised knowledge and skill.

Hospital type: teaching.

Theoretical: Teaching hospital refers to the whether an Ontario hospital is an accredited teaching institution involved in the formal education of new health practitioners, particularly medical education but also including nurses and other hospital caregiver categories.

Operational: An Ontario acute care hospital is considered a teaching hospital if designated as such by the Ontario Council of Teaching Hospitals. A dummy indicator variable was created to identify the teaching status of a hospital. A value of '1' was assigned to a teaching hospital and '0' if the hospital was not a teaching hospital. . All teaching hospitals are located in urban areas with a population greater than 100,000.

Hospital setting / location.

Theoretical: Hospital setting refers to the location of a hospital in an urban area with a population of at least 100,000 or outside of such an urban area.

Operational: Two dummy indicator variables were developed to identify hospital locations. The first dummy variable 'outside urban' was used to identify hospitals that were not located in an urban centre with a population of at least 100,000. The second hospital location variable 'urban non-teaching' was used to identify hospitals that were located inside an urban area with a population of at least 100,000, but excluded teaching hospitals. All teaching Ontario hospitals are located in urban areas. The source used to determine the nature of the hospital setting / location was the Statistics Canada Census 1996 Population Statistical Profiles of Canadian Communities file (Statistics Canada, 1996).

Data Management and Analysis

The unit of analysis in this study is the hospital. Hospital level variables were calculated for each of the study variables. All analyses were completed using SAS ® Version 8 (Cary, North Carolina). All data were managed within the UNIX system at the Institute for Clinical Evaluative Sciences in Toronto, Ontario. Because of the known effects that patient characteristics, including age, sex, and co-morbidity have on hospital mortality outcomes (Smith, 1994), these patient characteristics were controlled in the analyses. Logistic regression models were implemented to calculate the probability of death for each sample patient. The probabilities of death calculated for each patient were used to develop risk-adjusted and weighted mortality rates for sample Ontario hospitals. Multiple regression analyses were completed to determine which variables were statistically significant predictors of 30-day death and to identify the regression coefficients for these independent variables. The result of a multiple regression analysis is an equation that represents the best prediction of the dependent variable, 30-day medical mortality, from the independent variables (Tabachnick & Fidell, 1996). Two types of multiple regression were used; enter and stepwise. Study variables were entered into the regression model, with 30-day medical mortality rate being the dependent variable.

The general form of each multiple regression equation was:

$$Y = a + bS + cP + dZ + e.$$

In this equation

- Y is a vector of hospital 30-day risk-adjusted medical mortality rates
- a is the value of Y when all the values of S, P, and Z are equal to zero
- b is a vector of coefficients for the S matrix of nursing structural variables for each hospital (nurse staffing dose, skill mix of nurse staffing, professional role support, years of unit experience, and nurse capacity to work)
- c is a vector of coefficients for the P matrix of nursing-related process variables for each hospital (condition of the nursing practice environment and continuity of care)
- d is a vector of coefficients for the Z matrix of other determinants of mortality for each hospital (physician expertise, hospital type, and hospital location), and
- e is the vector of errors or residuals for each hospital.

Logistic Regression Risk Adjustment Models and Model Risk Factors

Logistic regression models were developed to predict 30-day mortality within each of the four diagnosis categories of acute myocardial infarction (AMI), stroke, pneumonia, and septicemia. Logistic regression was used to estimate the expected value or probability of death for each patient. The same 21 candidate predictors were first entered in all four logistic regression models and included age, sex, the Deyo modification of the Charlson co-morbidity variables, socioeconomic status (SES), and a 'chronicity of health condition' variable. Within the stroke logistic regression model, an additional indicator predictor variable for the diagnosis of hemorrhagic stroke was added. Table 5 describes each of the model predictor variables, the ICD-9 codes used to identify their occurrence (where appropriate), and the prevalence of each of the predictors in the models.

Age was entered as a continuous variable as it was a more effective predictor of 30-day death in all four models (yielded higher c-statistics) than a series of five dummy age category variables. Deyo-modified Charlson indices were developed as independent indicator variables by identifying the presence or absence of any of the co-morbid diagnosis codes in each predictor set if coded as either a pre-admission or secondary diagnosis. The Charlson co-morbidity index was first developed as a weighted prognostic taxonomy for co-morbid conditions that might alter the risk of short-term death (Charlson, Pompei, Ales, & MacKenzie, 1987). Deyo and colleagues later adapted the Charlson index by translating the index into a set of ICD-9-CM codes (Deyo, Cherkin, & Ciol, 1992). Three of the 17 Charlson variables indicate cancer and Human Immune Deficiency (HIV) disease. As this study excluded patients with cancer and HIV as secondary or pre-admission conditions, only 14 Charlson variables were used in the logistic regression models to predict death.

There is convincing evidence that socioeconomic status (SES) is inversely related to mortality (Gregario, Walsh, & Paturzo, 1997; Pappas, Queen, Hadden, & Fisher, 1993). Therefore, measures of SES were used as potential predictors of 30-day medical mortality. SES was estimated by linking the six-character domicile postal code for each patient with the average income for that postal code. Five dummy variables representing five average income quintiles were derived from the Statistics Canada 1996 population file (Ontario) ranging from very low income to very high income. The cutoffs for each Ontario average income category were:

- $7,680 - $39,851 (very low)
- $39,852 - $49,734 (low)
- $49,735 - $57,852 (middle)
- $57,853 - $70,494 (high)

- $70,495 - $304,454 (very high).

Four of the five dummy SES variables were entered as predictors into the logistic regression models with the 'very high income' variable being the reference group.

There is evidence of higher mortality rates among patients admitted to acute care hospitals from other long-term supportive health care environments (Green, Passman, & Wintfeld, 1991). It is reasonable to assume that these patients generally have decreased health status and functioning abilities necessitating their being cared for in a long-term supportive care environment. The dummy variable 'chronicity of health condition' was developed to identify the referral source of the patient from a non-acute care health care setting such as a chronic hospital, nursing home, or home for the aged and was entered as a predictor in each of the models. This variable is used as a crude proxy measure of patient health status and functioning.

Because the crude death rate for patients diagnosed with hemorrhagic stroke (ICD-9 code 431) is significantly higher than that for other stroke code diagnoses (41% versus 15% in this sample), a hemorrhagic stroke dummy variable was created and included within the stroke logistic regression model. The four prediction models were further refined to include only those statistically significant predictors with probabilities less than 0.05. If any of the SES predictor variables were statistically significant in a model, the four SES variables were maintained in the model.

Development of Weighted and Risk-Adjusted 30-Day Mortality Rates

Patient mix within the four diagnosis categories varied across hospitals in this study. When using indirect standardization methods employing logistic regression models to adjust for patient risk, such as those used in this study, differences in patient mix may have a strong effect on outcomes (Shwartz et al., 1997). In these situations, patient mix is a confounding factor. Therefore, to adjust for differences in diagnosis mix across hospitals, a weighted standard mortality rate (SMR) was calculated for each study hospital. First, the number of expected 30-day deaths per hospital diagnosis category was calculated by summing the predicted probability of death for each patient within each diagnosis category for that hospital. Similarly, the number of actual or observed 30-day deaths was summed within each hospital diagnosis category. Next, an un-weighted 30-day SMR for each hospital's diagnosis category was constructed as the ratio of the sum of actual deaths in that hospital diagnosis category divided by the sum of the predicted number of deaths in that same hospital category. A weighted diagnosis-specific SMR was calculated within each hospital diagnosis category by multiplying the diagnosis-specific un-weighted SMR in each hospital by the proportion of whole-sample cases in that category. The values of these proportions are shown in the second-to-last last column of Table 2. Finally, the hospital weighted SMR were calculated by summing the weighted SMR in each of the four hospital diagnosis categories. For ease of interpretation, a risk-adjusted hospital mortality rate was calculated by multiplying each hospital's weighted SMR by the crude whole-sample mortality rate of 14.7 percent.

Reliability of the Secondary Sources of Data

An ideal instrument is one that results in measurements that are relevant to the concept being measured, accurate, unbiased, sensitive to different values of the concept, unidimensional, and efficient (Polit & Hungler, 1987). The adequacy and quality of the data used in a study are judged on the degree to which the study measures possess these characteristics. Reliability and validity are two important evaluation criteria to establish the adequacy of a measurement method. Reliability is the degree of consistency with which a data collection instrument measures the attribute it is supposed to measure. Reliable data have the characteristics of being consistent, stable, and repeatable. Validity refers to the degree to which an instrument or data collection procedure measures what it is supposed to measure. Valid data have the properties of sampling adequacy (content validity), pragmatic usefulness as compared to other criteria (criterion-related validity), and being an adequate measurement of the abstract concept (construct validity) (Brink & Wood, 1994; Polit & Hungler, 1987). Errors in measurement may be systematic or random. Systematic measurement errors will result in incorrect measure of the variable for all cases and affects validity of the measure. Random error is unpredictable and results in inconsistent data and affects the reliability of the measure (LoBiondo-Wood & Haber, 1998; Roberts, Anthony, Madigan, & Chen, 1997).

In this study, issues of data quality are important to address particularly related to the data obtained from the Ontario DAD and the Ontario Hospital Reporting System (MIS) hospital files. Data in the patient discharge files are subject to a number of potential sources of error. Caregivers may inaccurately document patient-related data and abstractors in health record departments may make coding errors when abstracting the data from the chart. These errors may be random or systematic. However, because of the documentation training provided to care givers and the training provided to health record abstractors, it is more likely that these measurement errors are random in nature. The MIS files are largely compiled within hospitals through electronic linkage of various hospital data sets. Errors in these files are more likely to be systematic errors resulting from mis-application of definitions of terms and so on. It is vital for the researcher to minimise error in data collection, if collecting data, or in the case of this study, to assess the degree of error in the secondary data already collected (Roberts et al., 1997).

Direct measurements of the reliability of the administrative data used in this study were not completed but can be inferred from other studies that address the reliability of these data. There are several studies reporting on the accuracy of the data within the discharge abstract databases (DAD). In studies comparing patient data from the DAD with patient data re-abstracted directly from each medical record, background patient information such as admission and discharge dates, sex, death codes, birth dates, and postal codes have been found to be abstracted with very high accuracy ranging between 84.3 and 97 percent agreement (The Doctor's Hospital, 1992; Hawker, Coyte, Wright, Paul, & Bombardier, 1997; Ontario Hospital Association, Ontario Ministry of Health, & Hospital Medical Records Institute, 1991). Lower levels of agreement have been reported for accuracy in identification of the most responsible diagnosis ranging from 74 to 95 percent (Delfino, Becklake, & Hanley, 1993; Ontario Hospital Association et al., 1991; Newfoundland Department of Health, 1995). In one study involving the accuracy of coding for acute myocardial infarction, 100 percent accuracy at some hospitals has been reported (Tu, Naylor, & Austin, 1999). Accuracy in coding stroke ICD-9 codes was reported ranging from 70 to 80 percent of reviewed patient medical records with varying levels of discrepancies in the use of the correct stroke code (Mayo, Danys, Carlton, & Scott, 1993). Studies reporting the accuracy and completeness in abstracting and coding complications and co-morbid conditions have reported a much wider spread of agreement scores ranging from 37 to 95 percent (Malenka, McLerran, Roos, Fisher, & Wennberg, 1994; Newfoundland Department of Health, 1995; Ontario Hospital Association et al., 1991; Victoria Hospital, 1992).

After abstracting patient data from the medical record of each discharged patient, hospitals submit this data to the Canadian Institute for Health Information (CIHI) where it undergoes several series of edit checks. CIHI edits the submitted patient data for irregularities, impossible or unlikely coding, and missing data. Hospitals are then asked by CIHI to review certain aspects of the DAD and revise the submission. CIHI submits the edited and revised DAD to the various provincial ministries or departments of health. In Ontario, the Ministry of Health and Long-Term Care performs more edit checks and may reformat several of the variables before releasing the data for analysis or research purposes.

The Ontario Hospital Reporting System was established in Ontario to provide a comprehensive database of financial and statistical information based on the Guidelines for Management Information in Canadian Health Care Facilities (MIS Guidelines) (Ontario Ministry of Health, 1999). No studies were found that reported on the accuracy of these data. However, the Ontario Hospital Reporting System has been designed to enhance the consistency, quality, and comparability of hospital reporting of financial and statistical information. This is promoted by the development of standardized financial and statistical accounts. All hospital information is collected within a functional centre framework to enhance comparability. A functional centre is a five level hierarchical arrangement of hospital departments that can be used within any size health care facility. The functional centre structure permits information to be 'rolled up' or consolidated (Ontario Ministry of Health, 1999). Once submitted, the Ontario Ministry of Health edits these financial and statistical data for irregular, impossible, unlikely, or missing entries. Hospitals may then be asked to revise their submission before the data are released for analysis or research purposes.

Ethical Considerations

Ethics implies a code of conduct for one's behaviour (Everyday ethics: Putting the code into practice, 1998). The following ethical principles guided my research activities: 1) autonomy as effective deliberation, 2) nonmaleficence or the obligation to do no harm, 3) beneficence or the obligation to promote good, 4) justice and fairness, 5) veracity or the obligation to tell the truth, and 6) fidelity or loyalty (Fry, 1994). In this study, there were no human subjects. Rather, nursing-related hospital characteristics and outcomes of hospitalised patients were examined retrospectively. In accordance with the six ethical principles, the following guided my research behaviour throughout the study:

- reflection on the reasons and values behind research decisions
- doing no harm with the research process
- working to develop knowledge to do 'good'
- acting fairly in research activities
- seeking and telling the truth related to the research process
- remaining committed to the purposes of the study.

Ethical approval for this study was obtained from the Capital Health Region Ethics Review Panel, Edmonton, Alberta in January 2000 and was renewed again in February 2001.

Chapter Five

The Results

Study results are presented in the following order:

- the logistic regression coefficients and performance of the models used for risk-adjustment
- crude and risk-adjusted 30-day medical mortality rates
- the predictor variables
- relationships among the predictor variables, and
- the multiple regression models developed to answer the research questions.

Logistic Regression Model Coefficients and Model Performance

To develop hospital mortality rates that are risk-adjusted for patient characteristics, four logistic regression models were developed to calculate the expected probability of death for patients in each of the four diagnosis categories of acute myocardial infarction (AMI), stroke, pneumonia, and septicemia. The expected probability of death for each patient in each diagnosis category was summed by hospital to form the denominator in the hospital unweighted standard mortality rate.

Table 6 describes the 30-day expected mortality regression coefficient, the probability associated with that coefficient, the odds ratio (OR), and the 95 percent confidence interval for each of the predictors used in the final AMI model. The strongest predictor of 30-day AMI mortality was liver cirrhosis with an odds ratio of 4.47, followed by liver or esophageal disease (OR=3.53), chronicity of health condition (OR=2.11), and heart failure (OR=1.50). The area under the receiver operating characteristic (ROC) curve or c-statistic in the AMI model was 0.75.

Table 7 describes the 30-day expected mortality regression coefficient, the probability associated with that coefficient, the odds ratio, and the 95 percent confidence interval for each of the statistically significant predictors used in the final stroke model. The strongest predictor of 30-day stroke mortality was a history of liver or esophageal disease with an odds ratio of 6.16, followed by hemorrhagic stroke (OR=5.66), liver cirrhosis (OR=3.42), and chronicity of health condition (OR=3.18). The area under the ROC curve or c-statistic in the stroke model was 0.75.

Table 8 describes the 30-day expected mortality regression coefficient, the probability associated with that coefficient, the odds ratio, and the 95 percent confidence interval for each of the statistically significant predictors used in the final pneumonia model. The strongest predictor of 30-day pneumonia mortality was liver or esophageal disease with an odds ratio of 12.73, followed by kidney disease (OR=2.78), liver cirrhosis (OR=2.47), and chronicity of health condition (OR=2.18). The area under the ROC curve or c-statistic in the pneumonia model was 0.76.

Table 9 describes the 30-day expected mortality regression coefficient, the probability associated with that coefficient, the odds ratio, and the 95 percent confidence interval for each of the statistically significant predictors used in the final septicemia model. The strongest predictor of 30-day septicemia mortality was liver or esophageal disease with an odds ratio of 6.47, followed by kidney disease (OR=2.23), liver cirrhosis (OR=2.21), and heart failure (OR=2.04). None of the socioeconomic status variables were statistically significant predictors of 30-day death for septicemia patients. The area under the ROC curve or c-statistic in the septicemia model was 0.71.

In summary, the six following variables were statistically significant predictors of 30-day mortality in all four models: age, heart failure, liver cirrhosis, kidney disease, liver or esophageal disease, and chronicity of health condition. Three of the Deyo-adapted Charlson predictors were not statistically significant predictors in any of the models: rheumatic-like diseases, ulcers of the digestive system, and diabetes mellitus with complications. Interestingly, sex was a statistically significant predictor of 30-day mortality only in the pneumonia logistic regression model.

