THE IMPACT OF NURSE STAFFING ON IN-HOSPITAL CARDIAC ARREST PATIENT OUTCOMES

by

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Dedication

For my brother, Kiernan Rochman

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Abstract

The Impact of Nurse Staffing on In-Hospital Cardiac Arrest Patient Outcomes

by

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Delays in defibrillation for in-hospital cardiac arrest are associated with lower survival, with ten percent lower probability of survival for each additional minute of delay. Current guidelines dictate that patients should receive defibrillation within two minutes of recognition of a cardiac arrest. Certain hospital characteristics such as unmonitored units and cardiac arrests during nights and weekends have been associated with delays in defibrillation. These findings suggest that delayed defibrillation times may be related to the availability of nursing staff in the hospital at the time of arrest. This study examined the relationships between nurse staffing, defibrillation response times, and patient level outcomes of in-hospital cardiac arrests.

A cross-sectional design was used. Independent variables were registered nurse hours per patient day and time-to-defibrillation. Dependent variables include both survival and neurological status at discharge. The measures used in this study are from the American Heart Association's *Get with the Guidelines* national cardiac arrest database and from staffing productivity reports. Institutional review board exemption was

obtained prior to secondary data analysis from a convenience sample of 299 patients in 22 units from one mid-western hospital.

The findings indicate that there was a significant difference in mean staffing for delayed time to defibrillation, more than 2 minutes. While controlling for key covariates in the model, the analyses determined that one additional hour per patient day of RN care results in a 28% greater odds of surviving to discharge. The intensive care unit was found to be a predictor of time to defibrillation, survival, and neurological status at discharge. Finally, there was no relationship found between nurse staffing and neurological status at discharge.

These important empirical findings both complement and differ from other studies. Nurse staffing measured at the time of the event was found to predict survival, which gives a more accurate synopsis of the work environment at the time of cardiac arrest. These findings are an important contribution to understanding nurses' contribution to quality of care and improved patient outcomes. Future studies should include larger sample sizes and other measures of the work environment.

Chapter I

Introduction

There are an estimated 350,000 to 750,000 cases of in-hospital cardiac arrests (IHCA) annually in the United States. National survival rates with favorable neurological outcomes are 13.9% (Peberdy et al., 2008). For patients with cardiac arrest rhythms amenable to defibrillation treatment (pulseless ventricular tachycardia [VT] and ventricular fibrillation [VF]), the rate of survival to hospital discharge is about 30% (Chan, Nichol, Krumholz, Spertus, & Nallamouthu, 2009). Delays in defibrillation have been associated with lower survival, with a 7%-10% lower probability of survival for each additional minute of delay (American Heart Association [AHA], 2005). Moreover, the AHA recommends that patients with a VT/VF cardiac arrest should receive defibrillation within two minutes after recognition of a cardiac arrest (AHA, 2005). Certain hospital characteristics are associated with delays (more than two minutes) to defibrillation. These include small (less than 250 beds) hospitals, unmonitored hospital units, and cardiac arrests during after-hour periods (5 p.m. to 8 a.m. or weekends). These hospital-level findings suggest that delayed defibrillation times may be related to the availability of staff in the hospital at the time of cardiac arrest (Chan et al., 2008b).

In many instances, the most likely first responder to witness a cardiac arrest in the hospital is the registered nurse (RN). Nurses provide ongoing surveillance to patients twenty-four hours per day, and it is through this monitoring that the RN is able to assess changes in the patient's condition, detect errors, and prevent adverse events (Institute of

Medicine [IOM], 2004). Sufficient and adequately trained nursing staff with the capability to respond immediately is needed to improve survival of IHCA (Weil & Fries, 2005). Moreover, the IOM recognized that nurses' link to patient safety and staffing has become a prominent method of assessing the structure of acute hospital patient care.

Hospital level staffing is associated with improved outcomes in intensive care, surgical, and medical patients (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Kane, Shamliyan, Mueller, Duval, & Wilt, 2007; Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002). Aiken and colleagues (2002) found that each additional patient per nurse had a seven percent increase in 30-day mortality. Needleman et al. (2002) reported that an increase in RN hours per patient day was associated with lower risks of pneumonia, cardiac arrest, and failure to rescue. Furthermore, an increase by one RN per patient day is associated with decreased odds of cardiac arrest, and in the intensive care unit, a lower risk of failure to rescue in surgical patients (Kane et al., 2007). Although there is evidence supporting a relationship between hospital level nurse staffing and patient outcomes, the relationship between staffing at the time of the cardiac arrest event and patient outcomes is less clear.

Statement of the Problem

Nursing impact on patient outcomes is supported empirically in the literature. What is not as well documented is the "how" or the processes by which nursing procedures and interventions impact the health outcomes of patients. Therefore, a greater understanding of the relationship between the structure, process, and outcomes that encompass IHCA is needed. Furthermore, although research on cardiac arrest outcomes has alluded to nursing care impact on time to defibrillation and patient outcomes, no studies have examined the relationship of staffing at the time of the cardiac arrest event, vital time intervals, and patient outcomes of in-hospital cardiac arrest. Consequently, there is a need to understand and explore this relationship as a means to document the impact that nursing care has on survival of patients as well as to provide evidence of where systemic changes can be implemented to improve survival for those sustaining IHCA. Therefore, the primary purpose of this study was to examine the relationship between nurse staffing, time-to-respond, survival to discharge, and neurological status of IHCA.

Specific Aims

The research had three aims:

Aim 1: To examine the relationship between nurse staffing (registered nurse hours per patient day (RNHPPD), hours per patient day (HPPD), and skill mix and time-to-defibrillation for IHCA patients.

Aim 2: To examine the relationship between nurse staffing (RNHPPD, HPPD, and skill mix), time-to-defibrillation, and survival to discharge for IHCA patients.

Aim 3: To examine the relationship between nurse staffing (RNHPPD, HPPD, and skill mix), time-to-defibrillation, and neurological outcomes (cerebral performance category) of IHCA patients.

Conceptual Framework

The conceptual framework for this research is based on Donabedian's Triad (Structure-Process-Outcome) for quality assessment (Donabedian, 1988). Structure refers to the setting where care occurs, process refers to the manner in which care is delivered, and outcome denotes the effects of the health care status of the patient. The triad implies an integrated relationship that begins at the structure, which in turn influences the process, which in turn influences the outcome. The relationships implied could be used to assess the entirety of the quality of care surrounding cardiac arrest in the hospital, although a cause and effect relationship should not be assumed.

In this study, the structure portion of the framework represents staffing, time-to-defibrillation represents process, and survival to discharge and neurological status represent the outcomes. Currently, there is no empirical evidence to support the hypothesized relationship between staffing at the time of the event and time-to-defibrillation. This hypothesized relationship is based on previous research by Chan et al. (2008b). They found that certain hospital characteristics (i.e., unmonitored units and cardiac arrests during evening and night shifts) were associated with delays to defibrillation. Previous studies have suggested a relationship between time-to-defibrillation and survival and, also, that patients with delayed defibrillation were significantly less likely to survive to hospital discharge (Chan et al., 2008; Herlitz et al., 2005). In addition, among survivors, patients with delayed defibrillation were more likely to have unfavorable neurological outcomes. As stated earlier, these findings suggest that delayed defibrillation times may be related to the availability of staff in the hospital at the time of the event. Survival after cardiac arrest is improved if defibrillation is administered within two minutes (Eisenberg & Mengert, 2001; Nadkarni, Larkin & Peberdy et al., 2006).

Donabedian's framework was used as a guide to explicate the relationships between nurse staffing (structure), time-to-defibrillation (process), and both survival to discharge and neurological status (outcomes). The framework is displayed in Figure 1.

Figure 1. Conceptual Model

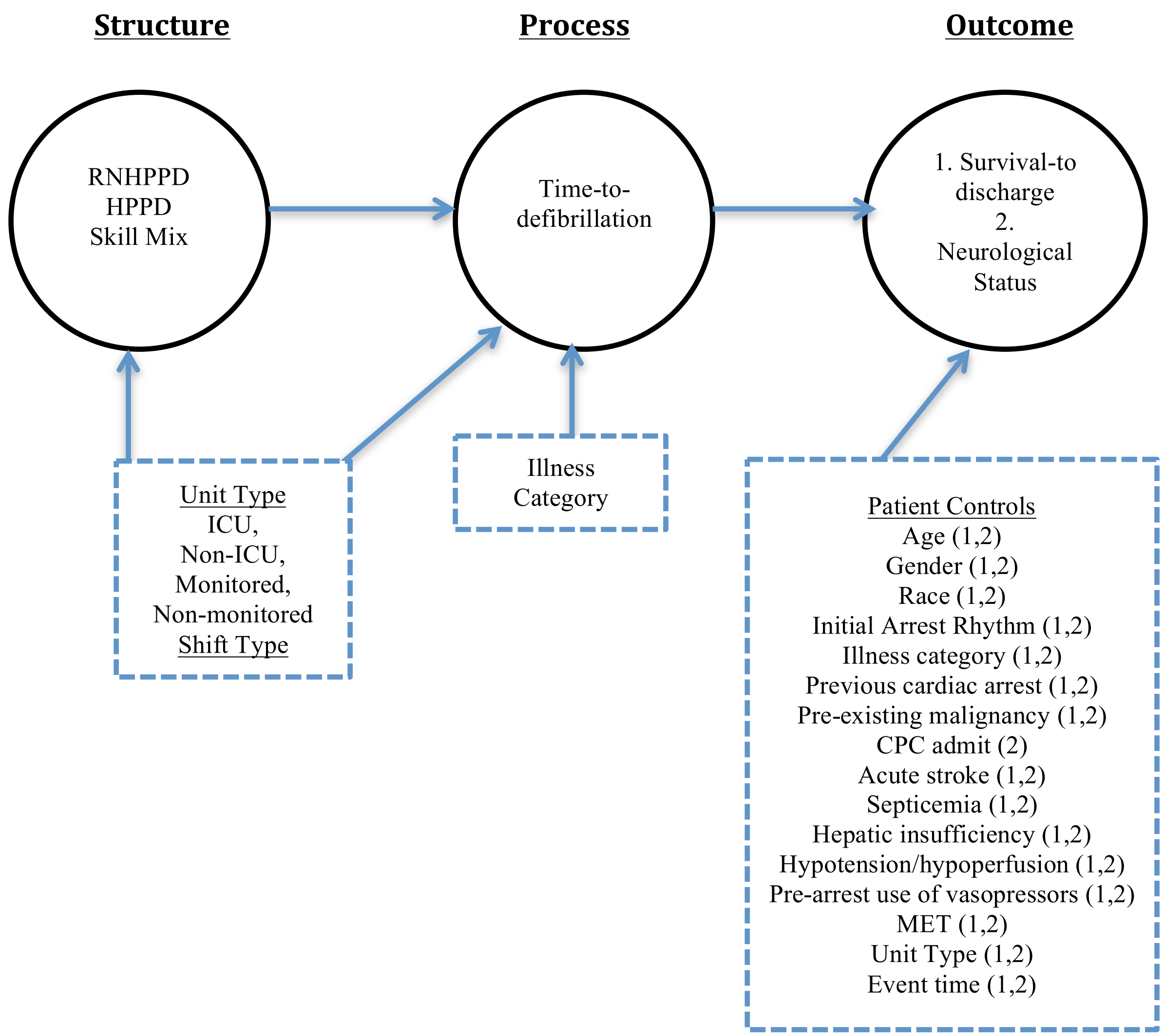

Figure 1. Conceptual Model: Based on Donabedian's Triad (Donabedian, 1988). This model explicates the relationship between staffing (structure), time-to-defibrillation (process) and survival-to-discharge and neurological status (outcome). Note: 1=Survival to Discharge, 2=Neurological Status

Significance

Cardiac disease is the leading cause of death in the United States and the leading cause of sudden cardiac arrest (Centers for Disease Control, 2009). In-hospital cardiac arrests are quite common, and delays in treatment result in increased mortality and reduced neurological outcomes (Chan, Khalid, Longmore et al., 2008a; Peberdy et al., 2008). Previous studies revealed that patient deterioration in heath status has been shown to develop several hours precipitating a sudden cardiac arrest event (Franklin & Mathew, 1994; Hillman et al., 2001; Schein, Hazday, Pena, Ruben, & Sprung, 1990).

Consequently, the Institute for Health Care Improvement (IHI) recommended in their 1,000,000 Lives Campaign to implement rapid response teams as a way to reduce in-hospital mortality (Institute for Health Care Improvement, 2010). Despite the popularity of implementation of rapid response teams for in-hospital cardiac arrest, research has demonstrated that rapid response teams are not associated with lower rates of either hospital wide cardiopulmonary arrests or in-hospital mortality (Chan et al., 2008a; Chan, Jain, Nallmothu, Berg & Sasson, 2010). In fact, nurses are considered "first responders" and many times provide defibrillation and cardiopulmonary resuscitative treatment prior to the arrival of the rapid response team (Spearpoint, McLean, & Zideman, 2000). Despite the growing trend in health services research exploring the relationship between nurse staffing and patient outcomes, no research has been conducted on the "process" in which nurses respond to cardiac arrest patients and its impact on the outcomes. Accordingly, exploration of the relationships between structure (nurse staffing), process (time-to- defibrillation), and outcomes (survival to discharge and neurological status) is warranted.

Organization of the Dissertation

The dissertation is divided into five chapters. The chapters include the introduction, three empirical papers, and a conclusion. The current paper, the introduction, provides a brief background, problem statement, conceptual framework and significance of the study. Chapter 2, the first paper, will discuss the influence of staffing on time-to-defibrillation of IHCA patients. Chapter 3, the second paper, will discuss the impact of staffing on survival to discharge of IHCA patients. Chapter 4, the third and final paper, will discuss the impact of staffing on neurological outcomes of IHCA patients. Chapter 5 presents the conclusion and recommendations for future research.

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Chapter II

The Impact of Nurse Staffing on Time-to-Defibrillation

The leading cause of cardiac arrest and death in the United States is cardiac disease (Centers for Disease Control, 2009). In-hospital cardiac arrests caused by cardiac disease occur up to 750,000 times per year, with fewer than 30% surviving to discharge (Eisenberg & Mengert, 2001). The foremost cause of cardiac arrest among hospitalized adults is pulseless ventricular tachycardia (VT) and ventricular fibrillation (VF) from electrical disturbances or ischemia (Nadkarni, Larkin, Peberdy et al., 2006; Peberdy, Kayne, Ornato et al., 2003). Survival rates from VF/VT are higher than that of non-shockable rhythms such as asystole or pulseless electrical activity (PEA) if defibrillation is administered rapidly (Eisenberg & Mengert, 2001; Nadkarni, et al., 2006; Peberdy, Kayne, Ornato et al., 2003; Spearpoint, McLean, & Zideman, 2000). For hospitalized patients, the interval from collapse to arrest to first defibrillation attempt may be the most important process indicator of effective response when shockable rhythms are present (Jacobs et al., 2004).

The American Heart Association (AHA) recommends that all hospitalized patients with VF or VT should receive defibrillation therapy within two minutes after recognition of cardiac arrest. Previous studies have suggested an association between time to defibrillation and patient outcomes (Chan, Krumholz, Nichol & Nallamothu, 2008a). Regardless of the regular use of in-hospital “code” teams, nurses are typically the first responders to in-hospital arrest and frequently provide defibrillation and cardiopulmonary resuscitative treatment prior to the arrival of the rapid response team (Coady, 1999; Spearpoint, McLean, & Zideman, 2000). Recognizing the importance of nursing care on patient outcomes, health services researchers have engaged in research exploring nurse staffing levels and ratios on outcomes. Despite this growing trend and the importance of nursing presence in the narrow window of defibrillation time of in-hospital cardiac arrest (IHCA) patients, no research has been conducted on the "process," such as time-to-defibrillation in which nurses respond to cardiac arrests at the time of the event. Overall, it remains unclear how nurse staffing influences response times and treatment of IHCA. Accordingly, exploration of the relationships between nurse staffing and time-to-defibrillation is warranted.

The purpose of this research was to investigate the association between nurse staffing and time-to-defibrillation of patients inflicted with IHCA. For this study, nurse staffing is defined collectively as registered nurse hours per patient day (RNHPPD), total hours per patient day (HPPD), and skill mix. Time-to-defibrillation is defined as the reported time from initial recognition of cardiac arrest to the reported time of first attempt to defibrillation.

Background

Nurse Staffing and to Time-to Defibrillation

Nurse staffing has been associated with lower risk-adjusted likelihoods of cardiac arrest in intensive care-, surgical-, and medical patients (Kane et al., 2007). Moreover, lower nurse-to-patient ratios have been associated with higher instances of shock and cardiac arrest-related incidence of pneumonia (Needleman et al., 2002). Nurse staffing research has been primarily directed towards patient outcomes related to cardiac arrest through the concept of failure to rescue (FTR) (Silber, Williams, Krakauer, & Schwartz, 1992). FTR is a quality indicator that describes a clinician's inability to save a hospitalized patient's life when complications arise that were not present on admission (Aiken, Clarke, Sloane, Sochalski, & Silber, 2003). FTR is based on the premise that while many hospital quality measures are dependent on conditions outside the control of hospital characteristics, treatment of complications developing in the hospital is dependent on quick recognition and treatment (Horwitz, Cuny, Cerese & Krumholz, 2007). FTR does not imply any wrongdoing; it refers to not recognizing deterioration in the patient status. This oversight can deter the health care professional from initiating the necessary steps to avoid adverse events that may lead to patient mortality. Silber and colleagues (1995) concluded that complications were associated with hospital characteristics and not as much with the characteristics of the patient.

The Agency for Health Care Research and Quality (AHRQ) currently uses FTR as a patient safety indicator to measure quality. The FTR measure includes five hospital complications: pneumonia; shock or cardiac arrest; upper gastrointestinal bleeding; sepsis; and deep vein thrombosis (Needleman, Buerhaus, Mattke, Stewart & Zelevinsky, 2002). Although FTR has been viewed as the preferred outcome measure (in lieu of 30-day mortality), researchers have found that FTR has limitations in that it is not an accurate measure for non-surgical cases; it is not widely variable across institutions; and it has limitations for external institutional comparisons (Horwitz et al., 2007). In addition, the FTR measure is obtained from billing codes in administrative data, which have a higher probability of measurement error (Horwitz et al., 2007; Ieozzni, 2003; Schmid, Hoffman, Happ, Wolf, & DaVita, 2007). This information suggests that a more accurate measure of process indicators for response time or failure to respond is needed to explore the influence of nurse staffing on cardiac arrest outcomes.

