Charge Nurse Expertise: Implications for Decision Support of the Nurse-Patient Assignment Process

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Elizabeth Lillian Meyers

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Dedication

I dedicate this work to the 650,000 inpatient medical-surgical nurses in the United States who are told to "suck it up, buttercup" when given a tough assignment, to the charge nurses that sometimes need to "hide in the mud room to make assignments," and to all healthcare clinicians who have ever been asked to use a computer program they had to "babysit because it didn't think they knew what they were doing."

Abstract

Each day, across thousands of medical-surgical inpatient nursing units, charge nurses make decisions about which nurse will care for each patient. Recent attempts have been made to introduce health information technology (HIT) solutions to automate the nurse-patient assignment process. This research investigated charge nurse decision making during the nurse-patient assignment process as an exemplar of the larger question: How can we leverage information technology to improve decision making in healthcare, while respecting individual clinician expertise and the unique context of individualized patient care? Four primary questions were used to guide research of the process, decision factors, goals and context of nurse-patient assignments. A mixed-methods approach of qualitative interviews ($N = 11$) and quantitative surveys ($N = 135$) was used.

Findings related to the charge nurse decision making process indicate that measurable, nurse-sensitive indicators of patient outcomes have not yet been standardized for nurse-patient assignments. HIT solutions and quality improvement efforts should define, collect and analyze measurable outcome criteria prior to attempting to improve or augment existing nurse-patient assignment practices to prevent unintended consequences.

When clear outcome measurements have been identified, informatics researchers and professionals should investigate the ability of machine learning to recognize goal priorities and factor weighting from patient, nurse and environmental factors within existing HIT solutions. Until that time, HIT solutions augmenting the nurse-patient assignment process should be designed with flexible configurations, to enable goals, decision factors and factor weights can be varied by hospital, unit, charge nurse and shift, in order to best meet the needs of charge nurses.

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List of Abbreviations

ADT	Admission-Discharge-Transfer
AHA	American Hospital Association
AMA	American Medical Association
AMSN	Academy of Medical-Surgical Nurses
CDM	Critical Decision Method
CINAHL	Cumulative Index to Nursing and Allied Health
CTA	Cognitive Task Analysis
EHR	Electronic Health Record
IRB	Institutional Review Board
HIT	Health Information Technology
NDM	Naturalistic Decision Making
PCS	Patient Classification System
RPD	Recognition Primed Decision-making

Chapter 1: Introduction

Overview

Every year in the United States 36 million patients are admitted for inpatient care (American Hospital Association [AHA], 2019). The majority of these patients are cared for on medical-surgical floors by more than 650,000 medical-surgical nurses (Academy of Medical-Surgical Nurses [AMSN], 2019). These patients and nurses are paired during a process called nurse-patient assignment. The nurse-patient assignment is completed prior to the start of each shift by a charge nurse, based on their knowledge of patients, nurses, and environment (Allen, 2015). Recent attempts have been made to introduce health information technology (HIT) solutions to automate the nurse-patient assignment process, but an evaluation has not been completed to determine how an HIT solution can best aid the charge nurses during the process.

Informatics and clinical decision making. The use of HIT to aid charge nurse decision making is an interesting exemplar of the dichotomy between the personalization of patient care based on clinician expertise and standardization of care based on best practices. Historically in healthcare, treatments and care plans have been designed and managed by expert clinicians. However, today the growth in clinical knowledge outpaces any individual clinician's capacity to stay current (Densen, 2011). As Dr. Atul Gawande (2010) states in *The Checklist Manifesto: How to get things right*, "The volume and complexity of what we know has exceeded our individual ability to deliver its benefits correctly, safely, or reliably" (p.14). Best practice guidelines have been introduced to shore up this gap. However, these tools are frequently at odds with the historically tacit intuitive nature of clinical care.

The clinical knowledge used to develop best practice guidelines can become obscured when the guideline is embedded as a decision support algorithm within information technology. Knowledge of clinical objectives, goals and workflows are necessary to develop decision aids and avoid unintended consequences (Osheroff, Pifer, Teich, Sittig & Jenders, 2005). However, these goals, objectives, and even workflows are

moving targets when situated in the varying contexts of real-world uncertainty. Healthcare informaticists must discover how to augment expert decision making to best leverage all available data and best practices, without restricting clinician autonomy and patient preference, in order to achieve personalized care. This research aims to add to the body of health informatics knowledge by studying charge nurse decision making during the nurse-patient assignment process as an exemplar of the question: How can we leverage information technology to improve decision making in healthcare, while respecting individual clinician expertise and the unique context of individualized patient care?

Scope and organization of paper. This chapter, Chapter 1, provides an introductory background to the field of judgment and decision making and the role of clinician as expert. Chapter 2 contains a review of the literature specific to the exemplar decision making case of charge nurse decision making during the nurse-patient assignment process. Chapter 3 discusses the methods used in this study. In Chapter 4, the study results are documented. The conclusions and implications of the research results are discussed in Chapter 5. References and appendices follow.

Clinical Expertise

Physician expertise. Historically, physicians ordered tests, treatments and referrals based on their training and individual expertise. However, this traditional practice of medicine based on individual clinical judgment, of a particular physician making decisions for a particular patient, has led to significant unwarranted variation in care (Wennberg & Thomson, 2011). Traditional, physician-prescribed care has also struggled to stay aligned to patient preference (Mühlbacher & Juhnke, 2013).

In her book, *How Doctors Think*, Dr. Kathryn Montgomery argues that evidence based medicine and clinical guidelines are not substitutes for the tacit, practical knowledge used by a physician when caring for a particular patient (2005). She describes physician angst with generalized evidence-based guidelines enforced by third-party payers. Physicians feel that guidelines are a barrier to personalization of treatment during

physician-patient interaction. This idea was reinforced by Rischatsch & Zweifel (2012). Their study of Swiss doctors showed that physicians disliked the guidelines, referring protocols, and restricted medication formularies imposed in a managed care environment.

In independent practice under the fee-for-service program, physicians held most of the decision-making responsibility (Montgomery, 2005). The transition away from independent practice has been a trade-off for physicians. "While becoming part of a large integrated health system allows access to clinical, financial, and managerial resources, it comes at the significant price of relinquishing autonomy and ultimate strategic decision-making authority to health system administrators" (Mergener, 2012, p. 23).

Physician pushback to regulation of clinical practice has been strong. In October 2011, the American Medical Association (AMA) launched an advertising campaign to champion the role of the patient-physician relationship. Its slogan was "American Medical Association: Protecting the relationship between patients and physicians" (AMA, 2011). As part of this campaign, a television commercial reinforced that patients have a special trust relationship with their doctor, who helps them understand and treat medical problems. The implication is that the patient-physician relationship is threatened and needs to be 'protected.'

Non-physician clinical expertise. Increasing regulation is impacting nurses and other clinicians in a similar manner to physicians. In 2006, more than 30 organizations, representing non-physician licensed health care professionals, joined forces to create the Coalition for Patients' Rights (2019). The coalition was formed to protect clinician scope of practice through federal and state legislative and regulatory advocacy.

Like physicians, nurses also develop expertise through years of hands-on experience (Benner & Tanner, 2009). Benner's description of nurse development from novice to expert is widely cited in nursing literature, taught in academia, and known in operational practice. Many researchers have validated and built models to describe nursing expertise and decision making based on Benner's work. Summarizing these models, Tanner (2006) describes nursing clinical judgment as nurse centric, patient

specific, and context specific, with variations in technique, and demonstrates improvement after retrospective reflection.

Miller and Hill (2018) found that nurses with more experience and higher levels of nursing proficiency were more likely to use intuitive judgments. The definition of intuition is important in the investigation of clinical decision making. Punnakitikashem, Rosenberger, & Behan, (2008) claim that because charge nurses intuitively assign nurses to patients, assignments made by charge nurses are similar to random assignment. This assertion does not align with definitions of intuition in the literature. In the nursing literature, "intuition is operationally defined as a non-conscious and non-analytical state of knowing" (Payne, 2015, p. 255). Scientists who study intuition as a subset of the field of judgment and decision science have developed robust definitions and theories about the development and conditions for skilled intuitive judgments.

Conditions for Expertise

Dr. Daniel Kahneman and Dr. Gary Klein (2009) have studied experts, such as clinicians, from two opposite approaches. Kahneman has focused on the errors in decision making that present as biases and flawed heuristics. Klein has studied expert decision making and intuition in real-life contexts, stressing the importance of retaining the complexity of natural decision making setting. Kahneman and Klein married their approaches to make joint recommendations for conditions necessary for experts to develop skilled intuitive decisions. "Two conditions must be satisfied for skilled intuition to develop: an environment of sufficiently high validity and adequate opportunity to practice the skill" (Kahneman & Klein, 2009, p. 520). These conditions lead to varying levels of development of expertise and reliable intuitive judgments. "The intuitive judgments of some professionals are impressively skilled, while the judgments of other professionals are remarkably flawed. Although not contradictory, these core observations suggest conflicting generalizations about the utility of expert judgment" (p. 518).

Previous studies have defined nurses and doctors as having fractionated expertise, that is, expertise in some activities, but not others (Kahneman & Klein, 2009). This

occurs when the conditions for development of expertise are met only part of the time. For instance, ". . . they may have received ample feedback supporting their confidence in the performance of some tasks—typically those that deal with the short term—but the feedback they receive from their failures in long-term judgments is delayed, sparse, and ambiguous" (Kahneman & Klein, 2009, p. 523). Fractionated expertise is particularly worrying in clinical care, because people are not good at knowing when an intuition is based on skill versus when a satisficing heuristic is in play. "There is no subjective marker that distinguishes correct intuitions from intuitions that are produced by highly imperfect heuristics. An important characteristic of intuitive judgments, which they share with perceptual impressions, is that a single response initially comes to mind" (p. 522).

It is important for informaticists to understand the conditions for development of skilled intuition and expertise when developing HIT decision support algorithms. Decision support may not be necessary when an environment offers predictable outcomes, reliable feedback, and the expert has adequate experience to incorporate feedback through a learning cycle. On the other hand, ". . . people perform significantly more poorly than algorithms in low-validity environments" (Kahneman & Klein, 2009, p. 523). The key is the validity of the environment. An environment has "'high-validity' if there are stable relationships between objectively identifiable cues and subsequent events or between cues and the outcomes of possible actions" (p. 524). "Validity, as we use the term, describes the causal and statistical structure of the relevant environment" (p. 520). The implication is that careful study of environment should precede attempts to improve expert intuitive decision making.

Charge Nurse Decision Making as an Exemplar

Charge nurse intuition. Charge nurses generally use personal judgment when creating the nurse-patient assignment (Acar & Butt, 2016). However, there is evidence that these intuitive judgments do not always produce optimal results, and sub-optimal decisions cost hospitals millions of dollars each year (St Laurent, Santovasi, & MacDonald, 2015). One hospital unit investigated perceived inequity of nurse-patient

assignment and found that certain nurses were routinely assigned to care for more patients than other nurses (Marine, Meehan, Lyons, & Curley, 2013). Simply presenting charge nurses with this data did not impact their decision process, "At the monthly meeting of charge nurses, we brought up this concern, but the group of charge nurses thought that the concern was not valid. Although they unanimously believed that they made out assignments fairly and without bias" (Marine et al., 2013, p. 74). These findings hint that the inpatient environment may not be consistent enough for charge nurses to develop skilled expert intuitive judgments regarding nurse-patient assignments.

Norby, Freund, & Wagner (1977) recognized gaps in intuition-based staffing over forty years ago:

> In many settings and agencies, nurse staffing is done rather intuitively, with those in leadership positions adding, subtracting, and reassigning staff on the basis of their general 'feel' for necessary personnel coverage. On the basis of intuition, the number of staff is increased to cover busy areas and reduced for light areas. A problem arises, however, when one must translate this intuition into quantifiable terms that can be understood by others (such as hospital administration, the Board of Directors, other nurses, and so on). Without such translation, a meeting of minds regarding staffing requirements, staff mix, philosophy of care, and quality objectives is virtually impossible, and the controls necessary for planning, evaluation, and cost-effective systems maintenance are unavailable. Likewise interpersonal relations within the nursing department frequently become strained because of real or perceived inequities in staffing decisions.
>
> It is for these reasons and others that intuition must be replaced by a sound, effective staffing methodology that provides appropriate information for decision making while remaining realistic, practical, and sensitive to the intricacy of modern nursing practice. (p. 2)

Motives for selection. The present research focuses on the expert decision making of charge nurses during the process of creating nurse-patient assignments. This

particular decision making process was selected as an exemplar of clinician decision making for several reasons.

First, nurses are generally chosen to lead the shift in the charge nurse role after they have developed expertise in routine nursing practice. As peer-selected experts, charge nurses serve as a clinician example with sufficient experience to have developed tacit knowledge and intuitions, without the need to pre-quantify this expertise explicitly (Kahneman & Klein, 2009, p. 519).

Second, the selection of this decision making process is sufficiently complex to warrant further research. The complexity of decision making during the nurse-patient assignment process allows for greater insights into context specific decision factors and investigation of deeply held tacit knowledge.

Third, the nurse-patient assignment process is not widely automated today and no single best practice exists. And finally, the process is important from both clinical (patient care) and operational (workforce management) perspectives. For these reasons, charge nurse decision making during the nurse-patient assignment process was chosen as focus of this research. Additional background about nurse-patient assignments is presented in the review of the literature in Chapter 2.

The goal of this research is to solidify the foundational understanding of charge nurse decision making during the nurse-patient assignment process to support development of a research-based, HIT decision support algorithm. This type of research is foundational to the practice of informatics. It documents the expert's pre-automation data-information-knowledge-wisdom model, so that appropriate HIT solutions can be applied.

> When tasks are complex, it is not enough to simply observe people's actions and behaviors – what they do. It is also important to find out how they think and what they know, how they organize and structure information, and what they seek to understand better. (Crandall, Klein, & Hoffman, 2006, p. 3)

Introduction to Decision Science

The study of decisions. Given the rich history of study of judgment and decision making, basic definitions are necessary to set the stage for this research. According to Yates (1990), a decision is a voluntary, conscious action taken to achieve a favorable outcome. Decisions can be placed into three categories: choices, evaluations, and constructions. Decisions are called choices when the goal is to select one of many options. They are called evaluations when the decision maker is evaluating the worth of a single, particular option in the context of its contribution to an optimal outcome. And, they are called constructions when the best outcome contains one or more options that are combined under the constraint of limited resources. All of these categories of decisions are influenced by judgments, the opinions and values associated with each option identified in the decision making process. Judgments are the foundation of decision making, and, as such, a study of decisions can uncover the underlying opinions of the decision maker.

In the case of charge nurse decision making during the nurse-patient assignment process, it is assumed that the charge nurse holds judgments about patients, nurses, and other contributing factors based on experience with the particular nurses and patients, and past experience with similar situations. Judgments about nurse-patient pairing options are evaluated to create a final construction of nurse-patient assignments for a shift. The complexity of the nurse-patient assignment process best fits Yate's (1990) definition of a construction due to the multiple decision factors and to time and information restraints that restrict the process. However, the decision process has added contextual complexity.

Traditional, rationalistic decision making models propose that decision makers mentally associate a value (utility) to options and goals within a specific decision making context, then act in a way that optimizes those values (Yates, 1990). This theory becomes overwhelmed by complexity when applied to dynamic, real-world, in-context, expert decision making (Gigerenzer & Gaissmaier, 2011; Kahneman & Klein, 2009; Klein, 2008; Schraagen, Ormerod, Militello, & Lipshitz, 2008). In the case of the nurse-patient

assignment process, there may be an infinite number of factors that become influential, depending on the particular charge nurse's past experiences, the various situational factors, and the charge nurse's valuation of each decision factor.

Naturalistic decision making. In real-life situations, decision makers do not have time to consider and to weigh every option. They are susceptible to decision errors and failures affecting decision processes and achieving less than the most favorable outcome. This reality has led decision theory to branch into new areas to consider real-life, in-context decision making. These include: behavioral economics, heuristics, biases, and two-system theories (Gigerenzer & Gaissmaier, 2011). These theories attempt to model the decision making techniques used in every day decisions, which usually involve some type of short-cut, satisficing, settling for less than the most favorable outcome, when compared to their rationalistic counterparts (Gigerenzer & Todd, 1999).

To support research of how experts truly make decisions in real-life scenarios, naturalistic decision making (NDM) was introduced in 1989 (Klein, 1998). "Instead of beginning with formal models of decision making, we began by conducting field research to try to discover the strategies people used" (Klein, 1998, p. 456). The general term for these in-the-field research techniques is cognitive task analysis (CTA) (Schraagen et al., 2008).

Cognitive theory. In chapter one of his book, *The Adaptive Character of Thought* (1990), Anderson compares many cognitive theories, describing how most have similar levels. The most abstract, overreaching level in David Marr's information processing theory is called computational theory. This level of analysis is proposed by Marr to provide the context of the problem, specifically how a decision maker is impacted by environmental structure and goals. Thus, most human responses are adaptive to the particular environment. By beginning with the environment, requirements for a solution can be understood, regardless of agent, and a theory of performance can be developed which will explain behavior based on the goal. This behaviorist theory complements the naturalistic decision theory by seeking to define the inputs that lead to the development of

expertise, so they can be categorized, and a representational algorithm can be developed to mimic expert intuition.

The computational model assumed at the outset of this research was adapted from the major groupings of decision factors proposed by Allen (2015): patient factors, nurse factors, and environment factors. The three groupings align with Marr's definition of environmental structures to influence charge nurse decision making. The pre-research assumption was that each grouping will contain judgment factors which have been developed by the decision maker in generalities prior to the current, specific construction scenario. These groupings create a flexible beginning model for concept mapping and could change as decision factors are 'coded' to the appropriate group during the data analysis phase (Crandall et al., 2006).

Decision technique considerations. Sandhu, Carpenter, Freeman, Nabors, & Olson (2006) identified basic pattern recognition as one of six types of decision making models used by emergency room (ER) physicians. The nurse-patient assignment process could be framed as either a series of evaluations (yes/no pattern recognition) or as a choice after exhaustive evaluation of multiple options. Proponents of decision analysis in healthcare have suggested that clinicians should reframe decisions from multiple angles and always consider all relevant options in order to minimize bias (Hunink et al., 2001). However, because additional options increase cognitive load, it is likely that charge-nurses primarily use basic pattern recognition decision techniques like evaluation and construction.

Pattern recognition aligns well with the RPD approach found in expert decision making (Klein, 1998). The basic pattern recognition model also fits with Gigerenzer and Todd's (1999) description of the recognition heuristic. They describe 'fast and frugal heuristics' that allow decisions to be made with limited search and non-optimized stopping points. Croskerry notes that pattern recognition relies heavily on System 1 (intuitive) decision making techniques in his editorial comments on Sandu et al.'s (2006) work. Klein (1998) describes a similar model for expert decision making, recognition

primed decision making (RPD). In RPD, an expert leverages skilled intuition to identify a single solution, evaluates the solution, and proceeds if no contra-indications are identified.

A variation of pattern recognition or RPD makes the most sense. A charge nurse who is determining which nurse to assign to a particular patient would logically: assess the patient's needs, the nurse's skills, environmental factors, and review his or her knowledge to determine if the presenting pattern matches that of previous successful assignments. Pattern recognition helps to perform the match.

Sandu et al. (2006) report that the two key shortcomings in the use of pattern recognition for decision making are anchoring bias and confirmation bias. These biases are likely to occur in unskilled intuitive situations, when conditions for expertise have not been met (Kahneman & Klein, 2009). However, an anchoring bias could also be adaptive: charge nurses sometimes describe using the last shift's assignments as a starting basis.

Experts versus algorithms. This chapter has provided a high-level overview of clinical expertise, the conditions for developing that expertise, the charge nurse as an expert, and decision science. This background provides the stage to begin to answer the question: How can information technology be leveraged to improve decision making in healthcare, while respecting individual clinician expertise and the unique context of individualized patient care?

HIT based algorithms can provide added benefit when criteria for intuitive expertise are not met.

> A statistical approach has two crucial advantages over human judgment when available cues are weak and uncertain: Statistical analysis is more likely to identify weakly valid cues, and a prediction algorithm will maintain above-chance accuracy by using such cues consistently. (Kahneman & Klein, 2009, p. 523)

Algorithms outperform humans when validity is very low (because humans cannot detect the weak regularities) and also when validity is very highly reliable (where human attention eventually plateaus out).

Kahneman & Klein (2009), reviewed research that compares the performance of experts with average or novice performance, and, research that compares expert performance with models that represent an optimal decision. They found that, "It is entirely possible for the predictions of experienced clinicians to be superior to those of novices but inferior to a linear model or an intelligent system" (Kahneman & Klein, 2009, p. 519). This means that a study of decision support of charge nurse decision making would ideally compare expert charge nurses results with results from a decision support system. However, the validity of the environment and goals of the nurse-patient assignment process must first be well documented in order to test that the conditions for expertise have been met.

Guidelines have been developed to test conditions of expertise. These guidelines can help health informaticists determine when expert opinion should be trusted and when decision support is needed.

> NDM proponents correctly emphasize that the conditions necessary for the construction and use of an algorithm are stringent. These conditions include (a) confidence in the adequacy of the list of variables that will be used, (b) a reliable and measurable criterion, (c) a body of similar cases, (d) a cost/benefit ratio that warrants the investment in the algorithmic approach, and (e) a low likelihood that changing conditions will render the algorithm obsolete. We also agree that algorithms that substitute for human judgment must remain under human supervision, to provide continuous monitoring of their performance and of relevant change in the environment. (Kahneman & Klein, 2009, p. 524)

In the exemplar of the nurse-patient assignment process, it is known that this process occurs regularly, and so it is assumed that a body of similar cases exists for algorithm development. A cost/benefit analysis for investment is outside the scope of this

research. The remaining three guidelines form the basis for the research described in the following chapters. To align them with Allen's (2015) work, hereafter throughout this paper they are referred to as: decision factors (list of variables), goals (measurable criteria), and environment (changing conditions). The next chapter contains a review of efforts to understand and improve the nurse-patient assignment process.

Chapter 2: Review of Literature

Inpatient Nursing Workforce Management

A review of literature related to nurse-patient assignments was completed in the spring and summer of 2015. On August 26, 2017 the literature was re-explored prior to commencement of data analysis using the following methodology. First, a search was undertaken using Ovid MEDLINE with the combination of search terms: nurse, patient, assignment. A separate search was undertaken for each term. All subheadings were included, combined with "OR". The keywords "nurse" and "patient" mapped to subject headings "nurses" and "patients" respectively. These subject headings and the respective auto-exploded narrower terms were included as well as the original keywords. The three resulting sets were combined with "AND" resulting in a pool of 240 articles. Next, the phrase "nurse patient assignment" was searched as a keyword with seven resulting articles. These were combined with the initial set for a net result of 247 articles.

A secondary search in the Cumulative Index to Nursing and Allied Health (CINAHL) to ensure capture of articles from nursing centric sources. First a search was conducted using terms: nurse, patient, and assignment combined with "AND" within all text fields. This search returned 17,218 results. This was refined to 216 results by selecting the major subject heading: work assignments. An additional search was completed with the phrase "nurse patient assignment" which returned 99 articles, for a combined total of 315 CINAHL articles.

The CINAHL results were combined with the original MEDLINE results set, totaling 562, then de-duplicated for a final set of 400 articles. Titles and abstracts of these articles were reviewed for inclusion criteria: inpatient setting, with a focus on nurse-patient assignment. Articles were excluded that solely addressed scheduling or staffing (the assignment of nurses to a particular shift and unit) or patient acuity/classification/workload. Of the 400 articles reviewed, 54 met inclusion criteria. Pertinent citations within these articles and articles citing these articles were also evaluated for inclusion. In February 2019, a quick search was completed to identify any

new articles. Google Scholar was used to explore any articles citing the core, foundational articles previously identified in the literature. These efforts resulted in the addition of 10 articles to the literature reviewed below.

A total of 64 articles related to nurse-patient assignments were reviewed, of these, only 8 articles were found to report on moderate of high quality studies. Many of the articles presented observational or case studies (22), but most expressed a single or consensus expert opinion (34). Articles were organized into three categories: workforce management and models of care (15), studies of assignment factors and goals (22), and descriptions of process improvement efforts and HIT solutions (27). This chapter reviews these articles, but first introduces the role of charge nurses and hospital workforce management.

The role of charge nurse. Most inpatient medical-surgical hospital units are managed by a nurse manager. The nurse manager is responsible for overall staffing, safety and quality of care on the unit. The nurse manager is assisted by a lead nurse who is appointed to coordinated and oversee care on each shift. The title of this lead varies from hospital-to-hospital, but is most commonly referred to as a charge nurse.

On most units, the charge nurse is not directly assigned to patients or expected to provide routine, direct patient care. Instead, they are responsible for leadership, quality, safety, and patient satisfaction on a shift-by-shift basis (Eggenberger, 2012). In a qualitative study of twenty medical-surgical charge nurses, Eggenberger found that charge nurses described their duties to include “balancing the staffing” “managing the flow” “coordinating care” and “putting out fires” (2012, p. 504). Only twenty percent of those interviewed received formal training in the role of charge nurse, which supports the idea that charge nurses have adequate opportunity to develop expertise through first-hand experience with a body of similar cases as required by Kahneman & Klein (2009).

Wilson, Talsma, & Martyn (2011) performed a qualitative investigation into the functions, skills and attributes of charge nurses. They found, “The charge nurses who were effective in staffing a unit usually demonstrated the following five behaviors:

resourcefulness, tactful communication, flexibility, decisiveness, and awareness of the big picture" (p. 812). The charge nurse is the key resource for information during the shift. They are responsible for constant assessment of staffing and patient needs and making decisions. "Mindful staffing as described in this study is a collection of charge nurses' effective decision making behaviors that are used to safely balance unexpected changes in patient acuity, and census with the availability and experience of staff nurses" (Wilson et al., 2011, p. 819). Thus, charge nurses play a crucial role in workforce management.

Workforce management. The nurse-patient assignment process is the final component of staffing or workforce management process (Norby et al., 1977; Rosenberger, Green, Keeling, Turpin, & Zhang, 2004; Wilson et al., 2011). In most inpatient hospitals, the workforce management process begins with the annual budgeting process. During the financial budgeting, nurse staffing budgets are developed based on the forecasted census (number of inpatients expected) in the coming year. Budgeting includes salaries, number of nurses, and a workforce management master planning regarding the number of nurses to employee and how the hospital will staff up/down for fluctuations in patient volumes.

Scheduling is the second phase of the workforce management process. Scheduling happens at the individual unit level, is usually supervised by the nurse manager of the unit, on a rolling basis approximately four to six weeks in advance. Scheduling policies, such as overtime rules, are usually standardized across the hospital. However, scheduling procedures frequently vary by department. Some examples of scheduling procedures include: number of nurses per shift, flexible self-scheduling versus repeated set schedules, seniority privileges, and rules for vacation time.

The third phase of the workforce management process is referred to as rescheduling or staffing. The staffing process is frequently managed by a centralized staffing office, especially at larger hospitals. Staffing is the process of coordinating nursing resources across the hospital to meet actual patient care requirements. Some

facilities use a workload, patient classification, or acuity system to represent patient care requirements, but most use a staffing grid. A staffing grid is a simple table showing how many nurses are required based on current or projected patient census. The drawback of staffing according to a staffing grid is that each nurse and each patient is assigned equal weight, regardless of capabilities or care requirements.

Staffing timeframe varies by hospital, but usually begins about 48 hours prior to a particular shift, climaxing at a daily 'bed planning meeting' a few hours before day shift begins, and culminating just before each shift begins, or when a plan is in place to resolve all over/under-staffing issues. Over-staffing issues could be resolved by having a nurse not report for a shift, stay at home on-call, work on non-patient care activities or 'float' to provide patient care on another unit. Under-staffing issues are usually resolved through a joint effort by the particular unit and the staffing office. First, the unit will attempt to call in nurses who are employed by the specific unit. If the unit is unable to fill the need, the staffing office may allocate nurses from pool of nurses that float between units, a third party staffing agency, or re-allocate from another unit.

Nurse-patient assignment is the fourth and last phase of the workforce management process. This process occurs prior to the beginning of the shift and continuously throughout the day as patients are admitted, discharged and transferred between units. The charge nurse is responsible for both pre-shift assignments and updating assignments throughout the day. The timeline for same-day pre-shift assignments is described by Acar & Butt (2016):

> The CN [charge nurse] has approximately 30 min to prepare these assignments prior to the shift start. Since there can be a large variation in patient needs on this unit, the assignment process can be complex and the manual development of balanced nurse-patient assignments can be difficult. (p. 194)

Pre-shift assignments are sometimes completed by a charge nurse for an upcoming shift (night shift charge nurse for oncoming day shift, or day shift for next day) and sometimes, as described above, completed by the charge nurse for the same shift (the

charge nurse arrives early). Assignments referenced throughout this paper refer to these, pre-shift assignments unless otherwise noted.

Mullinax and Lawley (2002) present a succinct overview of the nurse-patient assignment process and associated challenges in an inpatient neonatal nursery setting:

> At the beginning of each shift, the nurse supervisor groups infants for assignment to the staff nurses working that shift. This assignment is one to one so that each nurse cares for one group of infants throughout the shift. Because there is typically great variation in infant conditions, the assignment process is complex and developing balanced nurse workloads is difficult. To complicate the problem, every shift must maintain at least one 'admit' nurse to care for infants admitted during the shift. Thus, the admit nurse must initially receive a lighter work load. Further, it is essential that a nurse remains in close physical proximity to his or her assigned group of patients, and thus nurses must not be assigned across zones. Finally, state laws limit the number of patients that can be under the care of a single nurse. For example, the facility where we conducted this research allowed up to three patients per nurse. Because the head nurse generates a new assignment at the beginning of every shift, she typically has less than 30 minutes to perform this assignment task. The objective of the assignment process is to balance the nursing workloads while satisfying the constraints discussed above. (pp. 25-26)

Nurse-patient assignment is important to quality of care, cost of care, and patient and nurse satisfaction. Nurse-patient assignment has been viewed as a crucial factor in the quality of nursing care for many years (Peterson, 1973). In a large study, Choi & Miller (2018) found that nurses who rate their patient assignment positively also report higher job satisfaction and quality care. The authors recommend that "appropriate matching of RNs and patients should be tailored to particular unit situations and consider both quantity and quality of nurse staffing in relation to patient assignment" (p. 537). Nurse-patient assignments have also been used as a tool to better understand work intensity and variation in hospital costs (Welton, Zone-Smith, & Bandyopadhyay, 2009).

Welton et al. (2009) summarized the nurse-patient assignment: “The assignment is a reflection of different patient needs and the ability of a particular nurse to address those needs" (p. 278).

Care models and continuity. Direct nurse-patient assignment is not the only method of allocating nursing care. The assignment process is frequently described in studies of nursing care models, i.e., how nursing care should be organized. These studies provide insight into the environment, decision factors and goals of the nurse-patient assignment process, even though they do not study charge nurse decision making directly.

In Australia, the term *model of care* is used to describe the nurse-patient assignment process (Duffield, Roche, Diers, Catling-Paull, & Blay, 2010). Sometimes, nurses are not directly assigned to care for a particular patient, instead a group of nurses is responsible for a group of patients – team nursing. Other care models are primary nursing – with one nurse assigned to a patient for the duration of their admission, and task-based, functional nursing where nursing care is divided by task instead of by patient. Based on a survey of nurses across 80 med-surg units, direct nurse-patient assignment and team nursing were used nearly all the time. Interestingly, “Variability in the models of care reported by ward nurses indicates that nurses adapt the model of nursing care on a daily or shift basis, according to patients’ needs, skill mix and individual ward environments” (Duffield et al., 2010, p. 17). These factors align closely with the factor groupings (patient, nurse, environment) proposed by Allen (2015).