A common measure of logistic regression model performance is the c-statistic or the area under the receiver operating characteristic (ROC) curve. The predictive validity of a model can be assessed through the examination of the resulting c-statistic. The c-statistic is a measure of model discrimination and compares predicted and actual values of the 30-day death outcome (Ash & Shwartz, 1997; Hosmer & Lemeshow, 2000). A c-statistic value of 0.50 indicates that the model is no better than chance in predicting 30-day death and a c-statistic value of 1.00 indicates perfect prediction (Anthony, 1999; Ash & Shwartz, 1997; Green, Wintfeld, Sharkey, & Passman, 1990;

Tu, 1996). A c-statistic or area under the ROC curve between 0.70 and 0.80 is considered evidence of acceptable discrimination power of a model (Hosmer & Lemeshow, 2000; Roos, Walld, Romano, & Roberecki, 1996). Each of the four logistic regression models used in this study performed moderately well in predicting 30-day post admission mortality. The model with the greatest area under the ROC curve was the pneumonia model (c-statistic = 0.76). The model with the lowest area under the ROC curve was the septicemia model (c-statistic = 0.71).

<u>Crude and Risk-Adjusted 30-Day Medical Mortality Rates</u>

The mean crude 30-day mortality rate for all sample hospitals was 14.95 percent. When examined by hospital type and location, the ten teaching hospitals had the lowest mean crude 30-day mortality rate (14.68 percent) and the forty outside urban area hospitals had the highest mean crude 30-day mortality rate (15.06 percent). The mean risk-adjusted 30-day mortality rate for all sample hospitals was 15.03 percent. When examined by hospital type and location, teaching hospitals maintained the lowest mean risk-adjusted 30-day mortality rate (14.02 percent) and outside urban area hospitals maintained their rank of having the highest mean risk-adjusted 30-day mortality rates (15.27 percent). Table 10 describes the mean, standard deviation, lowest value, and highest value for each of the crude and risk-adjusted hospital 30-day mortality rates for the whole sample, and separately for teaching, urban non-teaching community, and outside urban area community hospitals.

Analysis of variance was used to determine that there were no statistically significant differences in mean risk-adjusted mortality rates among teaching, urban non-teaching, and outside urban area community hospitals. There was no evidence that the sampling distribution of risk-adjusted mortality was not a normal distribution: the Kolmogorov-Smirnov statistic was 0.08 and the probability for that statistic was greater than 0.15. Even though this variable is a proportion, it was deemed acceptable to apply normal techniques because all the values of the variable were above 0.10 and well below 0.90.

The mean risk-adjusted 30-day mortality rate for the whole sample is slightly higher than the mean crude rate (15.03 versus 14.95). The mean risk-adjusted 30-day mortality rate for teaching hospitals is lower than the mean crude rate for these hospitals. On average, risk-adjustment worked in the opposite direction within community hospitals. The mean risk-adjusted 30-day mortality rates for community hospitals, both urban non-teaching and outside urban, are higher than the mean crude rates for these hospitals. As expected, there were strong associations between crude and risk-adjusted 30-day mortality rates. Pearson's correlation between risk-adjusted and crude 30-day hospital mortality rates was 0.80 ($p < 0.0001$) and Spearman's rank correlation was lower at 0.74 ($p < 0.0001$). Though these correlations are moderately high, they indicate that the risk-adjustment methods resulted in changing both values and rankings of hospitals' risk-adjusted 30-day mortality rates from their crude 30-day mortality rates.

Multiple Regression Model Predictor Variables

Nurse Staffing Dose: Inpatient Clinical Worked Hours per Ontario Case Weight

The mean clinical inpatient nursing worked hours per weighted case was 39.9 for all sample hospitals. The least number of worked hours of nursing care per weighted case was 27.3 and occurred in a community hospital located outside an urban area. The highest number of worked hours per weighted case was 64.7 and occurred in a teaching hospital. Table 11 identifies the mean nurse-staffing dose for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Skill Mix: Proportion of Registered Nurse Staffing

The mean proportion of registered nurses of all nursing staff was 0.75 for all 75 sample hospitals. The smallest proportion of registered nurse staffing was 0.55 and occurred in a community hospital located outside an urban area. The largest proportion of registered nurse staffing was 1.00 and also occurred at a community hospital located outside an urban area. Table 11 identifies the mean proportion of registered nurse staffing for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Availability of Professional Role Support

The mean availability of professional role support reported by registered nurses in all 75 sample hospitals was 2.20, indicating a mean response slightly higher than 'somewhat disagree' to the item 'the opportunity for staff nurses to consult with clinical nurse specialists or expert nurse clinicians/educators' but lower than the next highest response category of 'somewhat agree'. The lowest hospital rating on the availability of professional role support was 1.18 and occurred in an outside urban area community hospital. The highest hospital rating on the availability of professional role support was 3.25 and occurred in a teaching hospital. Table 11 identifies the mean hospital availability of professional role support ratings for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Years of Registered Nurse Experience on the Clinical Unit

The mean number of years of experience on the clinical unit for all 75 sample hospitals was 9.1. The least number of years of clinical unit experience was 5.5 and occurred in a teaching hospital. The most number of years of clinical unit experience reported by registered nurses was 14.6 and occurred in a hospital located outside an urban area. Table 11 identifies the mean years of clinical unit experience reported for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Registered Nurse Capacity to Work: Average Shifts Missed in Three Months

The mean hospital number of shifts reported missed by nurse respondents in the preceding three months for all 75 sample hospitals was 1.5. The least mean hospital number of shifts missed as reported by registered nurses was 0.12 and occurred in a hospital located outside an urban area. The highest mean number of shifts missed in a hospital was 5.1 and also occurred in a community hospital located outside an urban area. Table 11 identifies the mean number of shifts missed for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Nursing Practice Environment Condition: The Canadian Practice Environment Index

The mean Canadian Practice Environment Index (CPEI) score for all 75 sample hospitals was 61.9. The theoretical range is from 24 through 104. The lowest hospital mean CPEI score was 53.1 and occurred in a hospital located outside an urban area. The highest hospital CPEI score was 70.5 and also occurred in a hospital located outside an urban area. Table 11 identifies the mean CPEI score for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Continuity of Care: Proportion of Fulltime Registered Nurse Earned Hours

The mean proportion of fulltime registered nurse earned hours for all 75 sample hospitals was 0.59. The lowest proportion of fulltime registered nurse earned hours was 0.35 and occurred in a hospital located outside an urban area. The highest proportion of fulltime registered nurse earned hours was 0.74 and occurred in a teaching hospital. Table 11 identifies the mean proportion of fulltime registered nurse earned hours for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Physician Expertise: Proportion of General Practitioners as Most Responsible Physician

The mean proportion of general practitioners as the most responsible physician for patients in all sample hospitals was 0.44. The lowest proportion of general practitioners as the most responsible physician was 0.00 and occurred in nine hospitals: three teaching hospitals, four urban non-teaching hospitals, and two outside urban area hospitals. The highest proportion of general practitioners as the most responsible physician was 1.00 and occurred at five community hospitals located outside urban areas. Table 12 identifies the mean proportion of general practitioners as the most responsible physician for all sample hospitals and separately for teaching, urban non-teaching, and outside urban area hospitals.

Hospital Type and Location

Ten of the 75 sample hospitals were teaching hospitals and all ten were located within an urban area. Urban areas were considered as those cities or towns with a 1996 Statistics Canada census population of at least 100,000. Twenty-five of the 75 sample hospitals were community hospitals located inside an urban area and were not teaching hospitals. Forty of the sample hospitals were community hospitals located outside an urban area. Table 13 reports the frequency of hospitals within each type and location as well as the modal percentage for each type / location.

Relationships among Study Continuous Variables

Pearson's correlations were completed among the nine study continuous variables. Table 14 lists these correlation results. The three strongest correlations were between the availability of professional role support and physician expertise (r = -0.60), between nursing skill mix and the availability of professional role support (r = 0.53), and between nursing skill mix and physician expertise (r = -0.51). As the availability of professional role support for nurses increased, the proportion of general practitioners as the most responsible physician tended to decrease. As the skill mix of nursing staff became richer with registered nurses, the availability of professional role support for nurses also tended to increase. As the skill mix of nursing staff became richer with registered nurses, the proportion of general practitioners as most responsible physician tended to decrease. This relationship indicates that the skill mix of physicians and registered nurses in sample hospitals are related – hospitals with a higher proportion of registered nurses tend to also have physicians with specialized knowledge and skills beyond that of a general practitioner.

There was no evidence of co-linearity among predictor variables (see Table 14). No correlations among predictor variables reached the critical range of 0.85 that might suggest issues related to co-linearity (Munro, 1997). The four predictors most strongly related to the outcome 30-day medical mortality were: registered nurse capacity to work (r = -0.30, p = 0.01), skill mix (r = -0.21, p = 0.07), nursing dose (r = 0.21, p = 0.07), and years of registered nurse experience on the clinical unit (r = -0.20, p = 0.08).

Multiple Regression Model Results

Multiple regression models were used to answer the study research questions and to test the study hypotheses. The two research questions are:

1. How well do the predictor variables in the 30-day mortality model (amount of registered nurse staffing, skill mix of nurse staffing, amount of professional role support for nurses, nurse experience, nurse capacity to work, perceived condition of the nursing practice environment, continuity of registered nurse care provider, physician expertise, and hospital type / location) explain differences in the outcome of 30-day medical mortality among a sample of Ontario acute care hospitals?

2. Is there a more parsimonious explanation of nursing-related hospital variables that predict 30-day medical mortality?

The seven study research hypotheses are:

1. hospitals with a higher amount or dose of nurse staffing will have lower 30-day medical mortality rates
2. hospitals with higher proportions of registered nurses among nursing care providers will have lower 30-day medical mortality rates
3. hospitals with more years of registered nurse experience on their clinical units will be have lower 30-day medical mortality rates
4. hospitals with increased nurse capacity (fewer shifts missed by nurses) will have lower 30-day medical mortality
5. hospitals in which registered nurses experience higher levels of a professional nursing practice environment will have lower 30-day medical mortality rates
6. hospitals that promote continuity of care by employing higher proportions of fulltime registered nurse staff will have lower 30-day medical mortality rates
7. hospitals that provide more professional role support to nursing staff will have lower 30-day medical mortality rates.

To answer the first research question, ten of the eleven '30-Day Mortality Model' predictor variables were forced to enter a multiple regression model to explain differences among 30-day risk-adjusted medical mortality rates for sample hospitals. The predictor variable 'hospital location outside an urban area' was left out of the model to act as the reference group for hospital type and location. The proportion of 30-day mortality rate variance explained in the model, or the resulting R-square, was 0.27. The overall p-value for this model was 0.02 suggesting that at least one model parameter estimate was likely different from zero. Table 15 lists the predictor variables, the parameter estimates for each predictor, the associated t-statistics, and the p-values for this model. Two of the ten predictors, the number of years of registered nurse experience on the clinical unit and the capacity of the registered nurse to work, had parameter estimates that were significantly different from zero at the 0.05 level. The results of this model are interpreted as:

- the mean 30-day risk-adjusted mortality rate for all sample hospitals is 15 percent (150/1000 patient deaths) but
- each additional mean hospital year of nurse experience on the clinical unit is associated with 4 fewer patient deaths in 1000 discharged patients, and
- each additional mean hospital increase of one missed shift of duty by nurses in the previous three-month period (less capacity of the nurse to work) is associated with 11 fewer patient deaths in 1000 discharged patients.

The results of this model suggest that there was no evidence to support the null hypothesis that the 30-Day Mortality Model was not useful in explaining 30-day medical mortality.

To determine whether the effectiveness of the two statistically significant nursing-related predictors of 30-day medical mortality found in the first model was the same across all hospital types / locations, interaction terms were introduced into a second multiple regression model. Therefore to address this, each of the interaction terms was pre-specified rather than allowing the analysis program to determine the interactions. The same ten predictors were forced to enter the model as well as the following four interaction variables:

- capacity to work multiplied by teaching hospital type
- capacity to work multiplied by urban non-teaching hospital
- years of nurse experience on the clinical unit multiplied by teaching hospital type, and
- years of nurse experience on the clinical unit multiplied by urban non-teaching hospital.

The proportion of 30-day mortality rate variance explained in this model, or the resulting R-square, was 0.34. The overall p-value for this model was also 0.02. Table 16 lists the predictor variables, the parameter estimates for each predictor, the associated t-statistics, and the p-values for this second model. With the addition of the four interaction variables in the model, more information is gained about the effectiveness of the two predictors that were statistically significant predictors in the first model. The effectiveness of both the years of nurse experience on the clinical unit and the capacity of nurses to work were shown to not be the same across all three types of hospitals and were conditional on hospital location / type. The results of this model are interpreted as

- the mean 30-day risk-adjusted mortality rate for all sample hospitals is 15 percent (150/1000 patient deaths) but
- in outside urban area hospitals, each additional mean hospital year of nurse experience on the clinical unit is associated with 3 fewer deaths in 1000 discharged patients
- in urban non-teaching hospitals, each additional mean hospital year of nurse experience on the clinical unit is associated with 7 fewer deaths in 1000 discharged patients, and
- in outside urban area hospitals, each additional mean hospital missed shift of duty by nurses in the previous three-month period (less capacity of the nurse to work) is associated with 15 fewer patient deaths in 1000 discharged patients.

For nurses who worked in teaching hospitals, neither the years of clinical unit experience nor the capacity of nurses to work were useful in explaining 30-day mortality. As well, in urban non-teaching hospitals, the capacity for nurses to work was not useful in explaining 30-day hospital mortality. When these 14 variables, which included interaction terms, were forced to enter the regression model, the amount of explained variance increased from that explained in the first model. The results of this second model also provide no evidence to support the null hypothesis that the 30-Day Mortality Model was not useful in explaining 30-day medical mortality.

As shown in Tables 15 and 16, some model predictors did not add much to the explanation of differences in 30-day medical mortality among sample hospitals. Therefore, to begin to find a more parsimonious explanation of factors predicting 30-day medical mortality, as asked in the second research question, stepwise regression was used. Stepwise regression combines both forward and backward regression procedures. In stepwise regression, the single best predictor is entered first. Then, the next best predictor is entered that contributes the greatest amount of unique variance, and so on. At each step, the new predictor entered in the model is that predictor with the greatest partial correlation with the dependent variable (30-day mortality) - when all the variables already included in the model have been partialed out (Glass & Hopkins, 1996; Munro, 1997; Tabachnick & Fidell, 1996). What differentiates stepwise from forward multiple regression is the extra step undertaken with the addition of each new predictor variable in the model. This additional step determines if the model predictors previously entered in the model continue to remain significant predictors and eliminates predictors from the model that no longer remain statistically significant.

In this third model, the original ten predictors used in the first model were entered using a stepwise method. Table 17 lists the statistically significant predictor variables that remained in the model, their parameter estimates, their associated F-statistics, and the p-values for this third model. The proportion of 30-day mortality rate variance explained in the model, or the resulting R-square was 0.24. The overall model p-value was 0.0002. In this model, the following three predictor variables were retained in the final iteration of the model and had statistically significant parameter estimates (at the 0.05 level): skill mix of nursing staff, number of years of registered nurse experience on their clinical units, and capacity of registered nurses to work. The results of this model are interpreted as:

- the mean 30-day risk-adjusted mortality rate for all sample hospitals is 15 percent (150/1000 patient deaths) but
- a 10 percent increase in the proportion of registered nurses in hospitals is associated with 6 fewer patient deaths in 1000 discharged patients
- each additional mean hospital year of registered nurse experience on the clinical unit is associated with 4 fewer patient deaths in 1000 discharged patients, and
- each additional mean hospital increase of one missed shift of duty by nurses in the previous three-month period (less capacity of the nurse to work) is associated with 11 fewer patients deaths in 1000 discharged patients.

To understand whether the effectiveness of these three statistically significant nursing-related predictors of 30-day medical mortality was the same across all hospital types, interaction terms were introduced into a fourth stepwise multiple regression model. Using stepwise multiple regression techniques, the same ten predictors used in the first and third models were entered in the model as well as the following six interaction variables:

- capacity to work multiplied by teaching hospital type
- capacity to work multiplied by urban non-teaching hospital
- years of unit experience multiplied by teaching hospital type
- years of unit experience multiplied by urban non-teaching hospital
- nursing skill mix multiplied by teaching hospital type, and
- nursing skill mix multiplied by urban non-teaching hospital.