In the hospital, the time interval from collapse to arrest to first defibrillation attempt may be the most important process indicator of effective response when VF or VT is the initial cardiac rhythm (Jacobs et al., 2004). Expert guidelines currently recommend defibrillation to occur within two minutes after IHCA is caused by a ventricular arrhythmia (Cummings, 1997). Certain hospital characteristics are associated with delays in time to defibrillation (> 2 minutes). These include: small hospitals (< 250 beds), unmonitored hospital units, and cardiac arrests during after-hour periods (5 p.m. to 8 a.m. or weekends). Although some patient characteristics are associated with time-to-defibrillation, delay in these times is a process indicator that can ultimately be improved at a system level. These hospital-level findings suggest that delayed defibrillation times may be related to the availability of trained staff in the hospital at the time of cardiac arrest (Chan et al., 2008).

Nurses are typically the first responders to IHCAs and most often provide defibrillation and resuscitative treatment prior to the arrival of cardiac arrest teams (Coady, 1999; Spearpoint, McLean, & Zideman, 2000; Wright, Bannister, & Mackintosh, 1994). However, no studies were uncovered that examined nurse staffing at the time of the event, although several studies were uncovered that explored nurse involvement with decreased defibrillation times. One study exploring the outcomes of witnessed VF/VT arrests and the impact of the chain of survival found that appropriately trained RNs provided 66% of the first sequence of shocks in a sub-group of patients when no other interventions were conducted (Spearpoint et al., 2000). Spearpoint and colleagues (2000) did not seek to explore the impact of nurse response times directly; however, recognizing the potential of decreased defibrillation times, the authors recommended the implementation of easily accessible defibrillators on general units coupled with training programs in defibrillation for nurses.

Coady (1999) discovered that on average, VF was present for at least 60 seconds prior to defibrillation by the cardiac arrest team. After execution of training for 247 nurses general medical surgical units, researchers found that nurse implemented defibrillation of VF/VT patients prior to the arrival of a cardiac arrest team increased from 12% to 46%. Despite this rise, overall survival did not have a significant increase. In addition, there is some empirical evidence that shift type (i.e., days versus nights) is predictive of survival, notably the "early nursing shift," defined as the hours between 0730-1500. However differences in observed time-to-defibrillation were not noted (Wright, Bannister, & Mackintosh, 1994).

In summary, studies about nurse staffing levels and time-to-defibrillation are non-existent. The two studies mentioned had marked nurse influence on IHCA indirectly, while the other provided a direct intervention for process improvement. In addition, research on nurse staffing measures is primarily directed towards patient outcomes and the FTR concept. This study is the first to explore the association of unit level, shift specific nurse staffing and time-to-defibrillation of IHCA patients.

Conceptual Model

This study is guided by a modified Donabedian Triad concept for quality assessment (Structure-Process-Outcome) (Donabedian, 1988). According to Donabedian, these three categories can be used to draw conclusions about quality in a given organization. *Structure* refers to the setting where health care occurs. The setting may be related to staffing, human resources or other organizational structures. Upon examining health care quality, the assessment of structure enables evaluation of the health care environment and functions available to be used for the delivery of care. *Process* refers to the manner in which care is delivered. The assessment of process requires the evaluation of activities of health care providers, such as nurses, in patient management. Finally, *outcome* denotes the effect of the healthcare status of the patient. Outcome assessment evaluates the end result in terms of the health status of the patient (Wyszewianski & Donabedian, 1981). This concept hypothesizes that robust structures will increase the probability of having a strong process, which in turn will increase the probability of a positive outcome (Donabedian, 1988).

This model was used to explicate the relationships between nurse staffing (structure), time-to-defibrillation (process) and survival to discharge and neurological status (outcome) of IHCA. The model implies an integrated and influential relationship that begins at the structure, which in turn influences the processes, which in turn influences the outcome. The relationships implied could be used to assess the entirety of the quality of care surrounding cardiac arrest in the hospital, although a cause and effect relationship should not be assumed. In this research, the relationship between nurse staffing (structure) and time-to-defibrillation (process) is examined as represented in the model. This analysis will focus specifically on the *structure-process* aspect of the model, which is operationalized by nurse staffing (RNHPPD, HPPD, and Skill Mix) and time-to-defibrillation. These constructs of the model are described below and illustrated in Figure 2.

Measures of nurse staffing. Nurse staffing has been measured in a variety of ways. Measurement for nurse staffing consists of *actual number of hours of care* (called nursing hours) delivered by RNs (American Nurses Association, 1997, 2000; Lichtig, Knauf, & Milholland, 1999) and RN *hours* as a percentage of all nursing care hours, referred to as skill mix and nurse intensity (American Nurses Association, 1997, 2000; Lichtig et al., 1999; Needleman et al, 2002). Other studies (Kovner & Gergen, 1998; Kovner, Jones, Zahn, Gergen, & Basu, 2002; Mark, Harless, McCue & Xu, 2004) have measured nurse staffing as the number or percentage of RN full-time equivalents (FTEs). The use of hours of care as an operational definition of nurse staffing may reflect a different construct than when nurse staffing is operationalized as FTEs (Mark, 2006). Hours of care reflect nursing care actually delivered to patients, assuming they are worked hours rather than just paid hours that are measured. In contrast, FTEs are thought of as a construct that reflects just the hospital's capacity to deliver nursing care (Mark, 2006).

Registered nurse hours per patient day (RNHPPD) takes into account the actual productive hours that are worked by nursing staff assigned to the unit who have direct patient care responsibilities for greater than 50% of their shift (Joint Commission, 2004). Productive hours are not budgeted or scheduled hours and exclude vacation, sick time, orientation, education leave, or committee time (American Nurses Association, 2000). The American Nurses Association developed this measure for the National Database of Nursing Quality Indicators (NDNQI). The nurse staffing indicators that are used in the NDNQI measure include: total nursing care hours per patient day, RN nursing care hours per patient day, and the percent of total nursing care hours provided by RNs (Joint

Commission, 2004).

Time-to-defibrillation. Time-to-defibrillation is the real time interval when the first shock is delivered after a witnessed or monitored cardiac arrest (Jacobs et al., 2004). In 2002, the International Liaison Committee on Resuscitation (ILCOR) published a series of guidelines to be used for consistent reporting of adult in-hospital resuscitation based on the Utstein-Style definitions for reporting in-hospital cardiac arrests (Cummings, 1997). ILCOR defines cardiac arrest as "the cessation of mechanical activity as confirmed with the absence of signs or circulation" (Jacobs et al., 2004, p. 3387). The group suggests that the time should be recorded in real-time when the first shock is delivered. Further, they recommend that the best way to obtain this information is through a conventional defibrillator with automated event documentation. The defibrillator provides precise details about initial rhythm, times, and responses of the therapy (Jacobs et al., 2004). In addition, the time of first rhythm analysis or assessment is when a cardiac rhythm is analyzed for a shockable rhythm, when the provider clinically assesses the need for cardiopulmonary resuscitation (CPR) or when a defibrillator is initially attached to the patient and turned on. For in-hospital patients on continuous electrocardiogram (ECG) monitoring, this is the time when the provider attempts to interpret the ECG for a shockable rhythm (Jacobs et al., 2004).

Figure 2. Conceptual Model Depicting the Relationship Between Nurse Staffing and Time-to-Defibrillation

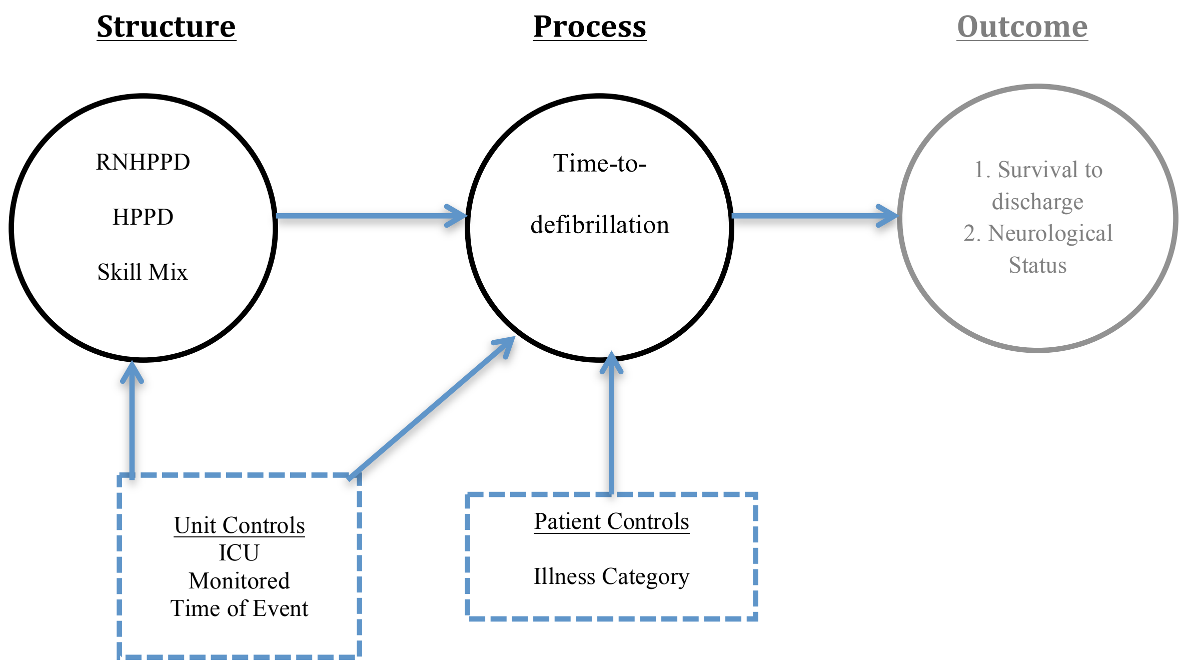

Figure 2. Conceptual Model: Based on Donabedian's Structure-Process-Outcome Triad (Donabedian, 1988).

Research Question and Hypothesis

This research examines the relationship between nurse staffing (RNHPPD, HPPD, and skill mix) and time-to-defibrillation of IHCA patients. The research question (Q) and hypothesis (H) are:

Q: To what extent does the level and type of nurse staffing (RNHPPD, HPPD, Skill Mix) have on time-to-defibrillation of IHCA patients?

H1: Nurse staffing will have relationship with time-to defibrillation of IHCA patients.

Methods

Design

This study was a secondary data analysis of the American Heart Association's *Get with the Guidelines* (GWTG) in-hospital cardiac arrest database. A descriptive correlational design was used to examine the relationship between nurse staffing and time-to-defibrillation. The study was cross-sectional in that staffing data and in-hospital cardiac arrests were examined at a single time point.

Sample and Setting

The sample was drawn from the GWTG data set between the years 2004-2009 from a large Midwest teaching center with 30 impatient units and with a total bed capacity of 913. Prior to inclusion and exclusion criteria, the entire sample consisted of 2,887 IHCA and respiratory arrest patients. The study population was limited to inpatient units at the time of cardiac arrest with first documentation of pulseless electrical activity (PEA), asystole, ventricular tachycardia, and ventricular fibrillation. Hospital units included for analysis as defined by National Database of Nursing Quality Indicators (NDNQI) are critical care, step down, medical, combined medical-surgical, and rehab (Montavlao, 2007). Exclusion criteria included: 1) patients with missing event time data (n = 1277); 2) patients under the age of 18 (n = 608); 3) unit type (obstetrics, pediatrics, and emergency room) or missing event location data (n = 151); 4) patients with implantable cardioverter-defibrillators (n = 21); and 5) missing time-to defibrillation data (n = 531). The final sample comprised 299 adult patients from one hospital and 22 in-patient units.

Procedures

Recruitment, consent, and data collection. Primary data collection was not required for this study nor was consent and recruitment of participants required. After Institutional Review (IRB) exemption was obtained, a request was sent to the GWTG coordinator at the Office of Clinical Affairs at the research institution for access to the dataset. The de-identified patient data were provided via several Excel files that were combined into one database and imported into SPSS statistical software version 19.0 for analysis. Staffing data were obtained from the staffing payroll database housed within the same hospital. Staffing data were matched based on the year, month, and time of the event and were entered manually into an Excel spreadsheet. A letter of support was obtained from the Department of Research, Quality and Innovation at the selected institution (Appendix A).

Measures

Independent Variables

Registered nurse hours per patient day (RNHPPD). The concept of RNHPPD refers to the overall time expended by RNs working on the unit that is relative to the patient workload (Joint Commission, 2004). RNHPPD is operationalized as the total RN hours per day divided by the number of patients per day.

Hours per patient day (HPPD). HPPD refers to the overall time expended by the registered nurses, licensed practical nurses and nursing assistants working on the unit per patient day. HPPD values were calculated as the sum of the total nursing hours per patient day divided by the number of patient days.

Skill mix. Skill mix is the calculation of the percentage of staff that are registered nurses.

Other key variables. Other variables for the study included: admitting illness categories: 1) medical cardiac; 2) medical non-cardiac; 3) surgical cardiac; and 4) surgical non-cardiac. The times of arrest were categorized into: 1) day shift (between the hours of 7:00 a.m.-2:59 p.m.); 2) evening shift (between the hours of 3:00 p.m.-10:59 p.m.); and 3) night shift (between the hours of 11:00 p.m. and 6:59 a.m.). Dichotomous variables included intensive care units (ICU) and monitored units.

Dependent Variables

Time-to-defibrillation. The dependent variable was *time-to-defibrillation* which is defined as the interval (in minutes) from the event onset to the initiation of cardiopulmonary resuscitation. Time-to-defibrillation was calculated by subtracting the time of collapse from the time CPR was first initiated. This time includes measures of restoration of circulation (ROC) defined as no further need for chest compression that was sustained for more than 20 minutes and discharge disposition (Cummins, 1997).

Instruments

Get With the Guidelines Database

In 2000 the American Heart Association (AHA)—committed to improving patient outcomes after in-hospital cardiac arrest through quality improvement with the use of data—created the National Registry for Cardiopulmonary Resuscitation (currently named *Get With the Guidelines* [GWTG]) database, which is based on the Utstein guidelines for in-hospital cardiac arrest (Jacobs et al., 2004). GWTG is a prospective, multi-center, observational registry of in-hospital cardiac arrest and resuscitation (Hunt, Mancini, Smyth, Truitt, & NRCPR Investigators, 2009). The main purpose of the GWTG data set is to gather information for healthcare organizations to help support performance improvement and evidenced based practice (American Heart Association, 2009a). Documentation and dissemination of data are expected to follow the Utstein framework guidelines for in-hospital cardiac arrest (Cummins, 1997). The guidelines recommend comparing the "key elements" of in-hospital processes that are major "links" in the chain of survival (Hunt et al., 2009). The Chain of Survival Framework links include access to emergency response system, early cardio-pulmonary resuscitation, early defibrillation, and early advanced cardiac life support (Hunt et al., 2009).

To maximize accuracy, reliability, and validity of the data, each participating hospital appoints a GWTG coordinator. Coordinators must pass the GWTG exam to ensure data integrity. The GWTG has a variety of training options available that help ensure that all participants are abstracting and interpreting data similarly as well as increasing the pass rates on the certification exam. Training options include interactive web based training and live web-based training sessions. Outcome Sciences, Inc. manages the GWTG data centrally. The data collection software has extensive built-in data quality checks as to data completeness, accuracy, range, date order, and validity. There were no published validity or reliability studies for review.

Nurse staffing data. RNHPPD, HPPD, and skill mix were requested directly from the Department of Research, Quality and Innovation at the selected hospital. The staffing data was obtained from a centralized and demographic database that provides accurate and detailed nurse-to-patient staffing ratios that are used primarily for budgetary purposes. In addition, this data provides validation for the Joint Commission, the NDNQI, and accommodates Department of Health and Human Services audits.

Data Analyses

The unit of analysis was the patient. At the completion of staffing data input missing data were assessed for completeness. First, descriptive statistics were conducted on patient and event characteristics to describe the features of the sample. Second, the modified Donabedian model was then tested for correlations to assess potential multicollinearity issues between the three staffing measures (RNHPPD, HPPD, skill mix) and to assess correlation between these variables and time-to-defibrillation. Third, mean staffing scores were assessed for event time categories (day, evening and night shifts) and unit type (ICU versus non-ICU). ANOVA and independent t-tests were conducted to determine significance between groups. Fourth, median time-to-defibrillation scores were calculated for patient and unit characteristics. Fifth, time-to-defibrillation was dichotomized into 2 minutes or less (0) and 2 minutes or more (1), which represents the "gold standard" of time-to-defibrillation of less than two minutes (AHA, 2009a). Sixth, simple negative binomial regressions between covariates and dependent variables were conducted to assess for significance. Finally, to examine the extent that nurse staffing has on time-to defibrillation, a negative binomial generalized linear model analysis was conducted. Negative binomial regression is appropriate for variables that have a skewed distribution, as does time-to-defibrillation (Hilbe, 2007). The Statistical Package for the Social Sciences (SPSS) software version 19.0 was used to run the analyses in this study.

Missing Data

All time variables in the study were deemed necessary and therefore it was imperative to assess missing data prior to analysis. Cases that did not include an event time or time-to defibrillation were excluded from analysis. Following the completion of data entry, 30% of staffing data were rechecked for accuracy and completeness. There were 7 cases with missing staffing information at the time of the event. Staffing data for these events were not available due to hospital restructuring during the time of the event. Overall, there was less than 5% missing items at the variable level across all items, which is below the 10% threshold (McKnight, McKnight, Sidani, & Figuerdo, 2007). Missing values were assumed to have occurred at random; therefore, these missing cases were not deleted and were included in the analysis.

Results

Patient and Event Characteristics

The final analytic sample was 292 (seven cases were excluded due to missing staffing data). However analysis of demographics included the entire sample of 299. The total number of units in the analysis was 22. The sample consisted of mostly white male patients. The main covariates included in the final model are discussed in this section. The remaining patient and event characteristics are presented in Table 2.1.

Approximately 90% of the sample was monitored at the time of the event. Just over half of the sample consisted of a shockable (VT/VF) initial rhythm (53.8%). During the time period analyzed, most IHCAs were witnessed (87.6%), and occurred most frequently on the evening shift (38.8%), on monitored units (92.3%), and in the ICU (58.5%).