Further exploration of care models shows that in Ireland in the 1970’s, nursing work was allocated by task (Chavasse, 1981). The opinions of patients and nurses were investigated when the care model was changed to assign nurses to individual patients. Patients were grouped by “most acutely” ill, assigned to most experienced nurse, slightly less ill to next nurse, and remaining patients (double the number) to the most junior nurse. Patients reported that nurses knew their likes and dislikes better with direct nurse-patient assignment. Nurses reported that they could spend more time with each patient,

but some patients may be neglected if one was seriously ill. A large study of Finnish nurses showed that nurses were more satisfied when care was patient focused instead of task oriented (Mäkinen, Kivimäki, Elovainio, Virtanen, & Bond, 2003). Bird (1974) also found an increase in nurse satisfaction with more individualized patient care. Conversely, Berry & Metcalf (1986) found no difference in patient satisfaction between patients cared for through direct assignment versus task-based nursing on a mother-baby unit.

In the United States, a study of 136 units in 40 randomly selected hospitals showed a large variation in models used and variation in level of implementation (Minnick, Minon, Johnson, & Catrambone, 2007). Most interestingly, they found that care models differed within the same institution. Care model groupings were functional, primary, team, and case management. "None of the traditional characteristics of the established models were implemented to the extent that a majority of units could be said to be using any particular model" (Minnick et al., 2007, p. 454). In non-ICU units, patients were assigned directly to a nurse most of the time (83%), but sometimes assigned to a care team (58%). Functional, task-based nursing was rarely used (1.3% reporting RNs assigned to tasks rather than patients). Attempts to assign the same nurse to the same patient on a consistent basis for continuity of care varied widely. This study also explored the number of clinical assistive personnel working on acute care units. These included: clinical nurse specialist, psychiatric nurse liaison, discharge planner, social worker, chaplain, pharmacist, dietitian, radiology technician, physical therapist, and respiratory therapist. These roles sometimes overlap with nursing duties and can impact the workload for nursing care required by the patient. The implication is that supportive staff should be considered when studying nurse-patient assignments.

Others have studied the effects of assigning the same nurse to the same patient on a consistent basis for continuity of care. Continuity was described by Allen (2012) as both a goal and a decision factor of the nurse-patient assignment process. A study of med-surg patients found that continuity of care was important for good patient outcomes (Yakusheva, Costa, Weiss, 2017). They found that discontinuity was correlated with

poorer outcomes on a standardized index. " . . . patients were assigned to a new nurse nearly half the time even during the later parts of these long hospitalization. . ." (p. 425). In addition to continuity, the authors reflected, "There are many considerations for assigning nurses to care for specific patients, including budgeted nurse-to patient ratios, patient acuity, patient room location, and nurse skill sets and expertise" (p. 425). Continuity was found to decrease use of invasive breathing support in neonatal intensive care units (Miedaner, Allendorf, Kuntz, Woopen, & Roth, 2016). Continuity is also frequently cited in expert opinion pieces such as Mion & Buck (2017).

In summary, the direct assignment that occurs during the nurse-patient assignment process is one of many nursing care models used to align nursing care to patient care requirements. Over the last fifty years the model of care used most widely has shifted from task-based, functional nursing to a form of primary nursing where a nurse is assigned responsibility for all tasks for a patient during a given shift. The primary nurse may be assisted by a plethora of various clinicians and assistive personnel in carrying out these tasks. Assigning a nurse to be directly responsible for patient care has sometimes been shown to increase nurse and patient satisfaction. Assigning the same nurse to care for a patient throughout their hospitalization has been found to be associated with improved patient outcomes.

Decision Factors and Goals

Understanding nurse-patient assignment. Charge nurse decision making during the nurse-patient assignment process has not been widely researched. However, several studies have investigated the goals and factors that are considered during the nurse-patient assignment process. These articles are reviewed below, followed by a review of attempts to improve and automate the process.

Bostrom & Suter (1992) performed the first and largest investigation into the decision making process of charge nurses during the nurse-patient assignment process. They developed a list of 19 decision factors from the literature and interviews of 6 charge nurses. Nurses who made nurse-patient assignments (n = 271) were asked to rate each on

a 1 to 5 Likert scale and rank the top 5 most important factors. Results showed that patient acuity, clinical judgement of patient needs, and nurse experience with the particular patient and type of patient were ranked the most important. Charge nurses with more experience were less likely to value acuity and more likely to value expert clinical opinion than less experienced charge nurses. Experienced charge nurses considered more factors. The survey showed considerable diversity in the ways in which charge nurse assign patients to nurses (p. 36). Results showed large standard deviations; most responses reflect 60% of the possible response range. Responses were also polarized, with a similar number of respondents scoring highest and lowest rating. "Although the textbook guidelines for patient assignment were reflected in the survey responses, the process by which assignments were made was found to be significantly more complex" (p. 36). The authors called for the development of research-based guidelines and further research into the decision making of experienced charge nurses.

Allen (2015) performed a recent, in depth study of the purpose and decision factors considered during the nurse-patient assignment process. Fourteen charge nurses from 11 units were studied. Using a semi-structured interview process, 14 purposes for the nurse-patient assignment process were identified: best care, care coordination, continuity of care, discharge planning, equal workload, fairness, maintaining the workflow, nurse development, nurse-patient match, patient advocacy, quality-patient satisfaction, safety, staff wellbeing, and workload completion (p. 630). Every interviewee identified multiple goals for the assignment process.

In Allen's review of the literature for her dissertation (2012), she found over 90 factors that were considered during the nurse-patient assignment process. She combined these with her first-hand findings during her data analysis to develop 14 factors that she grouped into three main categories: patient, nurse, and environmental factors. These three groupings are echoed throughout the literature, providing a simple framework (Gray & Kerfoot, 2016). However, the nurse-patient assignment process is not simple; competing goals and numerous decision factors exemplify the complexity of decision making

required by charge nurses (Allen, 2012). Allen's research lays the groundwork for a deeper exploration decision making undertaken by the study described in this dissertation. (See also Chapter 3.)

Cathro (2013) reviewed the literature and inductively developed a guide for patient assignments. The proposed groupings of regulatory, safety, acuity, continuity, flow and nursing factors align with Allen's patient-nurse-environment framework by re-labeling safety, continuity and flow as goals of the nurse-patient assignment process and aligning regulatory to environment, acuity to patient, and nursing factors to nursing. Articles that focus on these specific factors are described below.

Patient factors. Thomasos et al. (2015) studied acuity-based versus location-based assignments for unlicensed nursing personnel. The study was initiated due to staff complaints with assignments based solely geographic allocation. An acuity tool was developed to assess patient workload. Staff satisfaction was assessed by survey before, during and after changing assignment structure from 100% location-based to 100% acuity-based. The authors found that staff valued both location-based assignments and acuity-based assignments, but that acuity-based assignments increase the perception that work was fairly distributed, better care was given, and morale was improved. The major finding was that for this particular unit location-based assignments were perceived as unfair because certain rooms (those near the nursing station) were more likely to be used by high acuity patients. This consideration is likely applicable to nurse-patient assignments as well, and should be a consideration when evaluating the equity of zone- or pod-based assignments such as those suggested by Acar and Butt (2016), Donahue (2009), and Mullinax and Lawley (2002),.

Nurse factors. Individual traits of nurses have been shown to contribute to complexity of optimal nursing assignments in a study of inpatient psychiatric care (Haspeslagh, Eeckloo, & Delesie, 2012). Interestingly, nurse aptitude was not correlated with experience or age. "We conclude that managing patient assignments is more complex than current practise suggests. Individual patients and nurses are important.

Thus, management needs to consider each nurse's aptitude and each patient's needs when assigning nurses to patients" (p. 498). Given this conclusion, it is interesting to consider where the cost-benefit line should be drawn when gathering information about nurses prior to developing nurse-patient assignments.

One large study of neonatal intensive care nurses found that nurses with more credentials were assigned to care for sicker patients, but to a smaller extent than expected (Rogowski, et al., 2015). Nurse gender has also been identified as a factor for consideration in the literature (Calfee, Follows, Maher, McBride, & Spital, 1998a; Calfee, Follows, Maher, McBride, & Spital, 1998b).

Environmental factors. Hendrich, et al. (2009) used radio frequency identification data to track the movements of 53 nurses across 143 shifts in 5 med-surg units. Their analysis shows the impact of unit layout on nurses' movement patterns and time spent with patients. They found that nurses assigned to patients with rooms close to each other and close to the nurses' stations spent more time in patient rooms. They concluded that:

> It is possible, therefore, that altering the spatial properties of the nurse assignment will change the way nurses move, either increasing or decreasing the number of trips to patient rooms and the nurse station. Changes could be made either at the architecture level, by designing rooms with particular spatial properties, or at the organization level, by creating nurse assignments with particular average integration values. (Hendrich, et al., 2009, p. 16)

Patient room location was also found to be important in ICUs. Leaf, Homel & Factor, (2010) found that severely ill patients have higher mortality when admitted to a low visibility ICU room. Distance traveled was also found to be an important factor in a workflow assessment by Acar & Butt (2016), who found that fetching and in-transit times are 1.8% and 6.3%, respectively, but make up 9.6 and 24.9% of individual activities observed.

Refusing an assignment. An interesting addition to the literature describing factors that make a good assignment was a number of articles regarding bad or unsafe assignments. One way to look at what makes a good nurse-patient assignment is to look at what would make a nurse refuse a patient assignment. The six articles below describe the factors that are crucial to judging the safety of a particular assignment. These articles were generally written as advice from experts to nurses posing questions about when to refuse an assignment. As expert opinion pieces, they provide a low quality of evidence, but when taken as a whole, they add interesting insight into the determinants of nurse-patient assignment quality. They present an interesting view into the factors that a charge nurse should consider, as well as the legal and workforce issues that can result from poor assignments.

The articles share commonality in discussion of the purpose of nurse-patient assignments: providing safe, quality patient care (American Nurses Association, 2016; Higginbotham, 2002; Kansas Nurses Association, 2006; Massachusetts Nurses Association, 2002; Politi, 2015; Powers, 1993; Singh, 2015; Unfair assignments, 1994). Of these, only one mentioned fairness and equity of workload (Unfair assignments, 1994). With this exception, the articles were in agreement, suggesting that charge nurses focus on these factors when making assignments: nurse competence, support staff availability, standard of care, and overall staffing.

Notably, several authors recommended that charge nurses should consider individual nurse's emotions and energy levels described as nurse stamina (Massachusetts Nurses Association, 2002), fatigue (Politi, 2015), and nurse illness or "not feeling well." (Unfair assignments, 1994). Concern for nurse exhaustion and burnout is noted elsewhere in the literature (Bostrom & Suter, 1992), and reflects the human side of the profession of nursing. Nurse-patient assignment is not just about resource allocation; it is also about optimizing care of patients by professional care givers, who are humans. Nurses have good and bad days, and work in a constantly changing, stressful environment. It is concerning that this consideration is not discussed in the HIT literature (see Section 2.4).

Singh (2015), adds, “Forget about the numbers for a minute. While great efforts are made to determine what number of patients makes an assignment safe, nurses are not created equal. We all have our strengths and weaknesses. One nurse’s nightmare may be another nurse’s dream shift” (p. 10).

The other notable aspect introduced by these articles is the professional nature of nursing practice. Because nurses are professionals, they have the right to refuse an assignment. The role of chief nurse executive, “Recognizes that the final decision regarding delegation of specific tasks or accepting a work assignment is within the scope of the individual nurse’s professional judgment” (Massachusetts Nurses Association, 2002, pp. 10-11). Higginbotham (2002) elaborates:

> The Nurse Practice Act in every state requires RNs to accept only those assignments that they are qualified to handle, by education, training, and experience. Accepting an assignment you’re not competent to carry out make you vulnerable to civil and administrative liability from your licensing board. If you refuse, however, be sure to document, in a letter to your supervisor, the factual reasons for your refusal, as evidence that you are not abandoning the patient. Know, however, that even with a ‘proper’ refusal, you are not guaranteed your job. Also, your license could be at risk if the Board of Nurse Examiners determines that you abandoned the patient by inappropriately refusing care. (pp. 72-73)

Nurses are expected to provide feedback regarding their assignment and refuse assignments that are beyond their scope to avoid ethical and legal complications of unsafe care (Powers, 1993). One author even argues that nurse preference should be considered, because nurses know their personal skills and abilities best (Kidner, 1999). This adds complexity to the nurse-patient assignment problem that is not experienced in algorithmic resource distribution modeling. However, this same complexity makes the process ideal for algorithmic support of fair and equitable assignments according to Powers (1993).

Process Improvement Efforts

Process. No investigation into charge nurse decision making during the nurse-patient assignment process has been published in peer-reviewed literature. Two such studies are documented in published dissertations. Allen (2012) identified six process steps common across nurses making assignments in multiple unit types. These steps are: "assign nurse to area, assign patient to area, assign nurse to patient, divide patients into groups, assign nurse to group and review/change assignment" (p. 71). In qualitative interviews of eighteen med-surg charge nurses, Plover (2017) identified similar process steps of information gathering, which consisted of data sourcing and selection, and making the assignment, based on particular goal(s) using a specific strategy. Plover also found that charge nurses tended to value patient needs and preferences over nurse needs and preferences when sorting priorities by having charge nurses perform a card sort of these two factors.

Improvement. Several articles describe efforts to better understand and improve assignments. These articles are informative because they exemplify attempts to improve the decision making of the charge nurse through systemization and guidelines, although they generally do not reflect academic rigor. This section will discuss non-automated improvement projects followed by algorithmic and HIT solutions in the next section.

Perhaps the best example of nurse-patient assignment research combined with development of a decision support algorithm was completed by Van Oostveen, Braaksam & Vermeulen (2014) at a large Dutch academic hospital. The study was performed in two parts, first to validate and rank decision factors previously identified in the literature, and second to evaluate a computerized decision support system with an auto-assignment algorithm (discussed below). The first phase consisted of a focus group session at two separate units. Each session was 45 minutes long with a convenience sample of three nurses. The subjects were asked to write decision factors on post-it notes, then were presented additional factors from the literature, and were asked to group all factors into categories. The compiled factors were then ranked by nurses on the respective units by

survey, with a 50% response rate. The top ranked response aligned with previous studies: patient acuity information from last shift, and continuity of care also ranked highly in the literature and this study, but there was poor correlation between other factors ranked in the literature and the rankings identified in this study.

One small hospital initiated a process improvement project after finding that both charge nurses and non-charge nurses were unhappy with current practices (Shermont & Russell, 1996). Staff and charge nurse opinions were gathered. Findings revealed that educations programs on assignment-making were practically nonexistent, a lack of guidelines in the literature, and a lack of standardization regarding acuity and nurse competency. Hospital-side guidelines and training programs were developed to help charge nurses develop successful practices.

Dykstra & Bridges (2012), present a case study of load leveling to improve the number of nurses reporting manageable assignments. An acuity tool was developed, and charge nurses were instructed to balance acuity in addition to considering continuity of care and unit geography. Staff nurses reported a significant increase in perception of workload within a target range. “New charge nurses reported increased confidence in creating assignments, and many experienced charge nurses wondered how they made assignments before the tool was available” (p. 41). This study showed that a decision aid can improve decision making, even of experienced charge nurses.

Donahue (2009) describes the implementation of an assignment process based on pods to decrease walking distance and improve response times to patient calls. Patient satisfaction was measured by survey before and after the change. Staff were concerned about potentially unfair assignments with increased focus on unit geography. However, improvements were seen in patient satisfaction scores, decrease in patient complaints, less erratic nurse workflow, consistent increase in amount of time spent in direct patient care. This case study was uniquely specific in expectation of quality patient care. The authors “paid particular attention to patients’ assessments of nurses’ promptness in responding to their calls, attention to their personal needs, and overall care” (p. 39).

In a follow-up of her work with charge nurses, Allen (2018) interviewed five patients and five staff nurses to better understand their perceptions of nurse-patient assignments. Nurses reflected that they would like to provide input into the assignment process by describing the needs of current patients, maintain continuity by caring for the same patients, and be sure the charge nurse considers individual nursing needs. Interestingly, the patients in this study had no idea that assignments were made with a specific purpose in mind.

Synergy Model. Curley (1998) proposed a model of nursing practice to improve patient outcomes by matching patient characteristics to nurse competencies. Like Allen's (2015) model, Curley focuses on patients, nurses, and systems. Patient characteristics include: stability, complexity, predictability, resiliency, vulnerability, participation in care, and resource availability (Curley, 1998, p. 65). Nurse competencies include: clinical judgment, advocacy, caring practices, facilitation of learning, collaboration, systems thinking, responsiveness, and clinical inquiry. With so many factors, Curley's Synergy Model is complex. Two attempts have been made to validate its use in regard to nurse-patient assignments. One study of patient factors showed that all were regularly considered, but none stood out as most important, although stability, complexity and predictability were the most frequently selected indicators (Kohr, Hickey, & Curley, 2012).

Another study implemented changes to nurse-patient assignments as part of an overall improvement project implementing Curley's Synergy Model (Carter & Burnette, 2011). Improvement efforts were initiated with new acuity and nurse competency measurement systems. Nurses were assigned a competency of independent, competent, or expert. Patients were assigned an acuity of high, medium, low. The authors described the new process:

> Daily staffing assignments ensure at least one expert nurse is assigned for every shift. Each patient is assigned to a room with consideration of the patient's anticipated complexity level, age, and medical or surgical needs. The grid then is

> used to balance patient acuity based on stability, predictability, and complexity with the nursing skill mix for the day. The grid is useful to ensure assignments are fair and best suited to the needs of the unit's patients. (p. 253)

To create equity with this model, all nurses are ideally assigned 6 patients, but nurses with higher competencies should have more medium and high acuity patients. Implementation of these improvements were associated with better nurse engagement and improved patient outcomes (lower length of stay, better satisfaction, fewer falls, and better physician satisfaction). This is a great case study of a simple formula that potentially outperforms expert intuition as described by Kahneman & Egan (2011, p. 226).

Automation Attempts

Healthcare information technology. Over the last 20 years, hospitals and technology vendors have begun to develop health information technology (HIT) tools to automate the collection of data needed for nurse-patient assignments and assist charge nurses during the assignment making process. The first call for a technology-based solution discovered in a review of the literature was in the 1990s. An expert opinion article about best practices for assignments called for hospitals to maintain "A computer database program which includes licensing information, continuing education data, certification credentials, and previous work experiences" (Powers, 1993, p.66). Technology was suggested as a way to have information about nurses' qualifications and expertise available for the charge nurse. "This information is then used to make staffing assignments so that the most qualified nurse is selected for the assignment" (p.66). Power's opinion was validated by Baker et al. (2010). They found:

> After reviewing the literature and discussing with bedside nurses and nursing managers, it was determined that a computer-based assignment tool could help the charge nurse or nurse manager perform the task of nurse-to-patient assignment in a time-efficient, equitable, fair, and balanced manner. (Baker et al., 2010, p.58)

Adoption of the ideal of HIT supported nurse-patient assignments has been slow. Baker et al. (2010), also stated, "No software tools that assist charge nurses in making equitable nurse-patient workload assignments were found" (p. 58). However, much development has occurred in the last 10-15 years so that now, nurse-patient assignment decision support is a function commonly found in workforce management HIT tools. Today, much of the data required to create fair and balanced assignments can be mined from nursing documentation in the electronic health record (Giammona et al., 2016).

Rosenberger et al. Mullinax and Lawley (2002) published the first attempt at automating nurse-patient assignments based on acuity. Their attempt to balance workload under the constraints of proximity, ratio, time to make assignments and lighter load for admission nurse, was not successful. Their linear algorithm approach did not solve within an acceptable timeframe. Shortly after, a study found that an integer program outperformed both randomized assignments and a heuristic based on the number of patients (Rosenberger et al., 2004). The goal of the algorithm was solely focused on equitable distribution of workload, and the authors noted that a nurse may be penalized if assigned to patients in rooms not located near each other.

The work of Rosenberger et al. (2004) was a landmark study. It garnered the interest and sponsorship of the Robert Wood Johnson Foundation, and generated several additional studies, articles and professional presentations (Punnakitikashem et al., 2008; Punnakitikashem, Rosenberger, Behan, Baker, & Goss, 2006; Sundaramoorthi, Chen, Rosenberger, Kim, & Buckley-Behan, 2009; Sundaramoorthi, Rosenberger, Chen, Buckley-Behan & Kim, 2010; Baker et al., 2010). This research group studied current nurse movement patterns, developed an optimization algorithm, and created a prototype HIT program to optimize nurse-patient assignments.

The optimization algorithm was developed through supervised machine learning of nurse location data from four units in a Texas hospital (Sundaramoorthi et al., 2009). The algorithm used the variables shift, patient diagnosis, patient care requirements, and nurse licensure. The authors described:

> These nurse data contain information on month, day, shift, time, location, nurse, nurse type and time spent for the location visited by the nurse. [The hospital] also provided patient data, which contain information on admit date, discharge date, room number and diagnosis code for each patient. (p. 6)

It is unclear why the researchers assumed that variables needed for nurse-patient assignment process could be obtained through data mining of nurse location and this limited sub-set of patient information. The researchers suggest that variables may differ based on hospital. The resulting optimization algorithm used simulation to evaluate nurse-patient assignment.

The algorithm developed by Sundaramoorthi et al, was incorporated into a prototype HIT solution with 3 main components: data entry (patients, nurse, and shift information), assignment optimization algorithm, optimal assignment display (Punnakitikashem et al., 2006). The goal of the prototype was to balance workload among nurses. This goal was selected with the assumption that balanced workload will improve patient care and reduce nurse burnout.

The prototype was tested in a software lab setting by a convenience sample of undergraduate and graduate nursing students (Baker et al., 2010). Testing revealed that simplicity of the user interface and timeliness of recommendations were important factors for adoption. However, additional factors like patient acuity needed to be included as well.

Overall, this research group made several valuable contributions to the study of HIT assisted nurse-patient assignments. First, it was possible to create nurse-patient assignment recommendations based on a mathematical algorithm (Sundaramoorthi et al., 2009). Secondly, the majority of student nurses queried would support the use of such a program in their workplace (Baker, et al., 2010).

Best examples. Perhaps the best example of nurse-patient assignment research and algorithm design was completed by van Oostveen et al. (2014) at a large Dutch academic hospital. The study was performed in two parts, first to validate and rank

decision factors previously identified in the literature (described above), and second to evaluate a computerized decision support system with an auto-assignment algorithm. Four major factors were brought forward from the initial research into the assignment algorithm: even distribution of workload, continuity of care, nurse patient ratio and proximity. The HIT tool was then evaluated in a before-and-after study via a survey of charge nurse satisfaction with the process and nurse satisfaction with their workload at the end of the shift for six day shifts, with and without HIT intervention. It was unclear how the survey was developed and validated or if the same staff were surveyed in both instances.

Survey results showed a significant decrease in the time to perform assignments, no change in charge nurse satisfaction, no significant variance between the three units studied, and slight decreases in nurse satisfaction and perceived workload (van Oostveen et al., 2014). There were several key findings from this investigation:

> The investigators are convinced that a [Clinical Decision Support System] can never completely replace human insight. The nurse-to-patient assignment generated by the [integer linear program] model is a proposal that has to be assessed and, if necessary, adjusted by one or more nurses to obtain the final nurse-to-patient assignment. (p. 284)

A similar model was developed by Acar & Butt (2016) that balanced both acuity and distance traveled. First, a task analysis was performed through direct observation of 45 distinct nursing activities over 276 hours. Initial findings revealed that indirect care activities such as planning, documentation and care coordination take more time during a shift than direct patient care. The authors found that, "[Charge nurses] rated acuity approximately five times more important (0.833/0.167 = 4.988) than the distance measure" (p. 196). Pilot studies revealed that assignments created with a mathematical model could "outperform the assignments being generated by the charge nurses" (p. 198). Charge nurses interviewed described assignments created by the model as, "feasible, easy to implement, and would be perceived as equitable by the nursing staff. In addition, the

RNs would perceive the Model 1 assignments to be unbiased since they were not created by a [charge nurse]" (p. 203). The most interesting conclusion made by Acar & Butt is that their model cannot be directly applied to other units. This highlights the gap in the research that tells us which constraints are applicable in which setting and how to quickly model these constraints.

Another recent model was developed by Sir, Dundar, Steege, & Pasupathy (2015). Their research showed that a patient classification system (PCS) alone was not an adequate source of patient acuity to create fair and balanced assignments. Instead a value of "perceived workload" was developed and incorporated into assignment models. Workload of all patients assigned to a nurse was perceived as more balanced when PCS based acuity and perceived workload were used, than workload alone. The authors describe:

> The models assign patients to nurses in a balanced manner by distributing acuity scores from the PCS and survey-based perceived workload. Numerical results suggest that the proposed nurse–patient assignment models achieve a balanced assignment and lower overall survey-based perceived workload compared to the assignment based solely on acuity scores from the PCS. This results in an improvement of perceived workload that is upwards of five percent. (p. 237)

This study highlights the need to dive deeper into what drives workload perception, expanding factors included in nurse-patient assignment modeling algorithms.

Other algorithms and HIT. Others have continued work on assignment algorithms. In 2009, Schaus, Van Hentenryck, & Régin, developed a working algorithm to address the assignment of nurses to zones and within zones of a neonatal intensive care unit. They built on the work of Mullinax and Lawley (2002) by substituting a constraint programming model for the unsuccessful linear model. Pesant (2016) furthered this work by developing a constraint programming algorithm that also allowed patient acuity to vary by nurse, based on the work of Sir et al. (2015). Ku, Pinheiro, and Beck (2014) developed a similar load balancing algorithm to balance nurse-patient assignments by

acuity within a particular work-zone. Additionally, Unluturk (2014) used a simple sorting algorithm to assign patients by acuity.

Garcia & Nell (2012) published an article describing three case studies of hospitals that were using technology to augment nurse-patient assignments. Two organizations had technology systems that automatically calculated nursing acuity based on nursing documentation. Acuity information was shown on a combined dashboard with staffing, electronic health record, and admission-discharge-transfer systems (ADT) information. This provided a single location for charge nurses to gather pertinent staff and patient information when making nurse-patient assignments, augmenting their decision making process. The third hospital also used a nurse-patient assignment tool. "The technology helps nurses and leaders achieve balanced assignments while creating an electronic record of primary and relief assignments" (Garcia & Nell, 2012, p. SR19). Gray & Kerfoot (2016) agree that assignments should be based on data collected from many HIT solutions including: EHR, scheduling, patient classification (acuity), nurse call systems, bed-management systems (bedrail alerts), and physiological monitor device alerts (p. 10). They also point out that, "Nursing care takes place in an environment that is nonlinear, replete with surprises, and expected interruptions, requiring dynamic responses to continual dynamic changes" (Gray & Kerfoot, 2016, p. 11).

A multi-hospital system in northern California developed a similar HIT nurse-patient assignment tool (Massarweh, Tidyman, & Luu, 2017). This tool was developed as a quality improvement effort with the primary goal of capturing the nurse-patient assignment in a searchable format, instead of previous paper technology. Automation was restricted to data imports, automated calculations and color coding. The tool was developed to retain the look and feel of the legacy paper process to improve adoption. Even with limited functionality, the researchers classified this HIT tool as Clinical Decision Support with these purposes: record retention, regulatory compliance, contract compliance, equitable workload, competence, fatigue mitigation, standardized format, and cost savings. Twenty-one nurse managers completed a survey after implementation.

The major finding was that less time was spent on manual calculations. It was unclear how the survey was developed and validated.

Garcia & Nell (2012) closed their synopsis of technologies for augmenting nurse-patient assignments with this inspiring vision:

> Imagine a future where nursing is reimbursed for the value nurses bring—where nurses have easy access to staffing, patient progress, and financial information; where they maximize technology to clearly establish the relationships between an investment in nursing care and better patient outcomes; where they work with the finance officer to make the right investment. Imagine a future where technology helps us match the right nurse to the right patient at the right time. That future is now. (p. SR19)

Birmingham (2010) reinforced the vision, stating, "When the patient and nurse staffing systems come together in an automated patient assignment system, the charge nurse is supported with evidence to complement her expertise in the highly complex process of making patient assignments" (p. 25).

In summary, the automation literature focuses on fair assignments of equal patient burden. The nursing literature focuses on safe patient care, and nurse differences. These goals are sometimes competing and have shifting definitions and values depending on the environment and factors considered during the nurse-patient assignment process. There is not an easy, universal method to measure safe, quality nursing care.

Gaps in the Literature

The articles above describe the decision factors, goals and environment experienced by charge nurses during the nurse-patient assignment process. Several attempts have already been made to improve and automate assignment making through guidelines, algorithms and HIT solutions. However, to date, development of these tools has not been guided by principles of decision theory. The environment has not been studied through the lens of charge nurse expertise. The most notable gaps are the lack of

direct observational studies of charge nurses during the nurse-patient assignment process and of large, multi-unit, multi-hospital studies of the nurse-patient assignment process.

Table 2.1 maps the contributions of the literature to the conditions for algorithm use over intuitive expertise set out by Kahneman & Klein (2009, p. 524). The table identifies several gaps in conditions for algorithm use. Of these, the biggest gap is in the understanding of how environmental changes effect decision factor selection and desired outcome of the nurse-patient assignment process.

Table 2.1

Nurse-patient Assignment Literature Supporting Conditions for Algorithm Development

Condition	Finding in literature	Citing literature	Gap
(a) Confidence in the adequacy of the list of variables that will be used	Adequate decision factors have been identified, many accessible via automated HIT solutions	Allen, 2012; Bostrom & Suter, 1992; Garcia & Nell, 2012; Giammona, et al., 2016; Gray & Kerfoot, 2016; Van Oostveen et al., 2014	Is factor list comprehensive when studied at scale across multiple hospitals?
	Rating of factor importance is inconsistent	Bostrom & Suter, 1992; Kohr et al., 2012; Sir et al., 2015; Sundaramoorthi et al., 2009; Van Oostveen et al., 2014	Which factors are used most frequently? Which factors are most important to include in an algorithm?
(b) A reliable and measurable criterion	Many goals exist, but standardized definitions and criteria do not	Allen, 2015; Shermont & Russell, 1996	Can measurable criteria be agreed upon as a standard across units and hospitals?
	Some patient outcome related goals are measurable for individual patient care units	Miedaner et al., 2016; Yakusheva et al., 2017	
	Goals vary based on decision factors	Duffield et al., 2010; Minnick et al., 2007	Can reliable, universal goals be developed?
(c) A body of similar cases	Direct assignment of nurse is frequently performed as the most common care model	Minnick et al., 2007	n/a

Nurse-patient Assignment Literature Supporting Conditions for Algorithm Development (cont)

Condition	Finding in literature	Citing literature	Gap
(d) A cost/benefit ratio that warrants the investment in the algorithmic approach	Charge nurses spend approximately 30 minutes completing assignments	Acar & Butt, 2016; Mullinax & Lawley, 2002; Rosenberger et al., 2004	Is charge nurse time spent making assignments consistent when studied at scale across multiple hospitals?
(e) A low likelihood that changing conditions will render the algorithm obsolete	Environmental change can influence the valuation of decision factors	Bostrom & Suter, 1992; Minnick, et al., 2007; Singh, 2015; Van Oostveen et al., 2014	How much does the environmental context affect the nurse-patient assignment?
	The environment within a unit is stable enough for an algorithm or guideline to improve outcomes within a particular unit	Acar & Butt, 2016; Baker, et al., 2010; Carter & Burnette, 2011; Donahue, 2009; Dykstra & Bridges, 2012; Massarweh et al., 2017	Are environmental conditions similar across units and hospitals for a single algorithm to be useful?