Table 18 lists the predictor variables that remained in the model, their parameter estimates, their associated F-statistics, and the p-values for this fourth model. The proportion of 30-day mortality rate variance explained in the model, or the resulting R-square, was 0.32. The overall p-value for the model was less than 0.0001. The following four predictors were retained in the final iteration of the model: skill mix of nursing staff, number of years of nurse experience on the clinical unit for both teaching and outside urban area hospitals, years of nurse experience on the clinical unit for urban non-teaching hospitals only, and capacity of nurses to work for both teaching and outside urban area hospitals. The results of this model are interpreted as:

- the mean 30-day risk-adjusted mortality rate for all sample hospitals is 15 percent (150/1000 patient deaths) but
- across all hospital types, a 10 percent increase in the proportion of registered nurses is associated with 6 fewer patient deaths in 1000 discharged patients, and
- in both teaching and outside urban area hospitals, each additional mean hospital year of nurse experience on the clinical unit is associated with 4 fewer patient deaths in 1000 discharged patients, and
- in urban non-teaching hospitals, each additional mean hospital year of nurse experience on the clinical unit is associated with 6 fewer patient deaths in 1000 discharged patients, and

- in both teaching and outside urban area hospitals, each additional mean hospital increase of one missed shift of duty by nurses in the previous three-month period (less capacity of the nurse to work) is associated with 15 fewer patient deaths in 1000 discharged patients.

Though the effect of nursing skill mix was the same across all hospital types, the effectiveness of years of nurse experience on the clinical unit and the capacity of nurses to work were not the same across different hospital types. Years of nurse experience was a significant predictor of death but was conditional on the hospital type. Capacity of nurses to work was a significant predictor of 30-day mortality only for teaching and outside urban area hospitals but seemed to not be a predictor of 30-day mortality for urban non-teaching hospitals. In this fourth model, differences in the effectiveness of years of experience on the clinical unit and nurse capacity to work between outside urban area and teaching hospital types could not be calculated separately.

Therefore, a fifth model was implemented to better understand the effectiveness of years of clinical unit experience and capacity of nurses to work in explaining 30-day medical mortality for all three hospital types. In this last model, the following seven predictors were forced to enter the model:

- nursing skill mix
- years of nurse experience on the clinical unit for outside urban area hospitals
- years of nurse experience on the clinical unit for teaching hospitals
- years of nurse experience on the clinical unit for urban non-teaching hospitals
- capacity to work for outside urban area hospitals
- capacity to work for teaching hospitals, and
- capacity to work for urban non-teaching hospitals

Table 19 lists the predictor variables, their parameter estimates, their associated F-statistics, and the p-values for this fifth model. The proportion of 30-day mortality rate variance explained in the model, or the resulting R-square, was 0.32. The overall p-value for the model was 0.0004. The following four predictors were statistically significant predictors of 30-day medical mortality: skill mix of nursing staff, number of years of nurse experience on the clinical unit for outside urban area hospitals, number of years of nurse experience on the clinical unit for urban non-teaching hospitals, and the capacity of nurses to work for outside urban area hospitals only. The results of the model are interpreted as:

- the mean 30-day risk-adjusted mortality rate for all sample hospitals is 15 percent (150/1000 patient deaths) but
- a 10 percent increase in the proportion of registered nurses across all hospital types is associated with 5 fewer patient deaths in 1000 discharged patients, and
- in outside urban area hospitals, each additional mean hospital year of nurse experience on the clinical unit is associated with 4 fewer patient deaths in 1000 discharged patients, and
- in urban non-teaching hospitals, each additional mean hospital year of nurse experience on the clinical unit is associated with 6 fewer patient deaths in 1000 discharged patients, and
- in outside urban area hospitals only, each additional mean hospital shift missed by nurses (less capacity to work) is associated with 15 fewer patient deaths in 1000 discharged patients.

The effectiveness of years of nurse experience was not the same across the three hospital types. In this model, there was no effect found for the years of nurse experience on the clinical unit in teaching hospitals though there was an effect for both outside urban area and urban non-teaching hospitals. The parameter estimate for years of experience on the clinical unit for teaching hospitals was large but the probability was 0.11 and did not reach statistical significance, likely because of the small number of teaching hospitals in the sample. As well, this model found no effect of the capacity for nurses to work in both teaching and urban non-teaching hospitals even though there was a rather profound effect found for capacity for nurses to work in outside urban area hospitals. The effectiveness of nursing skill mix was the same across all hospital types / locations.

Summary of Results from the Multiple Regression Models

First Research Question

When the '30-Day Mortality Model' predictors were forced to enter both the first and second multiple regression models, there was evidence to reject the null hypotheses that these models were not able to explain any variance in the 30-day medical mortality outcome. Model 1 explained 27 percent of the variance and Model 2 explained 34 percent of the variance. The overall F-statistic in both models had a probability of 0.02, suggesting that at least one parameter estimate in each of the models was significantly different from 0.00. In Model 1, two of the ten model predictors, mean hospital years of nurse experience on the clinical unit and mean hospital capacity to work, had parameter estimates that were significantly different than 0.00. In Model 2, when interaction terms were introduced in the model for the variables that were significant predictors in the first model, differential or conditional effects by hospital type were found for both the mean hospital years of experience and the mean hospital capacity to work. However, though the results of both these models were evidence to support the usefulness of the predictors in the '30-Day Mortality Model', clearly not all variables in the model added to the explanation of differences among hospital 30-day mortality rates. These findings suggested that a more parsimonious explanation of nursing-related hospital variables could be used to predict 30-day medical mortality.

Second Research Question

Stepwise regression was first used to determine whether there was a more parsimonious explanation for differences among hospitals with respect to 30-day medical mortality rates. When the original ten predictors were entered in the third model using a stepwise method without any interaction terms, three variables were identified as significant predictors of 30-day medical mortality rates. These significant predictors were nursing skill mix within the hospital, mean hospital years of nurse experience on the clinical unit, and mean hospital capacity of nurses to work. Together these predictors accounted for 24 percent of the variance in 30-day medical mortality rates.

In the fourth model, interaction terms were entered using a stepwise method for each of the three significant predictors found in Model 3. The amount of explained variance in 30-day medical mortality increased in this model to 32 percent. The findings of this fourth model indicated that the effect of nursing skill mix on 30-day medical mortality was consistent across hospital types and was an inverse relationship. As the proportion of registered nurses in hospitals increased, 30-day medical mortality rates decreased. However, the results of this model indicated that the effectiveness of the other two predictors was conditional on the type of hospital. The mean hospital years of nurse experience on the clinical unit was inversely associated with lower 30-day medical mortality in outside urban area and teaching hospitals when considered together. As well, the effectiveness of the mean years of nurse experience was inversely related to 30-day medical mortality in urban non-teaching hospitals but the size of the effect was larger that for outside urban area and teaching hospitals.

In this fourth model, the effectiveness of the mean hospital nurse capacity to work was also conditional on the type of hospital. The mean hospital nurse capacity to work was significantly associated with 30-day medical mortality in outside urban area and teaching hospitals combined. However, no statistically significant association was found in urban non-teaching hospitals between capacity of nurses to work and 30-day medical mortality rates. In teaching and outside urban hospitals considered together, lower 30-day medical mortality was associated with less capacity of nurses to work or increased number of reported shifts of duty missed.

Because this fourth model was unable to isolate the effectiveness of the years of nurse experience on the clinical unit and capacity of nurses to work for each of the three hospital types individually, a fifth multiple regression model was developed. In this model, nursing skill mix, years of nurse experience on the clinical unit, capacity of nurses to work, as well as the four interaction terms involving hospital type with years of nurse experience and capacity to work were forced to enter a multiple regression model. The amount of variance explained among sample hospital 30-day medical mortality rates was 32 percent ($p = 0.0004$). The results of this model confirmed the uniformity in the effectiveness or relationship between nursing skill mix and 30-day medical mortality. As well, the results indicated that though the mean hospital years of nurse experience was inversely related to 30-day medical mortality in outside urban area and urban non-teaching hospitals, the size of the effect was different for both hospital types and was larger in urban non-teaching hospitals. The results of this model indicated that there was no significant relationship in teaching hospitals between years of nurse experience on the clinical unit and 30-day medical mortality.

The results of this fifth model also demonstrated that the effect of mean hospital capacity to work was conditional on the hospital type. The mean hospital capacity of nurses to work was significantly associated with 30-day medical mortality only in outside urban area hospitals and not in teaching and urban non-teaching hospitals. In outside urban area hospitals, less capacity of nurses to work or more frequent missed shifts of duty by nurses was associated with decreased 30-day medical mortality. The 30-Day Mortality Model implied from the fifth and final multiple regression model is illustrated in Figure 2. This model is able to explain 32 percent of the variance in risk-adjusted 30-day medical mortality rates across the 75 sample acute care teaching and community hospitals in Ontario, Canada.

The Research Hypotheses

There was no evidence to support hypotheses 1, 4, 5, 6, and 7. None of the models tested in this study found that higher amounts of nurse staffing, increased nurse capacity to work, higher levels of professional nursing practice environments, higher levels of continuity of care, and more availability of professional role support for nurses were significantly associated with 30-day medical mortality. Though it was hypothesized that increased nurse capacity to work (fewer shifts of duty missed by nurses) would be associated with lower 30-day mortality rates, the opposite relationship was found among outside urban area hospitals only. Hypothesis 2 was supported across all hospital types. A higher proportion of registered nurses or richer registered nurse skill mix was associated with lower 30-day medical mortality. Hypothesis 3 was supported for urban non-teaching hospitals and outside urban area hospitals, but not for teaching hospitals. In urban non-teaching and outside urban area hospitals, a higher number of mean hospital years of nurse experience on the clinical unit was associated with lower 30-day medical mortality rates.

Chapter Six

Discussion

Interpretation of Findings and Relationship with Previously Developed Knowledge

Nurse Staffing Dose and Nursing Skill Mix

The findings of this study have both similarities and differences with findings from previous research. In this study, a richer skill mix of registered nurses of all nursing staff was found to be associated with lower 30-day mortality while the dose of nurse staffing (the total amount of nursing staff worked hours per Ontario case weight) was not found to be related to 30-day medical mortality. The relationship between nursing skill mix and 30-day mortality persisted across all three types of sample hospitals: teaching, urban non-teaching community, and outside urban area community hospitals. Only one study reviewed found a statistically significant relationship between nursing skill mix and mortality (Hartz et al., 1989). In their study of Medicare patients in 7,217 American hospitals, Hartz et al explained 54 percent of the variance in Medicare mortality among sample hospitals using a number of predictors of hospital structure and characteristics as well as each hospital's predicted Health Care Financing Administration (HCFA) mortality rate. In their final regression model, the nursing skill mix variable rather than the nurse staffing dose variable of number of registered nurses per average daily census was entered and was found to be a significant predictor of Medicare mortality ($p < 0.01$). Both variables were not entered in the regression models because of the potential for confounding between the two predictors. Interestingly, several other reviewed study reports claimed an association between nursing skill mix and mortality without evidence of statistical significance (Blegen et al., 1998; Lake, 1999; Shortell & Hughes, 1988). Though no significant relationship was found between nursing skill mix and Medicare mortality in the final multiple regression models completed by Lake, it was reported that a statistically significant relationship between Medicare mortality and nursing skill mix had been found in some of the bi-variate regression models completed earlier in the analysis phase of the study.

The nursing skill mix variable has been operationalised in two different ways across the reviewed literature. While Hartz et al operationalised the nursing skill mix variable used in their study in a similar fashion to that used in this study (proportion of registered nurses of all nursing care providers), the nursing skill mix variable used by Shortell and Hughes was operationalised differently as the proportion of registered nurses of all hospital employees. As addressed in their study report, the proportion of registered nurses of all hospital employees as used by Shortell and Hughes was a measure of a hospital's clinical skill level.

No relationship was found between the dose of nurse staffing and 30-day medical mortality. The dose of nurse staffing was operationalised as the number of inpatient worked nursing hours per Ontario case weight. Worked nursing hours were those hours worked by registered nurses, registered practical nurses, and unlicensed assistive personnel providing direct patient care. No other studies had used a similar method of operationalising nurse staffing dose. However, four studies reviewed had found statistically significant relationships between the nurse staffing dose variables used and mortality (Farley & Ozminkowski, 1992; Manheim et al., 1992; Schultz, 1997; Shortell et al., 1994). In each of the studies, nurse staffing dose was operationalised as the amount of registered nurses (either as a fulltime equivalent, as worked hours, or as a number count) in the numerator and some measure of patient output in the denominator (inpatient day or patient admission). Interestingly, when nurse staffing dose was operationalised as the amount of worked hours by all nursing personnel per patient day, it was found to be a statistically significant predictor of patient mortality and was positively associated with mortality (Blegen et al., 1998). As well, in two of the studies investigating the relationship between nurse staffing dose and patient mortality, it was noted that their measures of nurse staffing dose and nursing skill mix were highly correlated (Blegen et al., 1998; Hartz et al., 1989). It is quite possible that when a measurement of nurse staffing dose incorporates the amount of registered nurses only per patient output rather than the amount of all nursing staff, that measure is really is a proxy variable for nursing skill mix. Nurse staffing dose is an elusive concept to operationalise and may not be adequately represented as a variable such as that used by Blegen et al. It is quite possible that variables such as amount of nursing care per patient unit of output in which the measure of patient output does not account for patient differences are really proxy measures of patient acuity, severity, or heaviness. This may be so, in part, because it is reasonable to consider that hospitals make some attempt to adjust their nurse staffing to meet the demands of their patients for care. Hospitals with sicker patients are likely to employ more nursing staff to meet patient needs. In studies such as that by Blegen et al that incorporate weak or more primitive patient risk-adjustment methods, a positive relationship between the nurse staffing dose and patient mortality will be expected and likely will be pronounced. In this current study, no such positive or inverse relationship between the dose of nurse staffing and mortality were found, likely because of the more extensive methods used for risk-adjustment and because the denominator of the nursing dose variable incorporated some measure that considered differences in patient heaviness.

Nonetheless, the findings of this current study suggest that a richer nursing skill mix with registered nurses is associated with lower 30-day medical mortality and that the dose of nurse staffing is not associated with 30-day mortality. I suggest that the use of a nurse staffing dose variable with registered nurse hours as the numerator and some measure of patient output such as patient day as the denominator is really a proxy measure of nursing skill mix and not a measure of nurse staffing dose. The study findings indicate that a ten percent richer skill mix of registered nurses is associated with five fewer patient deaths for each one thousand patients discharged from sample hospitals.

Availability of Professional Role Support

No evidence was found to support a relationship between the amount of professional role support for hospital nursing staff and 30-day medical mortality. Such a relationship had been found in a study of 13 American intensive care units (Knaus et al., 1986). Knaus et al found an association between low mortality and the presence of more intensive care unit resources such as clinical nurse specialists and nurse educators. Those units that had the lowest risk-adjusted mortality rates also had the most resources of professional role support in the form of clinical nurse specialists and nurse educators. Further indirect support was provided for a relationship between lower 30-day mortality and a higher amount of professional role support resources in the study that found lower

Medicare mortality rates in American magnet hospitals (Aiken et al., 1994). One characteristic of magnet hospitals is the emphasis or value placed on nursing staff education and development through a variety of initiatives, including higher levels of professional role support resources such as clinical nurse specialists.

The findings of no relationship between the amount of professional role support for nurses and 30-day mortality in this study might be related to the crude proxy variable used to measure the amount of professional role support in sample hospitals. The availability of professional role support resources for nurses was measured as each hospital's mean response to a survey item on the Revised Nursing Work Index included in the Ontario Registered Nurses Survey of Hospital Characteristics. Perhaps using a more exact and sensitive measure of the amount of professional role support as the numerator with an appropriate output term such as Ontario case weight as the denominator might have resulted in different findings. Development of this more precise measure of the amount of professional role support resources available for nursing staff might involve collecting primary hospital data or may be attained through secondary sources when Ontario hospitals engage in further implementation of the Management Information System (MIS) guidelines so that professional role support resources for nurses are reported in the format specified in the MIS guidelines.