Table 2.1. IHCA Patient and Event Characteristics (*N* = 299)

Variables	*N*	% of sample	*M*	*SD*
Age	299	100.0	57.79	17.03
Female	108	36.1		
Race				
White	211	70.6		
Black	35	11.7		
Asian/Pacific Islander	6	2.0		
American Indian/Eskimo/Aleut	2	0.7		
Other	14	4.7		
Hispanic origin	12	4.0		
Initial rhythm VF/VT	161	53.8		
ICU unit	175	58.5		
Monitored	276	92.3		
DNAR	68	22.7		
Illness category				
Medical cardiac	93	31.1		
Medical non-cardiac	96	32.1		
Surgical cardiac	54	18.1		
Surgical non-cardiac	50	16.7		
Trauma	6	2.0		
Time of cardiac arrest				
Days	88	29.4		
Evenings	116	38.8		
Nights	95	31.8		
Cardiac diagnosis				
Myocardial infarction admit	65	21.7		
Previous myocardial infarction	94	31.4		
Prior cardiopulmonary arrest	35	11.7		
Pre-existing medical conditions				
Metastatic cancer	29	9.7		
Renal insufficiency	122	40.8		
Acute stroke	7	2.3		
Pneumonia	34	11.4		
Septicemia	46	15.4		
Major trauma	5	1.7		
Hypotension	148	49.5		
Therapeutic interventions				
Medical Emergency Team	11	3.7		
Ventilator support	134	44.8		

Note: VF=Ventricular Fibrillation, VT=Ventricular Tachycardia, ICU=Intensive Care Unit, DNAR=Do not attempt resuscitation

Staffing Characteristics

Table 2.2 presents the staffing characteristics of the sample. During the time of the event, RNHPPD was highest on the day shift which is between the hours of 7:00 a.m. and 2:59 p.m. (*M* = 4.83, *SD* = 1.52) and lowest between the hours of 11:00pm and 6:59 a.m. (*M* = 4.62, *SD* = 1.91). Evening and night shifts had equivalent total hours per patient day, with day shift having the highest HPPD (*M* = 6.07, *SD* = 1.65). Skill mix was lowest on the day shift (*M* = .76, *SD* = .099). Results of ANOVA tests to determine difference in means between event times were not significant. There were significant differences found in staffing between ICU and non-ICU units. Overall nurse and total hours per patient day was almost twice as high in the ICU when compared to non-ICU units. On average the ICU was staffed with 83% RNs and while the staff on non-ICU units had 77% RNs.

Table 2.2. Staffing Characteristics, Mean Staffing for IHCA Per Event Time and Unit Type (*N* = 299)

	Event Time Category (Shift Type)			Unit Type	
Staffing	Days (n = 84)	Evenings (n = 115)	Nights (n = 92)	Non-ICU (n = 116)	ICU (n = 175)
RNHPPD	4.84 (1.53)	4.63 (1.46)	4.63 (1.92)	3.61 (1.82)	5.41 (0.97)**
HPPD	6.07 (1.65)	5.64 (1.55)	5.59 (2.05)	4.62 (1.96)	6.49 (1.10)**
Skill Mix	0.79 (0.09)	0.81 (0.08)	0.81 (0.10)	0.77 (0.10)	0.83 (0.07)**

Note. RNHPPD=Registered Nurse hours per patient, HPPD=Hours per patient day
**p < .001.

Time-to-Defibrillation

Table 2.3 depicts median time-to-defibrillation for the independent variables. Median time to defibrillation (in minutes) was shortest for arrests that occurred on the evening shift for patients admitted under a cardiac diagnosis (medical and surgical), monitored patients), patients with an initial rhythm of VT or VF, and for patients in the ICU.

Table 2.3. Median Time-to-Defibrillation in Minutes of Patient and Unit Characteristics (*N* = 299)

	N	Median (Min, Max)
Event time category (shift type)		
Days	88	4 (0, 52)
Evenings	116	3 (0, 60)
Nights	95	4 (0, 42)
Unit type		
Non-ICU	124	5 (0, 60)
ICU	175	2 (0, 42)
Illness category		
Medical cardiac	93	1 (0, 32)
Medical non-cardiac	96	5 (0, 42)
Surgical cardiac	54	2 (0, 52)
Surgical non-cardiac	50	5 (0, 60)
Trauma	6	11 (3, 42)
Initial Rhythm		
Non-VF/VT	136	9 (0, 60)
VF/VT	161	0 (0, 42)
Monitored		
No	23	5 (0, 42)
Yes	276	3 (0, 60)

Note. VF=Ventricular Fibrillation, VT=Ventricular Tachycardia, ICU=Intensive care unit

Fifty percent of ICU patients were defibrillated within two minutes or less in the ICU. Table 2.4 depicts time-to-defibrillation for patients who received defibrillation in two minutes or less only. In non-ICU patients, 37% were defibrillated in more than two minutes. Seventy-six percent of patients displaying an initial rhythm of VF or VT were defibrillated within 2 minutes or less.

Table 2.4. Time-to-Defibrillation for 2 Minutes or Less by Unit Type, Illness Category and Initial Rhythm (*N* = 299)

	N	% 2 minutes or less
Unit type		
Non-ICU	124	37.1
ICU	175	50.9
Illness category		
Medical cardiac	93	61.3
Medical non-cardiac	96	29.2
Surgical cardiac	54	57.4
Surgical non-cardiac	50	38.0
Initial Rhythm		
Non-VF/VT	136	8.8
VF/VT	161	76.4
Monitored only	276	46.7

Note. VF=Ventricular Fibrillation, VT=Ventricular Tachycardia

Bivariate Analysis

Analyses were conducted to test for correlations among the independent staffing variables and the dependent variable time-to-defibrillation. Table 2.5 depicts the relationship between the staffing variables (RNHPPD, HPPD, Skill Mix) and time-to-defibrillation. All staffing variables were found have strong positive correlations almost perfectly with one another, therefore HPPD and skill mix were dropped from further analyses. The relationship between RNHPPD and time-to-defibrillation was found to have a weak negative relationship ($r = -.07$, $p < .05$).

Table 2.5. Correlations of Staffing Variables and Time-to-Defibrillation (*N* = 299)

	1	*2*	*3*	*4*
RNHPPD	--			
HPPD	.961**	--		
Skill Mix	.604**	.377**	--	
Time to defibrillation	-.066	-.069	-.049	--

Note. RNHPPD=Registered Nurse hours per patient, HPPD=Hours per patient day.
***p* < .001.

Table 2.6 depicts an independent sample t-test that was conducted to compare RNHPPD with time-to-defibrillation (less than two minutes=0 and more than two minutes=1). There was a significant difference in mean scores for time-to-defibrillation of more than two minutes to defibrillation in less than 2 minutes ($t(286) = -2.02$, $p < .05$).

Table 2.6. Independent T-Test for RNHPPD and Binary Time to Defibrillation (*N*=299)

	Time to Defibrillation			
	More than 2 min (*N* = 159)	2 min or less (*N* = 133)	*t*	*df*
RNHPPD	4.52 (1.68)	4.90 (1.56)	-2.02*	286.69

Note. RNHPPD=Registered Nurse hours per patient day.
**p* < .05.

Results of the simple individual regression for all covariates are presented in Table 2.7. Without controlling for other variables in the model, only two covariates were found to have a significant negative relationship to the dependent variable. The covariates include patients in the ICU at the time of arrest and patients admitted under a cardiac illness category. All covariates were included in the final model for analysis.

Table 2.7. Simple Individual Regressions with a Negative Binomial for All Covariates. Dependent Variable is Time-To-Defibrillation (*N*=299)

Covariates	*β*	*SE β*	*p value*	*Exp(β)*	*95% CI*
ICU	-0.44	0.13	**.000**	0.65	[0.51, 0.83]
Monitored	-0.42	0.23	.064	0.66	[0.42, 1.03]
Event time category (shift type)[a]					
Days	0.15	0.16	.343	1.16	[0.85, 1.59]
Evenings	-0.17	0.15	.910	0.98	[0.73, 1.32]
Illness cardiac[b]	-0.49	0.09	**.000**	0.61	[0.48, 0.78]
RNHPPD	-0.05	0.04	.149	0.95	[0.88, 1.02]

Note. ICU=Intensive Care Unit, RNHPPD=Registered nurse hours per patient day.
[a] Reference category = Nights.
[b] Reference category = Trauma.

Hypothesis Testing

Hypothesis testing was done using a generalized linear model with a negative binomial distribution. Because the dependent variable (minutes to defibrillation) ranged from 0 to 60 and was highly skewed, ordinary linear regression or hierarchical linear regression models were not appropriate. Instead, a generalized linear model with a negative binomial distribution was used to take the skewness of the outcome into account (Hilbe, 2007). The initial negative binomial regression was carried out with generalized estimating equations (GEE) to take into account clustering within units that could result in possible correlations among observations in the same unit (Diggle, Heagerty, Liang, & Scott, 2002). However because the estimated correlation among observations in the same unit was found to be negligible (estimated within-unit correlation = -0.012), the GEE model was not used, and an ordinary negative binomial regression was employed for the analysis after controlling for other variables in the model. The hypothesis that nurse staffing would have a strong negative relationship to time-to-defibrillation was not supported (β = .07, p = .28). Table 2.8 depicts the results of the hypothesis test.

The results of this model indicate that patients who were in an ICU and had a cardiac diagnosis had significantly lower time-to-defibrillation ($p < .01$) after controlling for other covariates in the model. Those who were in an ICU during the time of the event had times-to-defibrillation which were on average 49% shorter than those in non-ICU units. Furthermore, patients with a cardiac diagnosis had times-to-defibrillation that were on average 47% shorter than non-cardiac diagnosis. Other predictors in the model were not significant.

Table 2.8. General Linear Regression Model with a Negative Binomial Distribution for Significant Covariates. Dependent Variable, Time-to-Defibrillation (*N* = 299)

Covariates	*β*	*SE β*	*p value*	*Exp(β)*	*95% CI*
Monitored	-0.01	0.31	.98	0.99	[0.54, 1.83]
ICU	-0.67	0.19	**.00**	0.51	[0.36, 0.74]
Event time category (shift type)[a]					
Days	0.07	0.23	.76	1.07	[0.68, 1.70]
Evenings	0.00	0.19	.99	1.00	[0.69, 1.46]
RNHPPD	0.07	0.07	.28	1.07	[0.95, 1.22]
Illness categories[b]					
Cardiac (medical and surgical)	-0.65	0.19	**.00**	0.53	[0.36, 0.76]

Note: ICU=Intensive Care Unit, RNHPPD=Registered nurse hours per patient day.
[a] Reference category = Nights.
[b] Reference category = Non-cardiac illnesses.

Discussion

The purpose of this study was to investigate the association between nurse staffing and time-to-defibrillation of patients inflicted with IHCA. This study extends upon the current literature in health services research that investigates the relationship between nurse staffing and quality of care. Defibrillation should be considered the first link in an in-hospital "chain of survival" and structural factors in the work environment should be aimed towards improving this process. Studies have shown that rates of defibrillation vary widely among hospitals, with hospital factors accounting for the variation such as bed volume, arrest location (i.e., ICU) and non-monitored units (Chan et al., 2009). Moreover, Chan et al.'s (2009) study found several factors relating to the hospital setting that were associated with delayed defibrillation times including unmonitored units and night shifts. Researchers concluded that the findings imply that response times could be related to the availability of staff; however, this hypothesis had not been explored empirically. The aforementioned findings suggest that nurse intervention could play an important role in decreasing defibrillation response times.

This is the first known study that examined the relationship between nurse staffing and time-to-defibrillation as a process indicator to be used to improve quality of care of IHCA patients. Furthermore, it is unlike previous studies that investigated nurse staffing in that this study examines nurse staffing at the time of a specific event in an attempt to capture the nursing care environment during an IHCA. In this regard, this study marks an important departure from current research that examines staffing at the hospital or unit level. This study identified an important process indicator that could be used to assess nurse response times and performance in patients who experience in-hospital cardiac arrest. In addition, exploration of staffing patterns that focused on patient outcomes such as the FTR measure did not consider the process of care that may play a stronger role in outcomes than measures of staffing alone (Silber et al., 1992; Needleman et al., 2002; Kane et al., 2007).

The hypothesis that nurse staffing will have a strong negative relationship with time-to defibrillation of IHCA patients was not supported. However the findings indicate that mean RNHPPD significantly differs in defibrillation time of less than two minutes.

Moreover, this study found that patients in the ICU at the time of the event and patients with cardiac diagnosis (medical and surgical) upon admission have shorter times-to-defibrillation which is consistent with findings from previous studies (Chan et al., 2008; Chan et al., 2009b). In regards to ICU arrests, results indicated that ICU had an almost 50% shorter time-to defibrillation than did non-ICU. Furthermore, ICU patients had more frequently occurring time-to-defibrillation of less than 2 minutes than did non-ICU patients—possibly the result of higher nurse to patient rations and more hours of nurse care per patient day. The findings also indicated that there was a significant difference in median scores for time-to-defibrillation of more than two minutes and less than two minutes, possibly the result of the variation of staffing levels between the ICU and non-ICU.

Other significant findings included patients with cardiac illnesses diagnosis had times-to-defibrillation that were on average half the time shorter than non-cardiac illness categories. In addition, cardiac patients had more frequently occurring time-to-defibrillation of less than 2 minutes than non-cardiac patients. This finding is consistent with another study that found medical and cardiac illness categories to be predictive of lower times to defibrillation (Chan et al., 2008). Cardiac patients are more likely to be monitored therefore arresting rhythms are more likely to be identified and treated in less time.

Arrests occurred most frequently on the evening shift and as evidenced by median time-to-defibrillation. Accordingly, response times on the evening shift were also 50 seconds less than on the other shifts, although the evening shift did not have the highest staffing levels. The frequency of IHCA occurrence on the evening shift could possibly indicate lack of identification of early warning signs of physical deterioration that is present six to eight hours prior to cardiac arrest (Schein et al., 1990). One study found that 70% of patients showed evidence of deterioration in respiratory or mental function within eight hours of a cardiac arrest (Shein et al., 1990).

Identification of early warning signs is imperative for improved patient outcomes in IHCA. Although staffing is typically highest on the day shifts, it is also considered a “busy” shift when attending physicians and residents make rounds, patients leave the unit for diagnostic tests, visiting hours are active, and full daily care is provided to patients. Consequently, nurses may be overwhelmed with daily tasks and distractions and slight changes in a patient’s condition may not be recognized or acted upon promptly.

Conclusion

In summary, a key contribution of this study is the finding that mean RNHPPD differs with defibrillation time of less than two minutes, which is currently the “gold standard” of response times for IHCA (AHA, 2005). In addition, this study presents an important first step in analyzing the association between the structure of nurse staffing and processes of care of IHCA. Previous studies using the GWTG database have not been able to explain hospital variation in time-to-defibrillation or delayed defibrillation. Researchers have introduced the possibility of the lack of available staff or access to proper equipment for immediate treatment. Nurses are considered the true first responders to cardiac arrest, a complication where seconds and minutes are critically important. Furthermore, nurses are the providers expected to call a “code,” alert medical staff, and provide immediate cardiopulmonary resuscitation prior to the arrival of rapid response teams or medical emergency teams. Despite lack of empirical support for this study's hypothesis, the findings suggest that level and type of nurse staffing is associated with time-to-defibrillation of less than two minutes, an important finding relative to nurses' contribution to the quality of care in patients afflicted with in-hospital cardiac arrest, which ultimately may impact survival.

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Chapter III

The Impact of Nurse Staffing on Time-to-Defibrillation and Survival to Discharge

For over a decade, health services researchers have reported associations between nurse staffing and patient outcomes. The terms traditionally used to link the association between nurse staffing and patient outcomes are "nurse sensitive outcomes" and "patient outcomes potentially sensitive to nursing." These measures are defined as "processes and outcomes that are affected, provided and/or are influenced by nursing personnel, but for which nursing is not exclusively responsible" (Clarke & Dondalson, 2008, p. 112). In 2004, the National Quality Forum (NQF) played an important role in an initiative to help standardize outcome measures for quality improvement (Joint Commission, 2004). Through consensus, an expert panel endorsed and explicated 15 standardized quality indicators that were deemed sensitive to nursing care, some of which include nursing hours per patient day, skill mix and failure to rescue (FTR). Many studies on nurse staffing have been focused on the *structure-outcome* component of quality, negating the aspect that explains "how" nurses impact patient outcomes. Nurses are imperative to quality health care delivery and patient safety, therefore nurse staffing is a crucial health care policy issue.

In regard to nurse staffing and patient outcomes, the concept most notable in the literature is FTR, a quality indicator that describes a clinician's inability to save a hospitalized patient's life when complications arise that were not present on admission (Aiken, Clarke, Sloane, Sochalski & Silber, 2003; Silber, Williams, Krakauer, &

Schwartz, 1992). FTR is based on the premise that while many hospital quality measures are dependent on conditions outside the control of hospital characteristics, treatment of complications developing in the hospital is additionally dependent on quick recognition and treatment (Horwitz, Cuny, Cerese, & Krumholz, 2007). FTR refers to not recognizing deterioration in the patient's status, and this oversight can deter the health care professional from initiating the necessary steps to avoid adverse events that may lead to patient mortality. The FTR measure includes five hospital complications: 1) pneumonia; 2) shock or cardiac arrest; 3) upper gastrointestinal bleeding; 4) sepsis; and 5) deep vein thrombosis (Needleman et al., 2002). Although FTR has been viewed as the preferred outcome measure (in lieu of 30-day mortality), it has limitations in that it is not an accurate measure for non-surgical cases, it is not variable across institutions, and it has limitations for external institutional comparisons (Horwitz et al., 2007; Ieozzni, 2003; Schmid, Hoffman, Happ, Wolf, & DaVita, 2007). Consequently, a more accurate measure of process indicators for response time or failure to respond is needed to explore the influence of nurse staffing on outcomes.

Cardiac disease is the leading cause of death in the United States and cardiac arrest is the leading cause of cardiac disease (Centers for Disease Control, 2009). The most important predictor for survival after in-hospital cardiac arrest (IHCA) is early defibrillation (Eisenberg & Mengert, 2001; Nadkarni, Larkin, Peberdy et al., 2006; Peberdy, Kayne, Ornato et al., 2003; Spearpoint, McLean, & Zideman, 2000). For hospitalized patients, the time interval from collapse to arrest to first defibrillation attempt may be the most important process indicator of effective response when ventricular fibrillation or ventricular tachycardia is the initial cardiac rhythm for hospitalized (Jacobs et al., 2004). Nurses are typically the first responders to in-hospital arrest and frequently provide defibrillation and cardiopulmonary resuscitative treatment prior to the arrival of the rapid response team (Coady, 1999; Spearpoint, McLean, & Zideman, 2000). With fewer than 30% of patients surviving to discharge after sustaining IHCA, important process improvement investigation is needed to determine nursing impact on time-to-defibrillation and survival of the patient population. Overall, it remains unclear how nurse staffing influences response times and treatment of IHCA. In place of the FTR concept that ultimately measures outcomes, examining staffing and time-to-defibrillation at the time of the event may provide a closer synopsis of the environment in which staffing and IHCA occur.