The next chapter will describe the methods used to investigate some of the gaps described above. But first, this chapter concludes with a forward-looking description of an ideal state nurse-patient assignment process described by Mullinax & Lawley (2002):

> For implementation, the assignment model needs to be integrated into a computer-based decision support system. Such a system would require a user-friendly interface, a patient database for storing and updating patient records and for automatically computing acuity scores from these records, a module providing nurse staffing information for the shift, a module implementing the assignment model, and finally a module for checking the feasibility of a given assignment. We envision that the charge nurse would first verify that the acuity scores of the patients are properly updated. Note that updating patient acuity is an ongoing process that should occur as patient care requirements evolve. Doctors and nurses should be able to access and update patient records in the database as these changes occur. In this case, patient records and their corresponding acuity scores should be largely up to date at the beginning of the shift.

The next step would be to verify that the nurses scheduled to work the shift are correctly represented in the system. Once this information is in place, the charge nurse may want to specify in advance that a certain nurse will care for a certain patient. This is easily accomplished by presetting some decision variables in the model, and so the decision support system should provide an interface for doing this. Finally, the charge nurse will execute the assignment module, which must automatically extract acuity and nurse staffing information from the database, and then compute an assignment within the constrained time budget. We note that this module could contain one or more of the assignment approaches investigated in this paper.

After an assignment has been created, the system should allow the charge nurse to make assignment adjustments as she sees fit. The finalized assignment would then be submitted to the assignment feasibility module to verify its feasibility, since manual changes to the computed assignment might violate some constraints. If the finalized assignment meets all model constraints, then the process is complete. If not, the constraints violated and the degree of violation must be reported to the charge nurse, who might make further adjustments or decide to accept minor infeasibilities. Thus, we believe that in practice the contribution of the patient assignment model will be to give the charge nurse a good initial assignment which she can adjust, based on intuition and judgement related to factors not included in the model, to arrive at the final assignment. (pp. 34-35)

Chapter 3: Methods

Problem Statement and Specific Aims

Chapter 1 provided a high-level overview of clinical expertise, the conditions for developing that expertise, the charge nurse as an expert, and decision science. Chapter 1 also introduced Kahneman & Klein's (2009) conditions for intuitive expertise and guidelines for determining when an algorithm can improve expert decision making. Chapter 2 reviewed the literature describing decision factors and goals of the nurse-patient assignment process and efforts to automate and improve it. Gaps were identified in understanding the decision process charge nurses use to make assignments and a lack of large-scale validation of factors and goals for inclusion in algorithm development. This chapter discusses the specific methods applied by this research to investigate gaps in the literature.

Several gaps exist in the understanding of the current process for nurse-patient assignment making, as shown in the conditions for algorithm development (Table 2.1). Heedless of these gaps, software developers have begun to develop and market automated nurse-patient assignment tools (Garcia & Nell, 2012). Nursing leaders have created best practice guidelines and training programs based on expert opinion (American Nurses Association, 2016; Cathro, 2013; Massachusetts Nurses Association, 2002; Shermont & Russell, 1996). Developers, nursing leaders, and workforce management teams need better information about the nurse-patient assignment process in order to plan improvements and minimize labor expenses based on scientific research (Welton et al., 2009). Given the importance of workforce optimization and the crucial role individual nurses play in providing individualized patient care, a better understanding of charge nurse decision making must be the first step for proper alignment of future improvement efforts.

The literature suggests that the nurse-patient assignment process is complex and that a myriad of patient, nurse and environmental factors are involved (Allen, 2012). Although many goals for nurse-patient assignment have been identified and discussed in the literature, standardized definitions of these goals do not exist, and it is unclear if

charge nurses receive regular feedback about the quality of their assignments (Allen, 2012; Duffield et al., 2010; Minnick et al., 2007; Shermont & Russell, 1996). Reliability of charge nurse expertise has been called into question despite the availability of criteria to measure success (Bostrom & Suter, 1992; Kohr et al., 2012; Sir et al., 2015; Sundaramoorthi et al., 2009; van Oostveen et al., 2014). Without clear goals and knowledge of the feedback cycle, it is unclear if conditions for intuitive expertise exist (Kahneman & Klein, 2009). Researchers have approached this as a nursing theory or allocation type problem and have not investigated the decision methods and crucial key requirements used by charge nurses in the nurse-patient assignment process (Ku et al., 2014; Pesant, 2016; Punnakitikashem et al., 2006; Schaus et al., 2009; Sir et al., 2015; Unluturk, 2014). Additional research is necessary to refine the goals and investigate the decision making processes of charge nurses through the lens of decision science.

As described in the literature review, several studies have been completed to identify decision factors and goals of the nurse-patient assignment process. Techniques used include semi-structured interview (Allen, 2012; Bostrom & Suter, 1992), group interviews (Kohr et al., 2012; van Oostveen et al., 2014), mixed-methods (Bostrom & Suter, 1992; Kohr et al., 2012; van Oostveen et al., 2014), and surveys (Bostrom & Suter, 1992; Kohr et al., 2012). These studies have several shared limitations. Each focused on a single or small set of unit(s) or hospital(s), they generally had small sample sizes, did not use consistent types of nursing units, and relied on self-report. Limited samples prevent lessons learned from implementation outside of the study unit or site (Acar & Butt, 2016). Logical extension of existing work suggests a multi-hospital approach to identify the decision factors that are used most frequently, and how factors and goals change with shifts in environmental context.

Research aim. This research investigates charge nurse decision making during the nurse-patient assignment process as an exemplar of the larger question: How can we leverage information technology to improve decision making in healthcare, while respecting individual clinician expertise and the unique context of individualized patient

care? Many gaps were identified in the documented knowledge about the nurse-patient assignment process, both in understanding the process that charge nurses use today and the evaluation of conditions for decision support algorithm development as shown in Table 2.1. These gaps could each be explored deeply as individual research projects. However, in order to maximize the investigative value of one study, the gaps were combined to create a single, tractable research project with four categories. These categories are: process, factors, goals, and environmental context. Primary and secondary research questions were developed for each category:

- Process: What decision techniques are used by charge nurses today?
    - How much time do charge nurses spend making nurse-patient assignments today?
    - How do charge nurses receive feedback about the quality of their assignments?
- Factors: What key requirements should be incorporated into a nurse-patient assignment decision support algorithm?
    - What data sources are used to gather information for decision making?
    - Which decision factors are considered most often?
- Goals: What should the goals of a nurse-patient assignment decision support algorithm be?
    - Are some goals valued more than others?
    - Are goals tied to measurable criteria?
- Context: How much does environmental context affect charge nurse decision making during the nurse-patient assignment process?
    - Do charge nurse's goal priorities change based on context?
    - Do charge nurse's consider different decision factors based on context?

Experimental Design

Mixed methods. The methods for this study were chosen to expand and validate the current understanding of the nurse-patient assignment process through a non-experimental design. This study added to current research by: gathering data from more than one hospital; improving the comparability across hospitals by focusing solely on med-surg units; preserving the complexity of contextual information of in context decision making; leveraging previously proposed frameworks for expert decision making and nurse decision making; and validating previously identified decision factors.

This research builds on findings from existing qualitative research, to reframe and validate current findings through the lens of cognition and decision theory. This was accomplished by the researcher using a mixed-methods approach (Tashakkori & Teddlie, 2010). The first portion was qualitative in nature. According to Coast et al. (2012) and Kløjgaard, Bech, & Søgaard (2012), qualitative research in a particular field is an important first step to creating a shared understanding and is more formal than relying solely on the literature or expert opinion. The qualitative portion of this research was exploratory in nature, using cognitive task analysis interviews to validate the key requirements and explore decision methods used by charge nurses. The second portion was quantitative in nature. The results of the interviews were combined with decision factors and purpose statements previously identified in the literature and a survey was developed to further investigate the processes, factors, goals and how these vary with context. The survey portion also leveraged cognitive task analysis-based methodology and allowed a much larger sample to be collected than could be accomplished through qualitative interviews alone.

Methods were completed in five steps: 1) Initial data was collected via critical incident-based interviews. 2) Interview responses were mapped to factors and goals previously identified in the literature and analyzed. 3) Interview responses were qualitatively analyzed to identify decision processes. 4) A survey was developed, tested and distributed. 5) Survey responses were quantitatively analyzed validate aspects of

process, factors, goals and variation based on environmental context. These five steps are discussed in the remainder of this chapter. Table 3.1 shows the method used to investigate each research question.

Table 3.1

Research Questions, Short Names, and Associated Research Methods

Short name	Question	Interview	Survey
FACTORS	What key requirements should be incorporated into a nurse-patient assignment decision support algorithm?	YES	NO
FACTORS-A	What data sources are used to gather information for decision making?	YES	YES
FACTORS-B	Which decision factors are considered most often?	YES	YES
GOALS	What should the goals of a nurse-patient assignment decision support algorithm be?	YES	YES
GOALS-A	Are some goals valued more than others?	YES	YES
GOALS-B	Are goals tied to measurable criteria?	YES	NO
PROCESS	What decision techniques are used by charge nurses today?	YES	NO
PROCESS-A	How much time do charge nurses spend making nurse-patient assignments today?	YES	YES
PROCESS-B	How do charge nurses receive feedback about the quality of their assignments?	YES	YES
CONTEXT	How much does environmental context affect charge nurse decision making during the nurse-patient assignment process?	NO	YES
CONTEXT-A	Do charge nurse's goal priorities change based on context	NO	YES
CONTEXT-B	Do charge nurse's consider different decision factors based on context	NO	YES

Sampling. Because the goal of this research was to enhance the understanding of the charge nurse decision making during the nurse-patient assignment process, it was not intended to definitively prove a pre-supposed hypothesis. Instead, at the outset of this study, the goal was to document reported charge nurse decision processes and describe them through comparison to published models of expert decision making. Of particular interest was the investigation of alignment with the expert decision making technique of recognition primed decision making (Klein, 2008). The decision model described in the finding can be incrementally tested in larger populations using quantitative and statistically valid techniques. To this end, a purposeful sampling methodology was

employed rather than a random sampling methodology; participant selection focused on finding candidates which met inclusion criteria.

Scope and assumptions. In practice, the nurse-patient assignment process is completed prior to the shift, and also throughout the day as patients are admitted and discharged from the unit and nurses come on and off shift and go on breaks. This study focuses on the primary assignment process, which occurs before the beginning of the shift.

This research assumes that medical-surgical charge nurses are experts, and as experts, can provide insight into the decision factors, goals, and process of the nurse-patient assignment process. Kahneman and Klein (2009) agreed upon two conditions for the development of expertise. Experts must have prolonged practice in a valid, predictable environment. In other words, they must receive regular feedback that reflects the quality of the decision, and, they must receive this feedback in a timely manner. The environmental validity of charge nurses making nurse-patient assignments had not been investigated at the outset of the research. However, the assumption of expertise was assumed, and validity of this assumption was explored as the research progressed.

Initial Data Collection – Interviews

Initial data collection was completed using the cognitive task analysis technique of critical incident-based interviews. "Cognitive task analysis is a family of methods used for studying and describing reasoning and knowledge" (Crandall et al., 2006, p. 3). Cognitive task analysis was selected to delve deep into the tacit knowledge of the charge nurses, while respecting the context and complexity of real-world decision making.

Interviews are the most commonly used method of cognitive task analysis knowledge elicitation (Crandall et al., 2006). Interviews provide an efficient way to elicit information including subtle dynamics that can be missed during observation or simulated environments. This method met the needs of this study because it is "specifically aimed at helping the domain practitioner in expressing knowledge and then representing that knowledge in a way that others can understand and put to use" (Crandall

et al., 2006, p. 41). A drawback to using interview for knowledge elicitation is that it requires deep reflection by study participants and well trained interviewers. These concerns were considered during the selection of the interview technique and pre-study researcher preparation.

Incident-based interviews. To encourage deep reflection of study participants, Critical Decision Method (CDM) was selected as the particular interview technique. CDM methodology was developed specifically to retrospectively assess expert decision making during critical events using knowledge elicitation techniques (Schraagen et al., 2008). CDM has been successfully adapted to study less critical, typical events, as long as a useful event can be generated for probing (Crandall et al., 2006). This adaption was a good match for the needs of this study because nurse-patient assignments are performed routinely. An interview guide was developed with the requirement of useful event generation in mind. Participants were requested to recall the most recent time they performed nurse-patient assignments [LAST] and also a particularly challenging (critical) incident [HARD]. This provided a set of two scenarios for each study participant. These same scenarios were repeated in the survey portion of the study.

CDM generally consists of one or more recorded interviews performed by a team of two interviewers, one who primarily asks the questions while both take notes.

> In a CDM interview, the researcher tries to elicit information about cognitive functions such as decision making and planning and sensemaking within a specific challenging incident. The overall data collection strategy is to gradually deepen on critical cognitive points by making multiple passes through the incident. The research team has to get to the story of the specific event and understand the cognitive demands of the task and setting. The interview is conducted in four phases, or sweeps: (1) Incident Identification, (2) Timeline Verification, (3) Deepening, and (4) 'What If' Queries. (Schraagen et al., 2008, p. 74)

These techniques were adopted for this study, with minor modifications described in the interview guide development section below.

The conceptual model proposed by Allen (2012) was used to aid in framing the interview sessions. Dr. Allen proposed that a charge nurse initiates the nurse-patient assignment process with a specific purpose in mind. This purpose directly influences decision factors and steps used to create the nurse-patient assignment. Steps are also influenced by decision factors. Unlike Allen's study, this study pre-identified the purpose (goal) and decision factors, as opposed to investigating them. Building on the goals and decision factors identified by Allen allowed this research to investigate the judgement regarding the value of the various goals and decision factors in order to determine the key requirements for the nurse-patient assignment process. Additionally, this research sought to understand the decision methods used, rather than just describing the process steps.

Participant selection. Candidates for knowledge elicitation types of cognitive task analysis should be experts who actually perform the task in question (Crandall et al., 2006). The number of interviewees for qualitative research depends on many factors (Baker, Edwards, & Doidge, 2012). For the proposed study, it was estimated that between 10-20 interviews would provide the necessary breadth of responses to assess a pattern among respondents yet keep the scope and data yield tractable. Additionally, it was logical to focus on a subset of available nurse-patient assignment situations in order to elicit comparable responses. It was important to find participants with enough experience to develop expertise as well as recent experience in order to promote ease of recall of recent nurse-patient assignment events.

Keeping these guidelines in mind, charge nurses were recruited who met the following criteria: more than 5 years of nursing experience; more than 2 years as a charge nurse on the same unit; and made nurse-patient assignments on a regular basis (at least once per week on average for the past 2 years, and have made at least 3 nurse-patient assignments in the 2 weeks directly preceding the interview). Additional criteria were applied to the units in which these nurses practiced: medical and/or surgical units in an

inpatient setting where the average length of patient stay was between 2 to 7 days and the average nurse was assigned between 3-6 patients. The researcher's personal knowledge of nursing practice was combined with criteria developed by Bostrom & Suter (1992) to develop the participant selection criteria. Selection criteria were validated through discussion of appropriateness with two PhD prepared nurse researchers and the dissertation advisor.

The charge nurse interview participant subset was selected to build knowledge in the most "general" type of inpatient nursing (medical-surgical) with the goal to create findings that can retested in the various nursing specialty areas. The length of employment time on a particular unit served as a proxy for the development of individual expertise and deep knowledge of the unit's staff and culture. Patient length of stay allowed for the study of continuity of care factors, which may not be present in short-stay units.

Human subjects oversight. Institutional Review Board (IRB) approval for the study was obtained from the University of Minnesota. Both the interview and survey components were classified as exempt. This study did not collect any data that could be used to identify a patient. All demographic identifying information regarding interview participants was stored separately from participant responses in a password secured demographics file. After IRB approval was obtained, participant recruitment began using the tools in Appendix A: *Participant Recruitment Materials*.

Participants were recruited from hospitals of various sizes and locations across the country identified informally through the researcher's professional network. A small stipend ($50 gift card) was offered to aid recruitment and presented to each participant post-interview. Interviews were scheduled at locations agreed upon by the participant and the researcher, convenient to the participant's work or home. Locations included: coffee shop, restaurant, conference room, and participant's office. At the outset of each interview, consent was obtained verbally after participant review of the IRB "Information

Sheet for Research." The Information Sheet for Research was given to each participant to keep for future reference or questions (see Appendix B).

After obtaining IRB approval and interviewee consent, data was collected as described below during a single interview, approximately 2 hours long, performed by two interviewers. One interviewer was the primary researcher, and the second interviewer was Dr. Stephanie Allen. Both interviewers took notes in addition to an audio recording of the interviews. Although not ideal, due to travel constraints, the second interviewer participated remotely via audio connection, or listened to the recording at later time. Dr. Allen was selected as the second interviewer given her previous experience with interviewing techniques, as the primary researcher was a novice, and the CDM interviewing technique is not recommended for novice interviewers (Schraagen et al., 2008).

The primary interviewer demonstrated interviewing proficiency through a series of practice interviews to evaluate technique, flow, and logic of the interview guide and interviewer style. The primary interviewer received training at the Naturalistic Decision Making Conference, 2015. Interview questions and methods were evaluated by two CDM experts (Dr. Helen Klein and Dr. Emilie Roth).

Interviews commenced with brief introductions. Next the participant was provided with a copy of the Information Sheet for Research and verbal consent to proceed was obtained. Participants were asked to avoid hospital, staff member, and patient identifiers to protect business, employee and patient privacy. Initial questions were demographic in nature, as outlined in Appendix C: *Interview Demographic Questions*. The interview then proceeded through the CDM interview as outlined in Appendix D: *Interview Guide*.

Interview demographics. Demographic data was collected from each interview participant to describe the participant and their workplace, and assess if inclusion criteria were met. The demographics collected reflect demographic data collected in previous studies identified in the literature, with the addition of questions about the hospital, but

leaving out percent of time employed and work history due to lack of perceived relevancy and to reduce response burden (Allen, 2012) (Bostrom & Suter, 1992). Age, race and gender were not expected to be key data points for analysis and were collected on a voluntary basis only. Demographics related to inclusion criteria were collected via direct questioning from the interviewer at the beginning of each interview. Additional demographics were collected at the end of the interview by asking the participant to complete a paper questionnaire. The post-interview questionnaire also included space for the participant to share any comments about the interview, which provided feedback for researcher technique improvement (see Appendix C).

Interview guide development. An interview guide was developed to assist the researcher in following the CDM method, create a similar experience for all participants, and generate responses specific to the study goals. The guide followed the 4 sweeps recommended by Schraagen et al. (2008): Incident Identification, Timeline Verification, Deepening, and 'What If' Queries. Relevant questions were adopted and adapted from the CDM interview template suggested in, "Working Minds: A Practitioner's Guide to Cognitive Task Analysis" (Crandall et al., 2006, p. 270). Sweep specific instructions were incorporated into the researcher's interview technique.

As noted above, incidents were pre-defined to assist participants in recollection of the context of a specific nurse-patient assignment. At the outset of each scenario, the participant was asked several questions to engage the memory of a specific event. Each interview guide question was designated to elicit purpose, steps, and/or key requirements in the nurse-patient assignment process. Purpose questions assessed GOALS; questions about steps assessed PROCESS, and key requirements assessed FACTORS.

Questioning began by asking the interviewee to recall the most recent time [LAST] that they made a nurse-patient assignment – a recognized variation of CDM (Crandall et al., 2006). This incident was explored using three sweeps to specific incident, create timeline and deepen inquiry while eliciting responses focused on purpose, factors, and decision making steps.

Next, the researcher prompted recall of a second specific memorable event in order to elicit goals and factors that vary by environmental context. Prompts for the second event followed CDM methods to discover a challenging incident [HARD]. Prompts were introduced if the participant could not recall a cognitively challenging incident. Suggestions were based on the researcher's personal experience and validated with a PhD-prepared nursing researcher. They included overstaffing, understaffing, unqualified staffing, or when a staff member complained about an assignment being unfair or not equitable. Defining two specific incidences allowed the researcher to identify a complete set of GOALS and FACTORS, including those that may only be used in specific contexts. The initial questions were repeated for this second incident using three sweeps to specify incident, create timeline and deepen inquiry.

Finally, the researcher elicited participant introspection about the nurse-patient assignment process using what-if queries. These questions probed the development of expertise in nurse-patient assignment making to investigate the deeper cognitive facets involved in the decision making process. The fourth sweep was withheld until after the HARD scenario was identified in an attempt to keep the memory of the HARD scenario pure, avoiding interviewee self-analysis until the details of both scenarios were described. The what-if queries were then repeated for the first scenario [LAST]. See Appendix D for the detailed interview guide.

After the CDM sweeps were completed, additional questions were asked to deepen the participant introspection. These questions investigated participant GOALS and FACTORS specifically related to computerized decision support for the nurse-patient assignment process [COMP] and to the general case with a primary intention to validate key requirements (decision factors and goals) described in the literature. These questions were added at the suggestion of CDA experts, and asked after the CDM portion of the interview in attempt to minimize self-report bias. At the conclusion of the interview, additional background questions were asked to gather information to augment future research.

In summary, for each interview, the researcher kept the following goals in mind: Record most recent incidence [LAST – description, purpose, timeline/steps, key requirements; Record challenging incidence [HARD] – description, purpose, timeline/steps, key requirements; Deepen inquiry [HARD, LAST]; Record general case – description, purpose, timeline/steps, key requirements; Follow 4 sweeps: Incident Identification, Timeline Verification, Deepening, and 'What If' Queries.

Interview documentation and data curation. The interview guide was used as a structured note taking tool during each interview. After the interview, these notes were typed "as soon as possible," retaining "the participant's style," and kept in "the order and sequence of the interview" as recommended by Crandall et al., 2006, p. 208). A record of interviewer observations and comments were documented along with the notes, as well as illustrative verbatim participant quotations. No hospital or staff member names, and no patient identifiers were included in notes. Notes from primary and secondary interviewers were combined and reviewed for completeness and approved by both interviewers. Notes were retained by the primary researcher in a password secured folder. Interviewer notes were used as the primary data source for analysis, with audio recording only utilized only to clarify or supplement gaps as needed, as recommended by Crandall et al. (2006). Audio recordings were transferred to a password secured folder and deleted from the initial recording device.

Mapping to Factors and Goals

In total, eleven interviews were completed between September 2015 and July 2017. Goals for sample diversity were met at this point, and additional interviews were unlikely to provide substantial value. Interview participants worked at 5 different hospitals on 8 inpatient units, allowing for the capture of variation between hospitals. In one hospital, participants were recruited from 4 units to capture within hospital variation. Two nurses participated from each of 3 units to capture within unit variation.

Interview data preparation. The recommended phases of qualitative data analysis are: preparation, data structuring, discovering meaning, and representing

findings (Crandall et al., 2006)(Thorne, 2000). Interview notes were prepared as noted above and analyzed following these phases while keeping the research goal and specific aims of the interview guide in mind. Each phase is described below. Primary and secondary research questions were used to guide data analysis, see Table 2, for the short name associated with each research question. Data analysis was completed by the primary researcher with support from Dr. Stephanie Allen and researcher's advisor.

Data structuring. Interview notes were prepared as described above. Initial data structuring was completed through codification of the purpose GOALS and FACTORS for each scenario. Interview responses were mapped to FACTORS and GOALS previously identified in the literature by Allen (2015). Dr. Allen's (2015) framework was selected because it was the most comprehensive, based both on her own research and from her comprehensive listing of purposes and factors identified in the literature (Allen, 2012).

The researcher intended to use the GOALS and FACTORS directly from Dr. Allen's research, but initial coding efforts uncovered challenges with the categories described by Dr. Allen. Dr. Allen identified 14 purpose (GOALS) categories in her research. Several of these were ambiguous upon attempted use for codification. Revisions were made by the researcher to disambiguate and simplify the purposes into 8 descriptive categories based on an initial review of interview notes. An additional purpose was identified during codification and was added to make a total of 9 purposes or goals of the nurse-patient assignment process. The revised, disambiguated goal list was discussed with and agreed upon by Dr. Allen. See Table 3.2: Cross-walk of Dr. Allen's purposes to those used in this study.

Table 3.2

Cross-walk of Allen (2015) Purposes to Disambiguated Goals with Short Names

Allen (2015) Purpose	Revised, Disambiguated Goal	Short Name
Equal Workload	Distribute workload fairly (give each nurse equal number of patients or equal total acuity)	Fairness
Fairness	Distribute workload fairly (give each nurse equal number of patients or equal total acuity)	
Continuity of Care	Maintain continuity of care (keep patient with same nurse)	Continuity
Nurse-Patient Match	Match each patient to best nurse	Nurse-Pt Match
Nurse Development	Meet nurse learning needs (orientation or ongoing development)	Training
Travel distance (new)	Minimize distance each nurse walks during shift	Distance
Maintaining the Workflow	Optimize workflow for unit (admits, discharges, transition of care, breaks)	Workflow
Best Care	Provide safe, quality patient care	Safety
Care Coordination	Provide safe, quality patient care	
Discharge Planning	Provide safe, quality patient care	
Patient Advocacy	Provide safe, quality patient care	
Safety	Provide safe, quality patient care	
Workload Completion	Provide safe, quality patient care	
Staff Wellbeing	Satisfy nurse preferences	Nurse Preference
Quality-Patient Satisfaction	Satisfy patients or family preferences	Patient Preference

Similar challenges were encountered when an attempt was made to utilize Dr. Allen's decision factors for codification of interview notes. Dr. Allen (2012) identified over 70 decision factors, grouped into 17 sub-groupings under 3 main headings: nurse, patient, environment. The granularity of individual decision factors was not conducive to codification. Instead, the 17 sub-groups were modified and defined to create twenty-three decision factors for codification. The revised, disambiguated decision factor list was discussed with and agreed upon by Dr. Allen (see Appendix E: *Cross-walk of Allen (2015) Decision Factors to Disambiguated List with Short Names*).

The revised GOALS and FACTORS were utilized to amalgamate the interview data into comparable concepts across scenarios. A "Short Name" for each factor was also

created for simplified reference in results and discussion (See Table 3.2 and Appendix E). Coding was completed by primary researcher by creating a digital version of the interview guide and copy-pasting the interview notes into text fields in the tool. Checkboxes were created for GOALS and FACTORS that were then used for mapping.

Discovery and representation. The third and fourth phases of qualitative data analysis are discovering meaning and representing findings. In order to identify all GOALS and FACTORS, multiple checkbox sections were created in the digital interview guide notes tool. Four opportunities were provided for mapping of FACTORS: LAST, HARD, COMP, and general case. Five opportunities were provided for mapping of goals: two for each scenario (initial and deepening sweeps) and one for the general case. A simple tally was then preformed to identify the frequency that each goal and decision factor was mentioned [FACTORS-B]. It was expected that a simple tally could be used to define a subset of 3-5 key requirements that best represented essential data needs for further validation by survey. However, review of the codified interview notes showed greater than expected variation in goals and decision factors (see Chapters 4 and 5 for further discussion).

Additional qualitative analysis grouped participant quotations into themes based on most frequently identified decision factors and goals. This grouping was performed by the primary researcher to provide illustrations of the most commonly cited factors and goals. Quotations are included in the results section as exemplars of themes surrounding factors and goals.

The general case and COMP interview questions were also evaluated qualitatively to assess response to specific research goals. COMP questions assessed GOALS and FACTORS. General case trade-offs assessed GOALS-A. The question of how charge nurses receive feedback about the quality of their assignments assessed PROCESS-B. These responses were assessed for themes and represented in written, discussion format with occasional exemplar quotations from individual participants. In addition, goals were examined to determine if/how goals were tied to measurable criteria [GOALS-B].

For each scenario, participants were asked to identify the tools or information used to complete the assignment process and how they got that information [FACTORS-A]. An initial review of the responses was completed, and 10 main categories were identified. The categories were: nurse scheduling system, staffing updates from hospital staffing office, patient chart, bed-tracking/ADT system, acuity system, report from off-going charge nurse, staff nurses, patients, families, and doctor. These categories were included as check boxes in the digital interview guide notes tool to quantify responses through mapping. Results were reported in written discussion format with occasional exemplar quotations from individual participants.

Qualitative Analysis of Decision Processes

After mapping of goals and decision factors was completed, interview responses were further analyzed to identify decision processes. The goal of this analysis was to answer the research question regarding process, identifying decision techniques used by charge nurses [PROCESS]. The same steps for data preparation, data structuring, discovering meaning, and representing findings were used as described above.

Preparation and data structuring. For this portion of the research, the primary researcher developed a process map summarizing information for each interview participant based on the two scenarios described during the interview. Process maps included: decision factors, goals, data sources, and steps notated on an event timeline. Decision processes were identified and codified to record use of various techniques along the timeline. Techniques identified were: written guidelines, recognition primed decision making, judgments, evaluations, constructions, satisficing, and heuristics. Additional notes were added based on descriptions of the general case, including trade-offs and consideration from the perspectives of nurse, patient and environment.

Interview participants were asked to report time it took them to complete assignments for each scenario. These times were compiled, and quantitative descriptions were prepared. This assessment provided a direct answer to the secondary research

question: How much time do charge nurses spend making nurse-patient assignments today? [PROCESS-A].

Discovery and representation. After data structuring was complete, evaluation of the process maps was completed by the primary researcher. The final evaluation of the completed process maps identified common processes, relationship of processes to scenario goals and decision factors, and alignment with documented decision theories. To the extent possible, the outcome of the analysis was shaped to contain a nontechnical description of the decision making methods such as: "model type and intended applications; funding sources; structure; inputs, outputs, other components that determine function, and their relationships; data sources; validation methods and results; and limitations" (Eddy et al., 2012, p. 733). These findings were represented by creating a single process diagram to encapsulate the process maps. Cognitive techniques for decision making identified during process mapping were summarized by process step and aligned with the process diagram. The summary diagram was supported by a written discussion of the analysis with occasional exemplar quotations from individual participants.

The model was reviewed with the dissertation advisor for endorsement. Additional external validation was not sought, as the goal of this portion of the research was solely to describe the decision methods used by this particular group of experts. As an initial work, the analysis of PROCESS creates only a basic level of face validity, and further development and research is required to build a comprehensive model with internal, cross, external and predictive validity (Eddy et al., 2012). Future research will be warranted with a probability sample in order to understand how findings could apply to the larger population of all charge nurses who make nurse-patient assignments on units like these or in general. Findings and implications for future research are discussed in Chapters 4 and 5 respectively.

Survey Development

The first portion of this research investigated FACTORS, GOALS, and PROCESS of the nurse-patient assignment process with interviews of charge nurses. After the interview portion of this research was complete, a survey was conducted to validate findings with a larger sample. Results were quantitatively analyzed to validate research questions relating to FACTORS, GOALS, PROCESS, and CONTEXT as shown in Table 3.1.