Nurse Characteristics of Experience and Capacity to Work

The average number of years of experience by registered nurses on their clinical units in their hospitals was significantly and inversely related to 30-day medical mortality in the majority of sample Ontario hospitals. This relationship was not found in the ten sample teaching hospitals though the relationship did approach significance ($p = 0.11$). The lack of evidence to support such a relationship in teaching hospitals might be due to the small number of teaching hospitals in the study. No other studies could be found that investigated such a relationship. It is reasonable to expect that the more experience registered nurses have with the patient population cared for on their clinical unit, the more prepared nurses are to assess and intervene effectively with serious patient complications. Prompt and effective assessment and resolution of serious patient complications will result in the prevention of unnecessary patient death. Over the past decade, many hospitals across Ontario and elsewhere in North America have undertaken reorganization activities that may have disrupted the tenure or amount of experience of registered nurses on their clinical units. Hospitals have embarked on these and many other strategies aimed at controlling and reducing total hospital costs (Angus et al., 1995). As nursing consumed large proportions of hospital budgets, nursing budgets were the most obvious targets in total hospital budgets to seek reductions in hospital expenditures. Some of the strategies used to contain hospital expenditures involved the elimination and reduction of registered nurse positions, the substitution of registered nurses with other categories of nursing personnel such as registered practical nurses and unlicensed assistive personnel, and the closure of clinical units. These other categories of nursing personnel do not have the level of knowledge, critical thinking and judgment skills required for complex and accurate patient assessment, as well as for effective intervention planning and implementation that registered nurses have. Furthermore, the processes of eliminating and substituting registered nurses in hospitals often involved the movement of registered nurses from one clinical unit to another through a process of bumping. Registered nurses often had to move from a unit in which they had developed clinical expertise in caring for that population to another unit with a patient population for whom they had no or limited experience. Given the findings of this study, one must consider what effect such movement and displacement of registered nurses actually had on patient mortality. The findings of this study suggest that hospital reorganization activities that resulted in fewer years of registered nurse experience on their clinical unit contributed to excess or unnecessary patient mortality in sample hospitals. The effect of registered nurses having an average of one more year of experience on the clinical unit in outside urban hospitals was associated with four fewer deaths for each one thousand patients discharged. The effect is even greater in urban non-teaching hospitals. The effect of registered nurses having an average of one additional year of experience on their clinical unit in an urban non-teaching hospital was associated with six fewer deaths for each one thousand discharged patients.

A higher nurse capacity to work or fewer tours of duty missed, was associated with higher 30-day medical mortality rates, but only in the 40 outside urban area sample hospitals. The nature of the relationship hypothesized between nurse capacity to work and 30-day mortality did not materialize in the anticipated direction and was found in the opposite direction only for outside urban area hospitals. The effect of nurses in outside urban area hospitals missing, on average, one additional shift in a three-month period was associated with 15 fewer deaths out of each one thousand discharged patients. When nurses in these hospitals missed more shifts, fewer patients died. As shown in Table 11, nurses in outside urban area hospitals reported missing an average of 1.41 tours of duty in the preceding three-month period which was less than the mean number of missed tours of duty reported by nurses in both teaching (1.81 tours of duty) and urban non-teaching (1.65 tours of duty) hospitals. This relationship between higher nurse capacity to work (fewer missed tours of duty) and higher 30-day medical mortality is a surprising and profound finding that is difficult to explain. Outside urban area hospital nurses also reported have the highest number of years of experience on their clinical units (9.47) compared to nurses in teaching (7.85) and urban non-teaching (8.89) hospitals. This is noteworthy because of the finding of a statistically significant negative relationship between years of registered nurse experience on their clinical units and 30-day medical mortality – more years of experience was associated with lower mortality. Tentative explanations might be related to other characteristics of nurses and hospitals in outside urban area hospitals. As shown in Table 11, outside urban area hospitals have the lowest proportion of registered nurses in their nursing skill mix (0.71) compared to both teaching (0.85) and urban non-teaching (0.79) hospitals. Nurses in these hospitals also reported having the least amount of professional role support resources available to support them in their practice (1.92) compared to nurses in teaching (2.84) and urban non-teaching (2.39) hospitals. As well, there is a lower proportion of fulltime registered nursing staff in outside urban area hospitals (0.55) compared with teaching (0.67) and urban non-teaching (0.62) hospitals. It is possible that these characteristics of hospital nursing exert a direct effect on nurse capacity to work. A nursing skill mix of a lower proportion of registered nurses means that nurses have fewer professional nurses to collaborate and consult with when they work. As well, when registered nurses are working on their clinical units, a lower proportion of registered nurse colleagues are fulltime employees. With fewer professional role support resources available for nurses to draw upon, nurses may not get adequate support to assist and support them in complex and stressful patient care situations. All together, these conditions may make it more difficult and burdensome for registered nurses to coordinate, plan, and communicate patient care from shift-to-shift, day-to-day, and even among various health members. Consequently, under these conditions, one way registered nurses in these environments may cope with workplace pressures is to take more time away from work to recuperate and regain the capacity to work. In outside urban area hospitals that report fewer mean missed tours of duty, nurses may not be taking additional time to recuperate and regain their capacity to work resulting in higher 30-day mortality. Further investigation is required to better understand the nature of this relationship between higher 30-day mortality and less capacity of nurses to work in outside urban area hospitals.

The Condition of the Nursing Practice Environment

No evidence was found to support the hypothesized relationship between the condition of the nursing practice environment and 30-day medical mortality. The newly derived Canadian Practice Environment Index (CPEI) was used to measure the condition of the nursing practice environment in sample hospitals. The CPEI is a single composite scale derived through a factor analysis process used with the Revised Nursing Work Index (NWI-R). The NWI-R was also previously used by both Aiken et al (Aiken et al., 1994) and Lake (Lake, 1999) in their studies examining relationships between hospital mortality and the organization of nursing in both magnet and non-magnet hospitals. However, in both studies, different sub-scales of the NWI-R were used to measure the condition of the nursing practice environment. Aiken et al found that hospitals that were known to be magnet hospitals also had significantly lower Medicare mortality. It was concluded that these same magnet hospitals had been previously shown to have higher levels of professional nursing practice environments because they had higher levels of nurse autonomy, higher levels of nurse control over the resources in their practice settings, and higher reported effective relationships between nurses and physicians. Aiken et al argued that professional nursing practice environments are characterized by high levels of nurse autonomy, nurse control over the practice setting, and better working relationships between physicians and nurses. However, no evidence was reported to support a direct relationship between mortality and any of these three sub-scales of the revised Nursing Work Index (NWI-R) believed to characterize the condition of the nursing practice environment. Lake used a similar argument in her study when she too found that sample magnet hospitals also had lower Medicare mortality. She completed a factor analysis process on the NWI-R items in her study and derived six constructs that were believed to reflect critical elements of a professional nursing practice environment in hospitals. She found that sample magnet hospitals had higher levels of scores in these six constructs. However, in the final multiple regression models used by Lake to predict 30-day mortality, none of the six construct of the condition of the nursing practice environment were statistically significant predictors of 30-day mortality.

The quality of relationships among physicians and nurses contributes to the condition of the nursing practice environment. In two previous studies, non-statistical associations were found in samples of intensive care units between lowest standard mortality ratios and high collaboration and communication among nurses and physicians (Knaus et al., 1986; Mitchell et al., 1989). Neither of these studies incorporated the same items investigating nurse-physician relationships as those items on the NWI-R and CPEI, nor its other sub-scales. A later and more rigorous study of 42 American hospital intensive care units tested the association between the quality of caregiver interactions and mortality (Shortell et al., 1994). This study incorporated yet a different measure of the quality of relationships among intensive care unit caregivers, composed primarily of nurses and physicians. They were unable to find evidence to support such a relationship.

Though there was some weak evidence of an association between the condition of the nursing practice environment and mortality in previous studies, no evidence was found in this study to support the hypothesized relationship. This result may be because there really is no association between the condition of the nursing practice environment and mortality or it may be because the association may not be a simple direct relationship between the condition of the nursing practice environment and 30-day medical mortality. Instead, the condition of the nursing practice environment may be a mediating factor that is itself effected by other predictor variables such as nursing skill mix and nurse staffing dose before effecting 30-day mortality. An alternative explanation may be that though there is a relationship between the condition of the nursing practice environment and 30-day medical mortality, the CPEI is not a valid measure of the condition of the nursing practice environment. Further use and study of the CPEI may help us better understand the predictive validity of the CPEI and any relationship between 30-day mortality and the condition of the nursing practice environment measured with the CPEI.

Continuity of Nursing Care Provider

The hypothesized relationship between continuity of registered nurse care providers and 30-day medical mortality was not found. No other studies were found in the literature testing this relationship. It is possible that there is no direct relationship between these two variables. A more likely explanation is that continuity of registered nurse care providers has an indirect effect on 30-day mortality perhaps mediated through the condition of the nursing practice environment and/or nurse capacity to work. Further investigation is needed to explore these relationships.

Other Determinants of 30-Day Mortality

Physician expertise was not found to be a significant predictor of 30-day medical mortality in this study. The research literature reveals conflicting evidence of a relationship between physician expertise and mortality. The finding of no relationship between physician expertise and 30-day mortality in this study is consistent with the findings in some studies (Al-Haider & Wan, 1991; Burns & Wholey, 1991; Schultz, 1997) but contrary to the findings in other studies (Farley & Ozminkowski, 1992; Hartz et al., 1989; Lake, 1999; Manheim et al., 1992).

The measurement of physician expertise in this current study was different than measures used in other reviewed studies. The most common measure of physician expertise in other studies was the percentage of physicians who were board-certified specialists, a common variable found in the American literature that cannot be exactly replicated in the Canadian context. A medical specialist is a physician who has undergone further education and experience in a specialized medical field above that completed by general medical practitioners. Though similar in concept, in this study, physician expertise was measured as the proportion of general practitioner physicians out of all physicians, both general practitioner and specialist, who were the physicians most responsible for the care of sample patients in relation to their most responsible diagnoses. The physician expertise variable is similar in principle to the nursing skill mix variable. Both the nursing skill mix and physician expertise variables measure the mix of different types of practitioners who have varying levels of knowledge and skill. Indeed, as shown in Table 14, the correlation between nursing skill mix and physician expertise is –0.51 ($p < 0.0001$) indicating that hospitals with a richer skill mix of registered nurses in their nursing staff also have a richer mix of medical practitioners who were specialists caring for sample patients. The findings of this study suggest that though nursing skill mix is negatively associated with 30-day mortality, physician expertise or skill mix is not associated with 30-day medical mortality.

None of the variables reflecting hospital teaching status and hospital location inside or outside an urban area were significantly associated with 30-day medical mortality. Though no evidence of a direct relationship was found in this study between teaching hospital status and 30-day medical mortality, other reviewed studies have provided conflicting evidence about this relationship. Several studies had findings similar to this study and reported no relationship between hospital teaching status and mortality (Al-Haider & Wan, 1991; Farley & Ozminkowski, 1992; Manheim et al., 1992; Schultz, 1997). Other reviewed studies found that teaching hospital status was significantly related to lower mortality (Hartz et al., 1989; Keeler et al., 1992; Rosenthal et al., 1997). Still other study results found that hospital teaching status was related to higher mortality outcomes (Burns & Wholey, 1991; Flood et al., 1984). One explanation for these conflicting findings is that the relationship between teaching status and mortality is dependent on the diagnoses of patients included in a study (van

Servellen & Schultz, 1999). A second explanation may be that teaching status exerts an indirect effect on 30-day mortality medicated through other variables such as nursing skill mix, registered nurse experience, and even physician expertise. As shown in Table 10, the ten sample teaching hospitals, on average, had lower 30-day risk-adjusted medical mortality rates than the entire sample, as well as lower than urban non-teaching and outside urban area hospitals though none of these differences were statistically significant. It is notable that teaching hospitals do have higher registered nurse skill mixes as well as higher levels of physician expertise than the sample as a whole as well as urban non-teaching and outside urban area hospitals. These characteristics of teaching hospitals provide some rationale for exploring indirect relationships between teaching hospital status and 30-day medical mortality.

Hospital location inside or outside urban areas was not directly associated with 30-day medical mortality. This finding was similar to that in a large sample of California hospitals involving only acute myocardial infarction patients (Schultz, 1997). Again, previous study results have provided conflicting evidence about the relationship between hospital location inside or outside urban areas. Some studies reported significantly lower mortality rates in urban area hospitals (Aiken et al., 1994; Keeler et al., 1992) and other studies found significantly higher mortality rates in urban areas (Al-Haider & Wan, 1991; Manheim et al., 1992). In each of these studies, urban location was operationalised in a different manner limiting comparison of these findings. Similar to teaching hospital status, hospital location may not exert a direct influence on mortality and might be mediated by the effects of other variables such as nurse capacity to work, nursing skill mix, and years of registered nurse experience on the clinical unit.

A Proposed Revised 30-Day Mortality Model from Study Findings

In each of the five study multiple regression models, the findings supported rejecting the null hypothesis that the predictors in the 30-Day Mortality Model were unable to explain any of the variance in 30-day medical mortality rates among study hospitals. Clearly, some of the predictors in the first two models (Tables 15 and 16) that included forcing all predictors to enter the model together did not add to the explanation of differences among hospital 30-day medical mortality rates. As well, the results of the last three study multiple regression models (Tables 17, 18, and 19) did not produce evidence supporting the credibility of the 30-Day Medical Mortality Model in its whole form as specified in Figure 1. The results of the fifth and final model (Table 19 and Figure 2) indicated that a higher registered nurse skill mix as well as more years of registered nurse experience on the clinical unit in both urban non-teaching and outside urban area hospitals were statistically significant predictors of lower 30-day medical mortality. This fifth model also indicated that less nurse capacity to work or registered nurses missing more tours of duty in outside urban area hospitals was also associated with lower 30-day medical mortality in those hospitals. The lack of significant parameter estimates with the remaining predictors in the model is evidence that the 30-Day Medical Mortality Model does not completely reflect the actual mechanisms and factors influencing 30-day mortality. Refinement and re-testing of the model is an important next step to further theory development. Such refinement should certainly include re-examination of the model predictors as well as careful consideration of adjusting the hypothesised relationships among these and maybe other important predictors. In the 30-Day Medical Mortality Model, each of the predictors was hypothesised to have a direct effect on the outcome 30-day medical mortality. It is very possible that some of these variables exert an indirect effect on 30-day mortality and their effects may be mediated through other variables. Testing the total effects of each predictor within a model, rather than just testing the direct effects, cannot be accomplished using multiple regression modelling techniques. Instead, analysis strategies such as structural equation modelling are more appropriate (Hayduk, 1996; Hayduk, 1987; Ratner, Bottoroff, & Johnson, 1998). Structural equation modelling analysis techniques are useful in testing theoretical models that include direct and indirect effects among model variables as well as variables involved in spurious and correlated cause relationships (Duncan, 1975).

Refinement of the 30-Day Mortality Model used in this study may lead to the development of a new model such as that shown in Figure 3. In this model, it is hypothesised that five of the predictors (availability of professional role support, nurse staffing dose, teaching hospital status, hospital location, and continuity of registered nurse care provider) have an indirect effect on 30-day mortality. These effects are mediated through five other predictor variables that are hypothesised to have direct effects on 30-day mortality. As well as testing the credibility of claims of both direct and indirect predictor effects on 30-day mortality, structural equation modelling techniques would be able to account for the effects of correlated predictors such as nursing skill mix and physician expertise within the revised model. Furthermore, structural equation modelling techniques would be able to analyse the effects of predictors that have spurious relationships or common causes such as nursing skill mix and nurse experience variables. Though structural equation modelling analysis techniques should always be driven by theory specification, such analyses also yield diagnostic results that offer suggestions for model improvement.

Study Limitations

There are a number of study limitations particularly related to the study design, hospital sampling procedures, secondary data sources used, and relationships among predictor variables. With a retrospective study design such as that used in this study, the researcher tries to establish links between events or outcomes of interest with hypothesised preceding events. In retrospective studies, it is important to specify the hypothesised cause-effect relationships among the independent and dependent variables. Because the researcher is unable to manipulate or control any of the study variables, the theoretical framework is an essential map that guides the methods used throughout the study (Wood & Brink, 1998; LoBiondo-Wood & Haber, 1998). The preceding events are considered to be the independent variables affecting the outcome of interest, which is 30-day medical mortality in this study. Because these preceding events are observed rather than controlled as in experimental and quasi-experimental research, alternate explanations threaten the validity of claims made about the relationships between the outcome of interest and the presumed independent variables. Some of the most compelling alternate explanations for the finding of relationships between the dependent variable and any of the independent variables arise from possible spurious or common cause relationships between the model predictors and other variables outside the pool of independent variables specified in the study. In this study, the 30-Day Mortality Model was developed a priori from the related literature and was used to guide both data collection and analysis procedures. However, because the model accounted for only 32 percent of the variance in 30-day medical mortality among sample hospitals, it is important to consider other explanations for factors determining 30-day mortality. The less variance accounted for in a multiple regression model, the more unstable the results are considered to be. Clearly, there are other unknown and unspecified determinants of 30-day medical mortality. Furthermore, it is possible that even those variables found to be significant predictors of 30-day mortality may not affect 30-day mortality but might be correlated with other factors that actually do affect 30-day mortality. For example, the variable nursing skill mix might be correlated with hospital financial status. Hospitals with a more favourable financial position might be better prepared to employ a higher mix of more costly registered nurse care providers. Yet, financial status of hospitals was not included as a predictor in the 30-Day Medical Mortality Model.