The purpose of this paper was to investigate the association between nurse staffing, time-to-defibrillation and survival to discharge of patients inflicted with IHCA. For this study, nurse staffing is defined as registered nurse hours per patient day (RNHPPD), total hours per patient day (HPPD) and skill mix. Time-to-defibrillation is defined as the reported time from initial recognition of cardiac arrest to the reported time of the first attempt to defibrillation. Survival to discharge is defined as documentation of return restoration of circulation which no further need for chest compression that was sustained for > 20 minutes at the time of discharge.

Background

Nurse Staffing and Survival

The link between nurse staffing and survival has been thoroughly documented in the literature. Nurse staffing has been associated with lower risk-adjusted likelihoods of cardiac arrest in intensive care, surgical, and medical patients (Kane et al., 2007). Studies in recent years have explored the association between staffing on reduced patient mortality (Aiken et al., 2002; Belgen, Goode, & Reed, 1998; Jiang, Stocks, & Wong, 2006; Mark, 2004; Needleman et al., 2002, & Sales, 2008); medication errors (Belgen & Vaughn, 1998); patient falls (Blegen, Goode, & Reed, 1998); and failure to rescue (FTR) (Aiken et al., 2002; Jiang, Stocks, & Wong, 2006; Silber, Rosenbaum, Schwartz, Ross, & Williams, 1995; Silber, Williams, Krakauer, & Schwartz, 1992). Lower nurse-to-patient ratios are associated with higher instances of shock and cardiac arrest-related incidence of pneumonia (Needleman et al., 2002). Aiken and colleagues (2002) found that each additional patient per nurse had a seven percent increase in 30-day mortality. Needleman et al. (2002) reported that an increase in registered nurse hours per patient day was associated with lower risks of pneumonia, cardiac arrest, and failure to rescue. Furthermore, an increase by one RN per patient day is associated with decreased odds of cardiac arrest and in the intensive care unit, a lower risk of FTR in surgical patients (Kane et al., 2007). Despite the ground breaking information uncovered in these studies, measures of nurse staffing were at the hospital level—an indication that differences in various staffing models and patient acuity on different units (i.e., medical-surgical vs. intensive care) were not accounted for and thus may not be an accurate measure of a true relationship (Spetz, Donaldson, Aydin & Brown, 2008).

There are many studies that explore factors related to survival to discharge after an in-hospital cardiac arrest. Research has shown the most important predictor of survival to discharge is the initial shockable rhythm (ventricular tachycardia or ventricular fibrillation) (Meaney, Nadkarni, Kern, Indik, Halperin & Berg, 2010; Peberdy, Kaye, Ornato, Larkin, Nadkarni et al., 2003; Peters & Boyd, 2007; Skrifvars, Pettilä, Rosenberg, & Castrén, 2003; Skogvoll, Sangolt, Isern, & Gisvold 1999; Tortolani Risucci, Rosati, & Dixon, 1990). Other patient factors associated with survival to discharge include patient age (Peters & Boyd, 2007), race (Chan et al., 2008), and witnessed arrest (Peters & Boyd, 2007). Hospital level factors associated with survival to discharge include time of arrest (Chan et al., 2008; Peters & Boyd, 2007), unit type [intensive care and monitored units] (Chan et al., 2008), and time to defibrillation (Chan et al., 2008; Peters & Boyd, 2007; Spearpoint et al., 2000). Pre-resuscitation factors found to predict cardiopulmonary event mortality include age, black race, non-cardiac illness categories, pre-existing malignancy, acute stroke, trauma, septicemia, hepatic insufficiency, and pre-arrest use of vasopressors and assisted/mechanical ventilation. In addition, cardiac monitoring and shockable initial pulseless rhythms are strongly associated with survival (Larkin, Copes, Nathonson, & Kaye, 2010).

There are studies which uncovered possible relationships between nursing care and survival to discharge among patients who sustain a cardiac arrest (Dane, Russell-Lindgren, Parish, Durham & Brown, 2000; Peberdy et al., 2003; Peters & Boyd, 2007; Skrifvars et al., 2003). One study conducted in a 750-bed facility in Australia suggested that increased survival to discharge could be attributed to nursing staff performing defibrillation due to higher nurse to patient ratios during the time of arrest (Peters & Boyd, 2007). Administration of defibrillation by advanced cardiac life support (ACLS) trained RNs was strongly associated with patient survival to discharge. In fact, patients were four times as likely to survive if defibrillation was administered by an ACLS nurse as opposed to a nurse who did not have the specialized training (Dane et al., 2000). Another study found that patients with ventricular fibrillation or ventricular tachycardia had a greater chance of survival if nurses rather than physicians performed defibrillation. The reason for the difference, however, still remains unclear (Skrifvars et al., 2003). In their study, Peberdy and colleagues (2003) found that survival rates from IHCA were lower during nights and weekends after adjusting for confounding patient variables. The authors suggest that this could be the result of different staffing patterns (e.g., lower nurse to patient ratios) during night and weekend shifts. Despite these findings and potential for improvement in the process of care, no studies were uncovered that directly sought to explore the relationship between nursing care hours per patient day and survival to discharge for in-hospital cardiac arrests.

In summary, although nurse staffing has been found to be associated with patient outcomes, most of the research has been conducted at the hospital level instead of the unit level and have used International Classification of Diseases, Clinical Modification codes (ICD-9-CM) instead of actual patient event data and have neglected to measure the process of care associated with patient outcomes. Furthermore, although research on cardiac arrest outcomes has alluded to the impact of nursing care's impact on time to defibrillation and patient outcomes, no studies have examined the relationship of nurse staffing on time-to-defibrillation and survival to discharge of IHCA. Consequently, there is a great need to understand and explore this relationship as a means to document the impact that nursing care has on survival of patients as well as to provide evidence of where systemic changes can be implemented to improve survival.

Conceptual Model

This study was guided by the Donabedian Triad concept for quality assessment (Structure-Process-Outcome) (Donabedian, 1988). *Structure* refers to the setting where care occurs, which may be related to staffing, human resources or other organizational structures. The assessment of structure enables evaluation of the health care setting as well as functions available to be used for the delivery of care. *Process* refers to the manner in which care is delivered. The assessment of process requires the evaluation of the activities of health care providers, such as nurses, in patient management. Finally, *outcome* assessment evaluates the end result in terms of the health status of the patient (Wyszewianski & Donabedian, 1981). These three categories enable conclusions to be drawn about the quality of healthcare services. It is hypothesized that strong structures will produce strong processes and in turn produce strong outcomes (Donabedian, 1988).

This conceptual model was used to explicate the relationships between nurse staffing (structure), time-to-defibrillation (process), and survival to discharge (outcome) of IHCAs. An influential relationship is implied, which begins at the structure and ends in the outcome, and influenced by process in between. The implied relationships could be used to assess the entirety of the quality of care surrounding cardiac arrest in the hospital, although a cause an effect relationship should not be assumed. In this paper, the relationship between nurse staffing (structure), time-to-defibrillation (process), and survival to discharge (outcome) is examined as represented in the model. This study was focused on all aspects of this model, which is operationalized by nurse staffing (RNHPPD, HPPD, and Skill Mix), time-to-defibrillation, and survival to discharge. These constructs are described below and illustrated in Figure 3.

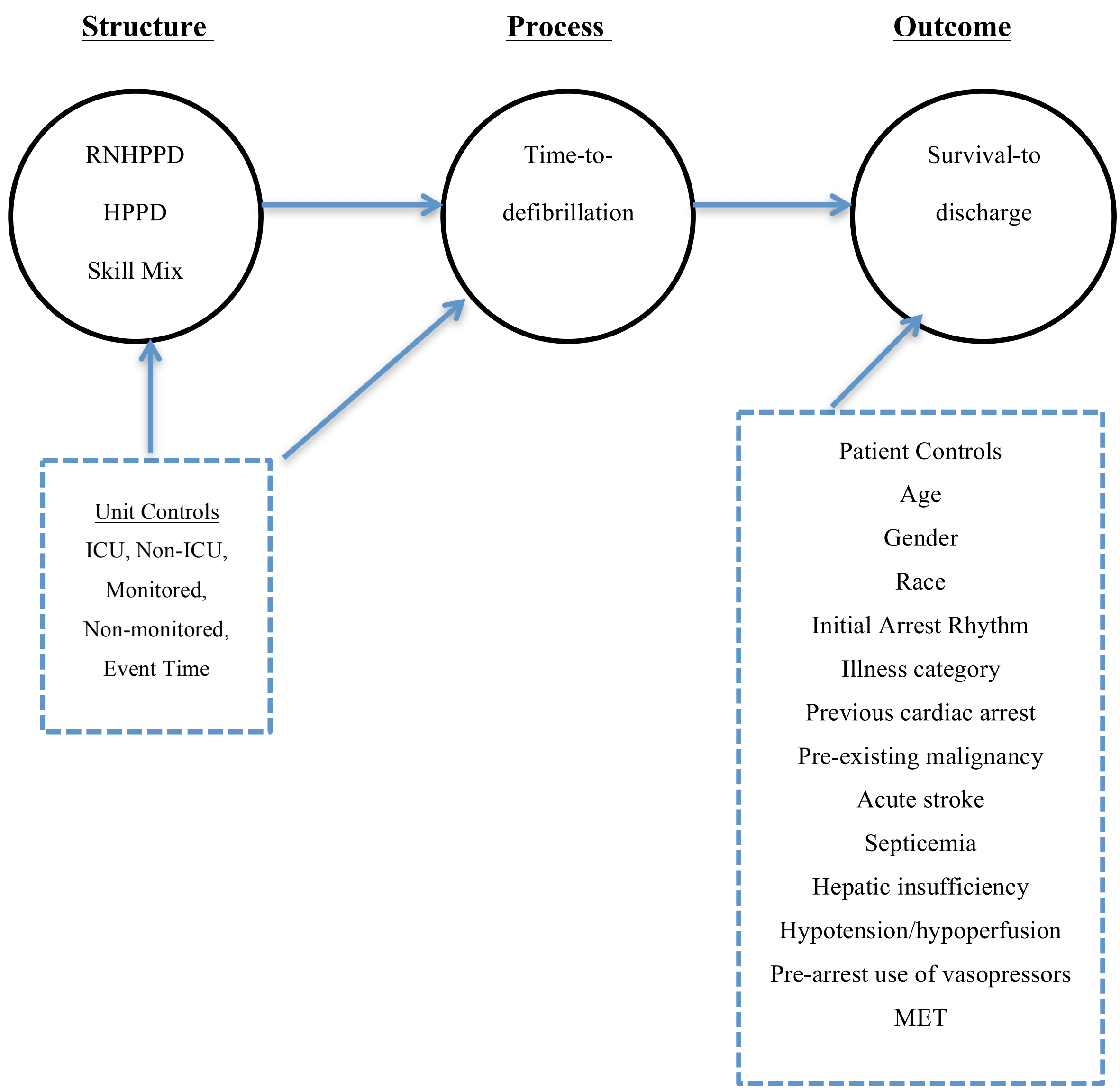
Measures of nurse staffing. Measurement for nurse staffing consists of *actual number of hours of care* (called nursing hours) delivered by RNs (American Nurses Association, 1997, 2000; Lichtig, Knauf, & Milholland, 1999) and *RN hours as a* *percentage of all nursing care hours*, referred to as skill mix and nurse intensity (American Nurses Association, 1997, 2000; Lichtig et al., 1999; Needleman et al, 2002). Other studies (Kovner & Gergen, 1998; Kovner, Jones, Zahn, Gergen, &Basu, 2002; Mark, Harless, McCue & Xu, 2004) have measured nurse staffing as the number or percentage of RN full-time equivalents (FTEs). The use of hours of care as an operational definition of nurse staffing may reflect a different construct than when nurse staffing is operationalized as FTEs (Mark, 2006). Hours of care reflect nursing care actually delivered to patients, assuming they are worked hours rather than just paid hours that are measured. In contrast, FTEs are thought of as a construct that reflects just the hospital's capacity to deliver nursing care (Mark, 2006).

The American Nurses Association (ANA) developed this measure of nurse staffing for the National Database of Nursing Quality Indicators (NDNQI). The nurse staffing indicators that are used in the NDNQI measure include: total nursing care hours per patient day, RN nursing care hours per patient day, and the percent of total nursing care hours provided by RNs (Joint Commission, 2004). Registered nurse hours per patient day (RNHPPD) is the actual productive hours worked by nursing staff who have direct patient care responsibilities for greater than 50% of their shift (Joint Commission, 2004). Productive hours are not budgeted or scheduled hours and exclude vacation, sick time, orientation, education leave, or committee time (ANA, 2009).

Time-to-defibrillation. Time-to-defibrillation is the interval when the first shock is delivered after a witnessed or monitored cardiac arrest (Jacobs et al., 2004). This is an official definition created by the International Liaison Committee on Resuscitation (ILCOR) who published a series of guidelines to be used for consistent reporting of adult in-hospital resuscitation. The guidelines are based on the Utstein-Style definition for reporting in-hospital cardiac arrests (Cummins, 1997). ILCOR defines cardiac arrest as "the cessation of mechanical activity as confirmed with the absence of signs or circulation" (Jacobs et al., 2004, p. 3387). ILCOR recommends that time should be recorded in real-time when the first shock is delivered. Further, they recommend that the best way to obtain this information be through a conventional defibrillator with automated event documentation if available. The defibrillator provides precise details about initial rhythm, times, and responses to therapy (Jacobs et al., 2004). In addition, the time of first rhythm analysis or assessment of need is when a cardiac rhythm is analyzed for a shockable rhythm, when the provider clinically assesses the need for cardiopulmonary resuscitation (CPR) or when a defibrillator is initially attached to the patient and turned on. For in-hospital patients on continuous ECG monitoring, this is the time when the provider attempts to interpret the ECG for a shockable rhythm (Jacobs et al., 2004).

Survival to discharge. Primary outcomes of IHCA are typically measured by mortality (Becker et al., 2011). Survival to hospital discharge is "the point at which the patient is discharged from the hospital's acute care unit regardless of neurological status, outcome, or destination" (Jacobs et al., 2004, p. 3387). This indicates survival to discharge from an acute care hospital. Survival to hospital discharge is contextualized as documentation of return restoration of circulation for greater than 20 minutes without further need defined need for chest compressions at the time of discharge (Cummins, 1997).

Figure 3. Conceptual Model Depicting the Relationship Between Nurse Staffing, Time-to-Defibrillation and Survival to Discharge.



Research Questions and Hypothesis

This research examined the relationship between nurse staffing (RNHPPD, HPPD, and skill mix), time-to-defibrillation, and survival to discharge of IHCA patients**.** The research question (Q) and hypothesis (H) were:

Q: To what extent does nurse staffing (RNHPPD, HPPD, Skill Mix) and time-to-defibrillation have on the of IHCA patients?

H1: Nurse staffing and time-to-defibrillation will predict survival to discharge of IHCA patients.

Methods

Design

A descriptive correlational design was used to examine the relationship between nurse staffing, time-to-defibrillation, and survival to discharge. This study was a secondary data analysis of the American Heart Association's Get with the Guidelines (GWTG) in-hospital cardiac arrest data set. The study was cross-sectional in that staffing data and in-hospital cardiac arrests were examined at a single time point.

Sample and Setting

The analysis included one Midwestern tertiary teaching center with 30 inpatient units with a total bed capacity of 550. The sample consisted of adult patients aged 18 and older who sustained an IHCA between dates May 2004 through December 2009. The sample was drawn from the GWTG database from the same institution. Exclusions from the sample included: 1) patients with missing event time data (n = 1277); 2) patients under the age of 18 (n = 608); 3) unit type (obstetrics) or missing event location data (n = 151); 4) patients with ICDs (n = 21); 5) missing time-to defibrillation data (n = 531); and

6) missing survival to discharge data. The final sample comprised 298 adult patients from one hospital and 22 inpatient units. Hospital units included for analysis as defined by National Database of Nursing Quality Indicators (NDNQI) included critical care, step down, medical, combined medical-surgical, rehab, and emergency department (Montavalo, 2007).

Procedures

Recruitment, consent, and data collection. Consent, recruitment, or primary data collection was not required for this study. After Institutional Review (IRB) exemption was obtained, a request was sent to the GWTG coordinator at the Office of Clinical Affairs at the research institution for access to the dataset. The de-identified patient data was provided via several Excel files that were combined into one database and imported into SPSS software for analysis. Staffing data were obtained from the staffing payroll database housed within the same university. Staffing data were matched based on the year, month and time of the event and were imputed manually into an Excel spreadsheet. A letter of support was obtained from the Department of Research, Quality and Innovation at the selected institution (Appendix A).

Measures

Independent Variables

Measurement for nurse staffing consists of *actual number of hours of care* delivered by RNs (American Nurses Association, 1997, 2000; Lichtig, Knauf, & Milholland, 1999) and *RN hours as a percentage of all nursing care hours*, referred to as skill mix and nurse intensity (American Nurses Association, 1997, 2000; Lichtig et al., 1999; Needleman et al., 2002).

Registered nurse hours per patient day (RNHPPD). The concept of RNHPPD refers to the overall time expended by RNs working on the unit that is relative to the patient workload (Joint Commission, 2004). RNHPPD is operationalized as the total RN hours per day divided by the number of patients per day. RNHPPD takes into account the actual productive hours that are worked by nursing staff assigned to the unit who have direct patient care responsibilities for greater than 50% of their shift (Joint Commission, 2004). Productive hours are not budgeted or scheduled hours and exclude vacation, sick time, orientation, education leave, or committee time (ANA, 2009).

Hours per patient day (HPPD). HPPD refers to the overall time expended by the RNs, LPNs, and NAs working on the unit per patient day. HPPD values were calculated as the sum of the total nursing hours per patient day divided by the number of patient days.

Skill mix. Skill mix is the calculation of the percentage registered nurse care hours.

Time-to-defibrillation. Time-to-defibrillation is defined as the interval (in minutes) from the event onset to the initiation of cardiopulmonary resuscitation. This variable was calculated by subtracting the time of collapse from the time when defibrillation was first initiated (Cummings, 1997).

Other key variables. Other variables for the study included illness categories: 1) medical cardiac; 2) medical non-cardiac; 3) surgical cardiac; and 4) surgical non-cardiac. The time of arrest were categorized into: 1) day shift (between the hours of 7:00 a.m. - 2:59 p.m.); 2) evening shift (between the hours of 3:00 p.m.-10:59 p.m.), and night shift (between the hours of 11:00 p.m. and 6:59 a.m.). Dichotomous variables included intensive care units (ICU) and monitored units. Pre-resuscitation factors found to predict cardiopulmonary event mortality in hospitalized adults were also added to the model (Larkin et al., 2010). These predictors include age, black race, non-cardiac illness categories, pre-existing malignancy, acute stroke, trauma, septicemia, hepatic insufficiency, and pre-arrest use of vasopressors and assisted/mechanical ventilation. In addition, cardiac monitoring and shockable initial pulseless rhythms are strongly associated with survival (Larkin et al., 2010). Predictor variables were dichotomized (0 = no, 1 = yes) for analysis.