Method selection. Several methods could have been used for the validation of key decision factors and goals. Traditionally, psychologists have used verbal report, ranking, rating, probability judgment, odds judgment, inference from choice, inference from indifference, or conjoint-analysis to assess likelihood judgments (Yates, 1990; Johnson et al., 2013). Naturalistic decision theorists have used scenario based cognitive task analysis techniques to validate models (Crandall et al., 2006). Others have suggested that a Delphi method of gaining expert consensus can be valid for health related decision making when literature is not robust enough to support action (Hunink et al., 2001).

In an ideal world, a list of all nurses with nurse-patient assignment responsibilities would have been available in a central registry and a probability sample could have been obtained based on candidate attributes. Unfortunately, this type of registry did not exist. The lack of a clearly defined study population ruled out a probability sampling technique for key decision factor and goal validation. Even if the population was estimated, it would not have been possible to distinguish variables that would differentiate a non-probability sample from the larger population. This would have made the development of a theoretical basis for post-study adjustments very challenging, as they could not have been easily validated, which, in turn would have invalidated external validity or generalizability from a non-probability sample (Baker et al., 2013). Given these constraints, the goal of key requirement validation was to identify the data sources used to gather information for decision making, distinguish the decision factors considered most often, rank the value of goals, investigate process time and feedback mechanisms,

and examine how these things change under varying environmental contexts. This validation adds to the existing knowledge base but may not be widely generalizable outside of the study participants.

With these options and constraints in mind, a survey was chosen as the best method for the second portion of this study. A survey allowed involvement of a larger number of respondents than additional cognitive task or Delphi analysis, and allowed study across various geographic, hospital, and unit settings. The context-dependent, situational nature of nurse-patient assignment decision factors made it important to choose a method that reduced bias associated with unfamiliar situations or concocted scenarios. With this in mind, survey questions were worded in a way to invoke the respondents' memories of current practice and current practice settings, in a way that best reflected true opinion, in keeping with naturalistic decision theory (Crandall et al., 2006). It was also expected that engaging respondents in a particular memory would also help reduce self-report bias from introspection about the general case.

Survey participant selection. Survey respondents were recruited from a group expected to have expertise in the nurse-patient assignment process on inpatient medical-surgical nursing units, namely, members of the Academy of Medical-Surgical Nurses. With permission of the organization, all members were offered a chance to complete an internet-based survey via a website based opt-in process. A goal was set to obtain at least 100 completed survey responses to provide the minimum satisfactory dataset to allow for comparison groups based on varying demographics. Participants were requested to self-identify for inclusion based on the following recruitment statement: "Are you currently responsible for making nurse-patient assignments at least once per week on an inpatient unit that cares for medical and/or surgical patients?" Participants were considered to meet primary criteria for inclusion if they reported working on a nursing unit that cared for medical-surgical patients, were responsible for completing nurse-patient assignments at least once per week.

The design of the interview portion of this research made additional assumptions about respondent's demographics in order to collect data from a homogeneous group of experts. These criteria were: years of experience on a particular unit, average patient length of stay, and number of patients per nurse. Although these criteria were required for interview participants, for the survey, it was determined that these should be considered secondary criteria, not exclusionary criteria. A goal related to these criteria was set: greater than 50% of respondents should have more than 2 years as a charge nurse on the same unit, work on a unit with an average length of stay between 2 and 7 days where the average nurse was assigned between 3-6 patients on day shifts. This decision allowed a simplified recruiting strategy to maximize participation, while ensuring a base of respondents from backgrounds that matched interview participants. Investigation of response variation by these attributes was outside the scope of this research study.

Survey development. Survey methodology experts recommend monitoring four areas prone to error in order to improve the quality of population estimation: coverage error, sampling error, nonresponse error, and measurement error (Dillman, Smyth, & Christian, 2014). Because the survey portion of this study was an attempt to validate findings within a non-probability sample, and the results were not extrapolated, survey development and validation focused solely on reducing measurement error. An initial draft of the survey was developed as part of the research proposal prior to completion of the interview portion of the study. The draft survey was significantly revised based on analysis of the interview results. The researcher had planned to identify the top 3-5 key requirements from the survey and literature review data, but findings of significant variability in decision making during the interview process led to a redesign that included all identified decision factors. Based on feedback from the dissertation committee, the scenarios in the survey were also changed to directly align with the scenarios in the interviews.

Final drafting was completed in a web-based survey tool, SurveyMonkey. The final survey sections used were titled: Section 1 - Your unit and job duties, Section 2 -

Your most recent experience, Sections 3 and 4 - Your most challenging assignment, Section 5 - Your general opinions about nurse-patient assignments, Section 6 - About you. Section 1 requested general information about the respondent to verify that inclusion criteria were met and an assessment of the amount of time spent on making assignments in general [PROCESS-A]. Section 6 asked additional demographic questions similar to those requested in the interview portion. Sections 2 and 4 asked scenario based questions closely following the CDM methodology described in discussion of the interview above. Section 2 asked respondents to recall the most recent time they made nurse-patient assignments [LAST], and Section 4 asked respondents to recount a particularly challenging nurse-patient assignment process [HARD]. Section 3 aided the recall of a particularly challenging assignment in lieu of face-to-face interviewer prompting.

Sections 2 and 4 had exactly the same sub-sections. Each started with questions about the particular scenario, to frame responses in the particular scenario. This initial set of questions included a self-report of data sources used and amount of time charge nurses spend making nurse-patient assignment for the particular scenario [PROCESS-A, FACTORS-A]. Next, respondents were asked to rate each of nine goals for the particular nurse-patient assignment scenario [GOALS-A]. Rating was completed by selecting a value from 0 to 100 on a slider from “not important” to “very important.” When the slider was moved, the numeric rating appeared in a box to the right of the slider. Alternatively, the respondent could directly enter a number in the rating box. The goals in this sub-section were derived from nurse-patient assignment decision factors and purposes defined by Allen (2015) with revisions made by the researcher to disambiguate and simplify the options based on interview findings in the initial portion of this study as noted above (Table 3.2). The final sub-section for survey sections 2 and 4 investigated the decision factors the respondent considered during the respective nurse-patient assignment scenario [FACTORS-B]. Twenty-three decision factors were listed on the survey and respondents were requested to check all that applied. Again, this list of decision factors was derived from the work of Dr. Allen (2015) and disambiguated as noted above (Appendix E).

Several additional factors were identified during the interview portion of this work, but they were not cited frequently enough to justify the additional response burden they would create if added to the survey.

Section 5 was developed to mirror the interview questions about the general case. Respondents were asked to rank the goals for an imaginary computer program that made nurse-patient assignments [GOALS]. This question differed from the sliding scale ratings in Sections 2 and 4, forcing respondents to assign a unique value (1 to 9) to each goal, where 1 was the most important and 9 was the least important. The survey software did not allow duplicate rankings and did not require all goals to be ranked for question completion. Section 5 also contained questions about how charge nurses receive feedback about the quality of their assignments, with options developed from responses to interview questions [PROCESS-B].

Analysis of interview data showed that interview participants considered factors for computer program development to be similar to factors considered during scenario description. Based on these findings, it was determined to investigate only the FACTORS-B research question directly, as this would adequately inform FACTORS without creating undue response burden.

Survey validation. As described above, validation focused solely on reducing measurement error. Questions were developed to minimize interpretation errors. Response options were reviewed to ensure that the full range possible responses were provided including an ‘other’ category with a free text field when applicable. Response options for questions regarding data sources for assignments (numbers 19 and 38) and decision factors (numbers 29 and 48) were randomized for each respondent to eliminate any effect of response ordering bias. The listing order of goals in Sections 2, 4 and 5 (pages 5 and 10, and question 49) were also randomized to eliminate any effect of ordering bias in the rating/ranking of each goal. A full copy of the finalized survey is available in Appendix F.

After initial set-up, the survey was subjected to a two-step review to reduce measurement error. First, 4 PhD prepared researchers (Allen, Pieczkiewicz, Curley, Clancy) were asked to review each survey question answering these questions: Will the respondent have a clear understanding of this question? Can the respondent accurately provide an answer? Will the respondent be willing to answer? Does the question have a clear task, topic, and relevant, mutually exclusive/exhaustive response options? Will the subject be likely to use past, personal experience when answering this question? Do the questions adequately cover the research goals below while minimizing the response burden? The survey questions were updated based on this initial feedback.

The second effort to reduce measurement error consisted of providing the survey to twelve nurses with medical-surgical experience. Nurse reviewers were asked to rate and comment on each question's clarity. The request was worded: "Could you provide feedback on the following things: Was each question clear? Are there any terms you don't understand? Do the response options make sense?"

Of the twelve nurse reviewer requests sent out, ten provided feedback. Six of the reviewers stated the survey looked good, with no specific feedback provided. Changes were made to the survey based on feedback of four reviewers. Two questions were reworded to improve clarity (1 & 7). A 3-month look-back period was added in the demographics section. Additionally, a less than one year option was added for question #3. The resulting edited survey was reviewed and approved by the researcher's advisor. It was observed during the review process that response burden for the survey was high, approximately 20 minutes. This was discussed between primary researcher and advisor, and determined to be acceptable, with the understanding that the non-completion rate may be higher than otherwise expected.

A final check for measurement error was built into the survey itself. The last page of the survey provided a free-text field which allowed respondents to provide any feedback or questions for the researchers. Reponses entered into this field were

monitored on a regular basis while the survey was open. No questions or concerns about question clarity were noted by survey participants who completed the survey.

Survey data collection and curation. After obtaining approval from the UMN IRB and the Academy of Medical-Surgical Nurses (AMSN), the survey questionnaire was distributed via internet links on Facebook, Twitter, and the AMSN website. Links were promoted by the researcher and AMSN. The internet link directed potential respondents to the online survey collection tool (SurveyMonkey). Response was encouraged by offering a chance to win a $100 gift card for all those who complete the survey and provide contact information. The survey was opened in January 2018 and closed in May 2018. At the completion of the study, data was downloaded from the online survey tool. Data was retained and secured by the primary researcher in a password protected folder.

Survey Data Cleansing and Quantitative Analysis

Survey responses were quantitatively analyzed validate aspects of process, factors, goals and variation based on environmental context. The first step in data analysis was cleansing of the survey data. The initial steps were taken as follows:

1) Download from Survey Monkey: New Export, All Responses Data;
2) Open file in Microsoft Excel;
3) Retitle columns to shorter names for data analysis;
4) Identify columns with respondent personal information;
5) Save as new Excel file ‘cleaned’ and delete Survey Monkey column headers, empty columns, time/date columns, and columns with personal information;
6) Add filter in Excel and review each column for outliers, inconsistent data, missing data.

Survey data cleansing. A total of 188 responses were received. Of these, 49 did not meet the inclusion criteria of working as a charge nurse on a medical-surgical inpatient unit or elected not to continue survey after initial worksite demographic questions. Additionally, 5 did not report that they cared for medical or surgical patients.

Of these, 4 were excluded because they reported working in units caring primarily for pediatric or ICU populations. One respondent reported caring for oncology and cardiology patients, so the category 'medical' was imputed. One respondent did not check the box "yes" to report they met inclusion criteria, but continued to complete the survey with further responses showing that criteria were met, so "yes" was imputed. This resulted in 135 respondents that met primary inclusion criteria.

As expected, not all of the 135 respondents completed all aspects of the survey. Attrition occurred at several points, likely due to the survey length and scenario-based question repetition. Respondents were grouped by level of completion in order to preserve as many responses as possible. Groups were created for surveys completed for each of the 3 scenarios, LAST, HARD, COMP. Analysis was completed by survey section and research question, then data sets were created to investigate CONTEXT related research questions.

Two initial analyses were completed. First, the percentage of respondents that met secondary inclusion criteria were calculated for the 3 main scenarios. Next, descriptive data was summarized for the full group of 135 responses. This data described the medical-surgical units of respondents and investigated PROCESS-A for the general case.

LAST. Next, responses were analyzed for completeness of response for the LAST scenario. Four respondents stated that they did not complete nurse-patient assignments during the two week period prior to completing the survey. These responses were evaluated for exclusion because the survey method relied on respondent recall of last assignment scenario, and it was estimated that a time frame of greater than two weeks would limit respondent ability to recall scenario details. However, in a follow-up question setting the timeframe for the LAST scenario, each of these respondents stated they had last completed assignments 14 or less days ago. Despite this contradiction in reports of time frame, the responses were included based on the indication of adequate recall given the respondents completed all sections of the survey. Six responses were excluded from analysis of FACTORS and GOALS related questions for non-completion of major

portions of the LAST scenario. This resulted in a total of 129 responses for the LAST scenario analysis of FACTORS and GOALS research questions and 135 responses for PROCESS related questions.

Of the 129, eleven responses were missing one to three ratings of goals. These sixteen ratings were imputed. Imputation was guided by two rules. First, if respondent also left blanks in HARD scenario or failed to complete HARD scenario, rating of "0" assigned to missing values in LAST scenario, assuming that respondent thought a blank was equal to zero (n=13). Otherwise, matching values were copied from the HARD scenario to the LAST scenario, assuming that the respondent inadvertently omitted a rating (n=3). These guidelines attempted to minimize bias while maximizing usable responses. The overall goal of the imputation was to minimize introduction of variance between the scenarios to avoid introduction of bias into the investigation of CONTEXT.

HARD. Next, response completeness for the HARD scenario was analyzed. All questions from the previous [LAST] scenario were repeated, which created significant response burden. As expected, this was a point of substantial attrition (n = 19). In addition, two respondents only completed the first few questions of the scenario. Additionally, one respondent did not mark the box to note they had an incident in mind, but proceeded to complete the remainder of the survey by selecting the next button, so it was imputed that they were ready to proceed. Additionally, one participant noted they could not think of a specific time, and jumped forward to the next section of the survey. This left a total of 107 responses for the HARD scenario.

Of the 107, twelve responses were missing one to six ratings of goals. These 33 ratings were imputed. Imputation was guided by three rules. First, if respondent also left blanks in the LAST scenario, a rating of zero was assigned to missing values in the HARD scenario, assuming that respondent thought a blank was equal to zero (n=8). Next, if multiple values were missing from the HARD scenario, but none were missing from the LAST scenario, all blanks in the HARD scenario were filled with zeros, assuming that respondent though a blank was equal to zero (n=20). For the remaining single

omissions, the matching value was copied from LAST scenario to HARD scenario, assuming that respondent inadvertently omitted rating (n=5). These guidelines again attempted to minimize bias while maximizing usable responses. The overall goal of imputation was to minimize the introduction of variance between the scenarios to avoid introduction of bias into the investigation of CONTEXT.

Notably different from the LAST scenario was question number 35, where respondents were asked to enter free text to describe what made this scenario particularly challenging. This survey question was not intended to answer a specific research question, but was analyzed to identify themes supporting the investigation of FACTORS-B. These were qualitatively analyzed and categorized to identify themes: short staffing, sicker patients, workflow issues, too many staff, inexperienced staff, and ancillary staffing issues. Direct quotations from free text were included in results to provide exemplars in the respondents' own words.

COMP. The final survey section asked respondents to rank goals by order of importance for inclusion in an imagined computer program that made nurse-patient assignments [GOALS]. Additional questions about the general case and demographics followed. Response completeness for ranking was analyzed. Of the 135 respondents who completed the first section of the survey, 108 completed at least one ranking and most of the general case questions.

The rankings in COMP had a poor rate of completion. Of the 108 respondents who completed at least one ranking, only 82 ranked all 9 goals. In total 83 individual rankings were missing from 782 ranking fields. This is likely due to the high response burden for the ranking. The online survey tool prevented duplicate rankings through automatic deletion of an initial ranking if the same rank was applied to a second goal. This feature could have been frustrating to respondents who judged goals to have the same value. It also could explain the singleton missing values found in five responses. The respondents could have thought they completed all goals, but inadvertently applied the same rank to two, resulting in an unranked goal. The complexity of the ranking task

confounded imputation efforts. Analysis was performed on data as reported, without imputing missing values, to avoid introducing unintended bias.

A similar technique was used to report on the remaining questions of the survey. The number of respondents was listed for each question to clarify the percentage of the 108 respondents who completed the question. No further data cleansing or manipulation was performed.

Scenario comparison. The final step of data preparation was to organize data for comparison of environmental contexts. Statistical analysis was used to evaluate contextual change research questions CONTEXT, CONTEXT-A and CONTEXT-B. Four sets of data were prepared for comparison. These were: data sources, decision factors, goals, and times. Data sources, decision factors, and goals were compared between LAST and HARD scenarios. These three data sets contained the 107 responses from the HARD scenario aligned to the respective answers from the LAST scenario. Assignment times for the HARD and LAST scenarios were compared to the usual time to complete assignments collected at the beginning of the survey with the background information. A total of 109 respondents reported times for all three instances.

***Nominal data analysis*.** The data sets for analysis of data sources and decision factors contained paired, binary, nominal data. Respondents selected yes or no for use of each data source and decision factor for each scenario. The data sets were assumed to be complete as reported, and no imputations were made. Data was matched by scenario, HARD and LAST, for each respondent and evaluated for differences by scenario. A 2x2 contingency table was created for each response option. The tables categorized responses as the same (respondent selected the option for both scenarios or for neither scenario) or as different (respondent selected the option only for the LAST or only for the HARD scenario). The responses categorized as different were summed and divided by the total respondents (n = 107) to find the percentage of responses that were different, which was listed adjacent to contingency table result. McNemar's test was completed to evaluate symmetry of changes, with the resulting p-values listed in the table. McNemar's test

evaluates the null hypothesis that the contingency table is symmetric; that is, the probability of respondent selecting a source or factor for LAST is equal to the probability of respondent selecting the source or factor for HARD. The alternative hypothesis is two-sided: The contingency table is not symmetric in either direction; that is, the probability that the respondent would choose a source or factor in the LAST scenario was greater or less than the probability in the HARD scenario. See Table 4.10 and 4.11 for results.

Ratio data analysis. The data sets for analysis for goals and time contained paired, continuous, ratio data. For these data sets, paired t-tests were used to investigate the changes between scenarios. Differences were tested for normality. The null hypothesis for each test was that the mean difference between paired observations was zero. The alternative hypothesis was that the mean difference between paired observations was not equal to zero.

Goals. Goals were assessed three times during the survey, LAST, HARD, COMP. Missing responses for LAST and HARD were imputed as described above. Goals for LAST and HARD were reported by respondents by moving a slider along a visual analog scale, rating the goal from "not important" to "very important." As the slider was moved, a corresponding number from 0 to 100 appeared in a box to the right. Alternatively, respondents could enter a number directly into the box. See Appendix F for depiction and question instructions. Goals for COMP were assessed via ranking, as described above. Data was matched for each respondent and evaluated for differences by scenarios LAST and HARD.

Goal rankings for COMP were not utilized for comparison for a number of reasons. First, the three scenarios were dissimilar. The LAST and HARD scenarios recorded goal measurements for specific instances, whereas the GOAL ranking was for an imagined scenario. Second, the scenarios addressed different research goals. The LAST and HARD scenarios were intended to address research questions CONTEXT, CONTEXT-A, and inform GOALS and GOALS-A. The COMP scenario was intended to specifically address GOALS and GOALS-A. Third, the ranking format of the responses

for the COMP scenario was not amenable to comparison with the rating format of LAST and HARD data.

Transformations to homogenize the data from all three scenarios were considered, but they presented additional challenges. Missing data for COMP could not be easily imputed. Imputation would have relied heavily on the HARD and LAST, confounding the effect of contextual change. If the incomplete COMP records were excluded, the transformation itself would have caused additional challenges. Transformation of ratings to rankings was attempted, but resulted in many ties in the HARD and LAST data sets, which were not allowed in the COMP responses. Analysis on this data set would have highlighted a disparity of measurement methods, not the true difference in value. Transformation of the rankings to ratings would have required an ascribing ratio qualities to the ranks which inherently are only ordinal. For these reasons, analysis of differences was contained to the LAST and HARD scenarios.

Time. The last data set to be analyzed for comparison of environmental contexts was length of time to make assignments for research question PROCESS-A and add to the analysis of CONTEXT. To investigate this question, respondents were asked to provide an estimate of the time it takes to complete assignments. This was recorded in three distinct instances during the survey. The first instance was a general statement of how long it usually takes to make assignments [USUAL], and an additional instance was recorded for each scenario [LAST, HARD]. The availability of three distinct results allowed for comparison of each scenario to the usual case, instead of an analysis between scenarios (as was completed for data sources, GOALS and FACTORS).

Initial review of normality revealed the data for all three instances (USUAL, LAST, HARD) to have extreme right skews (2.35, 2.21, 2.34) and extreme kurtosis (8.18, 6.33, 7.85). Box plots and inter-quartile ranges were examined for outliers. Ten outliers were identified where respondents reported times greater than 60 minutes. These data were excluded from analysis, creating a comparison group of respondents who completed

all assignments within 60 minutes (n = 99). Conditions of normality were re-examined and no extreme violations of normality were identified.

An analysis of variance for repeated measures was considered, but was rejected because the three instances provided dissimilar measurements. The USUAL measurement was a generalized description of the general case, whereas the LAST and HARD scenarios represented two specific scenarios. Analysis of variance for repeated measures would be more appropriate if all three measurements were taken from specific scenarios, or respondents were asked to rate the general case three times after recalling specific scenarios. Investigation of data suitability supported the rejection of analysis of variance for repeated measures. Type I error rate would have been increased as indicated by a highly significant violation of sphericity by Mauchly's test ($W = 0.05758$, $p < 2.2\text{-}16$). For these reasons, a paired t-test was used to compare USUAL to LAST and USUAL to HARD. Although the paired t-test had less overall statistical power (due to inclusion of systematic subject variation in the error term), the paired t-test better reflected the relationship between the instances. Bonferroni correction was used to adjusting the increased chance for false discovery with multiple tests on the same data, and α was lowered to 0.025 accordingly.

In summary, this chapter discussed the specific methods applied by this research to investigate gaps in the literature. A mixed-methods approach was taken via interviews and survey. Data was collected and prepared for analysis. Results of the analyses are described in Chapter 4 and a discussion of these results can be found in Chapter 5.

Chapter 4: Results

This research investigated charge nurse decision making during the nurse-patient assignment process as an exemplar of the larger question: How can we leverage information technology to improve decision making in healthcare, while respecting individual clinician expertise and the unique context of individualized patient care? Four primary research questions were used to guide research into the process, decision factors, goals and context of nurse-patient assignments. These questions were investigated by mixed-methods of qualitative interviews and quantitative surveys.

Interview: FACTORS and GOALS

Interviews were completed and analyzed as described by the methods in Chapter 3. Analysis of interview responses was completed to investigate the primary and secondary research questions related to PROCESS, FACTORS, and GOALS. This section reviews interview results related to FACTORS. The following sections review interview results related to GOALS and PROCESS research questions. A review of survey results follows in the final two sections.

In total, eleven interviews were completed between September 2015 and July 2017. Interview times ranged from 1 hour, 5 minutes to 1 hour, 59 minutes. Interview participants worked at five different hospitals on eight inpatient units, allowing for the capture of variation between hospitals. In one hospital, participants were recruited from four units to capture within hospital variation. Two nurses participated from each of three units to capture within unit variation.

Interview demographics. Interview participants identified themselves as females, Caucasian, between the ages of 32 and 54 ($M = 40.6$). Nine of the participants described their workplace as an academic hospital, two as community, critical-access hospitals, ranging in size from 25 beds to 834 beds ($M = 427$). Hospitals were located in Colorado, Tennessee, Wisconsin, and Minnesota. One participant reported her highest degree of education as an associate degree, the other ten reported holding Bachelor's degrees. All participants reported at least one advanced certification. Certifications

included: chemotherapy, biotherapy, car seat installer, Basic Life Support, Advanced Cardiac Life Support, Trauma Nurse Core Course, Neonatal Resuscitation Program, Oncology Certified Nurse, Board Certification, Certified Neuroscience Registered Nurse, Emergency Nursing Pediatric Course, Pediatric Advanced Life Support, and Certified Medical-Surgical Registered Nurse.

Interview participants had an average of 13.5 years of nursing experience (range: 5-29) and 12 years of experience working at the same hospital on the same unit (range: 2-29). They reported an average of 11 years of experience making nurse-patient assignments (range: 2-28) and an average of 10 years of experience making nurse-patient assignments on the particular unit they work on now (range: 2-28). Participants reported making nurse-patient assignments an average of 3 times per week (range: 2-6) and had completed assignments an average of 6.5 times in the two weeks prior to the interview (range: 3-16). Participants made assignments for day (n = 8), evening (n = 2), and night shifts (n = 6), but assignments were almost always made for an upcoming shift, not the same shift worked by the participant (n = 10). All participants learned to make assignments on-the-job from another charge nurse and on their own through trial-and-error.

Interview participants worked on nursing units with an average of 27 beds (range: 15-36), with an average daily census of 23 (range: 5-36). The nursing units cared for patients with medical diagnoses including: general medical, general surgical, oncology, cardiac, orthopedic, neurological, gastrointestinal, hepatological, urological, and/or gynecological disorders. Patient had an average length of stay of 4 days (range: 3-7). Nurses were usually assigned to care for four to five patients per shift.

A registered nurse was directly assigned to each patient for each shift for all nursing units. Nursing units were staffed by nursing assistants or patient care technicians in addition to registered nurses. Various other clinical resources were available including: respiratory care technicians, pharmacist, dieticians, occupational therapists, physical

therapists, patient educators, interpreters, care coordinators, social workers, case managers, unit coordinators, and advanced care practitioners.

Interview decision factors. Decision factors utilized by charge nurse interview participants were investigated to determine key requirements for incorporation into a nurse-patient assignment decision support algorithm [FACTORS]. Interview participants were asked to describe two specific scenarios where they performed nurse-patient assignments. After describing the scenarios, they were directly asked which factors they would include if they were asked to develop a computer program that made assignments [COMP]. At the end of the interview, questions were asked to probe the general case to identify any factors that may have been overlooked in the other three passes. (See Appendix D for detailed interview guide). Responses to these four passes were mapped to decision factors identified in the literature as described in the methods section, Chapter 3. A simple tally was performed of the factors mapped for each pass. These results directly answer the research questions FACTORS and FACTORS-B. Results are shown below in Table 4.1.

Of the twenty-three possible factors, each was identified at least once. An average of 12.5 factors was identified per participant, with a range of 8 to 16 factors. Factors were mapped an average of once out of a possible four times. Acuity was mapped most frequently (2.7 times/interview). The other most frequently cited factors were: continuity, interventions, and competence, which were cited 2.0, 1.7, and 1.5 times per interview, respectively. Counts for COMP tally reflect the overall trend, with less specific mentions of staffing and patient demographics.

Several factors were identified that did not map well into the pre-defined categories. These were: medical diagnosis and stability, new admissions/open beds, personality of nurse, personality of patient, physician attributes, and nurse idiosyncrasies. Participants identified isolation precautions and telemetry monitoring more frequently than other specific nursing interventions. Medical diagnosis was mentioned twice as an

additional factor for consideration by a computer program, along with physician and family attributes.

Table 4.1

Decision Factor Mentions per Interview

	Interview number											Sub-total	
Factor	1	2	3	4	5	6	7	8	9	10	11	COMP	Sum
Acuity	3	3	3	3	3	3	3	2	2	4	1	9	30
Continuity	1	2	2	3	2	2	3	2	2	1	2	7	22
Interventions	1	0	1	2	2	1	2	3	2	3	2	6	19
Competence	2	1	3	2	2	1	0	1	1	2	1	5	16
ADLs	0	1	0	2	1	2	1	1	2	2	2	5	14
Patient Psych	1	1	0	1	2	2	2	1	1	1	1	6	13
Staffing	0	0	3	2	1	1	2	1	2	0	0	1	12
Patient Demographics	1	0	0	0	1	1	1	2	2	2	1	1	11
LOS	0	0	1	0	0	2	3	1	1	0	3	4	11
Collegiality	3	0	1	2	2	1	0	2	0	0	0	2	11
Workload	0	1	0	3	1	0	0	1	1	2	1	3	10
Unit Layout	1	2	0	1	0	1	3	1	1	0	0	3	10
Nurse Demographics	1	0	1	0	1	0	0	2	3	1	0	1	9
Support Staff	0	0	1	1	0	0	0	2	1	2	1	1	8
Distance	0	1	0	1	0	1	2	1	2	0	0	2	8
Safety Measures	2	0	0	1	1	0	0	1	1	0	0	1	6
Coordination	0	0	0	0	0	0	0	0	0	2	3	1	5
Nurse Preference	0	0	0	1	0	0	0	0	2	1	0	1	4
Ratio	0	0	1	1	0	1	0	0	0	0	0	1	3
Time	0	0	0	0	0	0	2	0	0	0	0	0	2
Guidelines	0	0	0	1	0	0	0	0	0	0	0	0	1
Other Duties	0	0	1	0	0	0	0	0	0	0	0	0	1
Shift	0	0	0	0	0	1	0	0	0	0	0	0	1
Sum	10	8	11	16	12	14	11	16	16	12	11		

In addition to the direct mapping of factors and quantitative analysis, illustrative verbatim quotations were obtained to describe the key requirements for nurse-patient assignment in the participant's own words. These quotations provide insight into the four most frequently cited factors: acuity, continuity, interventions, and competence. Exemplars are described below.

Acuity: not just about the numbers. Several participants recounted struggles with the reliability of their acuity tool. One participant stated this very directly: "*In our particular hospital, I find that our acuity tool is not very correct in assigning acuity.*"

Another noted: "*It's not just numbers. It's not just the acuity numbers. You have to factor in 'what does that acuity mean?' Are they an acuity 6 patient because they have 3 chest tubes, and a foley and tube feeds and they are incontinent, or are they a 6 because they have security and they have a CNA and they are pulling at IVs? I mean those are two very different kinds of 6s, one's an emotional 6 and one's a physical 6 and, you can't just say, 'oh that's a 6' you actually have to know what's going on with that patient. They are not just a number, they are a person, with needs and expectations.*"

Another participant explained how acuity numbering does not reflect workload: *"These people had an acuity of 18 and 4 patients, these people had an acuity of 15 and 3 patients, so, on paper, it looks like your day is going to better, because you only have 3 patients, but I know for a fact you are going to have a worse day. Your day is going to be rougher. However, I'm not going to give you a discharge, you are just going to have those 3 patients."*

Other participants described how they make the most of the acuity tool by leveraging their experience. One said, *"We have an acuity tool that I use, not everybody uses. And, I feel like after I talk to nurses, because I sit down and talk to them and ask them questions, versus just reading what their notes say. That way I can engage where I think maybe the trouble spots may be in a patient assignment. Umm, sometimes I'll say, 'Do you really think they are only a 4, or do you really think they are a 5, tell me about what you think.' Versus having them necessarily fill out the acuity tool every time. If I really disagree with where they are going with that, we will fill it out together."* Another put it simply, *"Most of the charge nurses can get report on a patient or work with that patient and know kind of what acuity they should be."*

Although imperfect, acuity was likely identified the greatest number of times during the mapping analysis for its conciseness, as described by this participant, *"Your acuity is the idea of how busy you are going to be. This [assignment sheet] is the specificness of it. the [total acuity] number is probably the most important thing. Have I evened*

my numbers out appropriately, so that one person is not going to go home in tears and one person is not spending the day on Facebook?"