Instead of including all Ontario acute care hospitals in this study, efforts were undertaken to select a sample of Ontario hospitals that was more homogeneous in nature. Though this sampling procedure would ultimately weaken external validity of the study findings, this was done to strengthen study internal validity (Cook & Campbell, 1979). Small or rural Ontario hospitals were excluded from the study. These small hospitals are funded using different formulae than other acute care hospitals in Ontario. The size and lower amounts of patient activity in small hospitals usually result in fewer opportunities for economies of scale. These small hospitals also may have much larger nurse staffing doses to meet minimum nurse staffing requirements. Excluding these small and rural Ontario hospitals weakened one alternate explanation for any study findings that the heterogeneous nature or characteristics of the hospitals influenced the effects of any of the predictors.

Another important study limitation is the potential that sources of measurement error were introduced in the study, particularly from the use of secondary data sources (Clarke & Cossette, 2000; Lichtig et al., 1999). Study data sources may have both systematic and random sources of error that affect both the reliability and validity of the findings. Multiple regression analysis techniques, unlike structural equation modelling analysis techniques, do not incorporate estimates of measurement error within the analysis. In multiple regression analysis, it is assumed that the variables have been reliably measured. As described in Chapter Four, there is evidence of errors, more random in nature, with patient data extracted from the Discharge Abstract Database. These errors may inflate standard errors of estimates and ultimately diminish the credibility of the study results. Less is known about the reliability of the Management Information System or Ontario Hospital Reporting System files. Errors in these data files also diminish the credibility of the study findings. Similarly, responses in the Ontario Nurse Survey may contain sources of error. Nurses may have incorrectly estimated their years of experience on their current clinical units or the number of missed tours of duty over the previous three-month period. Inaccuracies in registered nurse reporting of these data may lead to erroneous study conclusions that are untrustworthy. No tests of stability such as test-retesting were undertaken with the Ontario Registered Nurse Survey and thus the degree of error in these three responses from the survey are unknown.

Correlations among predictor variables may indicate co-linearity problems even when the correlations among these variables are modest such as in this study. For example, the correlation between nursing skill mix and nurse staffing dose was –0.47 ($p < 0.0001$) and between nursing skill mix and the availability of professional role support was 0.53 ($p < 0.0001$). In multiple regression models, when variables are correlated with each other, only one of these variables may end up being statistically significant in the model. If this happens, only one of the correlated predictor variables will be discussed as an important predictor of the dependent variable and the other correlated predictor may be left out of the explanation as a predictor of the outcome.

Another important study limitation is that those predictor variables that were derived from the Ontario Nurse Survey included responses from medical and surgical nurses and nurses who work on combined medical-surgical patient care units. However, the 30-day mortality outcome was developed with patient conditions that are often cared for in medicine-specific areas of a hospital. In such cases, using nurse respondents from surgical and combined medical-surgical patient care units may not accurately reflect the experience of nurses caring for the medical patients included in this study. In teaching and larger community hospitals, medical and surgical nurses often work in different patient care units. This distinction is less prevalent in smaller community hospitals in which patients are more likely to be cared for in combined medical-surgical units.

The results of this study should only be generalised with caution across different diagnosis groups of discharged patients in Ontario hospitals. The sample of hospital patients used in this study consisted of those patients within the four acute medical diagnosis categories of acute myocardial infarction, stroke, pneumonia, and septicemia and included only four percent of all patients discharged from acute care Ontario hospitals during the period April 1, 1998 through to and including March 31, 1999. When different diagnosis groups of patients are studied, not only will the 30-day mortality rate for hospitals change, but the rankings of 30-day mortality rates among hospitals as well as the determinants of 30-day mortality may also be different. More study of the relationship between mortality rates and nursing-related determinants of mortality is needed with different diagnosis groups of patients. Furthermore, generalisation outside of the Province of Ontario should only be done with caution. Policies governing the funding and organisation of hospital care are a provincial responsibility. Because of health policy and other practical differences among provincial jurisdictions, there may be differences in the environment and characteristics of hospitals outside Ontario limiting generalisability of these findings. One important strategy to validate the robustness of the findings of this study is to repeat the analyses using the data from the Alberta and British Columbia teams participating in the 'International Study of Hospital Outcomes'. Those results could be compared to the results of this study.

Implications for Use of Study Findings

Despite previous claims that 30-day mortality is not a patient or hospital outcome that is sensitive to variations in nursing-related hospital factors, this study provides evidence and beginning theory that does support such relationships. As the body of knowledge about the relationship between 30-day mortality and nursing factors continues to expand, this and related developing theory should be incorporated in nursing education curricula. Hospital administrators, hospital nurse administrators, those organisations providing funding to hospitals, and health policy makers need to be informed about the state of the evidence and theory related to the relationships between patient mortality and nursing-related hospital characteristics. The results of this study suggest that at least several aspects of the organisation of nursing in acute care hospitals such as nursing skill mix and the years of experience attained by nurses in their clinical units have a direct effect on 30-day medical mortality.

This knowledge when joined with other developed knowledge can be used to plan for the results of proposed scenarios involving the reorganisation of nursing in hospitals. These results can be used to understand trade-offs related to patient mortality that would materialise when hospital activities are considered that involve changing the nursing skill mix and the amount of registered nurse experience on the clinical units. Study findings and the developed theory could be used to articulate the impact and importance of the role that registered nurses and registered nurse experience have on patient mortality.

These findings have implications for how hospitals and collective bargaining units for nurses have chosen to displace nursing staff in times of a perceived over-supply of nurses. The results shed some scepticism on the common practice of bumping that is used for the displacement of nurses within hospitals. A bumping strategy that results in lessening the years of experience of registered nurses on their clinical units is associated with higher patient 30-day mortality.

Areas for Further Research

There is much research to be done in the area of patient and hospital outcomes as they relate to the organisation of nursing in hospitals. The findings of this study can be used in further research examining the relationship between nursing-related hospital factors and patient outcomes such as but not limited to mortality. First, because of the complex specification of the proposed Revised 30-Day Mortality Model (Figure 3) that involves direct, indirect, correlated, and spurious cause relationships among model predictor variables, analysis of this model should be undertaken using structural equation modelling strategies. Such strategies will be able to examine and estimate the total effects that predictors may have on 30-day medical mortality rates.

Further research is needed to build on and test the predictive validity of the Canadian Practice Environment Index (CPEI) as a measure of the condition of the nursing practice environment in acute care hospitals. As well, further use and testing of the predictive validity of the nurse staffing dose variable used in this study might be an important step in establishing a more valid measure of the nurse staffing dose than the more traditional approaches used previously across the literature. These traditional measures of nurse staffing dose do not incorporate a patient output denominator that considers the weighting of differences in patient heaviness or demands for care.

The findings related to the relationship between less nurse capacity to work in outside urban area hospitals and lower 30-day medical mortality are surprising and require further examination before this relationship is understood. Such investigation may need to begin by further primary data collection using strategies such as registered nurse focus groups.

Another area for further research involves the continued development of effective risk-adjustment methodologies that account for differences in patient characteristics in the outcome being studied. The more differences in patient characteristics are accounted for in risk-adjustment methods, the more confident the researcher can be that the remaining variance in the outcome being studied is related to differences in hospital quality and random variation. In future studies investigating the outcome 30-day mortality, logistic regression models that perform better and yield higher c-statistics could be incorporated. The goal of logistic regression modelling in estimating each patient's probability of death is to get as close to perfect prediction as possible. By continuing to use the findings of other studies that incorporate logistic regression modelling to predict patient death, more of the variance in 30-day mortality that is caused by patient characteristics can be accounted for before multiple regression or other types of models are used to examine the other determinants of 30-day death.

Final Summary Conclusions

In summary, my primary study objective to determine the effects that the nursing-related predictors specified in the 30-Day Mortality Model (Figure 1) have on 30-day medical mortality in a sample of Ontario hospitals has been accomplished. A more parsimonious model specifying the determinants of risk-adjusted 30-day medical mortality that were implied from the fifth multiple regression model was also presented (Figure 2). As well, a Revised 30-Day Mortality Model has been proposed that postulates direct, indirect, correlated causes, and spurious relationships among the predictors of 30-day mortality (Figure 3). Though this model is complex in nature, it may more accurately reflect the reality of the determinants of 30-day mortality. Each of the three theories postulated above build on theory previously developed (Aiken et al., 1997; Havens & Aiken, 1999; Silber et al., 1992; Silber, Rosenbaum, Schwartz, Ross, & Williams, 1995; Silber & Rosenbaum, 1995). The specific contribution that this research makes is the refinement of theory specifying relationships of at least several nursing-related hospital variables with 30-day medical mortality.

Table 1

Characteristics of Sample Hospitals for the Whole Sample, as well as by Teaching, Urban Non-teaching, and Outside Urban Area Hospitals

Variable	Statistics	All Hospitals (n=75)	Teaching (n=10)	Urban Non-Teaching (n=25)	Outside Urban (n=40)
Total Hospital Patient Days	Mean:	100,845	253,739	123,496	48,465
	SD*:	89,596	115,749	59,067	29,254
	Range:	17,450 – 412,524	112,803 – 412,524	39,061 – 252,511	17,450 – 111,988
Total Hospital Discharges	Mean:	13,643	30,442	17,784	6855
	SD:	11,101	13,190	8,393	4442
	Range	1,601 – 57,894	17,747 – 57,894	5753 – 40,684	1601 – 15,943
Number of Sample Patients	Mean:	626	1011	852	389
	SD:	429	564	395	228
	Range:	101 – 2,090	464 – 2,090	303 – 1,819	101 – 1068
Total Ontario Weighted Cases	Mean:	17,321	49,123	20,530	7,365
	SD:	17,502	24,449	9,096	4,979
	Range:	1,883 - 87,602	21,905 – 87,602	7,899 – 41,245	1,883 – 17,687
Average Hospital Weighted Case	Mean:	1.17	1.57	1.18	1.07
	SD:	0.22	0.22	0.16	0.12
	Range:	0.88 – 1.91	1.20 – 1.91	0.94 – 1.58	0.88 – 1.42

Note. * SD refers to standard deviation.

Table 2

Characteristics of Sample Patients by Medical Diagnoses Discharged from Ontario Hospitals April 1, 1998 through March 31, 1999

Diagnosis Category	ICD-9 Codes for MRD*	Number of Cases	Average Age	Proportion of Cases in Sample	Crude Mortality Rate (%)
AMI**	410	17,617	67.8	0.38	11
Stroke	431 434 436	11,445	73.8	0.24	18
Pneumonia	481 482 485 486	15,643	71.1	0.33	12
Septicemia	038	2,236	69.8	0.05	20
Overall	--	46,941	70.4	1.00	14

Note. * MRD refers to Most Responsible Diagnosis.

** AMI refers to Acute Myocardial Infarction.

Table 3

Characteristics of Nurse Survey Respondents for the Whole Sample, and by Teaching, Urban Non-teaching, and Outside Urban Area Hospitals

Variable	Statistic	All Hospitals (n=3,988)	Teaching (n=1,005)	Urban Non-Teaching (n=1,570)	Outside Urban (n=1,413)
Age	Mean:	42.9	40.6	43.7	43.6
	SD*:	8.6	8.5	8.8	8.1
	Range:	23 – 71	23 – 63	25 – 71	24 – 65
Years Experience as Registered Nurse	Mean:	17.7	15.5	18.2	18.8
	SD:	8.8	8.5	8.9	8.5
	Range:	1 – 48	1 – 40	1 – 48	1 – 41
Years Experience in Current Hospital	Mean:	13.7	12.0	13.7	14.8
	SD:	7.3	6.8	7.2	7.5
	Range:	1 - 38	1 – 35	1 - 35	1 – 38
Fulltime Employment	% Fulltime:	48.9	57.7	48.0	43.6
Female	% Female:	97.6	96.3	98.2	97.9
Baccalaureate or More Education	%:	15.2	19.2	16.5	11.0

Note: * SD refers to standard deviation.

Table 4

The 26 Revised Nursing Work Index Items included in the Canadian Practice Environment Index

Item Number	Item
1	Adequate support services allow me to spend time with my patients.
3	A good orientation program for new employees.
4	A supervisory staff that is supportive of nurses.
6	Nursing controls its own practice.
7	Active staff development or continuing education programs for nurses.
8	Career development/clinical ladder opportunity.
9	Opportunity for staff nurses to participate in policy decisions.
10	Support for new and innovative ideas about patient care.
11	Enough time and opportunity to discuss patient care problems with other nurses.
12	Enough registered nurses on staff to provide quality patient care.
14	A senior nursing administrator who is highly visible and accessible to staff.
16	Enough staff to get work done.
17	Freedom to make important patient care and work decisions.
18	Praise and recognition for a job well done.
21	Not being placed in a position of having to do things against my nursing judgment.
24	A lot of team work between nurses and physicians.
26	Opportunities for advancement.
27	Nursing staff are supported in pursuing degrees in nursing.
28	A clear philosophy of nursing that pervades the patient care environment.
32	A nurse manager or supervisor who backs up the nursing staff in decision making, even if the conflict is with a physician.
33	Administration that listens and responds to employee concerns
34	An active quality assurance program.
35	Staff nurses are involved in the internal governance of the hospital.
36	Collaboration between nurses and physicians.
38	Nursing care is based on a nursing rather than a medical model.
40	The contributions that nurses make to patient care are publicly acknowledged.

Table 5

Prevalence of Potential Risk Factors for 30-Day Mortality in Each Diagnosis Category

Risk Factors	**ICD-9* Code**	**AMI (%)**	**Stroke (%)**	**Pneumonia (%)**	**Septicemia (%)**
Age					
Sex (Male)		64.1	48.8	49.9	49.2
Acute Myocardial Infarction	410, 412	10.4	6.7	5.0	5.1
Heart Failure	428	22.1	5.8	16.2	9.5
Peripheral Vascular Disease	441, v43.4, 443.9, 785.4	3.3	2.7	2.0	2.9
Cerebro-Vascular Disease	430, 431, 432, 433, 434, 435, 436, 437, 438	4.1	16.1	5.7	6.5
Pre/Senile Psychosis	290	1.4	3.8	4.7	5.8
Respiratory Disease	490, 491, 492, 493, 494, 495, 496, 500, 501, 502, 503, 504, 505, 506.4	9.4	6.3	30.4	8.5
Rheumatic-like Disease	710.0, 710.1, 710.4, 714.0, 714.1, 714.2, 714.8, 725	1.0	0.9	2.0	2.2
Ulcers of Digestive System	531, 532, 533, 534	0.4	0.6	0.5	0.6
Liver Cirrhosis	571.2, 571.5, 571.6, 571.4	0.1	0.3	0.6	1.6
Diabetes Mellitus	250.0, 250.1, 250.2, 250.3, 250.7	20.6	21.1	14.4	20.8
Diabetes Mellitus with Complications	250.4, 250.5, .6	1.7	1.7	0.9	2.6
Para/Hemi Plegia	344.1, 342	0.3	13.0	0.5	1.3
Kidney Disease	582, 583.0, 583.1, 583.2, 583.3, 583.4, 583.5, 583.6, 583.7, 585, 586, 588	3.5	1.9	3.5	9.6
Liver/Esophageal Disease	572.2, 572.3, 572.4, 572.5, 572.6, 572.7, 572.8, 456.0, 456.1, 456.2	0.1	0.2	0.3	1.4
Socioeconomic Status:					
- very low income		24.0	24.8	25.4	23.6
- low income		21.3	20.7	20.3	18.7
- middle income		22.7	24.5	28.1	29.9
- high income		17.1	15.9	14.1	15.4
-very high income		14.9	14.1	12.1	12.4
Chronicity		3.7	6.7	14.4	15.6
Hemorrhagic Stroke	431	--	11.8	--	--

Note. * ICD-9 refers to the International Classification of Diseases 9th revision.

Table 6

Acute Myocardial Infarction Logistic Regression Model Results

Predictors	30-Day Regression Coefficient	Odds Ratio	95% Confidence Interval	Probability
Age	0.06	1.06	1.06 - 1.07	< 0.0001
AMI *	-0.18	0.83	0.72 - 0.97	0.02
Heart Failure	0.41	1.50	1.36 - 1.67	< 0.0001
Cerebro-Vascular Disease	0.36	1.43	1.19 - 1.72	0.0002
Respiratory Disease	0.16	1.18	1.02 - 1.36	0.02
Liver Cirrhosis	1.50	4.47	1.91 - 10.47	0.0005
Diabetes Mellitus	0.13	1.14	1.02 - 1.28	0.02
Kidney Disease	0.58	1.79	1.48 - 2.17	< 0.0001
Liver/Esophageal Disease	1.26	3.53	1.13 - 11.06	0.03
Socioeconomic Status:**				
Very Low Income	0.16	1.18	1.00 - 1.38	0.04
Low Income	0.20	1.23	1.04 - 1.44	0.02
Middle Income	0.13	1.14	0.97 - 1.35	0.11
High Income	0.19	1.21	1.01 - 1.44	0.04
Chronicity	0.75	2.11	1.76 - 2.52	< 0.0001
Intercept	-6.72			< 0.0001

Note. * AMI refers to Acute Myocardial Infarction.