Dependent Variables

Survival to discharge. Survival to discharge is operationalized as 0 = died and 1 = survival to discharge.

Instruments

Get With the Guidelines (GWTG) dataset. The *Get with the Guidelines* (GWTG) dataset is a prospective, multi-center, observational registry of in-hospital cardiac arrest and resuscitation (Hunt et al., 2009). The main purpose of the GWTG data set is to gather information for hospitals to support performance improvement and evidence based practice (American Heart Association, 2009a). Documentation and dissemination of data are expected to follow the Utstein framework guidelines for in-hospital cardiac arrest (Cummins, 1997). The guidelines recommend comparing the "key elements" of in-hospital processes that are major "links" in the chain of survival (Hunt et al., 2009). The Chain of Survival Framework links include: 1) access to emergency response system; 2) early cardio-pulmonary resuscitation; 3) early defibrillation; and 4) early advanced cardiac life support (Hunt et al., 2009).

Hospitals participating in GWTG database appoint a coordinator to maximize accuracy, reliability, and validity of the data. Coordinators must pass the GWTG exam to ensure data integrity. The GWTG has a variety of training options available that ensure that all participants are abstracting and interpreting data similarly as well training to help increase pass rates on the certification exam. Training options include interactive web based training and live web-based training sessions. Outcome Sciences, Inc. manages the GWTG data centrally. The data collection software has extensive built-in data quality checks on data completeness, accuracy, range, date order, and validity. In addition, data is entered and checked for completeness in real time (AHA, 2009b). There were no published validity or reliability studies for review.

Data Analyses

The unit of analysis was the patient. At the completion of staffing data input missing data were assessed for completeness. First, descriptive statistics were conducted on patient and event characteristics by survival to discharge to describe the features of the sample. Second, chi-square statistics were conducted on all categorical variables to determine significance between groups; independent t-tests were conducted to determine difference in means for continuous variables. Third, mean staffing by survival to discharge was conducted and tested for significance using an independent t-test. Fourth, staffing variables (RNHPPD, HPPD, skill mix) were tested for correlations to assess potential multicollinearity issues. Fifth, an independent t-test was conducted to test for difference in RHPPD means between survival groups. Sixth, bivariate logistic regressions were run against the dependent variable to determine which covariates should be added to the final model. Finally, a generalized estimating equation model was used to take into account clustering within units that could result in possible correlations among observations in the same unit (Diggle, Heagerty, Liang, & Scott, 2002). The Statistical Package for the Social Sciences (SPSS) software version 19.0 was used to run the analyses in this study.

Missing Data

All time variables in the study were deemed necessary and therefore it was imperative to assess missing data prior to analysis. Cases that did not include an event time or time-to-defibrillation were excluded from analysis, as this was the study's key process variable. Following the completion of data entry, 30% of staffing data were rechecked for accuracy and completeness. There were 7 cases with missing staffing information at the time of the event. Staffing data for these events were not available due to hospital restructuring during the time of the event. In addition there was one case that did not have a discharge data point recorded. Missing values were assumed to have occurred at random; therefore missing cases were not deleted and were included in the analysis. Overall, there were less than 5% missing items at the variable level across all items, which is below the 10% threshold (McKnight, McKnight, Sidani & Figuerdo, 2007).

Results

Patient Characteristics by Survival to Discharge

Table 3.1 depicts the patient characteristics by survival to discharge. The final analytic sample was 298. In addition, there were 22 units included in the analysis. Twenty-two percent (n = 68) of the sample survived to discharge. The mean age of survivors was 55. A higher frequency of males (n = 49) than females survived to discharge. The majority of the survivors were of white race (72%), followed by black race (14%). Almost 50% of the patients that survived to discharge were admitted in the ICU at the time of the arrest. Cardiac patients had the highest percentage of survivors when compared to other illness categories (33.8% for both medical and cardiac). The most frequent medical condition for survivors was hypotension (35.5%) followed by hepatic insufficiency (30.9%). Fifteen percent of survivors reported a history of a prior cardiopulmonary arrest. Using chi-square and t-test statistics, differences between groups were analyzed. There were significant differences noted between patient characteristics of those who survived and of those who did not. ICU patients were more likely to survive than non-ICU patients; cardiac patients were more likely to survive to discharge (43%) than non-cardiac patients (21%); and patients with hypotension or hypoperfusion were more likely to expire prior to discharge (54%).

Table 3.1. Patient Characteristics by Survival to Discharge (*N* = 298)

	Did Not Survive to Discharge (N = 230)		*Survived to Discharge (N = 68)*		
Covariates	*N*	%	*N*	%	p value
Age[a]	230	58.48 (7.80)	68	55.49 (2.59)	.116
Female	89	38.7	19	27.9	
Race					.86
White	161	70.0	49	72.1	
Black	25	10.9	10	14.7	
Asian/Pacific Islander	5	2.2	1	1.5	
Hispanic origin	9	3.9	3	4.4	.85
ICU unit	142	61.7	33	48.5	.05
Illness category					<.001
Medical cardiac	70	30.4	23	33.8	
Medical non-cardiac	86	37.4	10	14.7	
Surgical cardiac	30	13.0	23	33.8	
Surgical non-cardiac	39	17.0	11	16.2	
Trauma	5	2.2	1	1.5	

(continued)

Table 3.1. Patient Characteristics by Survival to Discharge (*N* = 298) (continued)					
	Did Not Survive to Discharge (*N* = 230)		Survived to Discharge (*N* = 68)		
Covariates	*N*	%	*N*	%	p value
Pre-existing medical conditions					
Metastatic or hematologic malignancy	25	10.9	4	5.9	.350
Hepatic insufficiency	30	13.0	5	7.4	.28
Septicemia	35	15.2	11	16.2	.84
Major trauma	4	1.7	1	1.5	.88
Acute stroke	6	2.6	1	1.5	.30
Hypotension	123	53.5	24	35.3	.69
Prior cardiopulmonary arrest	58	10.9	20	14.7	.75

Note: ICU=Intensive care unit
[a] Mean age with standard deviation

Event Characteristics by Survival to Discharge

Event characteristics by survival to discharge are reported in Table 3.2. Over 80% of survivors had a first pulseless rhythm of ventricular fibrillation or ventricular tachycardia. The most common vasopressor in survivors was dobutamine (7.4%). The evening shift had the highest percentage of those who survived to discharge (46%). Three percent of survivors received MET intervention (n = 9). Most patients were monitored, however the analyses revealed that survival frequency was 2% higher in survivors. Assisted ventilation was present in 43% percent of survivors (n = 29). Median time-to-defibrillation for survivors was three minutes, compared to five minutes for non-survivors. Using chi-square and t-test statistics, differences between groups were analyzed. Patients who presented with an initial shockable rhythm of ventricular fibrillation or ventricular tachycardia were almost twice as likely to survive to discharge.

Overall staffing levels were slightly higher for survivors, however significant differences in staffing levels between survivors and those who expired were not found (see Table 3.3).

Table 3.2. Event Characteristics by Survival to Discharge (*N* = 298)

	Did Not Survive to Discharge (N = 230)		*Survived to Discharge (N = 68)*		*p value*
Variables	*N*	%	*N*	%	
First pulseless rhythm (VT/VF)	106	46.1	55	80.9	**<.001**
Continuous epinephrine	10	4.3	3	4.4	.98
Continuous phenylephrine	17	7.4	1	1.5	**<.05**
Continuous dopamine		12.0		6.2	.09
Continuous dobutamine	17	7.4	5	7.4	.99
Event time category (shift type)					.40
Days	70	30.4	18	26.5	
Evenings	84	36.5	31	45.6	
Nights	76	33.0	19	27.9	
Medical Emergency Team	9	3.9	2	2.9	.71
Monitored	211	91.7	64	94.1	.52
Assisted Ventilation	104	45.2	29	42.6	.71
Time-to-defibrillation[a]	230	5 (0, 42)	68	3 (0, 60)	**<.001**

[a] Median time-to-defibrillation with min., max. values

Table 3.3. Mean Staffing by Survival to Discharge and Independent T-test (*N* = 298)

	Survival to Discharge		T-test
Substance	No (*n* = 224)	Yes (*n* = 67)	p value
RNHPPD	4.79 (1.73)	4.65 (1.60)	.224
HPPD	5.77 (1.80)	5.73 (1.74)	.401
Skill Mix	0.81 (0.09)	0.80 (0.09)	.234

Note: RNHPPD=Registered Nurse hours per patient, HPPD=Hours per patient day.

Bivariate Analysis

Analyses were conducted to test for correlations among the independent staffing variables and the dependent variable time-to-defibrillation. Table 3.4 depicts the relationship between the staffing variables (RNHPPD, HPPD, Skill Mix) and time-to-defibrillation. All staffing variables were found have strong positive correlations almost perfectly and therefore HPPD and skill mix were dropped from further analyses.

Table 3.4. Correlations of Staffing Variables and Time-to-Defibrillation (*N* = 299)

	1	*2*	*3*
RNHPPD	--		
HPPD	.961**	--	
Skill Mix	.604**	.377**	--

Note: RNHPPD=Registered Nurse hours per patient, HPPD=Hours per patient day.
***p* < .001.

As a result of the large number of predictor variables for survival to discharge, logistic regression analyses were conducted on each independent variable for patient characteristics and event characteristics on the dependent variable (survival to discharge). Significant patient characteristics included unit type (ICU), cardiac illness category, and hypotension. Results are displayed in Table 3.5. Significant event characteristics (see Table 3.6) included initial rhythm of VT or VF (β = -1.67, p = .000) and as expected, time-to-defibrillation (β = -0.13, p = .000).

Table 3.5. Logistic Regressions of Patient Characteristics. Dependent Variable, Survival to Discharge (*N* = 298)

Covariate	*β*	*SE β*	*p value*	*Exp(β)*	*95% CI*
Age	-.010	0.08	.20	0.99	[0.974,1.01]
Black	-0.30	0.41	.46	0.74	[0.33, 1.64]
ICU	0.54	0.28	**.05**	1.71	[0.99, 2.95]
Cardiac illnesses	-1.00	0.29	**.00**	0.37	[0.21, 0.65]
Cancer (metastatic)	0.67	0.56	.23	1.95	[0.65, 5.81]
Hepatic insufficiency	-0.63	0.50	.20	0.53	[0.24, 0.42]
Septicemia	-0.08	0.38	.84	0.93	[0.44, 1.95]
Acute stroke	0.58	1.09	.59	1.79	[0.21, 15.15]
Major trauma	0.17	1.13	.88	1.18	[0.13, 10.78]
Hypotension	0.75	0.29	**.01**	2.12	[1.21, 3.72]
Prior CPA	-0.35	0.40	.39	0.71	[0.32, 1.56]

Note. ICU=Intensive Care Unit, CPA=Cardiopulmonary Arrest

Table 3.6. Logistic Regressions of Event Characteristics. Dependent Variable, Survival to Discharge (*N* = 298)

Covariate	*β*	*SE β*	*p value*	*Exp(β)*	*95% CI*
First pulseless rhythm (VT/VF)	-1.67	0.35	**.00**	0.19	[0.10, 0.37]
Continuous epinephrine	-0.02	0.67	.98	0.99	[0.26, 3.69]
Continuous phenylephrine	1.68	1.04	.11	5.35	[0.70, 40.94]
Continuous dopamine	0.91	0.55	.10	2.49	[0.85, 7.33]
Continuous dobutamine	0.01	0.53	.99	1.01	[0.36, 2.83]
Continuous norepinephrine	0.48	0.38	.21	1.61	[0.77, 3.38]
Event time category (shift type)					
Days	0.20	0.31	.53	1.22	[0.66, 2.23]
Evenings	-0.38	0.28	.18	0.69	[0.40, 1.19]
Nights	0.24	0.30	.43	1.27	[0.70, 2.31]
Medical Emergency Team Event	0.30	0.79	.71	1.34	[0.28, 6.37]
Monitored	-0.37	0.57	.52	0.69	[0.23, 2.11]
Assisted Ventilation	0.10	0.28	.71	1.11	[0.64, 1.92]
Time-to-Defibrillation	-0.13	0.03	**.00**	0.88	[0.82, 0.94]
RNHPPD	0.05	0.09	.54	1.05	[0.89, 1.25]

Note. VF=Ventricular Fibrillation, VT=Ventricular Tachycardia, RNHPPD=Registered Nurse Hours per Patient Day.

Hypothesis Testing

Hypothesis testing was conducted using a generalized estimating equation model (GEE) to examine the following hypothesis for the relationship between nurse staffing, time-to-defibrillation, and survival to discharge. In addition to controlling for age, black race, gender, event time, and RNHPPD, other significant patient and event variables where added to the final model.

The hypothesis that nurse staffing and time-to-defibrillation will predict survival to discharge of IHCA patients was partially supported. The results of the model indicate that one more hour per patient day of RN care results in a 28% greater odds of surviving to discharge after controlling for other factors in the model. In addition, ICU patients within this sample had a 72% lesser odds surviving to discharge. Furthermore, patients with a first pulseless rhythm of VT or VF are three times as likely to survive to discharge, and patients with cardiac admitting diagnoses were twice as likely to survive to discharge. Patients with hypotension had 65% lesser odds of surviving to discharge. Further, patients with less time to defibrillation were more likely to survive to discharge, although results were not significant (*OR* = .93, *CI* [.87, 1.00], *p* = .06). The remaining predictors in the model were not significant. Results for the model are depicted in Table 3.7.

Table 3.7. Generalized Estimating Equation Model for Significant Covariates. Dependent Variable, Survival to Discharge (*N* = 254)

Covariate	*β*	*SE β*	*p value*	*Exp(β)*	*95% CI*
Event time category (shift type)					
Days	-0.54	0.40	0.89	0.94	[0.43, 2.07]
Evenings	0.31	0.25	0.22	1.36	[0.83, 2.22]
[Nights][a]					
Female	-0.19	0.24	0.42	0.83	[0.52, 1.32]
ICU	-1.27	0.34	**0.00**	0.28	[0.14, 0.55]
Cardiac illnesses	0.71	0.23	**0.01**	2.04	[1.19, 3.49]
Hypotension	-1.05	0.23	**0.00**	0.35	[0.22, 0.56]
First pulseless rhythm VF/VT	1.23	0.45	**0.00**	3.56	[1.49, 8.52]
RNHPPD	0.25	0.07	**0.00**	1.28	**[1.12, 1.46]**
Black race	0.47	0.44	0.29	1.60	[0.67, 3.80]
Time to Defibrillation	-0.07	0.04	**0.06**	0.93	[0.87, 1.00]

Note. VF=Ventricular Fibrillation, VT=Ventricular Tachycardia, ICU=Intensive Care Unit, RNHPPD=Registered Nurse Hours per Patient Day.
[a] Reference category in brackets.

Discussion

The purpose of this paper was to investigate the association between nurse staffing, time-to-defibrillation, and survival to discharge of patients inflicted with IHCA. This study extends upon the current literature in health services research that investigates the relationship between nurse staffing and survival. This is the first known study that examined the relationship between nurse staffing, time-to-defibrillation, and survival to discharge of IHCA patients. It is unlike previous studies as past research on nurse staffing have examined staffing at the hospital or unit level and patient outcomes in terms of failure to rescue or 30-day mortality (Silber, Williams, Krakauer, & Schwartz, 1992; Silber et al., 995; Needleman et al., 2002; Aiken et al., 2002; Aiken et al., 2003; Kane et al., 2007; Jiang, Stocks, & Wong, 2006). In this regard, the current study marks an important departure from other empirical findings about the relationship between nurse staffing and cardiac arrest outcomes by capturing the work environment during a cardiac arrest as it actually occurred. In this study, the structure-process-outcome model was tested in regards to staffing, time-to-defibrillation, and survival to discharge in IHCA patients.

The hypothesis that nurse staffing and time-to-defibrillation will predict survival to discharge of IHCA patients was partially supported. The results of the final model indicated that patients with less time to defibrillation were more likely to survive to discharge, although results were not significant. Further, patients with less time to defibrillation were more likely to survive to discharge, although results were not significant. Chan et al.'s (2008) study found several factors relating to the hospital setting were associated with delayed defibrillation times, these included IHCAs that occurred on the evening and night shifts and unmonitored patients. Researchers concluded that the findings imply that response times could be related to the availability of staff; however, this hypothesis was not explored empirically in their study. Furthermore, median time-to-defibrillation for survivors was two minutes less than for non-survivors, and they differed significantly. As in this present study, decreased time to defibrillation has been associated with survival (Chan et al., 2008; Chan et al., 2009).

The main finding of this study specifies that more RN hours per patient day result in 28% greater odds of survival. In addition, overall staffing levels were slightly higher for survivors; however, significant differences in staffing levels between survivors and those who expired were not found. In their systemic review and meta-analysis, Kane et al. (2007) found that increased staffing was associated with lower hospital related mortality and that an increase by one RN hours per day was associated with a decreased odds ratio of cardiac arrest. Moreover, a study examining 799 hospitals in 11 states found that a higher proportion of hours per day provided by a nurse was associated with fewer incidences of cardiac arrest and failure to rescue. However, they did not find an association between staffing and in-hospital mortality (Needleman et al., 2002). In terms of arrests on shift type, most IHCAs occurred on the evening shift, which also included half of survivors within the sample; however, significant differences were not noted. This could possibly indicate lack of identification of early warning signs of the physical deterioration that is present six to eight hours prior to cardiac arrest (Schein et al., 1990).

Identification of early warning signs is imperative to improve patient outcomes for IHCA. Although staffing is typically highest on the day shifts, it is also considered a "busy" shift when attending physicians and residents make rounds, patients leave the unit for diagnostic tests, visiting hours are active, or full daily care is provided to patients. One study found that 70% of patients showed evidence of deterioration in respiratory or mental function within 8 hours of a cardiac arrest (Schein et al., 1990). Consequently, nurses might be overwhelmed with daily tasks and distractions, and therefore slight changes in the patient's condition may not be recognized or acted upon promptly.

The patient characteristics found within this sample are similar to findings in other studies that examine IHCA with the national GWTG dataset. Most of the patients were white and male, similar to a study conducted on 14,720 patients in the national database (Peberdy et al., 2003). Survival within this cohort was about five percent higher than the national database, and mean age was about 10 years younger (Peberdy et al., 2003). In this study, patients with hypotension or hypoperfusion were more likely to expire prior to discharge, which is a common cause of cardiac arrest (Perbedy et al., 2003). Cardiac diagnosis was found to be more predictive of survival, likely the result of being on a monitored unit where abnormal rhythms are quickly identified and proper equipment is more readily available (Peberdy et al., 2003). This study found that eighty percent of survivors has an initial shockable pulses rhythm (VT or VF), which consequently predicted survival, reflecting a common finding in the current literature that initial shockable rhythm is predictive of survival (Chan et al., 2008; Larkin et al., 2010).