Although acuity was the most frequently cited decision factor for assignments, several participants described how their hospital did not allow acuity to be used for staffing purposes. As an example, one participant stated: *"We don't allow that on the unit – to staff for acuity. But, I wasn't really staffing for acuity. I was staffing for numbers, having lost a staff member, I replaced it with a staff member. It just so happens it was a nurse and so I changed the staffing assignment."*

Continuity, or not. All interview participants voiced a similar theme regarding continuity, "*it's pretty standard to give nurses their same patients back."* One participant described using a visual reminder to track continuity, *"I put an X with a little line over it. That means that they had that patient the day before. As I change my assignments a million times, 'cuz you'll doubt yourself, I won't change those ones because they had that patient before."*

Although continuity was universally valued, participants described struggles regarding the trade-offs between acuity and continuity when balancing overall workload. One participant explained this as a difference between how she and other charge nurses on her unit make assignments. "*But, not everybody teaches that, or not everybody necessarily believes that. Like, if you are a numbers person, that's what you are going to look at: numbers, discharges, contacts [contact isolation]. I think continuity is big too. I think there is just one nurse on the floor that just doesn't understand the continuity. And I know I hear about it because they are like, 'I wish everybody would keep continuity like you keep continuity.'"*

Another participant described nurse reaction to the trade-offs: *"I will have done it by acuity. So everyone more or less has the same acuity. And, then I'll make sure the discharges are even. . . . Even if you've had all 4 of those patients. I will make that change in that assignment, so that you're not overwhelmed. . . Some of the nurses like it, when you take that consideration, and some of them will really get angry 'I wanted my*

patients back', well but you were going to have 4 discharges, 'I don't care.' Well they say that now. It's a judgment call. I chose. And, I'd be happy to explain my rationale, but I made this judgement call and this is the way it's going to be. . . I'm going to make it fair."

Another continuity theme commonly discussed by interview participants was when it should be disregarded, such as when it is overruled by nurse or patient preference. One participant described this scenario, *"The first thing I do is see who was here yesterday for continuity of care. Ideally you want your patients back. Unless of course, you specifically say, 'I can't take care of that patient again today.' For whatever reason, because there was an emotional conflict or they were just too draining. Or there was a personality issue. Sometimes the patient will say "I don't want that nurse back and sometimes the nurse will say 'I don't want that patient back'" and sometimes it's kind of like a mutual decision."*

Several participants described a type of patient as "one-and-done," meaning that a nurse can only handle the patient for one shift. *"There needs to be a way of saying, 'No, this is a horrible patient, and it's a one-and-done,' as we like to call it. Otherwise you get so burnt out so fast. So, we need to be able to say 'no'."* A participant described how it can be difficult to determine when a patient meets this definition by sharing, *"While she didn't say that she didn't want him back, by the end of the shift, she was like [frustrated sigh]."*

One of the most experienced interview participants described her philosophy about nurse-patient relationships: *"It's about the patient, not the nurse. I'm not here to make the nurse happy. I'm here to do what's best and safe for these patients."* And, *"If you don't want the patient back. . . . To me, I'd like to hear the patient doesn't want you back. I don't accept, 'I don't ever want a [particular] patient.'"* On the other hand, *"Patients can fire a nurse."*

Nursing interventions. Specific nursing interventions were mentioned as decision factors considered by all interview participant, except one charge nurse who

used a personally developed, unit specific, informal acuity rating. Some participants described mentally adding these interventions to acuity, others directly used interventions when making assignments. One participant noted, *"I split up PCAs [patient controlled analgesia], drips, procedures."* Another described changing an assignment based on nursing care when acuities were the same, *"I made an executive decision to switch up this assignment and this assignment. One, to give someone else a chance to interact with this patient who was kind of a challenge and this one an opportunity to not have to be trying to monitor 2 heparin drips and a PCA."*

On the other hand, some participants described purposeful exclusion of interventions to simplify the decision process: *"Then I write the acuities, just the 5's, because if you get too much in there, you have too much information to try and sort out."* Another commented, *"I don't factor in blood sugars, but used to, but it's not a big deal anymore since we have PODs [point of use devices] now."* Another described how interventions can vary by shift: *"I wish day shift would factor in central lines when they make night shift assignments."*

Nurse competence. All but one participant mentioned nurse competence as an important factor for consideration. The participant who didn't describe nurse competence, mentioned that she considers nurse idiosyncrasies when making assignments. She stated, *"You do learn those little idiosyncrasies about nurses. [One nurse] doesn't care if he has 4 discharges, he always wants his patients back. It doesn't matter. Where [another nurse] would give up 2 of her patients to only have 2 discharges."*

Four main themes around nurse competency were identified: nurses are not equally skilled, charge nurse knowledge of nurse strengths is regularly considered during assignments, lack of skill can have varied meanings for assignment, and charge nurses have concerns about algorithm incorporation of nurse strengths.

Skills. Many of the interview participants directly stated that nurses were not all equally skilled: *"Do all nurses on med-surg function at same level? No, they don't."* And, *"Everybody is created equal, but not really."* Describing nurses with less skill as

'Facebook nurses' or *'paycheck nurses'* versus *"good nurses with critical thinking skills."* Equity of competence is summarized well in this quote: *"In the end it's just, how competent that I feel that they are, from my working with them in the past. The ones [nurses] that I trust. If that were my family member in there, that were that acute, who do I want taking care of them?"*

Strengths. Many respondents commented on the theme of charge nurse knowledge of nurse strengths. This theme was supported by many quotations, most of which can be found in Appendix G: *Interview Quotations: Charge Nurse Knowledge of Nurse Strengths*. As an example, a participant stated, *"There is that one nurse who doesn't like eyeballs – you don't give her the eyeballs. There's another person that came from the eye clinic that, they like eyes. So, knowing their personal strengths and weaknesses and likes and dislikes sometimes is beneficial. Someone that is on end-of-life care – we have several nurses on our staff that came from hospice, you know, that's their background and their other passion. So, you typically give those [end-of-life patients] to them, because you know that that is something they are comfortable with and can easily handle. It doesn't add unnecessary stress to their day."*

Training and orientation. Interestingly, interview participants described nurse lack of skill as potentially having two very different effects on the nurse-patient assignment process. Sometimes when the nurse lacked a particular skill the charge nurse avoided matching them to a patient with those needs. A participant described this as, *"You don't give new grads the sickest patients."* However, other times it means assigning for that skill in order to gain specific experience, *"And all things change when you have new grads that need certain skills before they come off orientation."* Otherwise stated: *"At the same time, giving some of our newer nurses that experience."* A participant described how this requirement can outweigh other decision factors: *"'So and so needs [experience with] a chest tube. So, if we have a chest tube please make sure that, even if you have to change up our entire assignment and move us from central to south pod, we'll get that.'"*

Nurses and algorithms. The final of the four themes that emerged regarding nurse competence was regarding the concerns charge nurses have about the ability of a computer algorithm to know and incorporate knowledge about nurse competence. One participant stated, *"I have to keep in my mind who I'm assigning them [the patient] to. So, perhaps for the computer to know how seasoned the nurse is [would be important]."* However, another stated that seniority is not enough, *"I don't know how a computer would [know]. Sometimes a nurse with 2 years of experience might be better than a nurse with 20 years of experience."* Additionally, there are the personalities and idiosyncrasies that are hard to quantify, like, *"How would it know things about my nurses, like when they call in crying?"*

In summary, interview participants described considering each of the decision factors listed in Appendix E. The four most frequently noted factors were acuity, continuity, interventions, and competence. Factors recommended for a computer program were similar to factors considered for each scenario and the general case. Direct quotations from interview participants provided additional insight into these decision factors. Additional information about decision factors and key requirements for incorporation into a nurse-patient assignment decision support algorithm were assessed in the survey portion of this research and are described in the survey results section.

Tools and data sources. In addition to decision factors, for each scenario, participants were asked to identify the tools or information used to complete the assignment process and how they obtained that information. This was asked to answer the secondary FACTORS-A research question, "What data sources are used to gather information for decision making?" Responses to these questions were qualitatively analyzed for common themes and described below.

All participants reported using an assignment template to create nurse-patient assignments. These templates included nurse names from the nurse scheduling system and patient names from the ADT system, bed-tracking system or a census report. Assignment templates were kept after the shift was completed, and the completed

templates from previous shifts were utilized to access nurse-patient matches for continuity of care, and sometimes copied-forward as a starting place for the assignment process. Some participants reported use of a staffing matrix to determine the correct number of nurses for the current patient census. Nearly all participants from hospitals with more than 300 beds relied on a centralized staffing office to finalize staffing for the day.

The two most important data sources identified by participants were the patient's chart and discussion with other nurses. All participants accessed data from patients' charts. Some did this by printing off a charge nurse summary of patient information. Others accessed the patient's Kardex, monitoring module, or looked up specific information. Most participants reported that they summarize this information onto the assignment template. Usually by making notations with a special code of x's, underlines, dots and abbreviations. One participant explained, *"I have all my little notes."* Another mentioned that these notations are common practice among charge nurses on her unit: *"Just little clues, that most charges write, there is a couple that don't."*

The other information resource mentioned by all participants was direct conversation with the off-going charge nurse and/or nurses caring for the patients on the current shift. As an example, one participant stated, *"The main thing is communication with other staff. I think that's just so important than just looking at a MESH tool [acuity number] on-line. That MESH tool [acuity] is very important to me, I use it. But, it doesn't always say how the patient really is."* Another participant shared: *"I rely heavily on my charge report from the day prior. Because, they had the most contact with the case managers and physicians."* Interestingly, acuity systems were not universally mentioned as a data source, even though acuity was the most frequently mentioned decision factor. As noted above, participants' statements showed that they valued their own assessment of acuity over a standard number from an acuity system.

A few participants also noted that they considered patients and doctors as data sources. Three participants mentioned direct rounding on patients to make a first-hand

assessment of patient status. Two mentioned reviewing doctor's notes or incorporating physician preference for a specific nurse-patient match. One participant voiced the opposite view: "*Doctor opinion does not count when making assignments."*

Different results were noted from the two participants from the 25-bed hospital. They did not use automated nurse scheduling or acuity systems. And, as charge nurses, they were responsible for staffing for med-surg, OB, and ER as well as crafting the nurse-patient assignments. The assignment template used by these participants included nurse assignment to department, which is considered part of the staffing function at larger hospitals. Assignments were created for the next 3 upcoming shifts in order to better project staffing needs, as a centralized staffing function did not exist at their hospital. These participants struggled when asked to describe the nurse-patient assignment process separately from the staffing process.

In summary, ten categories of data sources were identified during analysis of interviews for the FACTORS-A research question. These included: staff nurses, reports from off-going charges nurses, acuity systems, staff scheduling systems, staffing office updates, patient charts, bed-tracking systems, patients, families and doctors. These were categories were used to create section options for the survey portion of this research, with results described below.

Thoughts on automation. The investigation of the primary FACTORS research question regarding key requirements for incorporation into a nurse-patient assignment HIT solution was deepened through direct questioning. Interview participants were asked to identify the factors that should be considered, how helpful such a system would be, and any concerns they had. These themes provide additional considerations into development of a decision support algorithm for nurse-patient assignments.

Nearly all participants rated the potential usefulness of a well-developed HIT solution as an 8 on a 10 point scale, or very useful, with only one low rating of 2-3/10. Positive comments included: *"I wish we had a system like that", "So helpful"* and

"Really cool". One participant said, *"To get that hour back in my day to take care of patients, I'd be in heaven."*

Interview participants estimated that a tool would have an accuracy of 50-85%, depending on how much information was included, particularly related to nurse skill set and patient details. Data accuracy was a concern, with one participant noting that nurse charting is not always timely or accurate, and that a system that relied on documentation in the electronic medical record or manual inputs would not be successful.

Participant responses to whether a system like this would save them time was varied. Seven respondents were positive that a system could save them time. Four were negative, concerned that they would still have to double check all the assignments, and that rework may take as much time as doing it all themselves. One participant stated: *"Is it doing me a favor and saving me time or is another system that I have to babysit because it doesn't think that I know what I'm doing."*

The three biggest concerns about a HIT solution to support the nurse-patient assignment process were accuracy, the potential lack of incorporation of tacit knowledge of "human factors" like personality and emotions, and concern that patients and nurses would be treated like numbers. Detailed participant responses can be viewed in Appendix H: *Interview Quotations: Participants Thoughts Regarding Computerization of Assignments*.

In summary, interview participants were generally positive about the potential helpfulness of HIT solutions to support the nurse-patient assignment process. They assessed that a system could be accurate and save them time. However, they had specific concerns about how factors like personality could be incorporated into a such a system.

Interview Goals

Interview participants were asked questions to identify goals that should be used by a nurse-patient assignment HIT solution [GOALS]. In total, goals were explored five times during each interview. First, GOALS were investigated by asking the participants to describe two specific scenarios where they performed nurse-patient assignments. After

describing the scenarios, they were directly asked about their specific goals for the particular scenario. Next, tacit knowledge was elicited through what-if queries that probed goals by asking if the participant would have made the same decision earlier in her career, or in a different setting. What-if queries also probed if the assignments for the scenario would have been different if another charge nurse completed them, and advice they would give a novice charge nurse about the nurse-patient assignment process. At the end of the interview, questions were asked to probe the general case to identify any goals that may have been overlooked in the other four passes (see Appendix D). Responses from these five areas were mapped to goals identified in the literature as described in Chapter 3, and a simple tally was performed. Results are shown in Table 4.2.

4.2.1 Goal mapping. Goals stated by interview participants during the various passes of interview questioning were mapped to the disambiguated categories defined in Table 3.2. One group of responses was harder to map. These four responses were related to a goal of creating manageable assignments for the nurses. One participant described this goal quite graphically, *"I don't want to kill my nurses off."* Another described it as creating assignments that were, *"not nice, but doable."* It was unclear if these responses fit best into the category of providing safe, quality care, optimizing workflow for the unit, or satisfying nurse preferences. These four responses were not mapped. All other responses were mapped as shown in Table 4.2 below.

All goals were identified by all participants at least once. The most commonly identified goals were to provide safe, quality patient care and maintain continuity of care. Fair distribution of workload and optimization of workflow for the unit were the next most frequently mapped goals. These were closely followed by the goal to minimize the distance each nurse walks during the shift and match each patient to the best nurse. Interestingly, one participant disagreed with this goal, stating: *"We've given up on grouping patients by location on my floor."*

The least mentioned goals were regarding nurse and patient preferences and nursing learning needs. When asked specifically about nurse preference, one participant

responded: *"I will take it into account if I can . . . I mean I can if I have the time and or the inclination. If I'm running super late or feel really crappy, as with anything, I may not be as motivated to be as obliging."*

Table 4.2

Goal Mentions per Interview

	Interview number											
Goal	1	2	3	4	5	6	7	8	9	10	11	Sum
Provide safe, quality patient care	2	4	3	4	4	4	4	3	4	3	5	40
Maintain continuity of care	3	2	3	5	3	4	4	3	3	3	4	37
Distribute workload fairly	3	3	2	3	3	3	4	4	4	3	2	34
Optimize workflow for unit	4	2	2	4	2	3	3	3	3	2	5	33
Minimize distance each nurse walks	2	3	2	2	3	3	4	3	3	2	4	31
Match each patient to best nurse	2	3	2	3	1	3	3	4	3	2	2	28
Satisfy nurse preferences	2	1	2	2	2	2	3	2	3	1	3	23
Meet nurse learning needs	2	1	2	4	2	2	2	3	1	2	2	23
Satisfy patient or family preferences	2	1	1	3	1	1	2	1	1	1	2	16
Sum	22	20	19	30	21	25	29	26	25	19	29	

Goal valuation. A secondary research question investigated if some goals were valued more than others [GOALS-A]. In the interview portion of the research, this was accomplished by a simple tally of most important goal mentioned when the participant was questioned about how they determine the best solution when goals conflict. This tally identified the most important goal as fair, equitable distribution of the workload, followed closely by safe, quality patient care. Matching each patient to the best nurse was next, followed by one participant who valued continuity of care over all other goals.

Quotations provide additional insight into these important goals. Regarding fairness, a participant said, *"Don't give a person an assignment you wouldn't want to take yourself. That's important. If it seems heavy, it probably is heavy."* Regarding safety, a participant commented, *"I don't want to jeopardize the patient or the nurse when I give assignments."* Regarding patient-nurse match, a participant noted, *"I try to match personalities."*

Goal criteria. The other secondary research question asked if measurable criteria exist for successful nurse-patient assignments [GOALS-B]. To investigate this question, participants were asked, "If your head nurse were to 'grade' your assignments, what should (s)he use to judge their quality?" Responses to this question were also used to investigate PROCESS-B about how charge nurses receive feedback about the quality of their assignments.

Interview participant responses to this question were qualitatively analyzed to identify themes. These themes were mapped back to the related goal. Table 4.3 outlines the alignment of suggested measurement criteria by goal. Participants most frequently mentioned that nurses' opinions about how the shift went were the most important feedback they received about their assignment quality. Nurse feedback was not an exact match for the goal of 'satisfy nurse preference' although it is shown mapped that way in Table 4.3. Participant descriptions indicated nurse preference as something that was expressed prior to an assignment being made, whereas nurse feedback was obtained after the shift and described broadly as feedback, complaints or satisfaction. Interestingly, participants described nurse feedback with a more favorable view than nurse preference.

Table 4.3

Criteria for Goal Measurement Identified by Interview Participants

Goal	Restated as measurement goal	Number of mentions	Suggested measurement criteria
Satisfy nurse preferences	Nurse feedback/complaints/ satisfaction	10	-perception -staff satisfaction
Provide safe, quality patient care	Patient safety/outcomes	4	-pass meds on time -charting completed close to time of care -everyone got lunch -discharged in a timely manner
Satisfy patient or family preferences	Patient feedback/satisfaction	4	-rounding result of "excellent patient care"
Optimize unit workflow	Smoothness of shift/ flow/task completion	4	-nurse overtime
Distribute workload fairly	Fair	2	-total acuity per nurse -even distribution of hard patients

All other suggested measurement criteria were easily mapped to goals as shown in Table 4.3. The goals of continuity, nurse walking distance and training needs were not identified as considerations for evaluation criteria. Nurse-patient match was mentioned by one participant, but no accompanying measurable criteria were identified, so it was not included in the summary table.

Participants were also asked if they received any feedback about their assignments as part of the deepening queries for the scenario describing their most recent assignment. Only two participants reported receiving feedback. One stated that a nurse provided unsolicited feedback expressing thanks for not assigning her a particularly challenging patient. Another participant relayed that she sought out patient feedback. Neither of these added to the measurable criteria identified in Table 4.3.

In summary of GOALS, each interview participant identified using each of the goals in Table 3.2 at least once during their description of the most recent time the made nurse-patient assignments, a challenging time they made assignments or in discussion of the general case. The goals most frequently identified were safety, continuity, fairness and workflow. Participants did not describe receiving regular feedback about their assignments, but voiced ideas about potential measurement criteria. Additional information about goals were assessed in the survey portion of this research and are described in the survey results section below.

Interview: PROCESS and Decision Techniques

After analyzing interview results for decision factors and goals identified by participants, the results were reviewed to investigate research questions about PROCESS. These questions were: What decision techniques are used by charge nurses today? [PROCESS] and How much time do charge nurses spend making nurse-patient assignments today? [PROCESS-A].

Assignment timing. To investigate PROCESS-A, interview participants were asked to report the time it took them to complete assignments for each of the two

scenarios [LAST, HARD]. The times were compiled; see Table 4.4. All interview participants except one recalled spending more time creating assignments during the description of a challenging [HARD] assignment scenario compared to the time to complete assignments during their most recent [LAST] assignment process. Two respondents reported spending more than double the time making assignments during the challenging scenario, and one respondent stated that she was unable to complete the assignment before the next shift started because they were still short staffed. Of note, only 3 of 11 participants described their last assignment as typical, with most describing it as challenging because of short staffing, high patient census or high patient acuities. Average time for the LAST assignment scenario was 37 minutes, 89 minutes for those who completed the HARD scenario and 62 minutes for all reported times.

Table 4.4

Minutes to Complete Assignment by Scenario per Interview

Interview Number	Last Assignment	Hard Assignment
1	30	60
2	25	150
3	15	never completed
4	90	165
5	10	15
6	55	75
7	20	35
8	45	60
9	45	60
10	30	240
11	45	30

Process maps. The final analysis of interview data investigated the PROCESS research question. This question was investigated by creating a process map based on the scenarios described by each participant. The eleven process maps were summarized into a single, encapsulating process diagram Figure 1. Cognitive techniques for decision making identified during process mapping were summarized by process step and aligned with the process diagram; see Figure 2.

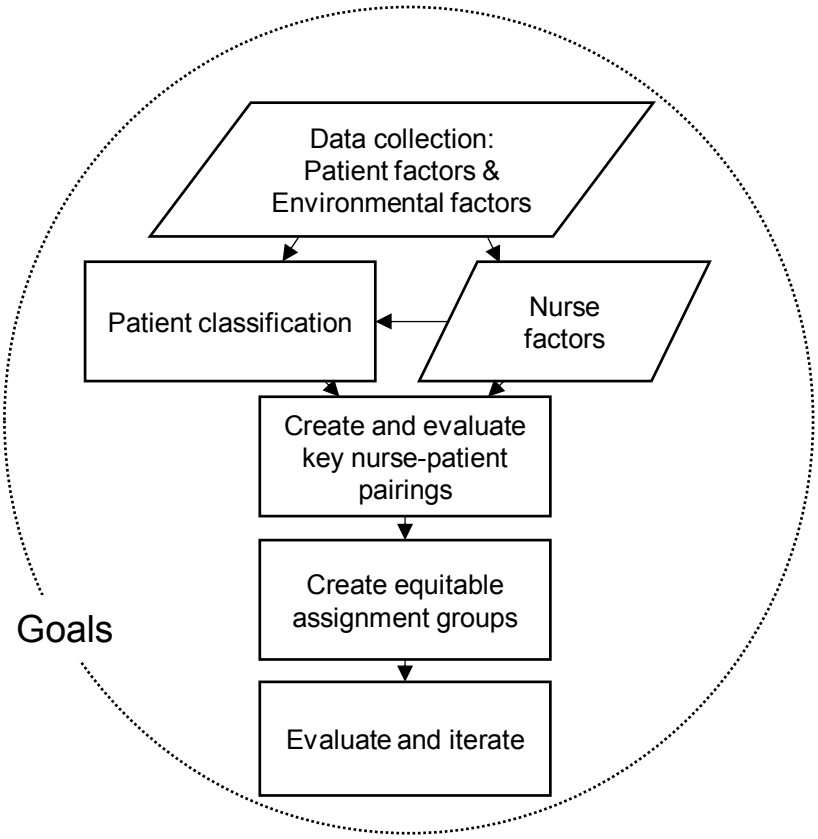


Figure 1. Process diagram of charge nurse decision making during creation of nurse-patient assignments.

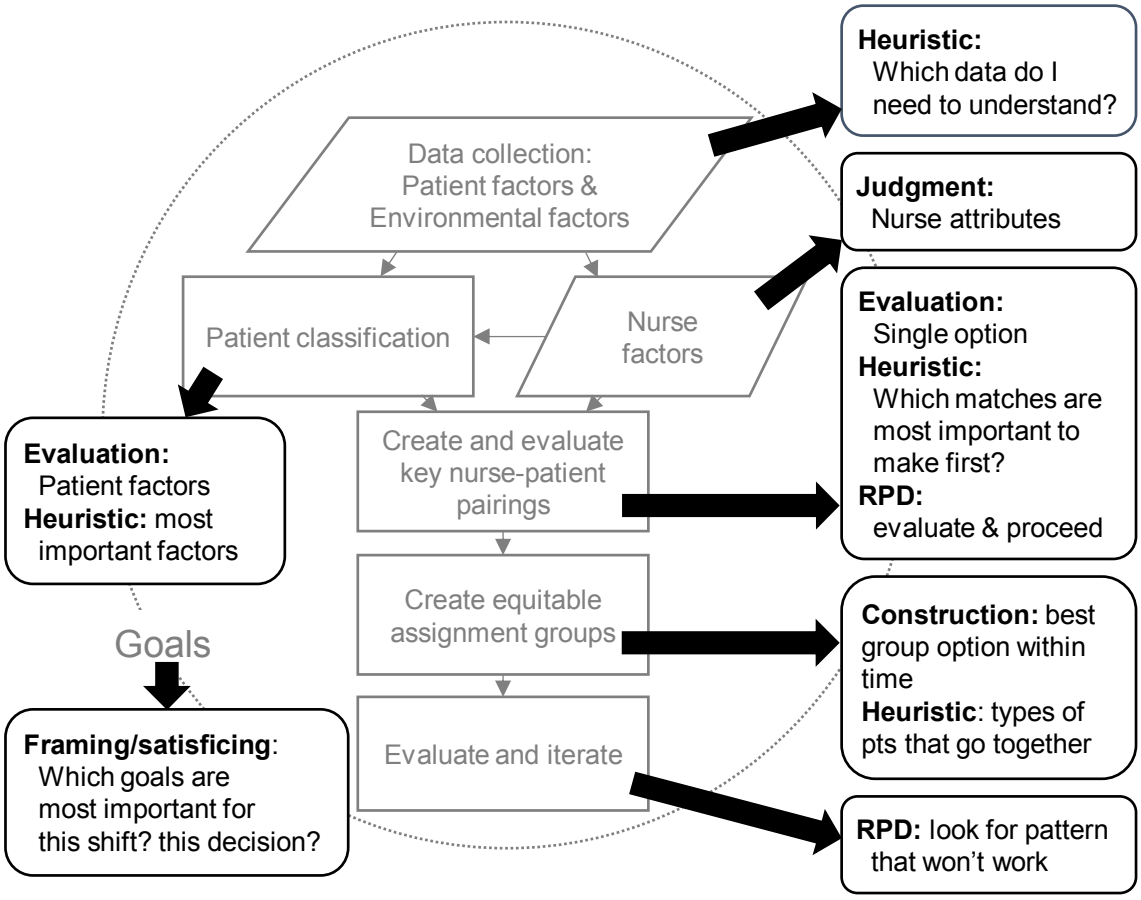


Figure 2. Process diagram of cognitive techniques identified in charge nurse decision making during creation of nurse-patient assignments.

A common process was universally observed across all eleven interview process maps. Interview participants described these common process steps: data collection, patient classification, creation of key nurse-patient pairings, adding additional patients to create equitable assignment groups, evaluating and iterating as needed. These steps relied on goals of the assignment process. The process diagram depicts data collection steps as parallelograms, analysis steps as rectangles, and goals encapsulating the entire process. The process is depicted as linear in the diagram, but this is an oversimplification. For example, one interview participant described creating a draft of assignments at the

beginning of the shift, based on previous assignment groupings, then collecting data and altering the assignments as needed based on goal prioritization and judgements about decision factors. As such, the process depicted in the diagram should not be considered a step-by-step guide, but rather a description of the main components and general ordering. The process is fluctuating, with continuous bi-directional movement between each step, where goals are fluid, informing each step, while at the same time, being informed by each step.

Process mapping for each participant also entailed identification of cognitive techniques used during each process step. These techniques were summarized in Figure 2 to reflect the techniques most commonly identified in the individual process maps. Notably, no participant described using a classical decision making approach of identification and weighting of all possible alternatives.

Participants described the first step of the process as data collection. During this step information was obtained about relevant decision factors and added to pre-existing judgments about patients, nurses, the environment and process goals. Nurse factors were frequently identified as being 'known' by interview participants, not collected as part of the assignment process. This is represented in the diagram by separation of nurse factors from the data collection process for patient and environmental factors.

After data was collected, participants described using collected and previously known data to classify patients, usually by identifying patients representing the heaviest workload or acuity. Next, the first category of patients was distributed evenly to nurses. The initial category of patients for distribution varied by participant based on the particular goals determined to hold the most value by the participant for the particular nurse-patient assignment event (continuity, nurse preference, etc.). Participants evaluated these initial groupings and then fleshed them out to create equitable groups of patients. These were sometimes created with a specific nurse in mind, and sometimes created as a group, then assigned to a nurse. Finally, the participants described a step of evaluation and iteration after all assignments had been made.

Cognitive techniques. Qualitative analysis of the process maps included mapping of the cognitive techniques used by the decision makers onto the process steps. Figure 2 illustrates a summary of the techniques most commonly identified with each step and how these techniques align with process steps. The first step, data collection, was guided by the participants' personal heuristics regarding which data will be most salient given the bounds of the particular situation. These data collection heuristics were very easy for the participants to relay as step-by-step actions taken prior to the commencement of the nurse-patient assignment process. Participant descriptions of data collection did not vary remarkably between scenarios, unless it was determined that additional data was needed.

Participants described nurse factors considered in detail, but they did not identify collecting this data directly during the decision process. Instead, participants generally relied on preexisting judgments regarding nurse attributes. If a participant had knowledge of patient attributes or environmental factors from previous experience, these judgements were also included in the analysis steps.

After data collection was complete, participants articulated the evaluation process and heuristics used to classify patient workload. The classification process was easy for participants to articulate. As noted above, classification was usually based on a personally developed heuristic for patient workload. Sometimes this heuristic was clearly definable based on quantifiable decision factors such as acuity or nursing interventions, sometimes it was described as a tacit 'knowing' that a patient had a 'heavy' workload. Patient classification was sometimes impacted by nurse factors, such as primary language and experience. For instance, a patient who was a native Spanish speaker had a higher workload for a non-Spanish speaking nurse than a nurse who was also a native Spanish speaker. Patient workload valuation varied by these type of nurse attributes and was this interaction between decision factors was considered throughout the remaining process steps.

After patient classification was complete, participants reported using a heuristic to determine the matches that were most important to make first. Most participants reported

using the previous assignments as a basis for creating new assignments, others started from scratch with even distribution of patients with the heaviest workload, and one participant reported assigning the patients with the lightest workload first. These matches were made as simple evaluations, one patient at a time, then rapidly evaluated through a pattern-matching or RPD cycle to evaluate fit. Next, additional patients were added to the group to create equitable patient groupings. As the options became more complex, participants used construction to determine the best grouping within the time available for decision making. The final groupings were then evaluated by a pattern-matching/RPD cycle to mentally simulate how the patient group fits with the nurse in the specific environment of the coming shift.

The entire process was framed by the goals valued most by the participant. As noted above, all participants identified using all nine goal categories at some point during the decision process. Satisficing was used to determine goal selection, and help participants adjust goals and factor weightings throughout the decision making process to find those that worked best with the environment particular to this nurse-patient assignment event. This was evident by ubiquitous expression by participants of consideration of alternation patient assignments and their descriptions of trade-offs made during the assignment process. Evaluation ended and participants considered the process complete when all nurses were assigned similar total workloads for the upcoming shift.

Quotations about process. The process diagram and cognitive techniques described above are supported by direct quotations from interview participants. Quotations are grouped by the process steps: data collection, patient classification, key nurse-patient pairings, equitable assignment groups, evaluate and iteration. Process steps interact with goals in a complex way.