**Reference group for odds ratio is very high income socioeconomic status.

Area under the receiving operator characteristic curve is 0.749.

Table 7

Stroke Logistic Regression Model Results

Predictors	30-Day Regression Coefficient	Odds Ratio	95% Confidence Interval	Probability
Age	0.04	1.05	1.04 - 1.05	< 0.0001
AMI *	0.20	1.22	1.00 - 1.49	0.04
Heart Failure	0.78	2.17	1.81 - 2.61	< 0.0001
Liver Cirrhosis	1.23	3.42	1.65 - 7.08	0.0009
Para/Hemi Plegia	-0.36	0.70	0.59 - 0.82	< 0.0001
Kidney Disease	0.69	1.99	1.44 - 2.74	< 0.0001
Liver/Esophageal Disease	1.82	6.16	2.47 – 15.34	< 0.0001
Socioeconomic Status: **				
Very Low Income	0.16	1.18	0.98 - 1.41	0.08
Low Income	0.18	1.20	1.00 - 1.44	0.06
Middle Income	0.21	1.23	1.03 - 1.48	0.02
High Income	0.25	1.28	1.06 - 1.56	0.01
Chronicity	1.16	3.18	2.69 - 3.76	< 0.0001
Hemorrhagic Stroke	1.73	5.66	4.96 - 6.45	< 0.0001
Intercept	-5.53			< 0.0001

Note. * AMI refers to Acute Myocardial Infarction.

**Reference group for odds ratio is very high income socioeconomic status.

Area under the receiving operator characteristic curve is 0.746.

Table 8

Pneumonia Logistic Regression Model Results

Predictors	30-Day Regression Coefficient	Odds Ratio	95% Confidence Interval	Probability
Age	0.05	1.06	1.05 - 1.06	< 0.0001
Sex (Male)	0.23	1.26	1.14 - 1.39	< 0.0001
Heart Failure	0.30	1.36	1.21 - 1.52	< 0.0001
Cerebro-Vascular Disease	0.38	1.46	1.23 - 1.73	< 0.0001
Pre/Senile Psychosis	0.40	1.50	1.26 - 1.78	< 0.0001
Liver Cirrhosis	0.90	2.47	1.37 - 4.45	0.003
Kidney Disease	1.02	2.78	2.27 - 3.41	< 0.0001
Liver/Esophageal Disease	2.54	12.73	6.69 - 24.22	< 0.0001
Socioeconomic Status: *				
Very Low Income	0.12	1.13	0.94 - 1.37	0.20
Low Income	0.22	1.25	1.03 - 1.51	0.03
Middle Income	0.29	1.34	1.12 - 1.61	0.002
High Income	0.16	1.17	0.95 - 1.45	0.14
Chronicity	0.78	2.18	1.93 - 2.46	< 0.0001
Intercept	-6.61			< 0.0001

Note. *Reference group for odds ratio is very high income socioeconomic status.

Area under the receiving operator characteristic curve is 0.763.

Table 9

Septicemia Logistic Regression Model Results

Predictors	30-Day Regression Coefficient	Odds Ratio	95% Confidence Interval	Probability
Age	0.03	1.03	1.02 - 1.04	< 0.0001
Heart Failure	0.71	2.04	1.49 - 2.80	< 0.0001
Peripheral Vascular Disease	0.74	2.11	1.23 - 3.62	0.01
Pre/Senile Psychosis	0.52	1.68	1.13 - 2.51	0.01
Liver Cirrhosis	0.79	2.21	1.00 - 4.89	0.049
Kidney Disease	0.80	2.23	1.62 - 3.09	< 0.0001
Liver/Esophageal Disease	1.87	6.47	3.05 - 13.71	< 0.0001
Chronicity	0.63	1.88	1.43 - 2.47	< 0.0001
Intercept	-3.95			< 0.0001

Note. Area under the receiving operator characteristic curve is 0.707.

Table 10

Mean Crude and Risk-Adjusted 30-Day Mortality Rates for Hospitals (as percentages): Whole Sample, Teaching, Urban Non-teaching, and Outside Urban Area Hospitals

Hospital Grouping	Mean	Standard Deviation	Lowest Value	Highest Value
All hospital: crude	14.95	2.43	10.26	20.76
All hospital: risk-adjusted	15.03	2.28	10.53	21.53
Teaching: crude (n=10)	14.68	1.52	12.54	16.38
Teaching: risk-adjusted	14.02	1.29	11.75	15.48
Urban non-Teaching Community: crude (n=25)	14.89	2.47	10.59	20.30
Urban non-Teaching Community: risk-adjusted	15.05	2.21	11.64	19.93
Outside Urban Community: crude (n=40)	15.06	2.62	10.26	20.76
Outside Urban Community: risk-adjusted	15.27	2.48	10.53	21.53

Table 11

Description of Nursing-Related Predictor Variables: All-Sample Hospitals and Separately for Teaching, Urban Non-Teaching, and Outside Urban Area Hospitals

Variable	Mean (SD)*: All-Sample Hospitals (n = 75)	Mean (SD): Teaching Hospitals (n = 10)	Mean (SD): Urban Non-Teaching Hospitals (n = 25)	Mean (SD): Outside Urban Area Hospitals (n=40)
Nurse Staffing Dose: Inpatient Clinical Worked Hours per Ontario Case Weight	39.92 (7.5)	41.61 (10.70)	36.36 (5.30)	41.73 (7.10)
Skill Mix: Proportion of Registered Nurse 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 Registered Nurse Experience on Clinical Unit	9.06 (2.0)	7.85 (1.00)	8.89 (1.80)	9.47 (2.20)
Registered Nurse 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 Fulltime Registered Nurse Earned Hours	0.59 (0.10)	0.67 (0.06)	0.62 (0.11)	0.55 (0.08)

Note. * SD refers to standard deviation.

** CPEI refers to the Canadian Practice Environment Index.

Table 12

Physician Expertise: All-Sample Hospitals and Separately for Teaching, Urban Non-Teaching, and Outside Urban Area Hospitals

Variable	**Mean (SD)*: All-Sample Hospitals (n = 75)**	**Mean (SD): Teaching Hospitals (n = 10)**	**Mean (SD): Urban Non-Teaching Hospitals (n = 25)**	**Mean (SD): Outside Urban Area Hospitals (n=40)**
Physician Expertise: Proportion of General Practitioners as Most Responsible Physician	0.44 (0.33)	0.02 (0.04)	0.32 (0.24)	0.62 (0.29)

Note. * SD refers to standard deviation.

Table 13

Frequencies of Hospital Type: Teaching, Urban Non-teaching, and Outside Urban Area Hospitals

Variable	Frequency (Modal Percentage)
Teaching Hospital	10 (13.3%)
Urban Non-Teaching Hospital	25 (33.3%)
Outside Urban Area Hospital	40 (53.3%)

Table 14

Correlations among Continuous Predictor Variables and 30-Day Medical 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

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

Table 15

Multiple Regression Model 1 Results: Ten Predictor Variables Forced to Enter the Model

Variable	Parameter Estimate	t-statistic	P-value
Nurse Staffing Dose	0.0004	0.86	0.39
Nursing Skill Mix	-0.0333	-1.00	0.32
Availability of Professional Role Support	0.0010	0.13	0.90
Years Clinical Unit Experience	-0.0038 **	-2.86	0.01
Capacity to Work	-0.0108 **	-3.08	0.003
Nursing Practice Environment Condition	-0.0004	-0.46	0.64
Continuity of Care	-0.0115	-0.39	0.70
Physician Expertise	-0.0018	-0.14	0.89
Teaching Hospital Type	-0.0095	-0.86	0.39
Hospital Location Inside Urban Area but Non-Teaching	0.0026	0.39	0.70

Note. ** Refers to parameter estimate that is significantly different from 0.00.

Model R-square = 0.27. Overall model F-value = 2.36, p = 0.02.

Table 16

Multiple Regression Model 2 Results: Ten Predictor Variables and Four Interaction Variables all Forced to Enter the Model

Variable	Parameter Estimate	t-statistic	P-value
Nurse Staffing Dose	0.0002	0.40	0.69
Nursing Skill Mix	-0.0502	-1.51	0.14
Availability of Professional Role Support	-0.0006	-0.07	0.94
Years Clinical Unit Experience for Outside Urban Area Hospitals	-0.0034 **	-2.11	0.04
Years Clinical Unit Experience for Teaching Hospitals	0.0031	0.18	0.68
Years Clinical Unit Experience for Urban Non-Teaching Hospitals	-0.0067 **	8.14	0.01
Capacity to Work for Outside Urban Area Hospitals	-0.0152 **	-3.59	0.001
Capacity to Work for Teaching Hospitals	0.0027	0.02	0.88
Capacity to Work for Urban Non-Teaching Hospital	-0.0012	0.03	0.85
Nursing Practice Environment Condition	0.00002	0.03	0.98
Continuity of Care	-0.0068	-0.23	0.82
Physician Expertise	-0.0063	-0.52	0.61
Teaching Hospital Type	-0.0906	-1.21	0.23
Hospital Location in Urban Area but Non-Teaching	0.0095	0.31	0.76

Note. ** Refers to parameter estimate that is significantly different from 0.00.

Model R-square = 0.34. Overall model F-value = 2.24, p = 0.02.

Table 17

Multiple Regression Model 3 Results: Stepwise Method Used to Enter the Ten Original Predictor Variables Only (no interaction variables)

Variable	**Parameter Estimate**	**F-statistic**	**P-value**
Nursing Skill Mix	-0.0556	6.42	0.01
Years Clinical Unit Experience	-0.0039	9.59	0.003
Capacity to Work	-0.0112	13.56	0.0004

Note. Model R-square = 0.24. Overall model F-value = 7.51, p = 0.0002.

Table 18

Multiple Regression Model 4 Results: Stepwise Method Used to Enter the Ten Original Predictor Variables and the Six Interaction Variables

Variable	Parameter Estimate	F-statistic	P-value
Nursing Skill Mix	-0.0561	6.67	0.01
Years Clinical Unit Experience for Teaching and Outside Urban Area Hospitals	-0.0035	8.26	0.01
Years Clinical Unit Experience for Urban Non-Teaching Hospitals	-0.0059	15.25	0.0002
Capacity to Work for Teaching and Outside Urban Area Hospitals	-0.0151	21.42	< 0.0001

Note. Model R-square = 0.32. Overall model F-value = 6.35, $p < 0.0001$.

Table 19

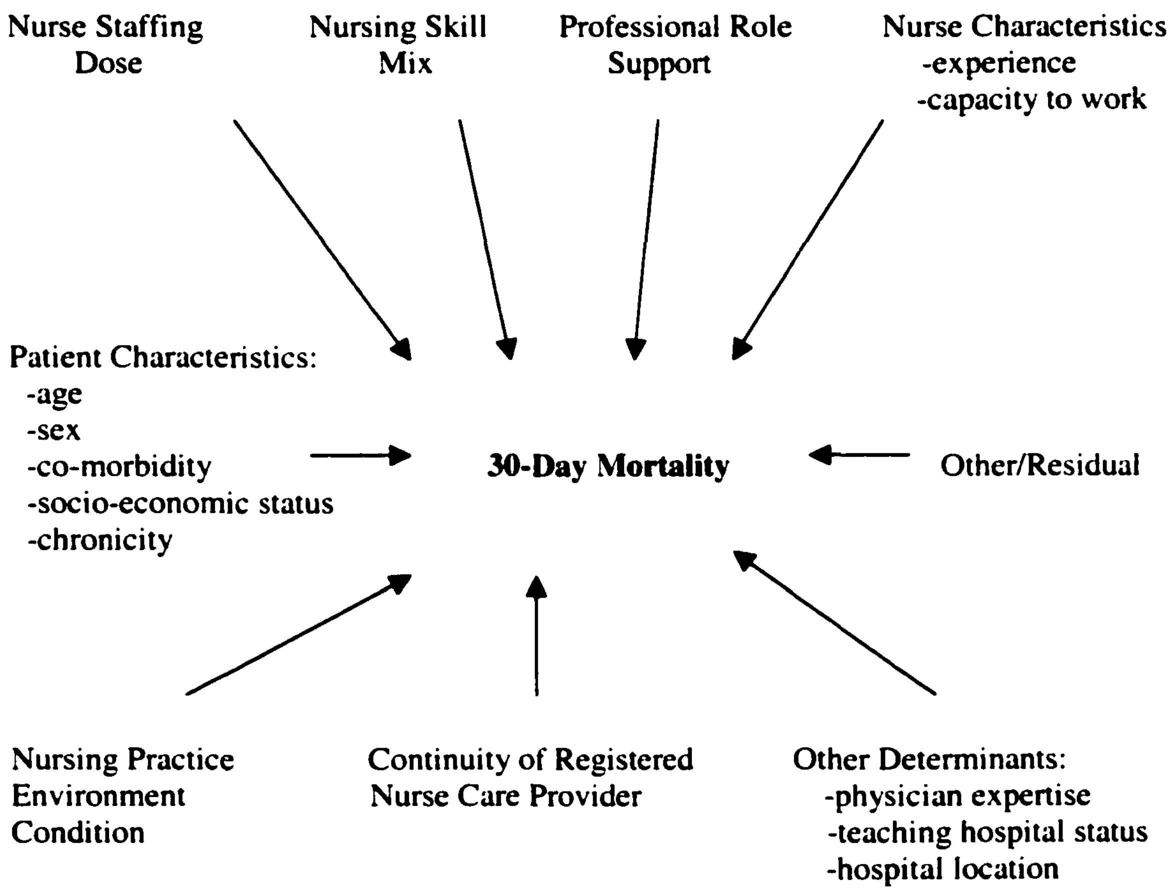
Multiple Regression Model 5 Results: Statistically Significant Predictors Including All Four Related Interaction Terms - Forced to Enter Model

Variable	Parameter Estimate	F-statistic	P-value
Nursing Skill Mix	-0.0489	-1.97	0.04
Years Clinical Unit Experience for Outside Urban Area Hospitals	-0.0035	-2.83	0.01
Years Clinical Unit Experience for Teaching Hospitals	-0.0052 *	2.59	0.11
Years Clinical Unit Experience for Urban Non-Teaching Hospitals	-0.0061	15.16	0.0002
Capacity to Work for Outside Urban Area Hospitals	-0.0149	-4.35	< 0.0001
Capacity to Work for Teaching Hospitals	-0.0100 *	0.60	0.44
Capacity to Work for Urban Non-Teaching Hospitals	0.0006 *	0.01	0.91

Note. * Refers to parameter estimate that is not significantly different from 0.00.

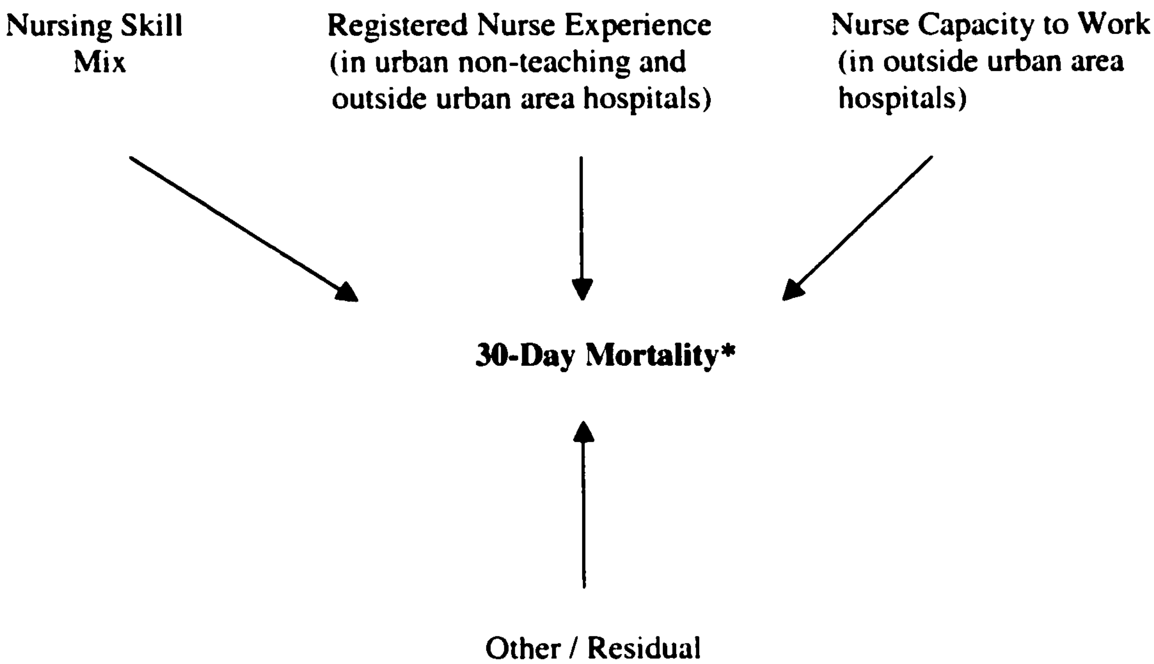
Model R-square = 0.32. Overall Model F-value = 4.50, p = 0.0004.