Fifteen percent of survivors reported a history of a prior cardiopulmonary arrest (in or out of the hospital), which is notably higher than other findings of less than one percent of the sample, with most dying prior to discharge (Larkin et al., 2010). This can be explained in part by the fact that cardiovascular disease in Michigan has been reported to have higher prevalence compared to the nation as a whole for a number of years (Michigan Department of Community Health, 2008). There were also significant differences noted between patient characteristics of those who survived and of those who did not. ICU patients were less likely to survive to discharge than non-ICU patients. Patients in the ICU tend to be more acutely ill as expected. In addition, RN staffing in the ICU has not shown to significantly affect inpatient mortality (Sales et al., 2008).

Conclusion

In summary, a key contribution of this study is the finding that one more hour of nursing care increases survival by almost 30% in IHCA patients. In addition, the findings suggest time-to-defibrillation coupled with staffing levels at the time of the event, may be a useful process indicator when looking examining survival of IHCAs. In previous studies addressing nurse staffing and patient outcomes, staffing was analyzed at the unit and hospital level and variations of shift type were not identified. This study provides empirical information on differences in staffing in terms of survival in patients who sustained IHCA. Nurses are considered the true first responders to cardiac arrest, a complication where seconds and minutes count towards quality patient outcomes. Nurses are the providers expected to call a “code,” alert medical staff, and provide immediate cardiopulmonary resuscitation prior to the arrival of rapid response teams or medical emergency teams. Although there has been national debate that more nursing hours may not lead to better patient outcomes—with regards to this study, and in this population, the opposite may be true.

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Chapter IV

The Impact of Nurse Staffing on Neurological Outcomes in Patients with In-Hospital Cardiac Arrest

Background

Historically, research on cardiac arrest outcomes has been directed towards survival to discharge. Although survival is of significant importance to clinicians and patients, survival is only a determinant of immediate and short-term outcomes and measures of longer-term survival are not accounted for. Even if a patient survives, dysfunction of other organ systems can be present which will affect the quality of life and health care utilization. In one study, more than 30% of survivors who were discharged from the hospital were either released to a rehabilitation center or skilled nursing home where fewer than six percent lived in such a facility prior to the cardiac arrest (Peberdy et al., 2003). Consequently, appropriate outcome measures are needed in addition to survival as a way to predict and account for patient conditions in long-term myocardial recovery and quality of life. Survival without higher neurological function is suboptimal; therefore, it is important to assess neurological outcomes at time of discharge.

A consensus statement from the American Heart Association presented guidelines for research of clinical outcomes from cardiac arrest (Becker et al., 2011). The goal of cardiopulmonary resuscitation is not only to restore biological function, but also to achieve pre-arrest neurological functions (Cummins, 1997). In context to Utstein-style reporting, the Cerebral Performance Category (CPC) was developed as the central nervous system outcome measure (Edgren, Hedstrand, Kelsey, Sutton-Tyyrell, & Safar, 1994). The CPC is a simple validated neurological score adapted from the Glasgow Outcome Scale. The CPC incorporates neurological and functional status, is extensively used, simple, and able to be separated into “good” and “poor” categories for outcomes measurement.

The CPC is a common secondary endpoint measuring neurologic and functional status for time-to-defibrillation and has suggested an association between time to defibrillation and patient outcomes (Chan et al., 2008; Peberdy et al., 2003; Perbedy et al., 2008). For hospitalized patients, the time interval from collapse to arrest to first defibrillation attempt may be the most important process indicator of effective response when ventricular fibrillation (VF) or ventricular tachycardia (VT) is the initial cardiac rhythm for hospitalized (Jacobs et al., 2004). The American Heart Association (AHA) recommends that all hospitalized patients with VF or VT should receive defibrillation therapy within two minutes after recognition of cardiac arrest. Early time to defibrillation is associated with better neurological outcomes. In their study of 6,789 patients within 369 hospitals, early defibrillation was associated with significantly lower likelihood of having no major disabilities in neurological status or functional status (Chan et al., 2008). Further, Peberdy et al. (2008) reported that favorable neurological outcomes were substantially lower during the night compared with day or evenings, suggesting that shift type and staffing might possibly have an interaction effect between time-to defibrillation and neurological outcomes.

Despite the frequent use of in-hospital “code” teams, nurses are typically the first responders to in-hospital arrest and frequently provide defibrillation and cardiopulmonary resuscitative treatment prior to the arrival of the rapid response team (Coady, 1999; Spearpoint, McLean, & Zideman, 2000). Health services researchers have engaged in exploration of nurse staffing levels and outcomes. The link between nurse staffing and survival has been thoroughly explored in the literature. Nurse staffing has been associated with lower risk-adjusted likelihoods of cardiac arrest in intensive care, surgical, and medical patients (Kane et al., 2007). Studies in recent years have explored the association between staffing on reduced patient mortality (Aiken et al., 2002; Belgen, Goode, & Reed, 1998; Jiang, Stocks, & Wong, 2006; Mark, 2004; Needleman et al., 2002, & Sales, 2008); medication errors (Belgen & Vaughn, 1998); and failure to rescue (FTR) (Aiken et al., 2002; Jiang, Stocks, & Wong, 2006; Silber, Rosenbaum, Schwartz, Ross, & Williams, 1995; Silber, Williams, Krakauer, & Schwartz, 1992). Moreover, lower nurse-to-patient ratios have also been associated with higher instances of shock and cardiac arrest-related incidence of pneumonia (Needleman et al., 2002). Needleman et al (2002) reported that an increase in registered nurse hours per patient day was associated with lower risks of pneumonia, cardiac arrest, and failure to rescue. Furthermore, an increase by one RN per patient day is associated with decreased odds of cardiac arrest and in the intensive care unit, a lower risk of failure to rescue in surgical patients (Kane et al., 2007). Despite these findings, there has been no research conducted on the “process,” such as time-to-defibrillation, in which nurses respond to cardiac arrest and how that is associated with neurological outcomes. Further, most research on neurological outcomes of IHCA has been focused on physiological functions and medical treatments aimed at improving CPC at discharge and over longer periods of observation after discharge. Overall, it remains unclear if and how nurse staffing influences response times and neurological outcomes of IHCA. Accordingly, exploration of the relationships between nurse staffing, time-to-defibrillation and neurological outcomes is warranted.

The purpose of this paper was to investigate the association between nurse staffing, time-to-defibrillation, and neurological outcomes of survivors after IHCA. For this study, nurse staffing is defined as registered nurse hours per patient day (RNHPPD), total hours per patient day (HPPD), and skill mix. Time-to-defibrillation is defined as the reported time from initial recognition of cardiac arrest to the reported time of first attempt to defibrillation. Neurological status is defined through cerebral performance categories and classified into either *favorable* or *unfavorable* neurological status.

Conceptual Model

The conceptual model used to guide this study was the Donabedian Triad concept for quality assessment (Donabedian, 1988). The model has three essential and non-mutually exclusive components that include structure, process, and outcome. *Structure* refers to the setting where care occurs, which may be related to staffing, human resources or other organizational structures. The assessment of structure enables evaluation of the health care setting as well as functions available to be used for the delivery of care. *Process* refers to the manner in which care is delivered. The assessment of process requires the evaluation of the activities of health care providers, such as nurses, in patient management. Finally, *outcome* assessment evaluates the end result in terms of the health status of the patient (Wyszewianski & Donabedian, 1981). These three categories enable conclusions to be drawn about the quality of healthcare services. It is hypothesized that strong structures will produce strong processes and in turn produce strong outcomes (Donabedian, 1988).

This model will be used to explain the relationships between nurse staffing (structure), time-to-defibrillation (process), and neurological status at discharge (outcome) of IHCAs. An influential relationship is implied, which begins at the structure, extends through the process, and completes at the outcome. The implied relationships can be used to assess the entirety of the quality of care surrounding cardiac arrest in the hospital, although a cause and effect relationship should not be assumed. In this paper, the relationship between nurse staffing (structure), time-to-defibrillation (process), and neurological status at discharge (outcome) is examined as represented in the model. This research focused on all aspects of this model, which is operationalized by nurse staffing (RNHPPD, HPPD, and Skill Mix), time-to-defibrillation, and favorable or unfavorable neurological status at discharge. These constructs are described below and illustrated in Figure 4.

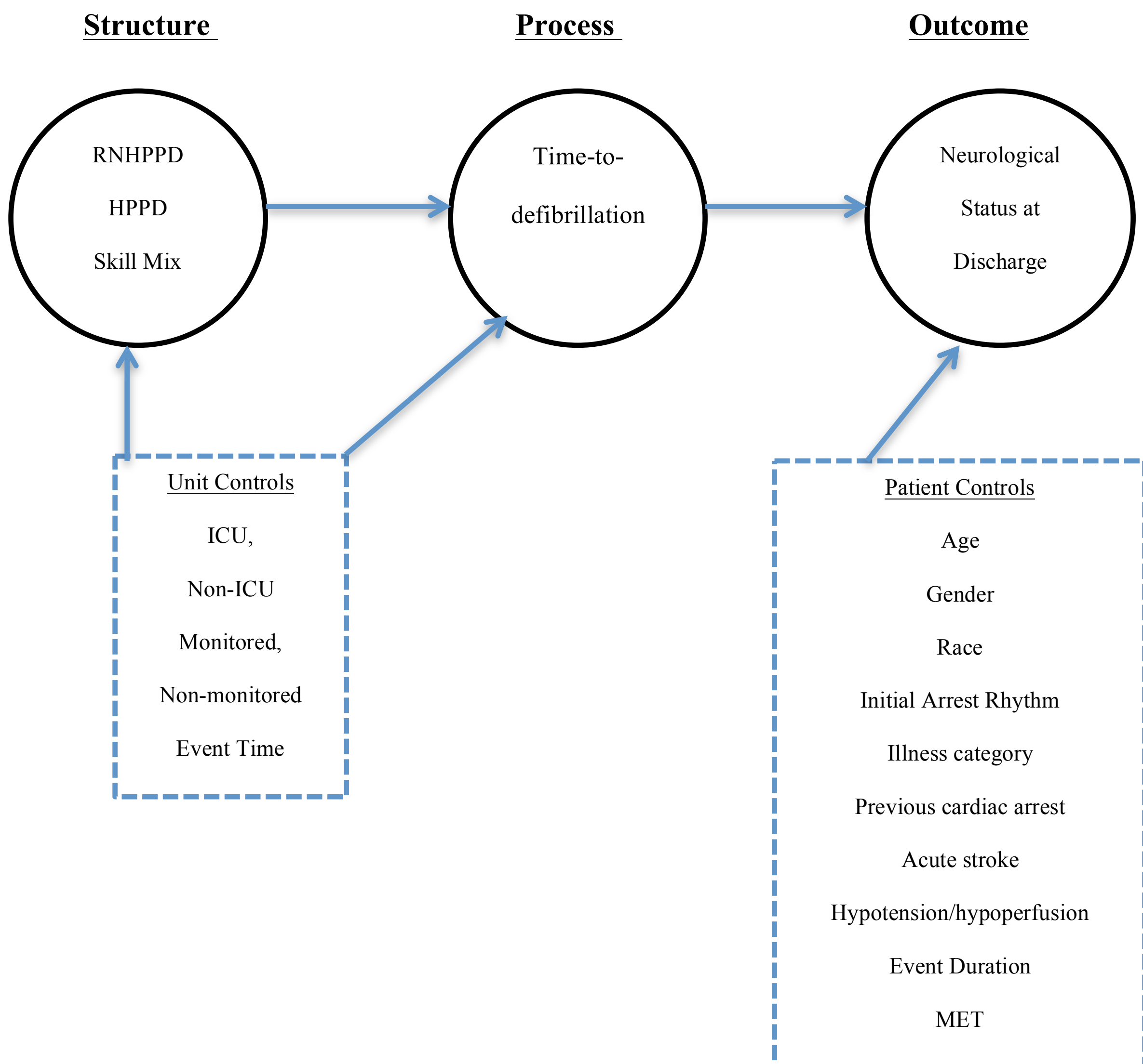
Measures of nurse staffing. Measurement for nurse staffing consists of *actual number of hours of care* (called nursing hours) delivered by RNs (American Nurses Association, 1997, 2000; Lichtig, Knauf, & Milholland, 1999) and *RN hours as a percentage of all nursing care hours*, referred to as skill mix and nurse intensity (American Nurses Association, 1997, 2000; Lichtig et al, 1999; Needleman et al, 2002). Other studies (Kovner & Gergen, 1998; Kovner, Jones, Zahn, Gergen, & Basu, 2002; Mark, Harless, McCue, & Xu, 2004) have measured nurse staffing as the number or percentage of RN full-time equivalents (FTEs). The use of hours of care as an operational definition of nurse staffing may reflect a different construct than when nurse staffing is operationalized as FTEs (Mark, 2006). Hours of care reflect nursing care actually delivered to patients—assuming they are worked hours rather than just paid hours that are measured. In contrast, FTEs are thought of as a construct that reflects just the hospital's capacity to deliver nursing care (Mark, 2006).

The American Nurses Association developed this measure for the National Database of Nursing Quality Indicators (NDNQI). The nurse staffing indicators that are used in the NDNQI measure include: total nursing care hours per patient day, RN nursing care hours per patient day, and the percent of total nursing care hours provided by RNs (Joint Commission, 2004). Registered nurse hours per patient day (RNHPPD) is the actual productive hours worked by nursing staff who have direct patient care responsibilities for greater than 50% of their shift (Joint Commission, 2004). Productive hours are not budgeted or scheduled hours and exclude vacation, sick time, orientation, education leave, or committee time (American Nurses Association, 2009).

Time-to-defibrillation. Time-to-defibrillation is the interval when the first shock is delivered after a witnessed or monitored cardiac arrest (Jacobs et al., 2004). In 2002, the International Liaison Committee on Resuscitation (ILCOR) published a series of guidelines to be used for consistent reporting of adult in-hospital resuscitation based on the Utstein-Style definitions for reporting in-hospital cardiac arrests (Cummins, 1997). ILCOR defines cardiac arrest as "the cessation of mechanical activity as confirmed with the absence of signs or circulation" (Jacobs et al., 2004, p. 3387). ILCOR recommends that time should be recorded in real-time when the first shock is delivered. Further, they recommend that the best way to obtain this information be through a conventional defibrillator with automated event documentation if available. The defibrillator provides precise details about initial rhythm, times, and responses of the therapy (Jacobs et al., 2004). In addition, the time of first rhythm analysis or assessment of need is when a cardiac rhythm is analyzed for a shockable rhythm, when the provider clinically assesses the need for cardiopulmonary resuscitation (CPR), or when a defibrillator is initially attached to the patient and turned on. For in-hospital patients on continuous ECG monitoring, this is the time when the provider attempts to interpret the ECG for a shockable rhythm (Jacobs et al., 2004).

Neurological status at discharge. Neurological status is conceptually defined by the nervous system outcome measure Cerebral Performance Category (CPC) (Edgren et al., 1994). Within the context of Utstein reporting, the CPC is the most commonly used standard for post-resuscitation outcome management. The CPC is adapted from the Glascow Outcome Scale for traumatic head injury. In comparison, the CPC is noted for its simplicity and ability to separate neurological outcomes into “good” or “bad” distinctions (Beck et al., 2011). Good status is indicative of a CPC 1 (where the patient is conscious, alert, able to work, and might have mild neurologic or psychological deficit) and CPC 2 (indicating moderate cerebral disability, and when the patient is conscious, has sufficient cerebral function for independent activities of daily life, and is able to work in sheltered environment). Poor status is indicative of a CPC 3 (where the patient has severe cerebral disability and is conscious, is dependent on others for daily support because of impaired brain function, and where neurological status ranges from ambulatory state to severe dementia or paralysis) and CPC 4 (indicating coma or vegetative state where the patient has any degree of coma without the presence of all brain death criteria or unawareness, even if the patient appears awake without interaction with the environment.

Figure 4. Conceptual Model Depicting the Relationship Between Nurse Staffing, Time-to-Defibrillation, and Neurological Status at Discharge



Research Questions and Hypothesis

This paper seeks to examine the relationship between nurse staffing (RNHPPD, HPPD, and skill mix), time-to-defibrillation, and neurological status at discharge of IHCA patients**.** The research question (Q) and hypothesis (H) are:

Q: To what extent does nurse staffing (RNHPPD, HPPD, Skill Mix) and time-to-defibrillation have on favorable neurological status at discharge of IHCA patients?

H1: Nurse staffing and time-to-defibrillation will predict neurological status of IHCA patients.

Methods

Design

A descriptive correlational design was used to examine the relationship between nurse staffing, time-to-defibrillation, and survival to discharge. This study was a secondary data analysis of the American Heart Association's Get with the Guidelines (GWTG) in-hospital cardiac arrest data set. The study was cross-sectional in that staffing data and in-hospital cardiac arrests were examined at a single time point.

Sample and Setting

The analysis included one Midwestern tertiary teaching center with 30 inpatient units with a total bed capacity of 550. The sample consisted of adult patients aged 18 and older who sustained and survived an IHCA between May 2004 and December 2009. The sample was drawn from the GWTG data set from the same institution. Exclusions from the sample included: 1) patients with missing event time data (n = 1277); 2) patients under the age of 18 (n = 608); 3) unit type (obstetrics) or missing event location data (n = 151); 4) patients with ICDs (n = 21); and 5) missing time-to defibrillation data (n = 531).

Survivors accounted for 194 patients within the entire sample. However, there were some cases with missing neurological status at the time of discharge (n = 12) and they were excluded from analysis.

The final sample yielded a sample size of 182. Hospital units included for analysis as defined by National Database of Nursing Quality Indicators (NDNQI) are critical care, step down, medical, combined medical-surgical, rehab, and emergency department (Montavalo, 2007).

Procedures

Recruitment, consent, and data collection. Consent, recruitment, or primary data collection was not required for this study. After Institutional Review (IRB) exemption was obtained, a request was sent to the GWTG coordinator at the Office of Clinical Affairs at the research institution for access the dataset. The de-identified patient data was provided via several Excel files that was combined into one database and imported into SPSS software for analysis. Staffing data were obtained from staffing productivity reports at the time of the arrest.

Measures

Independent Variables

Measurement for nurse staffing consist of *actual number of hours of care* delivered by RNs (American Nurses Association, 1997, 2000; Lichtig, Knauf, & Milholland, 1999) and *RN hours as a percentage of all nursing care hours*, referred to as skill mix and nurse intensity (American Nurses Association, 1997, 2000; Lichtig et al., 1999; Needleman et al., 2002).