***Process goals*.** Quotations regarding decision goals are listed above in the section investigating the GOALS research questions. Goal fluidity and trade-offs can best be described by interview participants in their own words. The process was described as complex and cognitively challenging. One participant described: *"I used to have to hide*

in the mud room to make assignments, so I wouldn't be interrupted." Another described a scenario where high acuity patient required a change in her heuristic, which slowed her process down: *"That one [assignment] took a long time, because when you are mucking about with trying to figure out how to only give a nurse 3 patients, it's not right in your brain."*

One participant described the complexity directly: *"I try not to look at it [the assignment sheet] too often though, because otherwise, I just get confused. It's too much."* Another said, *"There is always variation."* And another described the trade-offs: *"It's a challenge every day, to find the best balance for everybody. You're trying to please your patients. You're trying to please your nurses. You're trying to please yourself. You're trying to please your boss. You're trying to please the family. You're trying to please everybody. And, that's just hard. And, near impossible."* The process also invoked emotions as by a participant who said, *"You always feel guilty if something goes wrong. And, when you come back in and you hear that something went bad."*

***Data collection*.** Data gathering was the first step identified in the process diagram. Most of the quotations related to data gathering were mentioned above in the sections discussing data sources and decision factors. In addition, one participant described how her heuristic for data collection has evolved, *"I think I am a lot smarter now than when I first started. There is a lot more stuff that I look at now, that I didn't look at when I was a new charge nurse."* Another described how decision makers' personal heuristic varies from charge nurse to charge nurse: *"My perception of things might be slightly different. Somebody might not be as worried about discharges and giving someone three discharges versus one discharge. Or, if they feel they've had experience with one particular patient, and has had a bad experience with them, they might separate from another one based on the knowledge, based on their experiences. And if I haven't had that same experience, I wouldn't even know to separate those two. So, there is always variation. Sometimes, I feel like it's great when my assignment is very similar to the previous charge, and I'm like, 'We were thinking alike,' you know. And,*

that's good. And sometimes everything is so different, and I'm like, 'How did you, how do I have all these nurses in different pods.' Like, 'How did it vary so much?' It's rare that we are 100% on the same page every single day."

One participant described how judgments about nurse factors can be based on experience: *"I just know certain nurses can handle certain loads."* See Appendix G for additional examples of quotations of nurse factors. Sometimes nurse factors can be particularly challenging: *"I had one nurse on her first night [off of orientation]. The second nurse, it was her second night [on her own]. The third nurse, it was her fifth night. The fourth nurse had former experience, less than a year, but had just started at our hospital about a month ago. The fifth, the most seasoned nurse, had been on our unit since February [9 months]."*

Participants described how data collection involved both collecting and interpreting the decision factors. One participant described the collection process, *"It's just a lot of hunting and gathering for information. When I said I spent 20 minutes making assignments, that's just me thinking and writing X's down."* Another described using her intuitive knowledge of the environment, *"I'm aware of when people return from procedures, what kind of timeframe that's going to be. I can forecast if somebody is going to go bad. Or, I can see them declining."* Another added, *"More seasoned charge nurses understand the discharge process better and have a clearer picture to predict what will happen next day with patient and shift."*

Patient classification. The participants described using heuristics to classify patients into categories based on data collected about the decision factors. These heuristics were framed by individual judgments about assignment goals, based on first-hand experience. One participant described this as: *"Most of the charge nurses can get report on a patient or work with that patient and know kind of what acuity they should be."* Another said: *"Experience really makes you look at the big picture."*

Addressing variation in heuristics, one said, *"Everyone has their own special way of making assignments."* Another commented, *"Absolutely, [assignments would be*

different if another charge nurse completed them] we all process differently and put a higher emphasis on what we feel is important." Another commented: *"That's that nurse's choice, to do her assignments the way she does her assignments. I don't agree, but they are her assignments. It's like me telling you how to raise your kid."*

One participant shared these quotes about how her classifications are better than a novice charge nurse: *"They fill out the acuity board. All that information I just told you is on that acuity board. And they read it, where as I have it all in my head."* And: *"They may just focus on that they [the patients] are totals [require total care]. I focus on why they are totals. I look at the details. So, I might not put certain totals together, because they are the worse totals on the floor."*

Nurse-patient pairings. Initial assignments were guided by goals using a personal heuristic of the patients that were important to match first. Continuity was a commonly identified heuristic used by participants, *"If there were people who worked yesterday, I pencil them in first and make a check mark next to them."* The other most commonly identified heuristic was workload, *"I split up the 'heavy' patients."* Pairings for continuity were described as simple evaluations based on the assumption that if the pairing worked for the last shift, it will work for an upcoming shift. Each pairing evaluation consisted of brief RPD mental simulation, checking to see if what worked in the past will work for the future.

Create equitable assignment groups. The creation of equitable assignment groups was described as a construction involving multiple trade-offs and participant heuristics for which patients fit best together as a group. One participant said, *"You could never make up the scenarios that we see. So, it's best if it's live and in the mix and they've seen the flow of the floor – you know how it's either really fluid and smooth and everything is going right, or it's halting and nothing flows right. And so, they need to see, how to do it when it's in both those stages. I can't just make it up, and say, 'This is your acuities.' Because otherwise, they could just say, 'I can make all the numbers even, and the*

assignment is done.' It's never like that. So, they have to see real patients, real emotions, real problems, real things happen before they can make it [the assignment]."

Another described how her heuristics sometimes differ from the values of the nurses, *"I will have done it by acuity. So everyone more or less has the same acuity. And, then I'll make sure the discharges are even. . .. Even if you've had all 4 of those patients. I will make that change in that assignment, so that you're not overwhelmed. . . Some of the nurses like it, when you take that consideration, and some of them will really get angry 'I wanted my patients back', well but you were going to have 4 discharges, 'I don't care.' Well they say that now. It's a judgment call. I chose. And, I'd be happy to explain my rationale, but I made this judgement call and this is the way it's going to be. . . I'm going to make it fair."*

The trade-offs during this process step can be a struggle for participants who did not always have the first-hand knowledge required. One stated, *"I guess I go with, I don't know, my own interpretation of how busy I'd think they'd be. Which is sometimes very wrong, because I work straight nights, and I hear from day shift that maybe it's a different patient during the day. That's another thing too, patients are different shift to shift. So, what you might experience on one shift, I've heard is very different than what they might be on a different shift. They might be very easy on a night shift, but very difficult on a day shift, or vice versa. So, I guess I make my best guess. And, I take into account too, the nurses that I'm assigning them to. Because some nurses are very particular about certain issues."*

Another described the thought she put into the construction process, *"I feel like it's important for you to understand why I chose, and you can agree with me or you cannot agree with me. But, I want you to understand it wasn't just a willy-nilly decision. I put a great deal of thought into every assignment I make. I take pride in my assignments. That's the very last thing I'm going to do for you for the whole next 12 hours, how can I make that as positive as possible for you, to ensure that when I come in that next night, if I do come in that next night, you are not crying in a corner."*

Evaluate and iterate. The final groupings were evaluated by a pattern-matching/RPD cycle to mentally simulate how the patient group fits with the nurse in the specific environment of the coming shift. Participants described both objective and intuitive tests for completeness. One described, *"It's a moving puzzle; I'm done when acuities are balanced and admissions are balanced."* Another described picturing that patients will say, *"I may have been sick, but I had such wonderful care."* And nurses will say, *"I did my job and feel confident, and I want to come back the next day and do it again."*

In summary, interview participants were asked to describe the process they used to make nurse-patient assignments by describing two specific scenarios using a variation of the CDM method. Participant responses were used to investigate the decision techniques used and summarized into a process diagram [PROCESS]. Five process steps were identified: data collection, patient classification, key nurse-patient pairings, equitable assignment groups, evaluate and iteration. Participants described that process steps interact with goals in a complex way. Participants were also asked to how much time it took them to make assignments for each scenario [PROCESS-A]. Additional information about time requirements for assignments was assessed in the survey portion of this research.

Survey: PROCESS, FACTORS, and GOALS

The first three sections of this chapter describe the results of analysis of interview responses. Interviews were conducted to investigate primary and secondary research questions related to PROCESS, FACTORS, and GOALS. Interview findings informed survey development to validate findings with a larger sample. The remaining sections of this chapter describe the results of the survey. The survey was initiated specifically to investigate primary and secondary research questions related to FACTORS, GOALS, PROCESS and CONTEXT of charge nurse decision making during the nurse-patient assignment process as shown in Table 2.1.

Survey respondents were recruited from members of the Academy of Medical-Surgical Nurses. Respondents were considered to meet primary criteria for inclusion if they reported working on a nursing unit that cared for medical-surgical patients, were responsible for completing nurse-patient assignments at least once per week. Of 188 respondents that began the survey, 135 met primary inclusion criteria. Demographic information for these respondents is shown in Table 4.5 below. Secondary inclusion criteria were collected to evaluate match of survey respondents to interview participants. Table 4.6 shows these criteria for all respondents and for each of the scenario-based subgroups used for analysis as described in Chapter 3.

Table 4.5

*Demographic Characteristics of Survey Participants (*N = *135)*

Demographic	Min	Max	*M*	*SD*
Years of experience making assignments	0	55	8	8.5
Years making assignments on this unit	0	38	6	6.1
Number of times making assignments per week	1	20	3	2.1
Number of assignments made during last two weeks	0	40	6	4.4
Number of beds on unit	6	100	32	11.7
Number of patients (census)	5	100	28	11.5
Length of stay	1	8	4	1.5
Day shift number of patients per nurse	2	8	5	1.0
Average time to complete assignments	2	120	25	18.4

Table 4.6

Secondary Inclusion Criteria for Survey Respondents by Scenario Completed

	ALL (*N* = 135)		LAST (*N* = 129)		HARD (*N* = 107)		COMP (*N* = 108)	
Characteristic	*n*	%	*n*	%	*n*	%	*n*	%
Met all secondary inclusion criteria	96	71	94	73	76	71	77	71
More than 2 years as a charge nurse on the same unit	106	79	102	79	83	78	84	78
Average length of patient stay was between 2 to 7 days	127	94	122	95	102	95	103	95
Average nurse was assigned between 3-6 patients on day shift	126	93	121	94	101	94	100	93

LAST. After responding to basic demographic and inclusion criteria, respondents were asked to recall a specific scenario. Responses to the first scenario depict the most recent time the respondent completed the nurse-patient assignment process [LAST]. Most respondents completed this section ($N = 129$). Initial survey questions for this scenario were intended to help the respondent engage in the specific memory of the incident, rather than collect information related to a specific research question. However, they also provide insight into the environment experienced by respondents.

Environment: Respondents preformed the most recent assignment an average of three days prior to completing the survey. Most respondents were working day ($n = 73$), evening ($n = 12$), or night shifts ($n = 42$). Two respondents were working extended shifts they classified as 'other.' The assignment was sometimes for the same shift the respondent was working ($n = 17$), but usually for an upcoming shift. Assignments were most commonly completed for an upcoming night shift when the respondent was working days ($n = 46$), or an upcoming day shift when the respondent was working nights ($n = 32$). See Appendix I: *Survey Respondents' Shift Worked Compared to Shift Assignments Created For* for complete data.

Most frequently, about 70% of the time, the LAST scenario was categorized as an average shift by respondents ($n = 90$). The remaining respondents noted something special or unusual about the shift, most describing it has having high acuity ($n = 19$) or short staffing ($n = 11$).

Respondents completed the nurse-patient assignments while at the nurses' station ($n = 63$), the charge nurse desk ($n = 51$), in a private office ($n = 7$), in the break/report/staff room ($n = 6$), or at the assignment board ($n = 2$).

After engaging the respondent in the memory of the scenario, additional questions were asked to investigate the FACTORS, GOALS, and PROCESS used during the particular nurse-patient assignment event. These findings are summarized in Tables 4.7, 4.8 and 4.9 below.

PROCESS-A: Respondents reported that it took an average of 25 minutes to complete the assignments ($N = 135$, $SD = 19$).

FACTORS-A: Most respondents, 86%, reported obtaining information from staff nurses ($n = 111$), followed by 57% using information from report from off-going charge nurse ($n = 73$), and 47% accessing information from an acuity system ($n = 61$). Data sources are summarized in Table 4.7. In addition to the options listed, three respondents listed personal rounding and two named certified nursing assistants as information sources.

FACTORS-B: Staffing was the most cited decision factor ($n = 121$), followed closely by nurse workload ($n = 115$), patient acuity ($n = 114$), and nurse-patient ratio ($n = 110$). Nurse demographics was considered the least often ($n = 18$), followed closely by additional duties, collegiality, and care coordination ($n = 23$, 24, 25 respectively). Notably, all decision factors were chosen. Factors are summarized in Table 4.8 below.

GOALS-A: Every goal received an average score above 50, with Safety, Equity, Continuity, and Workflow topping the list averaging 94, 90, 89, and 79 respectively. Goals are summarized in Table 4.9 below.

Table 4.7

Data Source Use Reported by Survey Respondents by Scenario

	LAST ($N = 135$)		HARD ($N = 107$)	
Data Source	*n*	%	*n*	%
Staff nurses	111	86	94	88
Report from off-going charge nurse	73	57	66	62
Acuity system	61	47	53	50
Staff scheduling system	44	34	32	30
Staffing updates from staffing office	41	32	46	43
Patient chart	37	29	32	30
Bed-tracking system	32	25	31	29
Patients	22	17	20	19
Families	2	2	3	3
Doctors	4	3	4	4
Other	8	6	10	9

Table 4.8

Count of Decision Factors Reported by Survey Respondents by Scenario

	LAST (*N* = 129)		HARD (*N* = 107)	
Decision Factor	*n*	%	*n*	%
Staffing	121	90	97	91
Workload	115	85	93	87
Acuity	114	84	87	81
Ratio	110	81	95	89
Continuity	97	72	51	48
Competence	95	70	74	69
Safety Measures	89	66	77	72
Distance	84	62	45	42
Support Staff	75	56	68	64
Interventions	72	53	70	65
ADLs	67	50	57	53
Unit Layout	51	38	40	37
Guidelines	49	36	39	36
Nurse Preference	48	36	28	26
Time	45	33	37	35
Shift	37	27	26	24
Patient Demographics	31	23	22	21
LOS	31	23	20	19
Patient Psych	28	21	19	18
Coordination	25	19	25	23
Collegiality	24	18	26	24
Other Duties	23	17	22	21
Nurse Demographics	18	13	17	16

Table 4.9

Summary of Goals Reported by Survey Respondents by Scenario

	LAST (*N*=129)		HARD (*N* =107)		Computer (*N* =108)	
Goal - Short Name	*M*	*SD*	*M*	*SD*	Median Rank	Mode Rank
Safety	94	14	93	17	1	1
Fairness	90	16	86	18	2	2
Continuity	89	14	77	23	4	3
Workflow	79	24	69	31	5	5
Nurse-Pt Match	64	26	63	31	5	6
Training	64	30	52	33	6	6
Patient Preference	62	30	50	32	7	7
Nurse Preference	59	27	50	30	7	7
Distance	51	29	47	31	7	9

HARD. After responding to questions about the most recent time they made assignments, respondents were asked to recall a particularly challenging time they made assignments [HARD]. All questions from the previous [LAST] scenario were repeated, which created significant response burden. As expected, this was a point of substantial attrition (n = 21). Most respondents were able to recall a specifically challenging incident without additional prompting (n = 95). Ten respondents were able to recall a specifically challenging incident after examples were provided. And, one participant noted they really could not think of a specific time and survey logic skipped them forward to the final section of the survey.

Of the respondents to the HARD scenario (n = 107), nearly all reported the number of days between the scenario and survey completion (n = 105). Missing values were not imputed, as this question was primarily asked to help the respondent enter the mindset of the scenario date. It is likely that the missing values were due to a limitation in the survey design that capped the number of days respondents could enter at 100. Keeping this limitation in mind, the HARD scenarios took place an average of 16 days prior to survey completion (min = 0, max = 100, std dev = 17.4).

After engaging the respondent in the memory of the scenario, additional questions were asked to investigate the FACTORS, GOALS, and PROCESS used during the particular nurse-patient assignment event. These findings are summarized in Tables 4.7, 4.8, 4.9 above.

Environment: Respondents reported the HARD scenario took place while they were working day (n = 60), evening (n = 7), and night shifts (n = 40). The assignment was sometimes for the same shift respondent was working (n = 21), but usually for an upcoming day shift when the respondent was working nights (n = 28), or for an upcoming night shift when the respondent was working days (n = 41) (see Appendix I).

Respondents completed the HARD scenario nurse-patient assignments while at the nurses' station (n = 49), the charge nurse desk (n = 45), in a private office (n = 7), in the break/report/staff room (n = 3), at the assignment board (n = 2), and in the hallway on a mobile computer (n = 1).

PROCESS-A: Respondents reported that it took them an average of 36 minutes to complete the assignments (n=109, std dev = 26.4)

FACTORS-A: Respondents identified gathering data from an average of 3.6 sources. Most respondents, 88%, reported obtaining information from staff nurses (n = 94), followed by 62% using information from report from off-going charge nurse (n = 66), and 50% accessing information from an acuity system (n = 53). One respondent stated that she used no data sources, because, "none, I had no options." Data sources are summarized in Table 4.7 above.

FACTORS-B: Staffing was the most cited decision factor (n = 97), followed closely by nurse-patient ratio (n = 95), nurse workload (n = 93), patient acuity (n = 87), and nurse competence (n = 74). Nurse demographics was considered the least often (n = 17), followed closely by patient psycho-social support, patient length of stay, patient demographics and nurse additional duties (n = 19, 20, 22, 22 respectively). Notably, all decision factors were chosen. Decision factors are summarized in Table 4.8 above.

GOALS-A: For the HARD scenario, every goal except Distance received an average score above 50, with Safety, Equity, Continuity, and Workflow topping the list averaging 93, 86, 77, and 69 respectively. Goals are summarized in Table 4.9 above.

FACTORS-B: In an attempt to engage respondents in the specific memory of the incident, each respondent was asked to enter free text describing what made the scenario particularly unique or challenging. This question was one of the few free-text fields in the survey, giving the respondents a chance to describe decision factors in their own words. These responses were qualitatively analyzed. Responses were reviewed and a list of themes was identified. Responses were evaluated and each theme was tallied. Respondents most frequently noted the shift was short staffed (n = 37), had sicker or more acute patients (n = 24), or was both short staffed with more acute patients (n = 14). Respondents also noted workflow related issues that upset their usual goal heuristics (n = 22). Sometimes the issue was reported to be inexperienced staff (n = 19) or too many staff (n = 2). One respondent reported that patient preference issues made the assignments challenging, another reported nurse preference issues. Another common theme was related to ancillary staffing shortages (sitter, licensed practical nurse, unit secretary, certified nursing assistant, patient care technician), which were mentioned by 18 respondents. A few respondents did not enter a response but completed the other questions to help them develop the necessary mindset/framing for the scenario-based questions (n = 5). Examples of the themes are included below in the respondents' own words.

***Preference*.** The respondent with patient preference issues stated, *"There were multiple patients who wouldn't have certain nurses caring for them, limiting our staffing options/ratios."* Another described patient preference issues, *"had 3 frequent flyers that no one wanted as part of their assignment; they had also just recently been admitted prior and were back."*

***Goals trade-offs*.** Direct respondent quotations shed light into how environmental factors can impact respondent's standard heuristics for assignment goals. One respondent

noted, *"Decided to staff up with nurses as I knew the upcoming house officer typically gave our floor admissions during the night. We also had heavy patients in the same vicinity and needed to try to split them up but not have someone walk from one end of the floor to another. Also needed to start one nurse at three patients with the hopes that their next admission wouldn't be as heavy as the other patients they had."* Another described, *"21 bed unit becoming a 31 bed unit to accommodate the needs of the hospital. There were staff that wanted their same patients but i had to make changes to accommodate the new patients. It was difficult to keep everyone with their same pt load plus split up isolations, discharges and incoming patients that were not yet present on the floor."* Another said, *"Nurses are assigned in specific zones in an effort to reduce falls. This makes it hard to evenly distribute the acuity to each nurse in that zone."* One participant described the importance of knowing staff and patients, *"Worked as charge nurse at sister unit (related to all charge nurse on that unit called off) and do not know all the day shift staff. Had to asked night crew 2 of 5 nurse experience for patient's acuity and nurse's skills."*

Workflow. Workflow challenges were frequently described by respondents. One described, *"12 discharges and rooms being filled back to back. Who's coming, who's going? Does everyone have an equal number of empty rooms?"* Another described the complexity of ancillary staffing considerations, *"LPN and RN mix, lots of sitters, lack of CNAs, staff coming and going at different schedules, continuity of care, trying to separate staff that don't get along, no acuity tool, late admissions on day shift, late call-ins causing last minute change in assignments."* Another respondent voiced similar concerns, *"There was no continuity of care among nurses, while also giving report to 3 or 4 different nurses. The acuity for the entire floor was higher than normal with more than half the floor being incontinent and nothing having the proper ancillary staff to help. The pharmacy had multiple staff call out, so medications weren't being delivered to the floor in a timely manner. There was multiple ER holdovers that caused multiple med/surg nurses to take care of them while not having a float nurse to help with breaks*

or tasks in general." Workflow can be a significant concern as described, *"there were 15 discharges and they all happened after 500 pm, making it extremely hard to get assignment done for oncoming shift."*

Staffing. Staffing was the most frequently identified issue that made assignments challenging. One respondent voiced safety concerns: *"I had two call outs, 2 nurses coming in to 20 patients. Our manager could not come in, house manager could not provide staff. Me and another night shift nurse stayed two hours over till they could send a nurse. Had another nurse not come, they would have had to take 10 patients a piece. How do you provide staff if there is none? Prn people already being used. And why is that okay with the health system?"* Responses also alluded to how under-staffing makes it harder to balance acuity, *"Short staffed so oncoming charge nurse needed to take patient assignment. Multiple confused patients, either high fall risk or combative, as well as high acuity patients. Was difficult to split assignment evenly so one or two nurses didn't bear the brunt of the difficult patients."*

Sometimes staffing issues related to capabilities instead of lack of physical staffing shortage. For example, a respondent described having, *"2 pregnant nurses and no patient care techs and several patients in c-diff isolation."* Another was concerned about a, *"Lack of nurses trained to care for specialty population, (burns/epilepsy monitoring)."* Another described concerns regarding, *"A nurse recently off a 4 month orientation with less than desirable critical thinking skills."* Reported training issues extended to new technologies and processes like a, *"New insulin dosing system with a short treatment window around meal times."*

The respondent with too many nurses explained how this can also create an assignment challenge: *"Our census went down therefore our staffing grid told us to cancel a nurse. I then had to split that nurses team of pts. I had to determine if one nurse had to give up her whole team to take the cancelled nurses team or if I should split nurses down different halls to absorb the cancelled nurses team. I ended up splitting nurses down different halls because they agreed to it."*

Acuity. High patient acuities and workload were the second most frequently cited reason for challenging assignments. Acuity was frequently described with along with other factors. One responded described, *"The unit was short-staffed, there were many difficult patients, and we had patients in the hallway."* Another stated, *"High acuity, older staff, minimal support staff, lot of pt movement, minimum nurse collegiality."* Another said, *"There were 3 patients next to each other that were jumping out of bed frequently and were confused. We needed extra staff to keep them safe and watched."* A respondent also explained how challenging assignments can cause delay in the nurse-patient assignment process, *"Multiple high acuity patients on unit, 1 nurse resident that is new and only takes 3 patients. Had multiple patients setting bed alarms off and trying to give house supervisor report and it was 6 am which I normally have staffing done by 5:20-545 am."*

In summary, responses to the HARD scenario questions were analyzed in a similar manner to the LAST scenario. In addition, free text describing what made the scenario particularly unique or challenging was analyzed for themes, and respondent quotations are included above. After the scenarios, respondents were queried about the goals for a nurse-patient assignment computer algorithm and the general case. These responses are analyzed next, followed by a comparison of the differences between the scenarios.

Survey respondent goals. In the next section of the survey, respondents were asked to imagine they were responsible for developing a computer program that made nurse-patient assignments. They were asked to rank the same goals listed for each scenario from 1 to 9 where 1 was most important and 9 was least important. All participants of the HARD scenario completed this section of the survey, including the participant who could not identify a specifically challenging incident ($N = 108$). Of these 108 respondents, only 82 ranked all goals. Every ranking was used in data analysis, and as described in Chapter 3, no rankings were imputed. Goals rankings are summarized by their medians and modes in Table 4.9 above. Safety, equity, continuity, and workflow

were ranked the highest, which was consistent with goal rating for each scenario. Although the ranking data for goals is ordinal, a boxplot was created to visually depict the rankings and their spread. In this case, the boxplot is used as a visualization tool, and it should not be implied that differences between ranks have equal value. Means and interquartile ranges identified on the boxplot are not statistically valid. The boxplot can be viewed below in Figure 4.

Other data and demographics. The final questions of the survey were intended to collect data to aid the general understanding of the nurse-patient assignment process and gather demographic information.

Tools. Sixty-five percent of respondents reported that they made assignments manually on paper (n=69); seven percent entered them directly into a computer system (n=7), and twenty-three percent created the assignments on paper then entered them into a computer system (n=24). Six percent of respondents replied that they use another method, and all of these stated they used a dry-erase board where assignments could easily be viewed by the whole team (n=6).

Learning. Respondents were asked how they learned to make nurse-patient assignments. Eighty-four percent responded that they learned on-the-job from a colleague or mentor (n=91), while fourteen percent stated they learned on their own (n=15). Only one respondent reported learning from a formal hospital training course and one reported learning through college coursework.

PROCESS-B: Respondents were asked, "How do you know whether or not your assignments were good?" And were given the option to select multiple responses. Ninety-seven percent responded, "Feedback from nurses" (n=105), 42% said feedback from supervisor (n=45), and 28% responded feedback from patients or families (n=30). Six respondents entered comments. Three respondents commented on lack of feedback stating*: "none"*, *"Don't know"* and *"You don't. Regardless, no matter how you do it. The other nurses pick it apart."* The others commented: "*Least amount of complaints", "feedback from CNAs"* and *"Based on how the day goes."*

Acuity. Participants were asked how acuity was measured on their units. Interestingly, 42% of respondents reported not measuring acuity on their units or assigning an informal acuity rating without using a tool. Twenty-five percent reported using a hospital-wide computerized tool or a tool within their EHRs. A full listing of responses and respondent comments is available in Appendix J: *Survey Respondents' Use of Acuity Systems*.

The final survey questions asked for additional demographic information and allowed the respondents to add any additional comments about the nurse-patient assignment process or the survey itself. Open-ended comments were grouped into themes: Acuity (n = 8), difficulty of the assignment process (n = 12), additional information on goals/factors/process (n = 16), staffing (n = 3), and survey comments (n = 3), and computer program (n = 3). A full listing of comments is available in Appendix K: *Survey Respondents' Comments*.

End-of-survey demographics included level of education, advanced certifications, hospital type, hospital size, and hospital location by state. Respondents (N = 107) selected their level of education as diploma or associate degree (n = 19, 18%), Bachelor's degree (n = 17, 70%), Master's degree (n = 10, 9%), Doctoral degree (n = 3, 3%). Of the approximately 108 respondents who completed the demographics section, 77 listed at least one certification (72%). Certifications were collected in a free text field. The only notable observation was the high number of respondents reporting to be Certified Medical-Surgical Registered Nurses (n = 43, 40%). However, it is not surprising, given recruitment focused on ASMN members. Respondents (n = 108) reported working in academic (n = 31, 29%) and community hospitals (n = 77, 71%), with 200 or more beds (n = 64, 59%), 100-199 beds (n = 26, 24%), 26 to 99 beds (n = 13, 12%), or 25 or fewer beds (n = 5, 5%). Respondents' (N = 106) hospitals were located in 30 states, with 10 respondents from California and Illinois (9%), and 9 respondents from Pennsylvania (8%). A full list of respondents by State is available in Appendix L: *Survey Respondents' Location of Employment*.

Survey: Analysis of CONTEXT

The final results report the comparison of environmental contexts. Statistical analysis was used to evaluate research questions regarding the impact of environmental context on the nurse-patient assignment process [CONTEXT, CONTEXT-A and CONTEXT-B]. Four sets of data were compared: data sources, decision factors, goals, and times. Data sources, decision factors, and goals were compared between LAST and HARD scenarios. Times for HARD and LAST scenarios were compared to the usual time to complete assignments collected at the beginning of the survey with the background information.

CONTEXT. The first set of results examined differences in respondent report of data sources used during the LAST and HARD scenarios. Table 4.10 categorized responses as the same (respondent selected the data source for both scenarios or for neither scenario) or as different (respondent selected the data source only for the LAST or only for the HARD scenario). The responses categorized as different were summed and divided by the total respondents ($N = 107$) to find the percentage of responses that were different. McNemar's test was completed to evaluate symmetry of changes.

For all data sources except staffing updates, the findings suggest that the null hypothesis failed to be rejected. That is, the probability of a respondent selecting any data source except "staffing updates from hospital staffing office" for LAST is equal to the probability of respondent selecting the same data source for the HARD scenario. For the data source "staffing updates from hospital staffing office," the findings suggest that the alternative hypothesis be accepted: The probability that the respondent would choose staffing updates in the LAST scenario was greater or less than the probability they would choose staffing updates in the HARD scenario. From the count of times staffing updates was selected for each scenario, we can infer that respondents were more likely to report using staffing updates as a data source when describing a challenging scenario ($p = 0.01$).

Table 4.10

*Contingency Table of Sources Reported by Survey Respondents by Scenario (*N = *107)*

Source	Both	Neither	Only LAST	Only HARD	Different Response	p_m
Staff scheduling system	18	56	19	14	31%	0.4862
Patient chart	20	64	11	12	21%	1
Report from off-going charge nurse	52	34	7	14	20%	0.1904
Bed-tracking system	18	69	7	13	19%	0.2636
Patients	11	80	7	9	15%	0.8026
Staffing updates from hospital staffing office	33	59	2	13	14%	0.0098*
Staff nurses	88	5	8	6	13%	0.7893
Acuity system	47	47	7	6	12%	1
Other	3	92	5	7	11%	1
Families	0	103	1	3	4%	0.6171
Doctors	3	102	1	1	2%	0.4795

$_m$McNemar's test for symmetry
*Significant at p = 0.01

CONTEXT-B. The second set of results examined differences in respondent report of decision factors used during the LAST and HARD scenario. Table 4.11 categorized responses as the same (respondent selected the factor for both scenarios or for neither scenario) or as different (respondent selected the factor only for the LAST or only for the HARD scenario). The responses categorized as different were summed and divided by the total respondents (N = 107) to find the percentage of responses that were different. McNemar's test was completed to evaluate symmetry of changes.

For most decision factors (19 of 23), the findings suggest that the null hypothesis failed to be rejected. That is, the probability of respondent selecting the decision factor for the LAST scenario is equal to the probability of respondent selecting the same decision factor for the HARD scenario. For continuity, distance, nurse preference and interventions, the findings suggest that the alternative hypothesis be accepted: The probability that the respondent would choose these decision factors in the LAST scenario was greater or less than the probability they would choose the same decision factor in the HARD scenario. From the count of times they were selected for each scenario, we can

infer that respondents were more likely to report considering the decision factors continuity, distance, and nurse preference when describing their most recent nurse-patient assignment, and more likely to report patient interventions when describing factors considered during a challenging scenario ($p = 0.05$).

At borderline statistical significance, ($p = 0.1$), two additional factors, acuity and collegiality also qualify for acceptance of the alternate hypothesis. From the count of times they were selected for each scenario, we can infer that respondents were more likely to report considering acuity as a decision factor when describing their most recent nurse-patient assignment, and more likely to report collegiality when describing factors considered during a challenging scenario ($p = 0.1$).The repercussions of acceptance of this additional error has minimal impact, because conclusions about these results are restricted to survey participants.