Figure 1. 30-Day Mortality Model



Note. Adapted from Aiken, Sochalski, and Lake (1997).

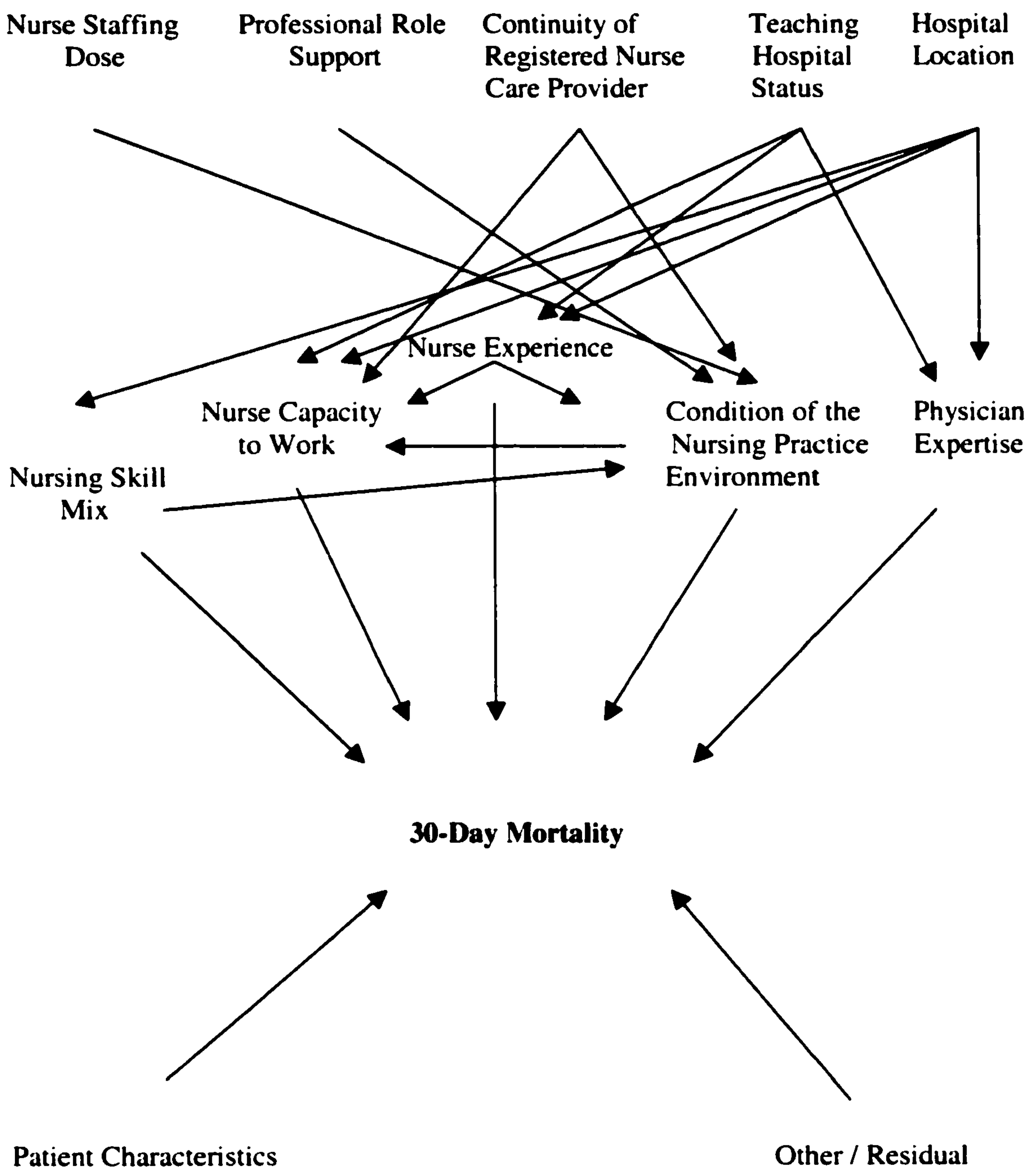
Figure 2. 30-Day Mortality Model Implied from the Final Regression Model



Note. * Refers to risk-adjusted (for patient characteristics) 30-day mortality rates.

After risk-adjustment, the above predictors explain 32 percent of the variation in 30-day medical mortality rates among sample hospitals. However, 68 percent of the variance is explained by other or residual factors.

Figure 3. Proposed Revised 30-Day Mortality Model



References

Everyday ethics: Putting the code into practice. (1998). Ottawa: ON: Canadian Nurses Association.

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., Busse, R., Clarke, H., Giovannetti, P., Hunt, J., Rafferty, A. M., & Shamian, J. (2001). Nurses' reports on hospital care in five countries. Health Affairs, 20(3), 43-53.

Aiken, L. H., & Fagin, C. M. (1997). Preface: Evaluating the consequences of hospital restructuring. Medical Care, 35(10 supplement), OS1-OS4.

Aiken, L. H., Havens, D. S., & Sloane, D. M. (2000). The magnet services recognition program: A comparison of two groups of magnet hospitals. American Journal of Nursing, 100(3), 26-35.

Aiken, L. H., & Patrician, P. A. (2000). Measuring organizational traits of hospitals: The revised nursing work index. Nursing Research, 49(3), 146-153.

Aiken, L. H., & Sloane, D. M. (1997). Effects of specialization and client differentiation on the status of nurses: The case of AIDS. Journal of Health and Social Behavior, 38(3), 203-222.

Aiken, L. H., Sloane, D. M., & Sochalski, J. (1998). Hospital organisation and outcomes. Quality in Health Care, 7(4), 222-226.

Aiken, L. H., Smith, H. L., & Lake, E. T. (1994). Lower medicare mortality among a set of hospitals known for good nursing care. Medical Care, 32(8), 771-787.

Aiken, L. H., Sochalski, J., & Anderson, G. (1996). Downsizing the hospital nursing workforce. Health Affairs, 15(4), 88-92.

Aiken, L. H., Sochalski, J., & Lake, E. T. (1997). Studying outcomes of organizational change in health services. Medical Care, 35(11), NS6-NS18.

Al-Haider, A. S., & Wan, T. T. (1991). Modeling organizational determinants of hospital mortality. Health Services Research, 26(3), 303-323.

Alexander, J. A. (1982). Nursing unit organization: Its effects on staff professionalism. Ann Arbor, MI: UMI Research Press.

Angus, D. E., Auer, L., Cloutier, J. E., & Albert, T. (1995). Sustainable health care for Canada: Synthesis report. Ottawa: ON: University of Ottawa.

Anthony, D. (1999). Understanding advanced statistics: A guide for nurses and health care researchers. Toronto, ON: Churchill Livingston.

Ash, A. S., & Shwartz, M. (1997). Evaluating the performance of risk-adjusted methods: Dichotomous outcomes. In L. I. Iezzoni (Editor), Risk adjustment for measuring healthcare outcomes (2nd ed., pp. 427-469). Chicago, IL: Health Administration Press.

Aydelotte, M. K. (1962). The use of patient welfare as a criterion measure. Nursing Research, 11(1), 19-14.

Ballard, K. A., Gray, R. F., Knauf, R. A., & Uppal, P. (1993). Measuring variations in nursing care per DRG. Nursing Management, 24(4), 33-41.

Behner, K. C., Fogg, L. F., Fournier, L. C., Frankenbach, J. T., & Robertson, S. B. (1990). Nursing resource management: Analyzing the relationship between costs and quality staffing decisions. Health Care Management Review, 15(4), 63-71.

Besner, J. F. (1985). Costing nursing services by complexity adjusted DRGs. Unpublished doctoral dissertation, University of Alberta, Edmonton, AB.

Blegen, M. A., Goode, C. J., & Reed, L. (1998). Nurse staffing and patient outcomes. Nursing Research, 47(1), 43-50.

Blegen, M. A., & Vaughn, T. (1998). A multisite study of nurse staffing and patient occurrences. Nursing Economic$, 16(4), 196-203.

Bostrom, J., & Zimmerman, J. (1993). Restructuring nursing for a competitive health care environment. Nursing Economic$, 11(1), 35-41, 54.

Bowles, K. H., & Naylor, M. D. (1996). Nursing intervention classification systems. Image: Journal of Nursing Scholarship, 28(4), 303-308.

Brink, P. J., & Wood, M. J. (1994). Basic steps in planning research: From question to proposal (4th ed.). Boston, MA: Jones and Bartlett.

Brooten, D., & Naylor, M. D. (1995). Nurses' effect on changing patient outcomes. Image: Journal of Nursing Scholarship, 27(2), 95-99.

Bryan, Y. E., Hitchings, K. S., Fuss, M. A., Fox, M. A., Kinneman, M. T., & Young, M. J. (1998). Measuring and evaluating hospital restructuring efforts: Eighteen month follow-up and extension to critical care. Journal of Nursing Administration, 28(9), 21-27.

Buchan, J. (1999). Still attractive after all these years? Magnet hospitals in a changing health care environment. Journal of Advanced Nursing, 30(1), 100-108.

Burns, L. W., & Wholey, D. R. (1991). The effects of patient, hospital, and physician characteristics on length of stay and mortality. Medical Care, 29(3), 251-271.

Canadian Institute for Health Information. (1995). CIHI abstracting manual. Ottawa, ON: Canadian Institute for Health Information.

Canadian Institute for Health Information. (1996). Resource intensity weights: Summary of methodology 1996/97.

Canadian Nurses Association. (1993). Papers from the Nursing Minimum Data Set Conference. Ottawa, ON: Canadian Nurses Association.

Charlson, M. E., Pompei, P., Ales, K. L., & MacKenzie, C. R. (1987). A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. Journal of Chronic Disease, 40(5), 373-383.

Chu, C. (1994). Resource intensity weighting and case mix grouping: Assumptions and implications for health service performance evaluation. Healthcare Management Forum, 7(1), 24-31.

Clarke, S. P., & Cossette, S. (2000). Secondary analysis: Theoretical, methodological, and practical considerations. Canadian Journal of Nursing Research, 32(3), 109-129.

Connor, R. J. (1961). A work sampling study of variations in nursing workload. Hospitals, 35(9), 40-41, 111.

Cook, T. D., & Campbell, D. T. (1979). Quasi-experimentation: Design & analysis issues for field settings . Boston: MA: Houghton Mifflin.

Cooper, H. M. (1982). Scientific guidelines for conduction integrative research reviews. Review of Educational Research, 52(2), 291-302.

Cooper, H. M. (1989). Integrating research: A guide for literature reviews (2nd Edition ed.). Newbury Park: CA: Sage.

Czaplinski, C., & Diers, D. (1998). The effect of staff nursing on length of stay and mortality. Medical Care, 36(12), 1626-1638.

Delfino, R. J., Becklake, M. R., & Hanley, J. A. (1993). Reliability of hospital data for population-based studies of air pollution. Archives of Environmental Health, 48, 140-146.

Deyo, R. A., Cherkin, D. C., & Ciol, M. A. (1992). Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. Journal of Clinical Epidemiology, 45(6), 613-619.

Donabedian, A. (1980). Exploration in quality assessment and monitoring: The definition of quality and approaches to its assessment. Ann Arbor, MI: Health Administration Press.

Donabedian, A. (1993). Continuity and change in the quest for quality. Clinical Performance and Quality Health Care, 1(1), 9-16.

Dubois, R. W., Rogers, W. H., Kosecoff, J., & et al. (1987). Explaining variations in hospital death rates: Randomness, severity of illness, quality of care. JAMA, 264, 484.

Dudek, R., & Gailani, D. M. (1960). Frequency of nursing procedures performed at the bedside. Nursing Research, 9(1), 43-45.

Duncan, O. D. (1975). Introduction to structural equation models. New York, NY: Academic Press.

Eastaugh, S. (1990). Hospital nursing technical efficiency: Nurse extenders and enhanced productivity. Hospital and Health Services Administration, 35(4), 561-573.

Edwardson, S. R., & Giovannetti, P. (1994). Nursing workload measurement systems. Annual Review of Nursing Research, 12, 95-123.

Estabrooks, C. A., Tourangeau, A., Humphrey, C. K., Hesketh, K., Giovannetti, P., Clarke, H., Acorn, S., Wong, J., & Shamian, J. (under review). Measuring the hospital practice environment: A Canadian context. Medical Care (Submitted).

Fagin, C., & Gordon, S. (1996). The abandonment of the patient. Nursing Outlook, 44(3), 109-156.

Farley, D. E., & Ozminkowski, R. J. (1992). Volume-outcome relationships and inhospital mortality: The effect of changes in volume over time. Medical Care, 30(1), 77-94.

Flood, A. B. (1994). The impact of organizational and managerial factors on the quality of care in health care organizations. Medical Care Research Review, 51, 381-428.

Flood, A. B., Scott, W. R., & Ewy, W. (1984). Does practice make perfect? Part II: The relationship between volume and outcomes and other hospital characteristics. Medical Care, 22(3), 115-125.

French, B. (1997). British studies which measure patient outcome, 1990-1994. Journal of Advanced Nursing, 26, 320-328.

Fry, S. T. (1994). Ethics in nursing practice: A guide to ethical decision making. Geneva, Switzerland: International Council of Nurses.

Garfink, C. M., Kirby, K. K., Bachman, S. S., & Starck, P. (1991). The University Hospital nurse extender model: Part III, program evaluation. Journal of Nursing Administration, 21(3), 21-27.

Giovannetti, P. (1979). Understanding patient classification. Journal of Nursing Administration, 9(2), 4-9.

Giovannetti, P., & O'Brien-Pallas, L. (1998). From nursing data to information to evidence: Are we prepared? Canadian Journal of Nursing Research, 30(1), 3-7.

Giovannetti, P., Smith, D. L., & Broad, E. (1999). Structuring and managing health information. In J. M. Hibberd, & D. L. Smith (Editors), Nursing management in Canada (2nd ed., pp. 297-318). Toronto, ON: Saunders.

Glass, G. V., & Hopkins, K. D. (1996). Statistical methods in education and psychology (3rd ed.). Boston, MA: Allyn and Bacon.

Green, J., Passman, L. J., & Wintfeld, N. (1991). Analyzing hospital mortality: The consequences of diversity in patient mix. JAMA, 265(14), 1849-1853.

Green, J., Wintfeld, N., Sharkey, P., & Passman, L. J. (1990). The importance of severity of illness in assessing hospital mortality. JAMA, 263(2), 241-246.

Gregario, D. I., Walsh, S. J., & Paturzo, D. (1997). The effects of occupation-based social position on mortality in a large American cohort. American Journal of Public Health, 87(9), 1472-1475.

Hartz, A. J., Krakauer, H., Kuhn, E. M., Young, M., Jacobsen, S. J., Gay, G., Muenz, L., Katzoff, M., Bailey, R. C., & Rimm, A. A. (1989). Hospital characteristics and mortality rates. The New England Journal of Medicine, 321(25), 1720-1725.

Havens, D. S., & Aiken, L. H. (1999). Shaping systems to promote desired outcomes: The magnet hospital model. Journal of Nursing Administration, 29(2), 14-20.

Hawker, G. A., Coyte, P. C., Wright, J. G., Paul, J. E., & Bombardier, C. (1997). Accuracy of administrative data for assessing outcomes after knee replacement surgery. Journal of Clinical Epidemiology, 50(3), 265-273.

Hayduk, L. A. (1987). Structural equation modeling with LISREL: Essentials and Advances. Baltimore, MD: The Johns Hopkins University Press.

Hayduk, L. A. (1996). LISREL issues, debates, and strategies. Baltimore, MD: The Johns Hopkins University Press.

Heinemann, D., Lengacher, C. A., VanCott, M. L., Mabe, P., & Swymer, S. (1996). Partners in patient care: Measuring the effects on patient satisfaction and other quality indicators. Nursing Economic$, 14(5), 276-285.

Henry, S. B., Holzemer, W. L., Randell, C., Hsieh, S., & Miller, T. J. (1997). Comparison of nursing interventions classification and current procedural terminology codes for categorizing nursing activities. Image: Journal of Nursing Scholarship, 29(2), 133-138.