Registered nurse hours per patient day (RNHPPD). The concept of RNHPPD refers to the overall time expended by RNs working on the unit that is relative to the patient workload (Joint Commission, 2004). RNHPPD is operationalized as the total RN hours per day divided by the number of patients per day. RNHPPD takes into account the actual productive hours that are worked by nursing staff assigned to the unit who have direct patient care responsibilities for greater than 50% of their shift (Joint Commission, 2004). Productive hours are not budgeted or scheduled hours and exclude vacation, sick time, orientation, education leave, or committee time (American Nurses Association, 2000).

Hours per patient day (HPPD). HPPD refers to the overall time expended by the RNs, LPNs, and NAs working on the unit per patient day. HPPD values were calculated as the sum of the total nursing hours per patient day divided by the number of patient days.

Skill mix. Skill mix is the calculation of the percentage of registered nurse care hours.

Time-to-defibrillation. Time-to-defibrillation is defined as the interval (in minutes) of the event onset to the initiation of cardiopulmonary resuscitation. This variable was calculated by subtracting the time of collapse from the time when defibrillation was first initiated (Cummins, 1997).

Other key variables. Other variables for the study included illness categories: 1) medical cardiac; 2) medical non-cardiac; 3) surgical cardiac; and 4) surgical non-cardiac. The time of arrest was categorized into: 1) day shift (between the hours of 7:00 a.m. -2:59 p.m.); 2) evening shift (between the hours of 3:00 p.m.-10:59 p.m.) and night shift (between the hours of 11:00 p.m. and 6:59 a.m.). Dichotomous variables included intensive care units (ICU) and monitored units. Predictors include age, black race, non-cardiac illness categories, acute stroke, trauma, or assisted/mechanical ventilation. Variables found to be associated with neurological outcomes include: 1) initial neurological function; 2) event duration; 4) initial rhythm; and 5) medical emergency team intervention (Peberdy et al., 2003). Predictor variables were dichotomized (0=no, 1=yes) for analysis.

Dependent Variables

Favorable neurological status. Neurological status was separated into two categories for analysis – *favorable* and *unfavorable* neurological status. Favorable neurological status is characterized as CPC scores of 1 and 2 – representing a fairly normal life with minimal neurological impairments. Unfavorable neurological status is characterized by CPC scores of 3 and 4 – representing diminished neurological functions with significant impacts on daily life. Favorable neurological status was dichotomized (0=unfavorable, 1=favorable).

Instruments

Get With the Guidelines (GWTG) dataset. The *Get with the Guidelines* dataset (GWTG) is a prospective, multi-center, observational registry of in-hospital cardiac arrest and resuscitation (Hunt et al., 2009). The main purpose of the GWTG is to gather information for hospitals to support performance improvement and evidence based practice (American Heart Association, 2009a). Documentation and dissemination of data are expected to follow the Utstein framework guidelines for in-hospital cardiac arrest (Cummins, 1997). The guidelines recommend comparing the “key elements” of in-hospital processes that are major "links" in the chain of survival (Hunt et al., 2009). The Chain of Survival Framework links include: 1) access to emergency response system; 2) early cardio-pulmonary resuscitation; 3) early defibrillation; and 4) early advanced cardiac life support (Hunt et al., 2009).

Each hospital that participates in GWTG appoints a coordinator to maximize accuracy, reliability, and validity of the data. Coordinators must pass the GWTG exam to ensure data integrity. The GWTG has a variety of training options available that help ensure that all participants are abstracting and interpreting data similarly as well as increasing the pass rates on the certification exam. Training options include interactive web based training and live web-based training sessions. Outcome Sciences, Inc. manages the GWTG data centrally. The data collection software has extensive built-in data quality checks on data completeness, accuracy, range, date order, and validity. In addition, data is entered and checked for completeness in real time (AHA, 2005).

Data Analyses

The unit of analysis was the patient. At the completion of staffing data input, missing data were assessed for completeness. First, descriptive statistics were computed on patient and event characteristics by favorable and unfavorable neurological status to describe the features of the sample. Second, Chi-square statistics were conducted on all categorical variables to determine significance between groups and independent t-tests were conducted to determine difference in means for continuous variables. Third, mean staffing by unfavorable and favorable neurological status was conducted and tested for significance using an independent t-test. Fourth, staffing variables (RNHPPD, HPPD, skill mix) were tested for correlations to assess potential multicollinearity issues. Fifth, bivariate logistic regressions were run against the dependent variable to determine which covariates should be added to the final model. Finally, a generalized estimating equation model was used to take into account clustering within units that could result in possible correlations among observations in the same unit (Diggle, Heagerty, Liang, & Scott, 2002). The Statistical Package for the Social Sciences (SPSS) software version 19.0 was used to run the analyses in this study.

Missing Data

It was imperative to assess for missing time data prior to analysis, as all time variables in the study were considered necessary. This study analyzed survivors of in-hospital cardiac arrest. Cases that did not include an event time or neurological status at discharge were excluded from analysis. Thirty percent of staffing data were rechecked for accuracy and completeness, following the completion of data entry. There were 12 cases missing with neurological status at discharge. Overall there were was about 6% of missing items at the variable level across all units, which is below the 10% threshold (McKnight, McKnight, Sidani, & Figuerdo, 2007). These cases were considered missing at random therefore data were not imputed.

Results

Patient Characteristics by Neurological Status

Patient characteristics by favorable and unfavorable CPC status are depicted in Table 4.1. The mean age for patients discharged with a favorable CPC status was 57 (n = 161). White patients comprised most of the ample (n = 182), followed by black patients (n = 26). Whites had a higher rate of favorable neurological outcomes (78%) than blacks (12.4%). More than 50% of patients in a non-ICU unit at the time of the IHCA had unfavorable neurological status. A majority of patients (*n* = 139) who had a favorable CPC admit had favorable CPC status at discharge. One hundred and forty eight (91.9%) monitored patients had favorable CPC at discharge. Surgical non-cardiac patients had the highest frequency of favorable CPC (26.7%), followed equally by medical cardiac (23%) and surgical cardiac (23%) illness categories. Medical non-cardiac patients were more likely to incur unfavorable neurological status at discharge. Approximately 64% of patients without ventilator support had favorable CPC. Patients who did not have a history for a prior CPA were more likely to have a favorable CPC at discharge.

Chi-square statistics were conducted to investigate the relationships between favorable and unfavorable neurological status for patient characteristics. There were significant differences noted between several variables for those with favorable (*n* = 161) and unfavorable (*n* = 21) neurological status. Cardiac patients had less frequency (15%) of unfavorable neurological outcomes than non-cardiac patients (85%). Almost all (*n* = 20) patients with a non-shockable first pulseless rhythm experienced unfavorable neurological status at discharge. Non-ICU patients were found to have significantly better neurological outcomes overall than ICU patients. Furthermore, 86% of patients with favorable neurological status upon admission also experienced favorable neurological status at discharge.

Table 4.1. Patient Characteristics by Favorable and Unfavorable Neurological Status (*N* = 182)

	Unfavorable Neurological Status (N = 21)		*Favorable Neurological Status (N = 161)*		
Patient Characteristics	*N*	*M (SD)* or %	*N*	*M (SD)* or %	p value
Age	21	49.86 (18.91)	161	56.82 (16.62)	
Female	8	38.1	62	38.5	.97
Race					.23
White	14	66.7	126	78.3	
Black	6	28.6	20	12.4	
Asian/Pacific Islander	0	0.0	2	1.2	
American Indian/Eskimo/Aleut	0	0.0	0	0.0	
Hispanic origin	1	4.8	4	2.5	.55
ICU unit	17	81.0	77	47.8	**<.001**
CPC favorable admit	13	61.9	139	86.3	**<.01**
First pulseless rhythm VF/VT	1	4.8	51	31.7	**<.05**
Monitored	19	90.5	148	91.9	.82
Defibrillated	5	23.8	59	36.6	
Illness category					
Medical cardiac	2	9.5	37	23.0	**<.01**
Medical non-cardiac	8	38.1	35	21.7	
Surgical cardiac	1	4.8	37	23.0	
Surgical non-cardiac	7	33.3	43	26.7	
Trauma	2	9.5	9	5.6	
Ventilator support	6	28.6	58	36.0	.50
Pre-existing medical conditions					
Major trauma	2	9.5	5	3.1	.15
Acute stroke	0	0.0	1	0.6	.72
Prior cardiopulmonary arrest	5	23.8	24	14.9	.29

Note: ICU=Intensive Care Unit, CPC=Cerebral Performance Category, VF=Ventricular Fibrillation, VT=Ventricular Tachycardia.

Event Characteristics by Survival to Discharge

Event characteristics are presented in Table 4.2. A total of nine patients received Medical Emergency Team intervention, all of which had favorable CPC at discharge. IHCAs that occurred on the day shift were the most likely to have favorable neurological status at discharge (*n* = 57, 35%). IHCAs with poor neurological status occurred most frequently on the evening shift (*n* = 12).

On average, mean event duration for favorable CPC was just over one minute less than for patients with unfavorable CPC. Moreover, time to defibrillation was less for favorable CPC (M = 2.49, SD = 4.10) than unfavorable CPC (M = 5.80, SD = 4.32). Finally, a significant difference was detected between the time of the event (day, evening or night shift) and neurological status at discharge ($\chi^2(161) = 5.62$, $p = .06$).

Table 4.2. Event Characteristics by Favorable and Unfavorable Neurological Status (*N* = 182)

	Unfavorable Neurological Status (N = 21)		*Favorable Neurological Status (N = 161)*		
Event Characteristics	*N*	*M (SD)* or %	*N*	*M (SD)* or %	p value
Medical Emergency Team	0	0.0	9	5.6	.27
Time of cardiac arrest					.06
Days	3	14.3	57	35.4	
Evenings	12	57.1	53	32.9	
Nights	6	28.6	51	31.7	
Mean event duration	20	5 (0,12)	161	1 (0,18)	.47
Mean time to defibrillation	5	5 (0,12)	59	1 (0,18)	.97

Table 4.3 depicts the staffing characteristics of the sample. Overall, mean staffing was marginally higher for RNHPPD, HPPD, and skill mix for patients with unfavorable neurological status (n = 21). Independent-samples t-tests were conducted to compare RNHPPD, HPPD, and mix for survivors with favorable and unfavorable neurological status at discharge. Results were not significant between groups.

Table 4.3. Staffing Characteristics by Favorable and Unfavorable Neurological Status (*N* = 182)

	Unfavorable Neurological Status (N = 21)		*Favorable Neurological Status (N = 161)*		
Staffing	*N*	*M (SD)*	*N*	*M (SD)*	*p* value
RNHPPD	21	4.87 (1.25)	159	4.68 (1.73)	.538
HPPD	21	5.89 (1.35)	159	5.72 (1.89)	.605
Skill Mix	21	0.82 (0.08)	159	0.81 (0.10)	.523

Note: RNHPPD=Registered Nurse Hours per Patient Day, HPPD=Hours per Patient Day

Bivariate Analysis

All staffing variables were found have strong positive correlations almost perfectly and therefore HPPD and skill mix were dropped from further analyses. Due to the large number of predictor variables for neurological outcomes of IHCA patients, logistic regression analyses were conducted on each independent variable for patient and event characteristics on favorable neurological status. Significant patient characteristics that increase the likelihood of favorable CPC status at discharge included non-ICU patients, cardiac illness category, and first pulseless rhythm of ventricular tachycardia or ventricular fibrillation, and favorable neurological status upon admission. There were only two cases of acute stroke within the sample; therefore, this variable was deleted for analysis. Results are displayed in Table 4.4. Next, simple logistic regressions of event characteristics were completed and are presented in Table 4.5. Significant event characteristics included IHCAs on the evening shift.

Table 4.4. Individual Regressions of Patient Characteristics. Dependent Variable, Favorable Neurological Status (*N* = 182)

Patient Characteristics	*B*	*SE β*	*p value*	*Exp(β)*	*95% CI*
Age	0.02	0.01	.08	1.02	[1.00, 1.05]
Female	0.02	0.48	.97	1.02	[0.40, 2.60]
Black[a]	-1.03	0.54	.06	0.36	[0.12, 1.03]
Cardiac illness[b]	1.57	0.65	**.02**	4.82	[1.36, 17.09]
Monitored	0.18	0.80	.82	1.20	[0.25, 5.72]
ICU	-1.53	0.58	**.01**	0.22	[0.07, 0.67]
First pulseless rhythm VF/VT	2.14	1.04	**.04**	8.50	[1.10, 65.67]
Major trauma	-1.18	0.87	.18	0.31	[0.06, 1.69]
Prior Arrest	-0.58	0.56	.30	0.56	[0.19, 1.67]
Assisted ventilation	0.34	0.51	.50	1.41	[0.52, 3.83]
Favorable status admit	-1.36	0.51	**.01**	0.26	[0.10, 0.69]

Note. ICU=Intensive Care Unit, VF=Ventricular Fibrillation, VT=Ventricular Tachycardia.
[a] Reference category = Not Black (White, Asian/Pacific Islander, American Indian/Eskimo/Aleut, and Other).
[b]Reference category = Non-cardiac illnesses.

Table 4.5. Individual Regressions of Event Characteristics. Dependent Variable, Favorable Neurological Status (*N* = 182)

Event Characteristics	*β*	*SE β*	*p value*	*Exp(β)*	*95% CI*
Days	1.19	0.65	.07	3.29	[0.93, 11.64]
Evenings	-1.00	0.47	**.03**	0.37	[0.15, 0.93]
Nights	0.15	0.51	.77	1.16	[0.43, 3.16]
Event Duration	-0.02	0.03	.51	0.98	[0.94, 1.03]
Time to Defibrillation	-0.14	0.09	.11	0.87	[0.74, 1.03]

Hypothesis Testing

Hypothesis testing was conducted using a generalized estimating equation model to examine the following hypothesis for the relationship between nurse staffing, time-to-defibrillation, and neurological status at discharge. In addition to controlling for age, race, gender, event time, event duration, and RNHPPD, other significant patient and event variables where added to the final model. Time-to defibrillation was not added to the model due to lack of sufficient sample size to run the model.

H1: Nurse staffing and time-to-defibrillation will be predictive of favorable neurological outcomes in IHCA patients.

The results of the model indicate that the hypothesis was not supported within this sample after controlling for all variables in the model. However those in an ICU during the time of the arrest on average were 97% less likely to have favorable neurological outcomes. Results are presented in Table 4.6.

Table 4.6. Generalized Estimating Equations of Significant Covariates. Dependent Variable, Favorable Neurological Status (*N* = 182)

Covariates	*β*	*SE β*	*p value*	*Exp(β)*	*95% CI*
Age	0.00	0.02	.87	1.00	[0.97, 1.04]
Black[a]	-1.41	0.83	.09	0.24	[0.05, 1.24]
Cardiac illnesses[b]	1.42	0.98	.15	4.13	[0.61, 28.15]
ICU	-3.41	1.33	**.01**	0.03	[0.00, 0.45]
First pulseless rhythm VF/VT	1.35	1.29	.30	3.84	[0.31, 47.71]
Favorable status admit	0.84	0.68	.22	2.31	[0.61, 8.76]
Event time[c]					
Days	1.45	1.17	.22	4.27	[0.43, 42.28]
Evenings	-1.04	0.72	.15	0.35	[0.09, 1.44]
Event duration	-0.03	0.04	.51	0.97	[0.90, 1.05]
RNHPPD	0.40	0.36	.27	1.49	[0.73, 3.02]

Note. ICU=Intensive Care Unit, VF=Ventricular Fibrillation, VT=Ventricular Tachycardia, RNHPPD=Registered nurse hours per patient day.

[a] Reference category = Not Black (White, Asian/Pacific Islander, American Indian/Eskimo/Aleut, and Other).

[b] Reference category = Non-cardiac illnesses.

[c] Reference category = Nights.

Discussion

The purpose of this paper was to investigate the association between nurse staffing, time-to-defibrillation, and neurological outcomes of patients inflicted with IHCA. This study extends upon the current literature in health services research that investigates the relationship between nurse staffing and patient outcomes. This is the first known study that examined nurse staffing using the *structure-process-outcome* model for quality improvement. In this regard, this study marks an important departure from other studies investigating the association between nurse staffing and patient outcomes. In addition, this study utilized the GWTG database for in-hospital cardiac arrests.

The hypothesis that nurse staffing and time to defibrillation will predict neurological outcomes was not supported. However there were significant differences noted between several variables for those with favorable and unfavorable neurological status that were consistent with current literature on the subject. First, cardiac patients had less frequency of unfavorable neurological outcomes than non-cardiac patients. Most patients with a non-shockable first pulseless rhythm experienced unfavorable neurological status at discharge. These findings are similar to studies conducted on the national GWTG database on neurological outcomes (Chan et al, 2008; Chan et al., 2009).

Furthermore non-ICU patients were found to have significantly better neurological outcomes overall than ICU patients, who were on average were 97% less likely to have favorable neurological outcomes. This is likely the result of ICU patients being more acutely ill and on ventilator support. This study also found that almost 90% of patients with favorable neurological status upon admission also experienced favorable neurological status at discharge. Again, this finding is consistent with other findings noted within the national GWTG database (Perbedy et al., 2003).

Significant differences were noted for neurological status between shifts. Also staffing levels were slightly lower and response times were shorter, indicating that staff were able to response and apply treatment in a timely manner. In terms of arrests on shift type, most IHCAs occurred on the evening shift, and significant differences were noted. This could possibly indicate lack of identification of early warning signs of physical deterioration that is present six to eight hours prior to cardiac arrest (Schein et al., 1990). Identification of early warning signs is imperative to improve patient outcomes for IHCA. Although staffing is typically highest on the day shifts, it is also considered a "busy" shift when attending physicians and residents make rounds, patients leave the unit for diagnostic tests, visiting hours are active, and full daily care is provided to patients One study found that 70% of patients showed evidence of deterioration in respiratory or mental function within 8 hours of a cardiac arrest (Shein et al., 1990). Consequently, nurses might be overwhelmed with daily tasks and distractions and slight changes in the patient's condition may not be recognized or acted upon promptly.

In conclusion, this study was unique because it used the Donabedian conceptual mode to examine the impact of nurse staffing on neurological outcomes of IHCA. However, the hypothesis was not supported, and due to an inadequate sample size the process variable (time-to-defibrillation) was dropped from the final model. Despite the potential implications for nurse staffing levels to improve patient outcomes, this study was not able to empirically support this hypothesis. There are likely other confounding patient variables that were not included in the final model that would more accurately predict favorable neurological status at discharge than what was able to be included in the current study.