Table 4.11

*Contingency Table of Factors Reported by Survey Respondents by Scenario (*N = *107)*

Decision Factor	Both	Neither	Only LAST	Only HARD	Different Response	p_m
Continuity	42	15	41	9	47%	0.0001***
Distance	43	34	28	2	28%	0.0001***
Time	22	56	14	15	27%	1
Nurse Preference	20	59	20	8	26%	0.0376**
Competence	65	17	16	9	23%	0.2301
Unit Layout	29	54	13	11	22%	0.8383
Safety Measures	64	20	10	13	21%	0.6767
Collegiality	10	74	7	16	21%	0.0953*
ADLs	45	40	10	12	21%	0.8312
Support Staff	56	29	10	12	21%	0.8212
Interventions	54	32	5	16	20%	0.0291**
Patient Psych	9	77	11	10	20%	1
Coordination	12	74	8	13	20%	0.3827
Guidelines	30	56	12	9	20%	0.6625
LOS	11	75	12	9	20%	0.6625
Patient Demographics	14	73	12	8	19%	0.5023
Shift	17	71	10	9	18%	1
Acuity	82	7	13	5	17%	0.0990*
Ratio	87	3	9	8	16%	1
Other Duties	11	79	6	11	16%	0.3320
Workload	87	6	8	6	13%	0.7893
Staffing	92	1	9	5	13%	0.4227
Nurse Demographics	9	86	4	8	11%	0.3865

$_m$McNemar's test for symmetry
*Significant at α = 0.1 **Significant at α = 0.05 ***Significant at α = 0.001

CONTEXT-A. The third set of results examined differences in respondent rating of goal importance during the LAST and HARD scenario. Table 4.12 summed the absolute value of changes in ratings for each participant and provides them as a percent of total possible change, i.e., if all respondents had rated the goals 0 for the LAST scenario and 100 for the HARD scenario. Differences were found to have fairly normal distributions, without extreme skew in either direction, so a paired t-test was completed

to test the mean differences between the paired observations from LAST and HARD scenarios.

Significant differences were found between the mean of the differences for goals related to training, patient preference, nurse preference, workflow, continuity, and fairness. The differences were all positive, from which we can infer that respondents reported these goals as less important when describing a challenging nurse-patient assignment [HARD] ($\alpha = 0.05$). These changes are visually depicted in boxplots in Figure 3. Figure 4 depicts goal rankings for COMP scenario. As stated above, the boxplot is included for visualization only, and it should not be implied that differences between ranks have equal value. Means and interquartile ranges identified on the boxplot are not statistically valid.

Table 4.12

*Differences in Goals Reported by Survey Respondents by Scenario (*N = *107)*

Goal	Sum of changed	% change	*t*	*p*	95% CI	Mean of differences
Training	2420	23	4.4215	<0.0001*	[6.7, 17.6]	12.2
Patient Preference	2245	21	4.4580	<0.0001*	[6.5, 16.8]	11.7
Nurse Preference	2031	19	3.9778	0.0001*	[4.8, 14.2]	9.5
Workflow	1964	18	3.3748	0.0010*	[3.6, 13.7]	8.7
Nurse-Pt Match	1681	16	1.1568	0.2499	[-1.8, 6.7]	2.5
Continuity	1666	16	5.6820	<0.0001*	[7.6, 15.9]	11.8
Distance	1658	15	1.6159	0.1091	[-0.8, 7.9]	3.5
Fairness	1000	9	2.7311	0.0074*	[1.1, 7.2]	4.2
Safety	698	7	0.9361	0.3683	[-1.8, 4.9]	1.5

*Significant at $\alpha = 0.05$

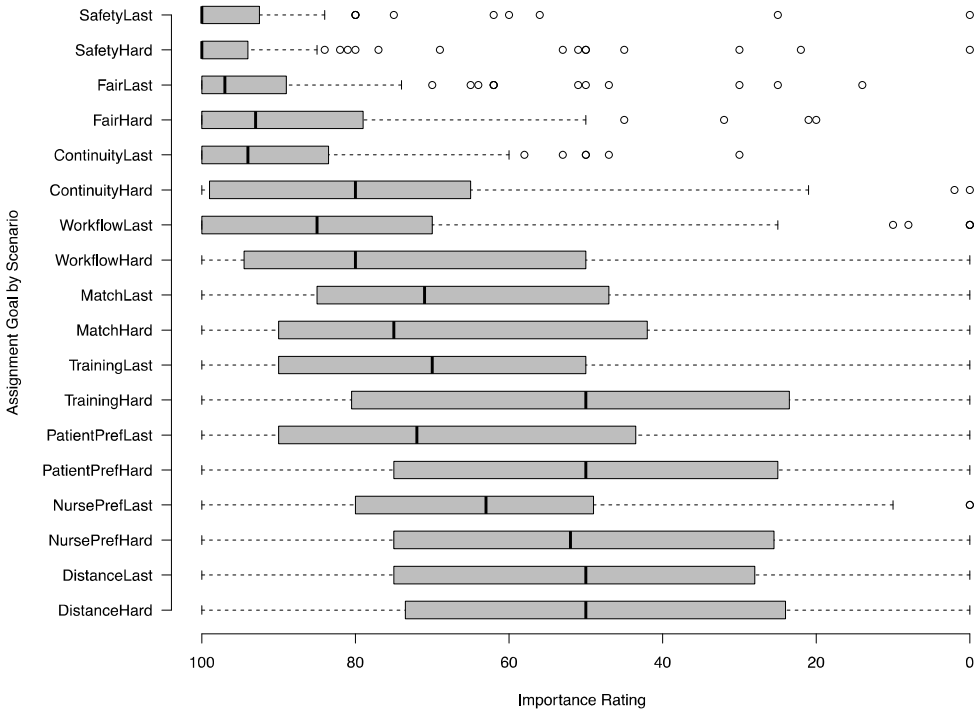
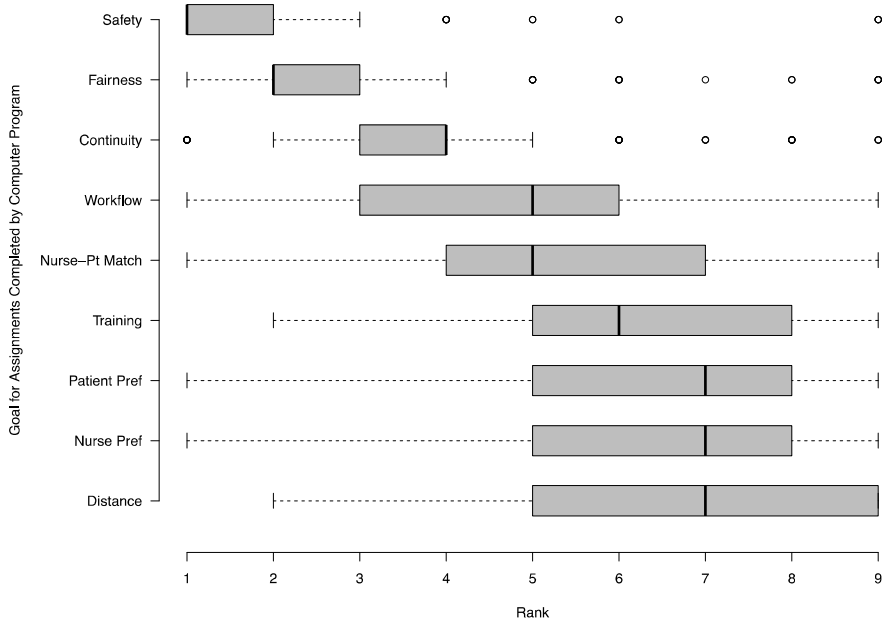


*Figure 3***.** Boxplot of survey respondent rating of goals for assignments by scenario.



*Ranks are ordinal - means and interquartile ranges identified on the boxplot are not statistically valid.

Figure 4. Visualization of survey respondent ranking of goals for assignments completed by computer program.

CONTEXT and PROCESS-A. The final set of results examined differences in respondent report of time to make assignments for the LAST and HARD scenarios in comparison to the USUAL case. Table 4.13 summed the absolute value of changes in ratings for each participant and provides them as a percent of total possible change, i.e., if all respondents had said it took 0 minutes to complete the USUAL case and 60 for the. LAST or HARD scenario. Differences were found to have fairly normal distributions, without extreme skew in either direction, so a paired t-test was completed to test the mean differences between the paired observations between USUAL and LAST and USUAL and HARD scenarios.

Comparison of the differences between the mean of the differences revealed significance between the USUAL case and the HARD scenario, but not between the USUAL case and the LAST scenario. The difference was negative, from which we can infer that respondents reported taking more time to complete an assignment when describing the challenging nurse-patient assignment scenario than when describing the usual case [USUAL-HARD] ($p = 0.025$).

Table 4.13

*Differences for Times Reported by Survey Respondents by Scenario Compared to USUAL (*N = *99)*

Time	Sum of changed	% change	*t*	*p*	95% CI	Mean of differences
USUAL to LAST	317	5	0.1633	0.8706	[-1.0, 1.2]	0.1
USUAL to HARD	849	14	-9.4963	<0.0001*	[-9.2, -6.0]	-7.6

In summary, this chapter discussed the results to research questions about the factors, goals, process and context of the nurse-patient assignment process. Qualitative and quantitative data analysis techniques were used to describing findings from interviews and a survey of charge nurses. Results were reported in summary and supported by direct quotations from interview participants and survey respondents. Implications of these results are described in Chapter 5.

Chapter 5: Discussion and Conclusions

This research investigated charge nurse decision making during the nurse-patient assignment process as an exemplar of the larger question: How can we leverage information technology to improve decision making in healthcare, while respecting individual clinician expertise and the unique context of individualized patient care? Four primary research questions were used to guide research into the process, decision factors, goals and context of nurse-patient assignments. These questions were investigated by mixed-methods of qualitative interviews and quantitative survey. This chapter discusses the results related to each of these questions in turn, then explores findings in relation to the conditions for charge nurse expertise and algorithm development. It concludes with recommendations for algorithm development and areas for future research.

Findings by Aim

Discussion of FACTORS. The first research aim was to identify the key requirements that should be incorporated into a nurse-patient assignment decision support algorithm [FACTORS]. Key requirements were explored by identifying the decision factors considered most frequently by charge nurses [FACTORS-B] and the data sources used to gather information for decision making [FACTORS-A]. Data for investigation of these questions was gathered both in interview and survey components of the research and evaluated for changes based on environmental context [CONTEXT-B].

Charge nurse interviews identified patient acuity as the most frequently cited decision factor, closely followed by continuity of care, nursing interventions and nurse

competence. Staffing, workload, acuity, nurse-patient ratio, continuity and nurse competence were the most frequently cited decision factors by survey respondents. These factors support the major groupings identified by Allen (2015) of patient, nurse and environment factors.

Patient Factors. Themes from qualitative analysis of interview notes revealed that acuity is important in creating fair and equal assignments, but was not inclusive enough to use as a single measure of patient workload for charge nurses similar to those studied. Acuity scores were routinely augmented by nursing interventions that identified patients with heavier workloads based on the culture of the specific nursing unit. The findings about the limitations of acuity support similar assertions in the literature (Acar & Butt, 2016; Sir et al, 2015). It follows that efforts to develop an algorithm based solely on acuity would be insufficient to meet the needs of the nurses from this research.

Assignments and acuity are inextricably linked, but until the definition of acuity is universally agreed upon, it will be hard to fully compare assignments across units and hospitals. On the other hand, subjective assessment of acuity may be good enough for the purpose of assignments. Charge nurses in this study did not rely on the acuity score alone, as noted by the frequency with which nursing interventions were reported in tandem with acuity. It is possible that the process could be simplified by trusting charge nurse expertise to judge the patients with the heaviest workload, with the understanding that this judgement will not be consistent between units or possibly even between charge nurses on the same unit. This should be investigated further.

With such high agreement about the importance of acuity, a surprising finding was that survey respondents were more likely to report considering acuity as a decision factor when describing their most recent nurse-patient assignment than during a particularly challenging assignment ($p = 0.1$). Most respondents (77%) reported that they would use acuity in both scenarios, but of the 17% who answered differently for each scenario, more reported not considering acuity during a particularly challenging assignment. This response likely reflects mistrust of the acuity system described by respondents in the acuity specific question or in the survey comments. This conclusion is supported by the finding that the opposite was true for respondents considering individual nursing interventions. Respondents were more likely to report considering interventions as a decision factor when describing a particularly challenging nurse-patient assignment than during their most recent assignment ($p = 0.05$). Details regarding concerns about acuity can be found in Appendix J and Appendix K.

Total workload per nurse also falls under the patient category. This factor is very closely tied to acuity but was described by research participants as also encompassing unit- or patient- or nurse-specific factors with values that vary with context. For instance, patient primary language considered individually does not necessarily hold the same value as taken in context with the primary language of the nurse and the other patients assigned to that nurse. As an example, imagine that the patient's primary language is Spanish. This adds different amounts of workload depending if the nurse's primary language is also Spanish. It also could change in value if the nurse was assigned other

patients who also speak Spanish versus various other non-native languages. HIT algorithms that can most closely calculate this workload data will be most successful in aiding charge nurses in the nurse-patient assignment process.

Nurse factors. Continuity was the most frequently cited nurse factor. Continuity serves two purposes for the charge nurses participating in this study. It enables a version of primary nursing that has been shown to benefit patient care, and it is used as a heuristic during the charge nurse decision process. Charge nurses assume that a previous assignment will work again when planning a future assignment. Continuity was valued differently by different members of the nursing team and may not always be the most important nurse factor.

Of all factors included in the survey, respondents had the least agreement about the value of continuity between scenarios. A total of 47% of respondents selected a different response regarding consideration of continuity. Respondents were much more likely to report considering the continuity when describing their most recent nurse-patient assignment ($p = 0.0001$). This exemplifies the trade-offs described by interview participants. Although continuity is valued highly by participants in this study, other considerations surpass it in value when the environmental context becomes more complex.

At face value, continuity of care appears to be an easy consideration to add to a decision support algorithm. It is easy for software to identify and track nurses who have previously cared for a patient and/or a patient's primary nurse. But continuity can become

convoluted when set in context. Sometimes patients or nurses request not to be assigned together again. Any automation of the assignment process should include a feature to notate this for future assignments. Additionally, factors other than continuity must sometimes be accommodated first, like even distribution of workload, or best/safest nursing care. Further research is required to investigate how an algorithm can determine how and when these trade-offs are necessary.

Nurse competence was mentioned frequently in interviews and identified by 70% of survey respondents. Charge nurses in this study reported that the nurses they work with do not have equal skills and have varying attributes, strengths, personalities and idiosyncrasies. This humanness sets the nurse-patient assignment process aside from a simple mathematical problem of supply and demand or allocation of resources, such as Mullinax & Lawley's (2002) comparison of this process to "bin packing and line-balancing" (p. 26). The charge nurses in this study gained knowledge of nursing staff over time. Most of this knowledge is tacit, and interview participants voiced concerns about how a computer algorithm would 'know' these details.

Nurse competence also provides an interesting challenge for algorithm development. Nurse credentials, certification, education and experience are recorded in human resource computer systems. However, charge nurses reported using more nuanced classifications of nursing skill. They gain tacit knowledge about nurse competencies, likes and dislikes over years of working with nurses on a unit. Sometimes assignments are made to provide best care by matching nurse strengths to patient needs, and other

times assignments focus on nurse weaknesses in order to provide additional learning opportunities with specific patient requirements. Training needs would likely need to be entered by hand by the unit's education coordinator, then could be easily automated. Nurse competence, skills and preferences could be assessed by creating a feedback loop for the nurse, patient and co-workers to rate assignments on a shift-by-shift basis. This could help teach an algorithm to look for and match nurses in a method that resembles the tacit knowledge described by charge nurses. Ideally this learning algorithm would also be tied to medium and long-term nurse sensitive patient outcomes.

Two nurse-related factors were not ranked highly for consideration, but had significant findings related to context. These were nurse preference and collegiality. When considered together, they paint and interesting picture of how the responding charge nurses' considerations differed by scenario. During an average nurse-patient assignment process, these charge nurse considered the preference of individual nurses. When the situation was more complex, they considered how well the staff worked together as a team. The survey finding echoes the quotation from an interview participant who, when asked specifically about nurse preference, responded: *"I will take it into account if I can. . . I mean I can if I have the time and or the inclination. If I'm running super late or feel really crappy, as with anything, I may not be as motivated to be as obliging."* In instances like these, a HIT solution may provide more consistent assignments.

Environmental factors. The environmental factors described most frequently were staffing and nurse-patient ratios. These are obvious and necessary for the completion of the nurse-patient assignment question. Both are readily available for inclusion in a HIT algorithm. The number of respondents reporting considering these factors was congruent across scenarios.

Notably absent from the list of top factors considered were distance and unit layout with an average of 52% and 38% of respondents considering these factors respectively. One cause of the low average reporting for distance was the highly significant finding that respondents were more likely to report considering distance as a decision factor when describing their most recent nurse-patient assignment than during a particularly challenging assignment ($p = 0.001$). This again exemplifies the trade-offs described by interview participants. Although total nurse walking distance is generally valued by participants in this study, other considerations quickly surpass it in value when the environmental context becomes more complex. This provided one of the clearest examples of the importance of research guided development of IT solutions. Further research is required to investigate how an algorithm can determine how and when these trade-offs are necessary.

Data sources. In addition to factors, information about data sources was collected in support of the FACTORS research question by investigating FACTORS-A. It was clear from interview data that respondents combined both standardized data sources and sought out specific knowledge when completing assignments. Survey respondents

supported interview findings by reporting that staff nurses and the off-going charge nurse were the data sources used most often. Neither of these sources can provide an automated source of information for a HIT algorithm. Each digital information source was selected by less than 50% of respondents. This could present a major dilemma for algorithm development. Further research is required to determine if digital sources of information are adequate but not used by charge nurses in this study, or are not adequate and additional data must be entered for a HIT algorithm to be successful.

Current automation attempts by HIT vendors are based on a digital version of the template with nurses listed on the vertical axis and patients on the horizontal (or vice versa). Systems are interfaced with nurse scheduling systems to pull in staffing information and with ADT systems to pull in patient census data. Acuity information is pulled in, and sometimes feeds a simple algorithm to check if nurses have been assigned a similar total workload number. These existing systems are helpful in automating this portion of data collection but lack the robust data collection described by charge nurses in this study.

Data sources used were not significantly different between the LAST and HARD scenario, except that staffing updates from the hospital office were reported as a data source more frequently for the HARD scenario. Based on descriptions from the interview participants, these updates were most currently given at the hospital-wide staffing or 'bed' meeting or via telephone. This information also needs to be automated for inclusion into an HIT algorithm. Algorithm developers should consider the implications of staffing

updates to assignment updates and consider manual and automatic update capabilities based on staffing. Logic for automatic updates should be clear and traceable.

Future algorithm development efforts should focus on integration of data sources containing factors most important to nurse-patient assignment. This study supports the notion that data sources and factors will vary based on the culture of a particular unit (Acar & Butt, 2016; Sir et al., 2015). With this understanding, HIT solutions attempting to improve or automate the process should be configurable at the unit level, incorporate machine learning to integrate data not currently found in HIT solutions, or provide complete transparency in algorithm deficiencies in order to allow charge nurse to understand gaps and edit algorithm outputs effectively.

Key FACTORS finding. HIT algorithms based on a limited set of factors would not be sufficient to meet the needs of the charge nurses participating in this research. More than 50% of participants reported considering eleven or more decision factors each time they made nurse-patient assignments. Interview participants reported inconsistent use of factors across similar units within and between hospitals and survey respondents reported inconsistent use of factors based on context.

FACTORS recommendation. At a minimum, developers of HIT decision algorithms for nurse-patient assignments for charge nurses similar to those studied should consider incorporating data regarding: staffing, workload, acuity, nurse-patient ratio, continuity, nurse competence, patient safety measures, patient psycho-social needs, distance, support staff availability, nursing interventions, patient independence in

activities of daily living, and patient and nurse gender and primary language (see Appendix E for a full description of each factor). To best meet the needs of charge nurses like those that participated in this study, developers should build solutions with flexible configurations, so decision factors and factor weight can be varied by hospital, unit, charge nurse and shift.

Discussion of GOALS. The second aim of this research was to identify the goals that should be utilized by a nurse-patient assignment decision support algorithm. As noted in the literature review, most algorithm development has focused on minimizing the distance nurses walk during a shift and equitable distribution of workload. Goals were investigated directly by asking survey respondents to rank goals for use in an imagined computer program that made nurse-patient assignments [GOALS]. Secondary research questions investigated the value of goals in general [GOALS-A], the criteria used to measure goals [GOALS-B, PROCESS-B] and changes in goal priority based on context [CONTEXT-A]

Analysis of participant responses of goals revealed that the nurse-patient assignment process is a complex construction task with multiple goals and trade-offs. All interview participants identified all goals as considerations at some point during their descriptions of scenario or general-case nurse-patient assignment making. Similarly, all goals were given an average rating of 47 or higher (out of 100) on a scale of ‘not important’ to ‘very important.’ Safe, quality patient care and fair and equitable assignments were valued the most by interview participants and survey participants. The

order of goal importance did not vary by scenario, but the significant differences in ratings between the LAST and HARD scenarios alludes to the trade-offs required in response to contextual changes. Survey respondents were steadfast in agreement in safety as the most important goal and distance as the least important goal. The low rating of distance as a goal corresponds with its low rating as a decision factor, again something for HIT algorithm developers to consider.

The measurement criteria identified in this research require further investigation before a recommendation can be made regarding their adoption. For example, staff satisfaction was identified, but is complex in itself. Results of this study allude to the likelihood that nurse preferences vary by the individual nurse. Nurses could be more satisfied when they receive the same patients they had the day before, or more satisfied if they receive patients with rooms close together, or more satisfied if they have an assignment they deem fair and equitable. Other measurement criteria suggested by interview participants were more straightforward, but still require investigation to determine a direct link to nurse-patient assignment.

If staff feedback is confirmed to be the most important outcome measure, then nurse preference and staff input should be considered in a HIT algorithm. This could be accomplished by providing an opportunity for staff nurses to set their preferences for types of patients and types of assignments at the unit level. This could also be accomplished in an automated fashion by creating a machine learning algorithm that collects and incorporates feedback from nurses on each shifts' assignments.

Key GOALS finding. This study found that participants have multiple goals when creating nurse-patient assignments. Goals of safety, fairness and continuity were consistently rated the most important, but goal value varied by scenario and trade-offs were required. Most charge nurses received feedback about their assignment quality from other nurses but standardized measurable criteria do not exist to quantify a 'good' nurse-patient assignment. It is unlikely that a universal set of goals can be identified because goals must take individual patient, nurse, and environmental factors into account. For instance, a nurse who has a challenge with mobility will likely value having patients in rooms closer together over having a fair and equitable assignment.

GOALS recommendation. Implications for HIT algorithm development of a solution for charge nurses like those studied are that a flexible user experience should be developed to show what goals the algorithm based its recommendations on, and allow the charge nurse interaction by setting goals based on environmental factors of the upcoming shift. This type of interface is recommended in the literature for developing probability based nursing clinical decision support tools (Jeffery, Novak, Kennedy, Dietrich, & Mion, 2017). Machine learning could be taught to learn goal priorities from environmental factors if clear outcome measurements are identified. Until that time, implementation of any HIT algorithm should include investigating the particular goals most relevant to the hospital, unit or charge nurse following a methodology like the one used in this research or by reported in the literature, such as Acar & Butt (2016), Sir et al.

(2015), or van Oosteveen et al. (2014). Additional research is required to identify reliable and measurable criteria for the nurse-patient assignment process.

Discussion of PROCESS. The decision techniques used by charge nurses today [PROCESS] were investigated in the interview portion of the research. The secondary process question of how much time do charge nurses spend making nurse-patient assignments today [PROCESS-A] was investigated both by interview and by survey. Findings for PROCESS-A are straight forward and provide a benchmark for improving the process of nurse-patient assignments for charge nurses like those that participated in this study. Interview responses indicated that a HIT algorithm could potentially save charge nurses time, so this benchmark may be useful as a measure of algorithm success.

The decision process diagram described in Chapter 4 is similar to the process described by Allen (2012) and Plover (2107). Plover (2017) describes information gathering in his description of "process" but breaks it into "information sourcing" and "selection" (p. 57). Allen (2012) describes similar steps of nurse assignment to individual patients then groups of patients and the last step of evaluation and change. Plover (2017) describes the trade-offs between goals and factors in his description of structure and prioritization. Cognitive techniques used by interview participants reflected those described by a multitude of decision theorists.

***Key PROCESS findings*.** The process of making nurse-patient assignments was described as complex and cognitively challenging by interview participants, using multiple heuristics and decision techniques. Participants were receptive to a HIT solution

with mostly positive ratings about potential usefulness. A few notable quotations are worth repeating. On complexity, *"I used to have to hide in the mud room to make assignments, so I wouldn't be interrupted."* Positivity related to HIT solution, *"If I had an extra hour back in my day, to take care of my staff and my patients and make sure they had everything they need, I'd be in heaven."* Concerns about computer system, *"Is it doing me a favor and saving me time, or is another system that I have to babysit because it doesn't think that I know what I'm doing."*

PROCESS recommendations. Additional research is needed to validate the process diagram and cognitive techniques described in Chapter 4. Process improvement efforts should appreciate the complexity of the current nurse-patient assignment process (in charge nurses like those who participated in the interview portion of this study) and investigate current techniques used before attempting to improve them. HIT algorithm developers should consider this process diagram within the larger conceptual framework for user- and context-dependent clinical decision support systems depicted by Jeffery et al. (2017). A flexible, configurable user experience would also allow software to be aligned with how experts currently process information, instead of forcing the user to understand the algorithm. For example, most interview participants started by assigning the most challenging patients, but one started with those requiring the least amount of care.

Experts are Good

Fractionated expertise. Kahneman and Klein's (2009) conditions for intuitive expertise were described in Chapter 1. Although investigation of charge nurse expertise was not a specific goal of this research, expertise was assumed, and it follows that that assumption should be discussed with the other research outcomes. The two conditions for expertise are adequate practice in a valid environment.

Most of the charge nurses that participated in this study had adequate practice making nurse-patient assignments. Interview participants made assignments an average of 3 times per week over an average of 11 years. Survey respondents made assignments an average of 3 times per week over an average of 6 years, although approximately 21% of survey respondents had less than 2 years of experience making assignments on the particular unit they currently worked on. Data could be used to analyze novice versus expert responses in a further study.

Environmental validity is achieved when cues are associated with outcomes in a causal structure, and the expert is provided timely feedback about the outcomes. From this standpoint, expertise was much more difficult to judge. Evidence was found to support that charge nurses have fractionated expertise regarding the nurse-patient assignment process.

Although 97% of survey respondents indicated that they received feedback from nurses that their assignments are good, the comments from several respondents indicated they received no feedback. And nearly all respondents learned how to make assignments

on-the-job training. Apprenticeship is generally associated with processes that have not been standardized. Outcomes can be observed, but a single standard of quality has not yet been set by the larger industry. For nurse-patient assignments this was directly observed by a lack of cohesive response defining measurable outcomes by interview participants.

Without standardized outcomes, cues (like a nurse-patient match) cannot be associated with a measurable outcome in a causal structure. Participants described receiving feedback regarding eight of the nine goals investigated in this research: safety/quality, fairness, continuity, workflow, training, nurse preference, patient preference and distance. However, the adequacy of this feedback was not measured and requires further investigation. One of the biggest barriers to feedback was that most assignments were made for an upcoming shift, not the same shift the charge nurse worked (see Appendix I). Interview participants described receiving feedback when they arrived back to work following the shift they made assignments for, but no feedback if they had days off.

It is also likely that any feedback related to patient outcomes was limited to outcomes that could be observed during the patient stay, which do not necessarily reflect long-term outcomes. Detsky et al. (2017) observed this effect among ICU physicians and nurses. Knowledge of long term outcomes could improve safety/quality, training, and nurse-patient match. As the adage goes, if it can't be measured, it can't be improved. All outcomes could be improved by defining measurable criteria for each goal. This would also improve the expertise of charge nurses in making nurse-patient assignments, and is a

necessary requirement for the development of an HIT algorithm. Knowledge of clinical objectives, goals and workflows are necessary to develop decision aids and avoid unintended consequences (Osheroff et al., 2005).

The biggest concern about fractionated expertise is that the expert is blind to the line defining where expertise exists and where it does not. Repeating a quote from Chapter 1, "There is no subjective marker that distinguishes correct intuitions from intuitions that are produced by highly imperfect heuristics. An important characteristic of intuitive judgments, which they share with perceptual impressions, is that a single response initially comes to mind" (Kahneman & Klein, 2009, p. 522). This gap is a consideration when any type of self-skill rating is assessed, such as self-rating of quality of care (Choi & Miller, 2018).

***Implications*.** Readers of this and similar studies should consider the fractionated nature of charge nurse expertise regarding the nurse-patient assignment process. Charge nurses likely do not receive valid feedback regarding the effect of assignments on patient outcomes, nurse training, or optimal nurse-patient match.

Recommendations for expertise. Nurse-patient assignments must be tied to measurable, nurse-sensitive indicators of patient outcomes. HIT solutions and quality improvement efforts should collect and analyze measurable outcome data prior to attempting to improve or augment existing nurse-patient assignment practices to prevent unintended consequences.

Algorithms are Good

Kahneman and Klein (2009) describe two scenarios where HIT algorithms outperform experts and defined conditions for algorithm development, as discussed in Chapter 2. This section will investigate the findings of this research in light of the preceding recommendations for algorithm development.

First, the easy test of automation is to evaluate a process for frequency and the validity of the environment. Tasks that are highly repetitive with highly valid environments should be automated to eliminate human error. The nurse-patient assignment process does not fit this definition. The other group of tasks recommended for automation is the in the face of low validity environments. Low validity environments do not provide feedback at an amplitude that can be detected by the decision maker or in a manner that is timely enough for the decision maker to associate a particular cue to a particular outcome. Both of these were observed in the case of charge nurses making nurse-patient assignments. Charge nurses encounter feedback that they may not associate with a particular nurse-patient assignment because the specific outcome occurs infrequently, such as a patient infection or patient fall. These could be considered low amplitude events, which would be easier to track in an automated algorithm. Concerns about timeliness of feedback were described above. Given this, an algorithm may be helpful to charge nurses during the nurse-patient assignment process if clearly defined outcomes were available for training a machine learning algorithm.

The conditions for algorithm development from Table 2.1 were revisited in Table 5.1 below. Significant gaps remain in two of the five conditions. The first is development of reliable and measurable criteria, which has been discussed in several sections above. The second is a low likelihood that changing conditions will render the algorithm obsolete. This condition is not met by the nurse-patient assignments, both from findings in the literature review, and as supported by survey respondents in this study. To address this gap, it was suggested above that instead of creating an algorithm that is completely prescriptive, developers should consider adding flexibility for goals for a particular shift to be defined at the user level. This interface could be temporary, until enough data can be collected about environmental context to enable algorithmic prediction of the best outcome based on context specificity.

Table 5.1

Study Findings in Relation to Conditions for Algorithm Development

Conditions for algorithm development	Finding in literature review	Gaps	Finding for this study
(a) Confidence in the adequacy of the list of variables that will be used	Adequate decision factors have been identified, many accessible via automated HIT solutions	Is factor list comprehensive when studied at scale across multiple hospitals?	Yes, no new factors were typed into the comments field by survey respondents.
	Rating of factor importance is inconsistent	Which factors are used most frequently? Which factors are most important to include in an algorithm?	Results for this study add to existing literature but fall short of creating a conclusive list.