Hosmer, D. W., & Lemeshow, S. (2000). Applied logistic regression (Second edition ed.). New York, NY: John Wiley & Sons.

Iezzoni, L. I. (1997). The risks of risk adjustment. JAMA, 278(19), 1600-1607.

Iezzoni, L. I., Shwartz, M., Ash, A. S., Hughes, J. S., Daley, J., & Mackiernan, Y. D. (1996). Severity measurement methods and judging hospital death rates for pneumonia. Medical Care, 34(1), 11-28.

Irvine, D., Sidani, S., & McGillis Hall, L. (1998). Linking outcomes to nurses' role in health care. Nursing Economic$, 16(2), 58-64, 87.

Jeffs, L. (1998). Proving what you practice: The role of outcomes research. Registered Nurse Journal: Registered Nurses Association of Ontario, 10(5), 5-6.

Jencks, S. F., Williams, D. K., & Kay, T. L. (1988). Assessing hospital-associated deaths from discharge data: The role of length of stay and comorbidities. JAMA, 260(15), 2240-2246.

Jennings, B. M., & Staggers, N. (1998). The language of outcomes. Advances in Nursing Science, 20(4), 72-80.

Keeler, E. B., Rubenstein, L. V., & Kahn, K. L. e. a. (1992). Hospital characteristics and quality of care. JAMA, 268(13), 1709-1714.

Kitson, A. (1997). Using evidence to demonstrate the value of nursing. Nursing Standard, 11(28), 34-39.

Knaus, W. A., Draper, E. A., Wagner, D. P., & Zimmerman, J. E. (1986). An evaluation of outcome from intensive care in major medical centers. Annals of Internal Medicine, 104, 410-418.

Kramer, M. (1990). The magnet hospitals: Excellence revisited. Journal of Nursing Administration, 20(9), 35-44.

Kramer, M., & Schmalenberg, C. (1987a). Magnet hospitals talk about the impact of DRGs on nursing care - Part I. Nursing Management, 18(8), 38-42.

Kramer, M., & Schmalenberg, C. (1987b). Magnet hospitals talk about the impact of DRGs on nursing on nursing care - Part II. Nursing Management, 18(10), 33-40.

Kramer, M., & Schmalenberg, C. (1988a). Magnet hospitals: Part I. Institutions of excellence. Journal of Nursing Administration, 18(1), 13-24.

Kramer, M., & Schmalenberg, C. (1988b). Magnet hospitals: Part II. Institutions of excellence. Journal of Nursing Administration, 18(2), 11-19.

Kramer, M., & Schmalenberg, C. (1991a). Job satisfaction and retention insight for the 90's: Part I. Nursing 91, 21(3), 50-55.

Kramer, M., & Schmalenberg, C. (1991b). Job satisfaction and retention insight for the 90's: Part II. Nursing91, 21(4), 51-55.

Kramer, M., & Schmalenberg, C. (1993). Learning from success: Autonomy and empowerment. Nursing Management, 24(5), 58-64.

Krapohl, G. L., & Larson, E. (1996). The impact of unlicensed assistive personnel on nursing care delivery. Nursing Economic$, 14(2), 99-110, 122.

Lake, E. T. (1999). The organization of hospital nursing. Unpublished doctoral dissertation, University of Pennsylvania.

Lengacher, C. A., & Mabe, P. R. (1993). Nurse extenders. Journal of Nursing Administration, 23(3), 16-19.

Lichtig, L. K., Knauf, R. A., & Milholland, D. K. (1999). Some impacts of nursing on acute care hospital outcomes. Journal of Nursing Administration, 29(2), 25-33.

LoBiondo-Wood, G., & Haber, J. (1998). Nursing research: Methods, critical appraisal, and utilization (4th ed.). St. Louis, MO: Mosby.

Maas, M. L., Johnson, M., & Moorhead S. (1996). Classifying nursing-sensitive patient outcomes. Image: Journal of Nursing Scholarship, 28(4), 295-301.

MacKenzie, T., Giovannetti, P., Gerlach, J., & Slobodan, M. (1992). The Alberta nursing workload study: An exploration of the relationship between severity of illness and nursing resource use. Edmonton, AB: Alberta Health.

Malenka, D. J., McLerran, D., Roos, N., Fisher, E. S., & Wennberg, J. E. (1994). Using administrative data to describe casemix: A comparison with the medical record. Journal of Clinical Epidemiology, 47(9), 1027-1032.

Malloch, K., & Conovaloff, A. (1999). Patient classification systems, Part I: The third generation. Journal of Nursing Administration, 29(7/8), 49-56.

Manheim, L. M., Feinglass, J., Shortell, S. M., & Hughes, E. F. (1992). Regional variation in Medicare hospital mortality. Inquiry, 29(1), 55-66.

Marek, K. D., & Lang, N. M. (1993). Nursing sensitive outcomes. Papers from the nursing minimum data set conference Ottawa, ON: The Canadian Nurses Association.

Mark, B. A. (1995). The black box of patient outcomes research. Image: Journal of Nursing Scholarship, 27(1), 42.

Mayo, N. E., Danys, I., Carlton, J., & Scott, S. C. (1993). Accuracy of hospital discharge coding for stroke. Canadian Journal of Cardiology, 9(Supplement D), 121D-124D.

McCloskey, J. C., & Bulechek, G. M. (1993). Nursing intervention schemes. Papers from the nursing minimum data set conference Ottawa, ON: The Canadian Nurses Association.

McClure, M., Poulin, M., Sovie, M., & Wandelt, M. (1983). Magnet hospitals: Attraction and retention of professional nurses. Kansas City, MO: American Nurses Association.

Micek, W. T., Berry, L., Gilski, D., Kallenbach, A., Link, D., & Scharer, K. (1996). Patient outcomes: The link between nursing diagnoses and interventions. Journal of Nursing Administration, 26(11), 29-35.

Mitchell, P. H., Armstrong, S., Simpson, T. F., & Lentz, M. (1989). American Association of Critical-Care Nurses demonstration project: Profile of excellence in critical care nursing. Heart & Lung, 18(3), 219-237.

Mitchell, P. H., Ferketich, S., & Jennings, B. M. (1998). Quality health outcomes model. Image: Journal of Nursing Scholarship, 30(1), 43-46.

Mitchell, P. H., & Shortell, S. M. (1997). Adverse outcomes and variations in organization of care delivery. Medical Care, 35(11), NS19-NS32.

Munro, B. H. (1997). Statistical methods for health care research (3rd ed.). Philadelphia, PA: Lippincott.

Neidlinger, S. H., Bostrom, J., Stricker, A., Hild, J., & Zhang, J. Q. (1993). Incorporating nursing assistive personnel into a nursing professional practice model. Journal of Nursing Administration, 23(3), 29-37.

Newfoundland Department of Health. (1995). Report of the Newfoundland reabstracting project. St. John's, NF: Newfoundland Department of Health.

Nielsen, G. H., & Mortensen, R. A. (1997). The architecture of ICNP: Time for outcomes - Part I. International Nursing Review, 44(6), 182-188, 176.

Nielsen, G. H., & Mortensen, R. A. (1998). The architecture of ICNP: Time for outcomes - Part II. International Nursing Review, 45(1), 27-31.

O'Brien-Pallas, L. L. (1987). Analysis of variation in nursing workload associated with patients' medical and nursing diagnoses and patient classification methods. Unpublished doctoral dissertation, University of Toronto, Toronto, ON.

O'Brien-Pallas, L. L., Cockerill, R., & Leatt, P. (1991). A comparison of the workload estimates of five patient classification systems in nursing. (Report No. Report No. 6606-3706-57). Ottawa, ON: Health and Welfare Canada.

O'Brien-Pallas, L. L., Cockerill, R., & Leatt, P. (1992). Different systems? Different costs? An examination of the comparability of workload of workload measurement systems. Journal of Nursing Administration, 22(12), 17-22.

O'Brien-Pallas, L. L., & Giovannetti, P. (1993). Nursing intensity. Papers from the nursing minimum data set conference Ottawa, ON: The Canadian Nurses Association.

O'Brien-Pallas, L. L., Giovannetti, P., Peereboom, E., & Marton, C. (1995). Case costing and nursing workload: Past, present, and future. (Report No. Paper 95-1). Hamilton, ON: Quality of Nursing Worklife Research Unit.

O'Brien-Pallas, L. L., Irvine, D., Peereboom, E., & Murray, M. (1997). Measuring nursing workload: Understanding the variability. Nursing Economic$, 15(4), 171-182.

O'Brien-Pallas, L. L., Leatt, P., Deber, R., & Till, J. (1989). A comparison of workload estimates using three methods of patient classification. Canadian Journal of Nursing Administration, 2(3), 16-23.

Ontario Hospital Association, Ontario Ministry of Health, & Hospital Medical Records Institute. (1991). Report of the Ontario data quality reabstracting study. Toronto, ON: Ontario Hospital Association.

Ontario Ministry of Health. (1999). Ontario Hospital Reporting System Version

4. Toronto, ON: Ontario Ministry of Health and Long Term Care.

Pappas, G., Queen, S., Hadden, W., & Fisher, G. (1993). The increasing disparity in mortality between socioeconomic groups in the United States, 1966 and 1986. The New England Journal of Medicine, 329(2), 103-109.

Park, R. E., Brook, R. H., Kosecoff, J., Keesey, J., Rubenstein, L., Keeler, E., Kahn, K. L., Rogers, W. H., & Chassin, M. R. (1990). Explaining variations in hospital death rates: Randomness, severity of illness, quality of care. JAMA, 264(4), 484-490.

Peacock, K. (1993). The MIS guidelines: Information for the management of nursing resources. Papers from the Nursing Minimum Data Set Conference Ottawa, ON: The Canadian Nurses Association.

Peters, T. J., & Waterman, R. H. (1982). In search of excellence. New York, NY: Harper & Row.

Pfefferkorn, B., & Rovetta, C. A. (1940). Administrative cost analysis for nursing service and education. Chicago, IL: American Hospital Association and National League of Nursing Education.

Pierce, S. F. (1997). Nurse-sensitive health care outcomes in acute care settings: An integrative analysis of the literature. Journal of Nursing Care Quality, 11(4), 60-72.

Polit, D. F., & Hungler, B. P. (1987). Nursing research: Principles and methods (3rd ed.). Philadelphia, PA: Lippincott.

Poole, B., Robinson, S., & MacKinnon, M. (1998). Resource intensity weights and Canadian hospital costs: some preliminary data. Healthcare Management Forum, 11(1), 22-26.

Powers, P. H., Dickey, C. A., & Ford, A. (1990). Evaluating an RN / co-worker model. Journal of Nursing Administration, 20(3), 11-15.

Ratner, P. A., Bottoroff, J. L., & Johnson, J. L. (1998). Structural equation modeling. In P. J. Brink, & M. J. Wood (editors), Advanced design in nursing research (2nd ed., pp. 178-209). Thousand Oaks, CA: Sage.

Roberts, B. L., Anthony, M. K., Madigan, E. A., & Chen, Y. (1997). Data management: Cleaning and checking. Nursing Research, 46(6), 350-352.

Roos, L. L., Walld, R. K., Romano, P. S., & Roberecki, S. (1996). Short-term mortality after repair of hip fracture. Medical Care, 34(4), 310-326.

Rosenthal, G. E., Harper, D. L., Quinn, L. M., & Cooper, G. S. (1997). Severity-adjusted mortality and length of stay in teaching and non-teaching hospitals. JAMA, 278(6), 485-490.

Schultz, M. A. (1997). The associations of hospital structure and financial characteristics to mortality and length of stay in patients with acute myocardial infarction. Unpublished doctoral dissertation, University of California, Los Angeles, CA.

Scott, J. G., Sochalski, J., & Aiken, L. H. (1999). Review of magnet hospital research: Findings and implication for professional nursing practice. Journal of Nursing Administration, 29 (1), 9-19.

Shortell, S. M., & Hughes, E. F. (1988). The effects of regulation, competition, and ownership on mortality rates among hospital inpatients. The New England Journal of Medicine, 318(17), 1100-1107.

Shortell, S. M., Zimmerman, J. E., Rousseau, D. M., Gillies, R. R., Wagner, D. P., Draper, E. A., Knaus, W. A., & Duffy, J. (1994). The performance of intensive care units: Does good management make a difference? Medical Care, 32(5), 508-525.

Shwartz, M., Ash, A. S., & Iezzoni, L. I. (1997). Comparing outcomes across providers. In L. I. Iezzoni (Editor), Risk adjustment for measuring healthcare outcomes

(2nd ed., pp. 471-516). Chicago, IL: Health Administration Press.

Sidani, S., & Braden, C. J. (1998). Evaluating nursing interventions: A theory driven approach. Thousand Oaks: Sage.

Silber, J. H., & Rosenbaum, P. R. (1995). Measuring quality of hospital care. JAMA, 273(1), 21-22.

Silber, J. H., & Rosenbaum, P. R. (1997). A spurious correlation between hospital mortality and complication rates. Medical Care, 35(10), OS77-OS92.

Silber, J. H., Rosenbaum, P. R., Schwartz, J. S., Ross, R. N., & Williams, S. V. (1995). Evaluation of the complication rate as a measure of quality of care in coronary artery bypass graft surgery. JAMA, 274(4), 317-323.

Silber, J. H., Schwartz, J. S., Rosenbaum, P., Ross, R. N., & Williams, S. V. (1993). Hospital quality rank depends on choice of outcome measure. Clinical Research, 41(2), 181A.

Silber, J. H., Williams, S. V., Krakauer, H., & Schwartz, J. S. (1992). Hospital and patient characteristics associated with death after surgery: A study of adverse occurrence and failure to rescue. Medical Care, 30(7), 615-628.

Smith, D. W. (1994). Evaluating risk adjustment by partitioning variation in hospital mortality rates. Statistics in Medicine, 13(10), 1001-1013.

Sochalski, J., Aiken, L. H., & Fagin, C. M. (1997). Hospital restructuring in the United States, Canada, and Western Europe: An outcomes research agenda. Medical Care, 35(10 supplement), OS13-OS25.

Sochalski, J., Aiken, L. H., Rafferty, A. M., Shamian, J., Muller-Mundt, G., Hunt, J., Giovannetti, P., & Clark, H. (1998). Building multinational research. Reflections, 24(3), 20-23, 45.

Sochalski, J., Estabrooks, C. A., & Humphrey, C. K. (1999). Nurse staffing and patient outcomes: Evolution of an international study. Canadian Journal of Nursing Research, 31(3), 69-88.

Statistics Canada. (1996). Statistics Canada census 1996 statistical profiles of Canadian communities. Ottawa, ON: Statistics Canada.

Tabachnick, B. G., & Fidell, L. S. (1996). Using multivariate statistics (3rd ed.). New York, NY: HarperCollins College Publishers.

The Doctor's Hospital. (1992). Data quality and utilization study. Toronto, ON: Doctor's Hospital.

Tibert, J. (1999a). Technical documentation phase 1: Ontario registered nurse survey of hospital characteristics. Toronto, ON: Institute for Social Research.

Tibert, J. (1999b). Technical documentation phase 2: Ontario registered nurse survey of hospital characteristics Toronto, ON: Institute for Social Research.

Tourangeau, A. E., White, P., Scott, J., McAllister, M., & Giles, L. (1999). Evaluation of a partnership model of care delivery involving Registered Nurses and unlicensed assistive personnel. Canadian Journal of Nursing Leadership, 12(2), 4-20.

Tu, J. V. (1996). Quality of cardiac surgical care in Ontario, Canada. Cambridge, MA: Harvard University.

Tu, J. V., Naylor, C. D., & Austin, P. (1999). Temporal changes in the outcomes of acute myocardial infarction in Ontario, 1992-1996. Canadian Medical Association Journal, 161(10), 1257-1261.

van Servellen, G., & Schultz, M. A. (1999). Demystifying the influence of hospital characteristics on inpatient mortality rates. Journal of Nursing Administration, 29(4), 39-47.

Victoria Hospital. (1992). CMG coding validation study. London, ON: Victoria Hospital.

Wan, T. T., & Shukla, R. K. (1987). Contextual and organizational correlates of the quality of hospital nursing care. Quality Review Bulletin, 13(2), 61-64.

Werley, H. H. (1988). Introduction to the nursing minimum data set and its development. In H. H. Werley, & N. M. Lang (Editors), Identification of the nursing minimum data set (pp. 1-15). New York, NY: Springer.

Williams, M. A., & Murphy, L. N. (1979). Subjective and objective measures of staffing adequacy. Journal of Nursing Administration, 9(11), 21-29.

Wood, M. J., & Brink, P. J. (1998). Comparative designs. In P. J. Brink, & M. J. Wood (editors), Advanced design in nursing research (2nd ed., pp. 143-159). Thousand Oaks, CA: Sage.