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Chapter V

Summary, Conclusions and Recommendations

This dissertation examined the impact of nurse staffing on time-to-defibrillation and patient outcomes. The outcomes measured were survival and neurological status at discharge of in-hospital cardiac arrests. This study used the American Heart Association's *Get with the Guidelines* (GWTG) national database for in-hospital cardiac arrests. The GWTG is a prospective, multi-center, observational registry of in-hospital cardiac arrest and resuscitation. This registry is the only one of its kind in the world, and it has the potential to assist in data driven decision making to improve the structure of healthcare organizations, processes of clinical practice, and patient outcomes. A major strength of this study is use of the GWTG, which currently uses Utstein guidelines and standardized definitions for in-hospital cardiac arrest. In addition, staffing levels were obtained at the time of the actual event.

The study was guided by the Donabedian model for quality assessment (Structure-Process-Outcome). The concept posits that solid structures will produce strong processes and in turn produce favorable outcomes. Within the context of this dissertation, structure was conceptualized as registered nurse hours per patient day, process is contextualized as time-to-defibrillation, and outcomes are conceptualized as survival and neurological status at discharge. An integrated and influential relationship is implied in this model, which begins at the structure extends through the process and ends at the outcome, and influenced by process in between. The implied relationships could be used to assess the entirety of the quality of care surrounding cardiac arrest in the hospital, although a cause and effect relationship should not be assumed.

The results suggested that both nursing care hours per patient day at the time of the arrest and time-to-defibrillation predict survival to discharge of in-hospital cardiac arrest. The findings provided important insights on survival and defibrillation times for patients afflicted with in-hospital cardiac arrest. These findings are important because previous studies examining cardiac arrest have not been able to explain hospital variation of delayed defibrillation or differences in survival rates on "off" shifts (Chan et al., 2008; Chan et al., 2009). The results of this study may in part explain some of this variation and differences. In this chapter, the summary of the study findings and their implications to policy and practice are presented. The limitations, revision of the proposed Donabedian model and recommendations for future research are also discussed.

Summary

In Chapter 2, the research hypothesis that nurse staffing will have a strong negative relationship on time-to-defibrillation of IHCA patients was not supported. The purpose of this analysis was to investigate the association between nurse staffing and time-to-defibrillation of patients afflicted with IHCA. Although the hypothesis was not supported, the study did have some interesting findings. First, registered nurse hours per patient day (RNHPPD) differed significantly in defibrillation time of less than two minutes. Second, arrests that occurred on the intensive care unit (ICU) had shorter times-to-defibrillation than non-ICU patients. Third, IHCAs occurred most frequently during the evening shifts where response times were on average 50 seconds less than on the other shifts. Despite lack of empirical support for this study's hypothesis, the findings suggest that nursing staffing is associated with time-to-defibrillation of less than two minutes, which is an important finding with regards to nursing contribution to quality of care of cardiac arrests that occur in the hospital, which ultimately may impact survival.

Chapter 3 investigated the hypothesis that nurse staffing and time-to-defibrillation will predict survival to discharge of IHCA patients. This hypothesis was partially supported. The main finding of this study explained that one more hour per patient day of nursing care results in 28% greater odds of survival. In addition, the study found that overall staffing levels were slightly higher for survivors; however, significant differences between staffing levels of survivors and non-survivors were not found. In addition, the findings suggest that time-to-defibrillation coupled with staffing levels at the time of the event may be a useful process indicator when explaining outcomes of IHCAs. This study provided empirical evidence supporting that increased nursing hours improves survival to discharge. In addition, the paper argued that measures of nurse staffing at the time of the event could potentially be a useful indicator for assessing quality and implementing process improvement.

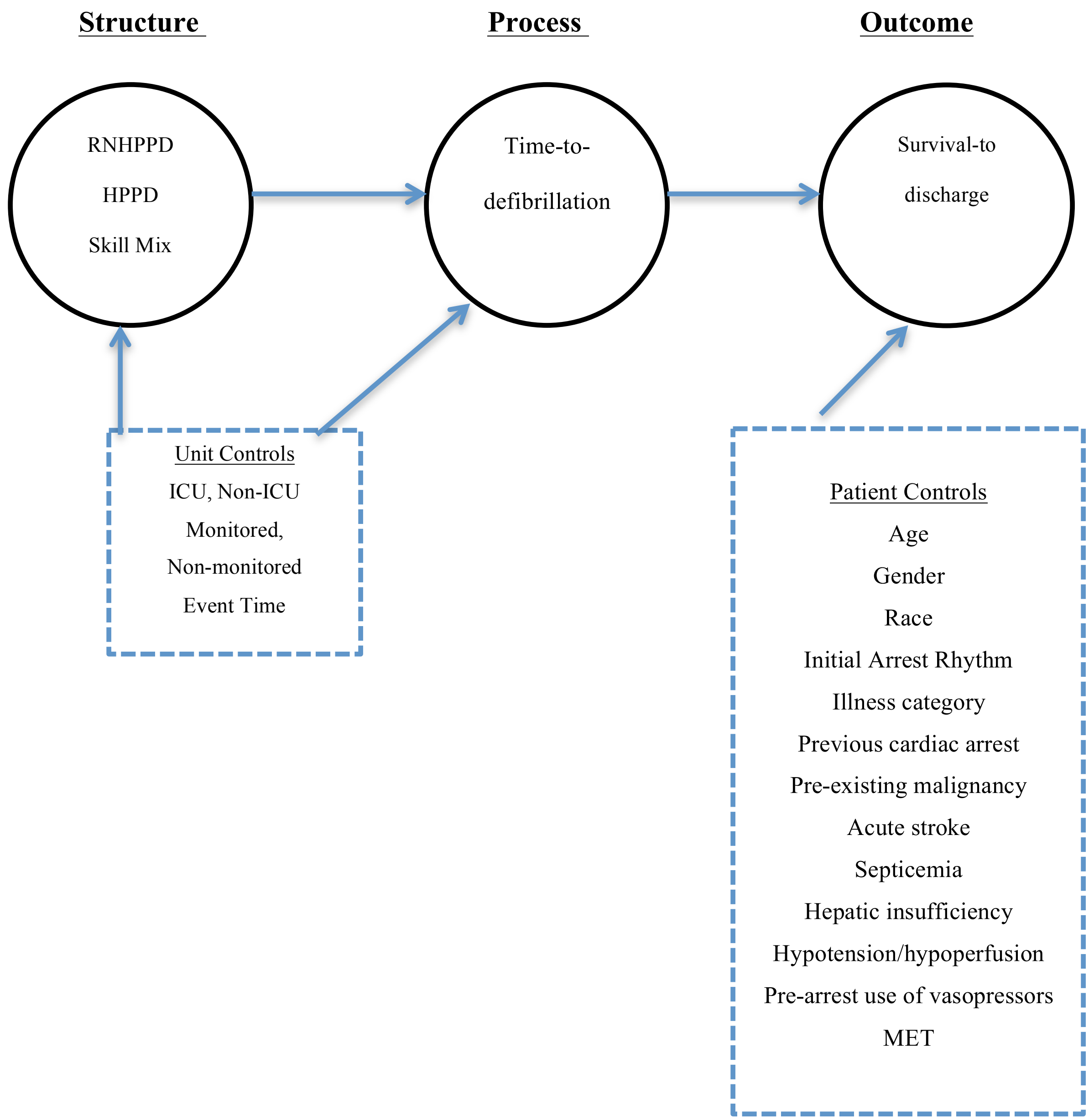
Chapter 4 examined the hypothesis that nurse staffing and time-to-defibrillation will predict neurological status of IHCA patients. The model and hypothesis was not supported. The process variable (time-to-defibrillation) was dropped from the final analysis because there was an insufficient number of survivors to warrant inclusion of this variable. Certain patient characteristics were found to be predictive of favorable neurological status that was consistent with the current literature; however, when these same characteristics were included in the final model, nothing was significant. Nonetheless, non-ICU patients were found to have better neurological outcomes overall than ICU patients. This is likely the result of ICU patients being more acutely ill and on ventilator support.

Model Revision

The Donabedian triad model was used to test associations between the structure (nurse staffing), process (time-to-defibrillation), and outcomes (survival and neurological status at discharge). The model hypothesizes that solid structures will produce strong processes and in turn produce favorable outcomes, thus positing that a linear relationship exists between nurse staffing, response times, and patient outcomes of in-hospital cardiac arrests. Therefore, this research hypothesized that nurse staffing does not improve quality of care for patients unless a strong process is in place. The hypothesized model attempts to extend upon current linkages to patient outcome in nurse staffing research by including a process indicator, which is an imperative construct when assessing quality of care in hospitals.

There was partial support in this study for the hypothesized model. There was evidence of direct associations between *structure-process-outcome* (survival-to-discharge), but there was no evidence to support the *structure-process* portion when examined separately (Chapter 2). Furthermore, there was no empirical evidence to support the model in its entirety when examining neurological outcomes (Chapter 4). It is therefore recommended that the model be used and tested in its entirety as intended for predicting survival. Furthermore, the examination of neurological outcomes may still provide insights into nurse staffing and defibrillation times of IHCA; however, a larger sample size that includes more survivors might yield more reliable results. The revised model is presented in Figure 5.

Figure 5. Conceptual Model Depicting the Relationship Between Nurse Staffing, Time-to-Defibrillation, and Survival to Discharge



Limitations

This study should be interpreted in the context of the following limitations. First, although the *Get with the Guidelines* (GWTG) database allowed for adjustment for key variables that have been linked to defibrillation time, survival, and neurological outcomes, the study used a cross-sectional design and there were variables that were not or could not be assessed (i.e., nurse work environment, teamwork, nurse education, and distractions). These confounding variables may have influenced defibrillation times that may have impacted survival. Next, analysis is limited to a single tertiary institution that has a reputation of being a leader in quality and patient safety; therefore results are not generalizable to other institutions. Third, changes in the process of care (i.e., implementation of a rapid response team and changes in staffing patterns) were not accounted for in the analysis and could affect internal validity of the study.

Implementation of medical emergency teams (MET) began at this university in 2007; however, only a small number of patients received MET intervention and therefore they were not included in the analysis. Further, a researcher conducting a secondary data analysis typically does not participate in data collection or operational definition and cannot account for data quality (Lacey & Hughes, 2007). Fourth, large data sets contain a large amount of missing data due to inconsistency of original data collected from the institution. There is some concern that missing time data, negative calculated Utstein gold-standard process intervals, unlikely intervals of 0 minutes from arrest to recognition to Advanced Life Support interventions, and use of multiple time pieces for recording time data would also affect the validity and reliability of the study (Kaye, Mancini, & Truitt, 2005). Time-to-defibrillation relied on reported time of cardiac arrest and defibrillation from hospital records. The use of multiple clocks and lack of synchronization between monitors on units might lead to variability in calculated times (Kane et al., 2005). Next, because time-to-defibrillation was recorded in minutes, the analysis primarily explored skewed distribution of data on the higher end, and times less than 1 minute or negative times could not be analyzed. As a result, a small sample was examined for the final analysis. A larger sample size in multiple institutions might yield different results. Furthermore, data were obtained directly from the institution and not from the Get with The Guidelines central database. Finally, adjusting for a unit's case mix index (CMI)—the average diagnosis–related group weight of Medicare volume—would have been useful to examine as this measure will provide insight into the acuity and type of patients that may affect response times and ultimately survival.

Recommendations

Recommendations suggested are applicable to research, practice, and policy issues in regards to nurse staffing and survival for patients with IHCA. The research has demonstrated the importance of adequate levels of staffing and cardiac arrest outcomes. However, this study could have been enhanced with inclusion of the following considerations. First, the GWTG is a large national database which includes over 500 hospitals in the United States. Use of the entire data set would not only have provided a larger sample, it would provide a closer synopsis of variation of staffing levels on survival in a variety of hospital types (i.e., bed size, teaching, and geographical locations). However, staffing data obtained from productivity reports from payroll might not be feasible. Staffing information would need to be obtained at the unit or hospital level from large staffing databases such as the *National Database of Nursing Quality*

Indicators® (*NDNQI®*) or from the American Hospital Association. In addition, GWTG database participants are de-identified, and staffing data would need to be linked externally through a separate entity. This should be done with caution, however.

Furthermore, there are many issues with measurement error bias in nurse staffing research (Mark, 2006). Previous studies that have examined nurse staffing at the hospital level did not distinguish acute inpatient nurse staffing for inpatient services at ancillary cost centers (see Kovner & Gergen, 1998; Kovner et al., 2002; Needleman et al., 2002; Mark et al., 2002). Moreover, most studies have been conducted at the hospital level and aggregated nurse-staffing across all units (Sales et al., 2008). One study found that aggregating both patient and nurse staffing data to the hospital level resulted in biased estimates of the effect of nurse staffing by mixing heterogeneous groups (e.g., ICU and non-ICU patients). Their results suggest that it is not the absolute staffing but the staffing relative to the patient need and the nursing organization of that unit that may influence outcomes (Sales et al., 2008). Although these prospects are challenging, they are not impossible and certainly would provide significant insight into research as well as contribute to the vast literature already disseminated on the impact of nursing care and patient outcomes.

The findings from this study will serve to inform nursing practice in regards to the importance to staffing levels and response times. Response times to cardiac arrests depend on recognizing the arrest and the ability to respond and provide treatment in a timely manner. This is directly the result of the availability of staff to react to such a situation. However, the main finding of this dissertation was that one more hour of nursing care increases survival by almost 30%; this may be in part due to staff presence on the unit. Sochalski (2004) concluded that processes of care indicators had more of an effect on quality ratings than staffing. Sixty-five percent of their model was explained by nurse workload, alone which suggests that quality assessments and patient safety issues are related to workload.

Future research that investigates staffing at the shift prior to the index event (cardiac arrest) could also provide significant insight to the work environment at that time as well as provide an impetus for the development of strategies to prevent IHCA (i.e., advanced cardiac life support education or mock code simulations). Future studies should examine individual hospitals and survey nursing staff about their perceptions of teamwork, perceptions of staffing adequacy, knowledge regarding deterioration of status prior to cardiac arrest, and comfort and confidence of advanced life support equipment. With regards to policy, the proposed research and its findings could inform decisions about minimal education requirements and nursing scope of practice. Previous research analyzing response times found that nurses were frequently the first responders. Although nursing staff were not permitted to provide defibrillation, policies were later implemented to train qualified nursing staff to use defibrillators on medical wards prior to arrival of medical staff as a means to speed up defibrillation times and reduce incidences of incorrect shocks (Wright, Bannister & Mackintosh, 1994).

Conclusion

As a way to reduce in-hospital mortality, the implementation of rapid response teams (RRT) has gained recognition by the Institute for Healthcare Improvement. RRTs are multidisciplinary teams comprised of medical, nursing, and respiratory staff with the primary responsibility to evaluate and treat the signs of clinical deterioration. Their purposes are to reduce incidences of cardiac or respiratory arrest and improve patient outcomes. Despite the popularity of implementation of RRTs for in-hospital cardiac arrest, research has demonstrated that rapid response teams do not reduce in-hospital cardiac arrests or in-hospital mortality and nurses are, more often than not, the first responders to cardiac arrest. Therefore examination of nurse involvement with cardiac arrest outcomes was warranted. In addition, most studies investigating the influence of nurse staffing on patient outcomes have used hospital and unit level staffing measures and linked survival to administrative data sets only. This dissertation is the first known study that explored nurse staffing at the time of the event, defibrillation times, and patient outcomes of IHCA. The closer in scope that clinicians and researchers can examine an index event, such as cardiac arrest, the more likely that important process improvement initiatives will be appropriate and successful. The potential contribution to the literature is significant and an initial first step in understanding and explaining what nurses "do" to improve the quality of lives of their patients.

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APPENDICES

Appendix A

Letter of Support

Nursing at Michigan

University of Michigan Health System

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February 14, 2012

RE: Letter of Support and Participation for the Proposed Study: The Impact of Nurse Staffing on in-Hospital Cardiac Arrest Outcomes.

PI: Monica Faye Rochman PhD(c), RN

Dear Ms. Monica Rochman,

Thank you for soliciting the participation of the University of Michigan University Hospital, in your proposed study, "The Impact of Nurse Staffing on in-Hospital Cardiac Arrest Outcomes" which examines staffing influence on cardiac arrest response times, survival-to-hospital discharge and neurological status of adult patients. The findings of this study provide a clearer synopsis of staffing patterns and interventions that impact patient outcomes at the time of the actual cardiac arrest event. We are excited to be a part of this innovative research study. Results generated from the proposed study will impact patient safety.

We understand that this study received exempt status because it is research involving the study of existing data and that the information was recorded in such a manner that subjects cannot be identified directly or through identifiers linked to subjects. We understand that the principal investigator (PI) will serve as primary liaison between the study and the University of Michigan research team. We agree to participate specifically in the following ways:

- Provide access to de-identified staffing data (Skill Mix, RNHPPD and HPPD) for selected cases from the years 2004-2009.

We will provide administrative support to assist in the coordination of these data and your ongoing research. We understand that all data will be confidential and reported in the aggregate, making it impossible to identify our institution through any of the information we will provide. Institution-specific results will be made available to us, upon our request.

I will be your contact person at the hospital and can be reached at (734)647-7373. If you have questions or we can provide you with information about our hospital, please do not hesitate to call. Again, thank you for choosing the University of Michigan University Hospital to partner with you for the proposed study. We look forward to working with you on this important initiative.

Sincerely,

Leah L. Shever

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Appendix B

Table. Descriptive Statistics for Registered Nurse Hours per Patient Day, by Unit and Unit Type (*N* = 292)

	RNHPPD				
Unit	*n*	*Mean*	*Minimum*	*Maximum*	*pvalue*
Non-ICU					
1	2	4.40	4.15	4.65	**<.001**
2	12	2.83	2.08	3.32	
3	7	2.79	2.52	3.39	
4	1	2.02	2.02	2.02	
5	6	2.18	1.43	2.48	
6	2	2.19	1.38	3.00	
7	1	2.36	2.36	2.36	
8	6	1.86	1.08	2.67	
9	13	2.80	2.12	3.54	
10	18	2.78	1.92	4.22	
11	9	2.26	1.55	3.03	
12	5	1.99	1.53	2.59	
13	2	3.24	2.42	4.06	
14	31	6.38	5.00	8.36	
15	1	2.67	2.67	2.67	
16	1	3.20	3.20	3.20	
ICU					
17	25	5.65	4.00	8.00	
18	29	5.71	3.16	7.98	
19	45	5.31	3.14	7.58	
20	65	5.20	1.60	7.38	
21	7	4.90	4.27	5.87	
22	4	7.30	6.77	7.95	

Note. RNHPPD=Registered Nurse hours per patient day, ICU=Intensive Care Unit