Study Findings in Relation to Conditions for Algorithm Development (cont.)

Conditions for algorithm development	Finding in literature review	Gaps	Finding for this study
(b) A reliable and measurable criterion	Many goals exist, but standardized definitions and criteria do not Some patient outcome related goals are measurable for individual patient care units	Can measurable criteria be agreed upon as a standard across units and hospitals?	Confirmed that standardized criteria have yet to be defined.
	Goals vary based on decision factors	Can reliable, universal goals be developed?	Results for this study indicate a consistent set of goals but fall short of creating a conclusive list.
(c) A body of similar cases	Direct assignment of nurse is frequently performed as the most common care model	None	None
(d) A cost/benefit ratio that warrants the investment in the algorithmic approach	Charge nurses spend approximately 30 minutes completing assignments	Is charge nurse time spent making assignments consistent when studied at scale across multiple hospitals?	Study participants spent an average of 25 minutes making assignments, and interviewees thought this can likely be shortened.
(e) A low likelihood that changing conditions will render the algorithm obsolete	Environmental change can influence the valuation of decision factors The environment within a unit is stable enough for an algorithm or guideline to improve outcomes within a particular unit	How much does the environmental context affect the nurse-patient assignment? Are environmental conditions similar across units and hospitals for a single algorithm to be useful?	Effects of environmental context were shown to be statistically significant between context for data sources used, decision factors considered, goals and time to complete assignments for survey participants.

Limitations and Future Research

Limitations. The scope of this research did not include an investigation of several topics related to nurse-patient assignments. The first of these is acuity. As noted in the

literature review, interview results and survey results, patient acuity plays a major role in the nurse-patient assignment process, but a standard definition has not been agreed upon by the industry. In fact, even the term acuity is referred to alternatively as patient classification or workload. Further industry work to standardize the terminology and measurements for nursing related patient acuity would benefit nurse-patient assignments. Without a standardized definition an HIT algorithm based on acuity would only be valid for units with a shared definition of acuity.

Another related topic is computerized decision support in healthcare. Although this paper refers to the creation of a HIT algorithm, references to decision support were generic in nature. The literature exploring computerized decision support in healthcare was not explored. Findings discussed in this chapter should be combined with best practices from CDS literature when designing an HIT solution to support the nurse-patient assignment process.

The final related topic for discussion is outcome measures or nursing-sensitive indicators. Much work has been done to connect nursing care to patient outcomes. A review of this work was not performed, as it relates to measurable outcome criteria for the nurse-patient assignment process. Outcome measures suggested by interview participants in Chapter 4 should be assessed in light of nursing-sensitive outcome literature before adoption.

Future research. Several suggestions for future research were made in the sections above. Additional ideas include:

- Further investigation of environmental validity.
- Nursing team "Care Model" effect on nurse patient assignment especially related to nursing assistant availability which was recurring theme in staffing comments.
- Studies of the secondary, or ongoing assignment process. None were identified in a review of the literature.
- What criteria is used by nurses who refuse an assignment. How often does this occur?

- Can the introduction of formal training for role of charge nurse improve charge nurse decision making?
- When does adding additional information cease improving nurse-patient assignments? Where should cost-benefit line should be drawn when gathering data? At what point does the return-on-investment matter for patient outcomes?

Conclusion. Each day, across thousands of medical-surgical inpatient nursing units, charge nurses make decisions about which nurse will care for each patient. This research indicates that attempts to introduce health information technology (HIT) solutions to automate the nurse-patient assignment process may have been premature.

Findings related to the charge nurse decision making process indicate that measurable, nurse-sensitive indicators of patient outcomes have not been previously identified for nurse-patient assignments. HIT solutions and quality improvement efforts should define, collect and analyze measurable outcome criteria prior to attempting to improve or augment existing nurse-patient assignment practices to prevent unintended consequences.

When clear outcome measurements have been identified, informatics researchers and professionals should investigate the ability of machine learning to recognize goal priorities and factor weighting from patient, nurse and environmental factors within existing HIT solutions. Until that time, HIT solutions augmenting the nurse-patient assignment process should be designed with flexible configurations, so goals, decision factors and factor weights can be varied by hospital, unit, charge nurse and shift to best meet the needs of charge nurses.

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Appendix A
Participant Recruitment Materials

Recruitment Email for Interview:

Thanks for your interest in participating in a research study of the nurse-patient assignment process.

Do you work on a med-surg unit?
We are looking for nurses who work on a medical and/or surgical unit in an inpatient setting where the average length of patient stay is between 2 to 7 days and the average nurse is assigned between 3 and 6 patients.

Does this description fit you?
We are looking for nurses with more than 5 years of experience, who've been responsible for making nurse-patient assignments on the same unit for more than 2 years and continue to make nurse-patient assignments on a regular basis (about 2 times per week).

What can you expect?
We are looking for nurses who are willing to spend about 1 ½ to 2 hours telling us about their current and past experiences of making nurse-patient assignments. Participants will be presented with a $50 iTunes or Amazon gift card as compensation for their time.

Ready to sign up?
I'll be interviewing in your hospital on Month/Days. Please let me know what times would work for you on those dates.

Recruitment Email/Posting for Survey:

Charge Nurses Wanted! Tell us how you make Nurse-Patient Assignments
Adequate staffing is important for patient safety and nurse satisfaction, and assigning a specific nurse to care for each patient is the final step in the staffing process. However, there is little known about this important task. This research will add to the understanding of decision making during the nurse-patient assignment process.

Are you currently responsible for making nurse-patient assignments at least once per week on an inpatient unit that cares for medical and/or surgical patients? If so, your help is needed!
Participation requires completion of a short, one-time survey that will take approximately 15-20 minutes to complete.
Your response will enhance future efforts to develop decision aids, and you will be eligible to win a $100 Amazon gift card!

This research has been approved by the Institutional Review Board at the University of Minnesota. Please direct any questions or comments to Elizabeth Meyers, RN, MS, PhD Candidate, at drav0008@umn.edu.

Please click here to access the survey.

Appendix B
Information Sheet for Research

Analysis of Charge Nurses During the Nurse-Patient Assignment Process

You are invited to be in a research study of the nurse-patient assignment process. You were selected as a possible participant because you are a charge nurse with more than 5 years nursing experience, more than 2 years on the same unit, and make nurse-patient assignments on a regular basis. We ask that you read this form and ask any question you may have before agreeing to be in the study.

This study is being conducted by: Elizabeth Meyers, PhD Candidate in Healthcare Informatics at the University of Minnesota.

Procedures:

If you agree to be in this study, we would ask you to do the following things:
Engage in conversation with the researcher about your past experiences and current nurse-patient assignment practices. Allow an assistant to listen to the conversation over speaker phone. Allow audio recording of the conversation.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only the researchers will have access to the records. Audio recordings will serve only to supplement notes taken by the researchers during the conversation. Only the two researchers will have access to these recordings. All audio recordings will be deleted after the notes have been reviewed for completeness.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researchers conducting this study are: Elizabeth Meyers and Dr. David Pieczkiewicz. You may ask any questions you have now. If you have questions later, you are encouraged to contact them at University of Minnesota, 651-705-6074, drav0008@umn.edu or David Pieczkiewicz, 612-626-8591, piecz001@umn.edu

If you have any questions or concerns regarding this study and would like to talk to someone other than the researchers, you are encouraged to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota, 55455; (612) 625-1650.

You will be given a copy of this information to keep for your records.

Appendix C
Interview Demographic Questions

Verbal Consent:

Please take a few minutes to look over this information sheet (see Appendix B)
I'm seeking your consent to

- Listen to your stories about nurse-patient assignments and take notes that will be used to better understand this process.
- Allow my colleague, Dr Stephanie Allen to listen in remotely
- Record our conversation
- Your participation is voluntary – you may ask to stop at any time

As we are speaking, please avoid hospital, staff and patient identifiers to protect business, employee and patient privacy.

Verbal Demographic Questions:

How long have you been a nurse?
How long have you worked at this hospital?
In this particular unit?
How long have you worked in a position where you made nurse-patient assignments?
Tell me about your unit. . . How many beds?
Average daily census?
What type of patients do you care for on this unit?
What is the average length of stay on your unit?
How many patients is the average nurse assigned to care for on a given shift?
What types of nurses and support staff work on this unit?
How long have you made assignments on this particular unit?
How many times in the average week do you make nurse-patient assignments?
What shift do you usually make assignments for?
Is it the same shift you work?
How many times have you made nurse-patient assignments in the last 2 weeks?
When was the last day and shift where you made nurse-patient assignments?

Written Demographic Questions (participant completed at end of interview):

How would you describe your hospital? (Community, Academic, Research)
About how many beds does your hospital have?
What is your highest level of education?
Please list any certifications.
Optional – if you would like, please provide your: Age, Gender, Race
Please provide any feedback you have about the interview process:
In thanks and recognition of your time today, which option would you prefer?

□ $50 iTunes e-gift card
□ $50 Amazon d-gift card

Please provide an email address you'd like the e-gift card to be sent to:

Appendix D
Interview Guide

<u>Investigative questions:</u>

I'd like you to think about the last time you made nurse-patient assignments. Can you describe the situation to me?

[Specify Incident]

- How many days ago?
- What shift? Did you work on that shift? Where were you physically? {Engage interviewee in memory of specific event}
- Was there anything particularly special or unique about that shift? {Goals}

[Create Timeline]

- How long did it take you? {Steps}
- Walk me though it step-by-step describing how and what you did along the way. {Steps}

[Deepen Inquiry]

- What tools or information did you use to complete the assignment process? {Steps}
- How did you get this information? {Steps}
- What knowledge was necessary or the most helpful? {Key Requirements}
- What were your specific goals? {Goals}
- Did you consider alternative nurse-patient assignments? {Steps}
- How did the staff react to your decision? Any feedback from staff or patients about the assignments you made? {Goals, Steps, Key Requirements}

Now I'd like you to think about a specific time that you were asked to make assignments that was particularly challenging. *If interviewee has a hard time recalling, interviewer will probe suggesting: overstaffing, understaffing, unqualified staffing, or complaint.*

[Specify Incident]

- What about this incident made it particularly challenging? {Goals}
- How many days ago? What shift? Did you work on that shift? Where were you physically? {Engage interviewee in memory of specific event}
- Was there anything particularly special or unique about that shift? {Goals}

[Create Timeline]

- How long did it take you? {Steps}
- Walk me though it step-by-step describing how and what you did along the way. Different than your last time? {Steps}

[Deepen Inquiry]

- What tools or information did you use to complete the assignment process? {Steps}
- How did you get this information? {Steps}
- What knowledge was necessary or the most helpful? {Key Requirements}
- What were your specific goals? {Goals}
- Did you consider alternative nurse-patient assignments? {Steps}

[What-if Queries]

- Would you made the same decision at an earlier point in your career? Why? {Goals, Steps, Key Requirements}
- If you started at a new hospital tomorrow? Why? {Goals, Steps, Key Requirements}
- Would the assignments be different if someone else did them? Better/worse? Why? {Goals, Steps, Key Requirements}
- If you were asked to give advice about making nurse-patient assignments to a new charge nurse, what advice would you give? {Goals, Steps, Key Requirements}

Let's revisit the assignments you made most recently with those last questions:

Repeat What-if Queries for the first scenario.
[What-if Queries]

- Would you made the same decision at an earlier point in your career? Why? {Goals, Steps, Key Requirements}
- If you started at a new hospital tomorrow? Why? {Goals, Steps, Key Requirements}
- Would the assignments be different if someone else did them? Better/worse? Why? {Goals, Steps, Key Requirements}
- If you were asked to give advice about making nurse-patient assignments to a new charge nurse, what advice would you give? {Goals, Steps, Key Requirements}

Understanding the general case: {to support key requirement validation survey}
Imagine you were asked to develop a computer program that made assignments.

- What are the key factors you would include? {Key Requirements}
- How helpful would such a system be? {Goals}
- How accurate would the computer's recommendations be? {Key Requirements}
- Would a computer system like this save you time? {Goals}
- What concerns would you have about such a system (things that might make it fail)? {Goals}
- What features s/he would want to see the system have so that it would be successful. {Goals}

If you were asked to develop a teaching program for new charge nurses what are the most important things you would be sure to include? {Key Requirements}
If your head nurse were to "grade" your assignments what should she use to judge the quality of assignments? {Key Requirements}
Can you describe for me more generally what factors you take into account when making nurse-patient assignments? {Key Requirements}
What happens when the factors conflict, or you need to make trade-offs? How do go about coming up with a decision in those cases? {Goals, Steps}
When you make decisions about nurse-patient assignments, do you strictly consider one patient at a time, or do you (sometimes) have to make decisions that involve multiple patients that you need to match to multiple nurses? {Steps}
Presumably making nurse-patient assignments involves considerations from the perspective of the nurses (what is best for them), the patients (what is best for them) and the organization (the hospital/the unit — what is best for them). Can you tell us a little bit about the objectives and considerations from each of these perspectives? {Goals, Steps}
Are there any other perspectives, objectives, or considerations that we haven't yet talked about? {Goals, Steps, Key Requirements}
What haven't I asked you about nurse-patient assignments that you think is important for me to know or will help me better understand the process? {Goals, Steps, Key Requirements}
Additional background questions: {to augment future research}
How did you learn how to make nurse/patient assignments?
When you have concerns or problems regarding nurse-patient assignments whom do you consult or ask for advice?
In general, how do you know whether or not the assignment process met your expectations?
How do you measure patient acuity on your unit?

Appendix E
Cross-walk of Allen (2015) Decision Factors to Disambiguated List with Short Names

Allen (2015) Factor	Revised, Disambiguated Decision Factor	Short Name
Chief complaint	Patient acuity (nursing workload or intensity for particular patient)	Acuity
Code status	Patient acuity (nursing workload or intensity for particular patient)	
Cognitive status	Patient acuity (nursing workload or intensity for particular patient)	
Comorbidities	Patient acuity (nursing workload or intensity for particular patient)	
Condition	Patient acuity (nursing workload or intensity for particular patient)	
Diagnosis	Patient acuity (nursing workload or intensity for particular patient)	
History	Patient acuity (nursing workload or intensity for particular patient)	
Labwork	Patient acuity (nursing workload or intensity for particular patient)	
Procedures	Patient acuity (nursing workload or intensity for particular patient)	
Type of surgery	Patient acuity (nursing workload or intensity for particular patient)	
Vital signs	Patient acuity (nursing workload or intensity for particular patient)	
Weight	Patient acuity (nursing workload or intensity for particular patient)	
Bowel incontinence	Patient independence in activities of daily living (feeding, bathing, bowel continence)	ADLs
Feedings	Patient independence in activities of daily living (feeding, bathing, bowel continence)	
Total care	Patient independence in activities of daily living (feeding, bathing, bowel continence)	
Collegiality	Nurse collegiality (relationship with other staff, helpfulness)	Collegiality
Certification	Nurse competence (experience, skill, efficiency, certifications, knowledge)	Competence
Education	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Efficiency	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Experience	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Knowledge/ Knowledge Deficit	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Licensure	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Orienting	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Skills	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Speed	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Status	Nurse competence (experience, skill, efficiency, certifications, knowledge)	
Nurse-Patient Relationship	Nurse-patient relationship (continuity of care, stated preference)	Continuity

continued

Cross-walk of Allen (2015) Decision Factors to Disambiguated List with Short Names (continued)

Allen (2015) Factor	Revised, Disambiguated Decision Factor	Short Name
Consultations	Care coordination (indirect care - consultation, discharge planning, off-unit tests)	Coordination
Diagnostic tests	Care coordination (indirect care - consultation, discharge planning, off-unit tests)	
Orders	Care coordination (indirect care - consultation, discharge planning, off-unit tests)	
Physician Visit	Care coordination (indirect care - consultation, discharge planning, off-unit tests)	
Proximity	Proximity (distance between rooms of patients assigned to same nurse)	Distance
Care Standard	Care standard (written guidelines for staffing or assignments)	Guidelines
ADTs	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	Interventions
Blood products	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Chemotherapy	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Drains	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Dressing Changes	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
End of life care	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
IV Therapy	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Lines	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Medications	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Phototherapy	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Treatments	Nursing interventions (direct care: medications, IVs, dressing changes, treatments)	
Time of Arrival	Patient length of stay (post-op day, expected discharge date)	LOS
Culture/Race	Nurse demographics (gender, age, culture, language)	Nurse Demographics
Gender	Nurse demographics (gender, age, culture, language)	
Generation/Age	Nurse demographics (gender, age, culture, language)	
Personality	Nurse demographics (gender, age, culture, language)	
Preference	Nurse preference (stated like or dislike for particular patient or patient type)	Nurse Preference
Additional duties	Nurse additional duties (education)	Other Duties
Age	Patient demographics (gender, age, culture, language)	Patient Demographics
Cultural Background	Patient demographics (gender, age, culture, language)	
Gender	Patient demographics (gender, age, culture, language)	
Language	Patient demographics (gender, age, culture, language)	
Name	Patient demographics (gender, age, culture, language)	

continued

Cross-walk of Allen (2015) Decision Factors to Disambiguated List with Short Names (continued)

Allen (2015) Factor	Revised, Disambiguated Decision Factor	Short Name
Emotional Needs	Patient psychosocial support (family support, emotional support)	Patient Psych
Familial support	Patient psychosocial support (family support, emotional support)	
Intellectual needs	Patient psychosocial support (family support, emotional support)	
Airway	Patient safety measures (fall risk, restraints, skin risk, sitter needed)	Safety Measures
Contact Precautions	Patient safety measures (fall risk, restraints, skin risk, sitter needed)	
Dermatological Precautions	Patient safety measures (fall risk, restraints, skin risk, sitter needed)	
Fall Precautions	Patient safety measures (fall risk, restraints, skin risk, sitter needed)	
Restraints	Patient safety measures (fall risk, restraints, skin risk, sitter needed)	
Surveillance	Patient safety measures (fall risk, restraints, skin risk, sitter needed)	
Nurse-Patient Ratio	Nurse-patient ratio (required maximum number of patients per nurse)	Ratio
Work Shift	Shift (length of shift, unit activities that vary by time of day)	Shift
Staffing	Staffing (number of staff available, number of patients on unit, empty beds)	Staffing
Support Staff Availability	Support Staff Availability (nursing assistants or techs and staff groupings)	Support Staff
Time	Time (available to make assignments, before shift begins)	Time
Empty beds	Unit physical layout (number of halls, medication carts, nursing workstations)	Unit Layout
Workload	Nurse workload (total workload for all patients assigned to one nurse)	Workload

Appendix F
Survey

INFORMATION SHEET FOR RESEARCH

Cognitive Task Analysis of Charge Nurses During the Nurse-Patient Assignment Process

You are invited to be in a research study of the nurse-patient assignment process. You were selected as a possible participant because you are an inpatient medical-surgical nurse who makes nurse-patient assignments on a regular basis. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Elizabeth Meyers, PhD Candidate in Health Informatics at the University of Minnesota.

Procedures:
If you agree to be in this study, we would ask you to do the following: Complete the survey questions that follow.

Confidentiality:
The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records.

Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:
The researchers conducting this study are: Elizabeth Meyers, PhD Candidate and David Pieczkiewicz, PhD, Faculty Advisor. You may ask any questions you have now. If you have questions later, you are encouraged to contact them at University of Minnesota, 651-705-6074, drav0008@umn.edu. David Pieczkiewicz, 612-626-8591, piecz001@umn.edu

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

You may print a copy of this information to keep for your records or request a copy by emailing the researchers.

Contribution and Response Burden:
This research will add to the understanding of decision making during the nurse-patient assignment process. Your response will improve understanding of the current process which will enhance future efforts to aid the decision maker.

Survey (Continued)

Estimated completion time is 20 minutes.

Survey (Continued)

Section 1: Your unit and job duties

1. Are you currently responsible for making nurse-patient assignments at least once per week on an inpatient unit that cares for medical and/or surgical patients?

- Yes
- No

Survey (Continued)

Section 1: Your unit and job duties

For the following questions, if not specified, please describe the average state during the last three months.

2. How many years have you worked in a position where you made nurse-patient assignments?
(if less than one year, please enter zero)

3. How many years have you made assignments on your current unit?
(if less than one year, please enter zero)

4. How many times in an average week do you make assignments?

5. How many times have you made assignments in the past 2 weeks?

6. On average, about how long does it take you to make assignments?
(please enter as number of minutes)

Survey (Continued)

7. What types of patients are cared for on your unit?
(please check all that apply)

- [ ] Medical
- [ ] Surgical
- [ ] Oncology
- [ ] Cardiology/Telemetry
- [ ] Orthopedic
- [ ] Neurology/Neuro-surgical
- [ ] GI/Hepatology
- [ ] Psychiatric
- [ ] Pediatric
- [ ] Urology/Gynecology
- [ ] Other (please specify)

8. What is the maximum number of patients that can be cared for on your unit? (number of beds)

9. How many patients does your unit usually have? (average daily census)

10. What is the average length of stay on your unit?

- ○ Less than 1 day
- ○ 1 day
- ○ 2 days
- ○ 3 days
- ○ 4 days
- ○ 5 days
- ○ 6 days
- ○ 7 days
- ○ 8 or more days

Survey (Continued)

11. On your unit, how many patients is the average nurse assigned to care for on a **day** shift?

- ◯ 1 patient
- ◯ 2 patients
- ◯ 3 patients
- ◯ 4 patients
- ◯ 5 patients
- ◯ 6 patients
- ◯ 7 patients
- ◯ 8 or more patients

12. On your unit, how many patients is the average nurse assigned to care for on a **night** shift?

- ◯ 1 patient
- ◯ 2 patients
- ◯ 3 patients
- ◯ 4 patients
- ◯ 5 patients
- ◯ 6 patients
- ◯ 7 patients
- ◯ 8 or more patients

Survey (Continued)

Section 2: Your most recent experience

For the following questions, please tell us about the last time you made nurse-patient assignments for all staff and nurses working during a specific shift.

13. How many days ago did you last make nurse-patient assignments?

14. What shift were you working?

- ◯ Day
- ◯ Evening
- ◯ Night
- ◯ Other (please specify)

15. What shift were the assignments for?

- ◯ Same shift I worked
- ◯ Upcoming Day
- ◯ Upcoming Evening
- ◯ Upcoming Night
- ◯ Other (please specify)

16. Describe anything particularly special or unique about that shift?

- ◯ It was an average shift - nothing special or unique
- ◯ It was special or unique because:

Survey (Continued)

17. Where did you complete the assignments

- ○ Charge Nurse desk
- ○ Nurses' station
- ○ Private office
- ○ Other (please specify)

18. How many minutes did it take you?

19. Which source(s) did you gather information from?

- ☐ Staff scheduling system
- ☐ Staffing updates from hospital staffing office
- ☐ Patient chart
- ☐ Bed-tracking system
- ☐ Acuity system
- ☐ Report from off-going charge nurse
- ☐ Staff nurses
- ☐ Patients
- ☐ Families
- ☐ Doctors
- ☐ Other (please specify)

Survey (Continued)

Section 2: Your most recent experience

How important were each of these specific goals the last time you made assignments?
(For questions 20-28, please drag the slider or enter a number from 0 to 100 for each goal, where 0 is not important, and 100 is very important.)

20. Maintain continuity of care (keep patient with same nurse)

Not important Very important

21. Provide safe, quality patient care

Not important Very important

22. Distribute workload fairly (give each nurse equal number of patients or equal total acuity)

Not important Very important

23. Minimize distance each nurse walks during shift

Not important Very important

24. Match each patient to best nurse

Not important Very important

25. Satisfy patient or family preferences

Not important Very important

Survey (Continued)

26. Satisfy nurse preferences

Not important Very important

27. Meet nurse learning needs (orientation or ongoing development)

Not important Very important

28. Optimize workflow for unit (admissions, discharges, transitions/report, breaks)

Not important Very important

Survey (Continued)

Section 3: Your most recent experience

29. **The last time** you made assignments, which information did you consider? *(check all that apply)*

- ☐ **Patient demographics** (gender, age, culture, language)
- ☐ **Patient acuity** (nursing workload or intensity for particular patient)
- ☐ **Nurse demographics** (gender, age, culture, language)
- ☐ **Nurse competence** (experience, skill, efficiency, certifications, knowledge)
- ☐ **Nurse preference** (stated like or dislike for particular patient or patient type)
- ☐ **Nurse workload** (total workload for all patients assigned to one nurse)
- ☐ **Nursing interventions** (direct care: medications, IVs, dressing changes, treatments)
- ☐ **Patient independence in activities of daily living** (feeding, bathing, bowel continence)
- ☐ **Patient safety measures** (fall risk, restraints, skin risk, sitter needed)
- ☐ **Patient psychosocial support** (family support, emotional support)
- ☐ **Care coordination** (indirect care: consultation, discharge planning, off-unit tests)
- ☐ **Nurse-patient ratio** (required maxium number of patients per nurse)
- ☐ **Nurse-patient relationship** (continuity of care, stated preference)
- ☐ **Unit physical layout** (number of halls, medication carts, nursing workstations)
- ☐ **Time** (available to make assignments, before shift begins)
- ☐ **Support staff availability** (nursing assistants or techs and staff groupings)
- ☐ **Care standard** (written guidelines for staffing or assignments)
- ☐ **Patient length of stay** (post-op day, expected discharge date)
- ☐ **Proximity** (distance between rooms of patients assigned to same nurse)
- ☐ **Nurse collegiality** (relationship among staff, helpfulness)
- ☐ **Nurse additional duties** (education, non-patient care activities)
- ☐ **Shift** (length of shift, unit activities that vary by time of day)
- ☐ **Staffing** (number of staff available, number of patients on unit, empty beds)

Survey (Continued)

Section 3: Your most challenging assignment

30. Now, please take a moment to think about a specific time that you were asked to make assignments that was **particularly challenging**.

Ready to proceed?

- ◯ Yes, I have a particular time in mind
- ◯ No, I need some suggestions

Survey (Continued)

Section 3: Your most challenging assignment

31. Here are some examples of times when it can be harder to make assignments:
- You didn't have enough nurses
- You had too many nurses
- You had too many floats or new grads
- There were more or sicker patients than usual

Take a moment to think about **a specific challenging time**.

- ○ I am ready to proceed
- ○ I really can't think of a specific time. . .

Survey (Continued)

Section 4: Your most challenging assignment

For the following questions, please tell us about a specific time that you were asked to make nurse-patient assignments that was particularly challenging.

32. How many days ago was the **particularly challenging time** you made nurse-patient assignments?

33. What shift were you working?

- ◯ Day
- ◯ Evening
- ◯ Night

34. What shift were the assignments for?

- ◯ Same shift I worked
- ◯ Upcoming Day
- ◯ Upcoming Evening
- ◯ Upcoming Night
- ◯ Other (please specify)

35. Describe what was particularly special or unique about that shift.

36. Where did you complete the assignments

- ◯ Charge Nurse desk
- ◯ Nurses station
- ◯ Private office
- ◯ Other (please specify)

Survey (Continued)

37. How many minutes did it take you?

38. Which source(s) did you gather information from?

- [ ] Staff scheduling system
- [ ] Staffing updates from hospital staffing office
- [ ] Patient chart
- [ ] Bed-tracking system
- [ ] Acuity system
- [ ] Report from off-going charge nurse
- [ ] Staff nurses
- [ ] Patients
- [ ] Families
- [ ] Doctors
- [ ] Other (please specify)

Survey (Continued)

Section 4: Your most challenging assignment

How important were each of these specific goals during the particularly challenging time you made assignments?
(For questions 39-47, please drag the slider or enter a number from 0 to 100 for each goal, where 0 is not important, and 100 is very important goals.)

39. Maintain continuity of care (keep patient with same nurse)

Not important Very important

40. Provide safe, quality patient care

Not important Very important

41. Distribute workload fairly (give each nurse equal number of patients or equal total acuity)

Not important Very important

42. Minimize distance each nurse walks during shift

Not important Very important

43. Match each patient to best nurse

Not important Very important

44. Satisfy patient or family preferences

Not important Very important

Survey (Continued)

45. Satisfy nurse preferences

Not important Very important

46. Meet nurse learning needs (orientation or ongoing development)

Not important Very important

47. Optimize workflow for unit (admissions, discharges, transitions/report, breaks)

Not important Very important

Survey (Continued)

Section 4: Your most challenging assignment

48. **During the particularly challenging time** you made assignments, which information did you consider?
(check all that apply)

- ☐ **Patient demographics** (gender, age, culture, language)
- ☐ **Patient acuity** (nursing workload or intensity for particular patient)
- ☐ **Nurse demographics** (gender, age, culture, language)
- ☐ **Nurse competence** (experience, skill, efficiency, certifications, knowledge)
- ☐ **Nurse preference** (stated like or dislike for particular patient or patient type)
- ☐ **Nurse workload** (total workload for all patients assigned to one nurse)
- ☐ **Nursing interventions** (direct care: medications, IVs, dressing changes, treatments)
- ☐ **Patient independence in activities of daily living** (feeding, bathing, bowel continence)
- ☐ **Patient safety measures** (fall risk, restraints, skin risk, sitter needed)
- ☐ **Patient psychosocial support** (family support, emotional support)
- ☐ **Care coordination** (indirect care: consultation, discharge planning, off-unit tests)
- ☐ **Nurse-patient ratio** (required maxium number of patients per nurse)
- ☐ **Nurse-patient relationship** (continuity of care, stated preference)
- ☐ **Unit physical layout** (number of halls, medication carts, nursing workstations)
- ☐ **Time** (available to make assignments, before shift begins)
- ☐ **Support staff availability** (nursing assistants or techs and staff groupings)
- ☐ **Care standard** (written guidelines for staffing or assignments)
- ☐ **Patient length of stay** (post-op day, expected discharge date)
- ☐ **Proximity** (distance between rooms of patients assigned to same nurse)
- ☐ **Nurse collegiality** (relationship among staff, helpfulness)
- ☐ **Nurse additional duties** (education, non-patient care activities)
- ☐ **Shift** (length of shift, unit activities that vary by time of day)
- ☐ **Staffing** (number of staff available, number of patients on unit, empty beds)

Survey (Continued)

Section 5: Your general opinions about nurse-patient assignments

49. Imagine you were asked to develop a computer program that made nurse-patient assignments. Please rank the following goals for the program.
(Place a #1 by the most important goal and continue to #9 for the least important goal)

- [ ] Maintain continuity of care (keep patient with same nurse)
- [ ] Provide safe, quality patient care
- [ ] Distribute workload fairly (give each nurse equal number of patients or equal total acuity)
- [ ] Minimize distance each nurse walks during shift
- [ ] Match each patient to best nurse
- [ ] Satisfy patient or family preferences
- [ ] Satisfy nurse preferences
- [ ] Meet nurse learning needs (orientation or ongoing development)
- [ ] Optimize workflow for unit (admissions, discharges, transitions/report, breaks)

50. How do you usually complete assignments on your unit?

- ○ Manually, on paper
- ○ First on paper, then document them in a computer system
- ○ Directly in a computer system
- ○ A computer system completes assignments, and I review them
- ○ Other (please specify)

Survey (Continued)

51. What was the primary way you learned to make nurse-patient assignments?

- ◯ College or university course
- ◯ Formal hospital training course
- ◯ On-the-job from a colleague/mentor
- ◯ On my own
- ◯ Other

Comments:

52. How do you know whether or not your assignments were good?
(check all that apply)

- ☐ Feedback from nurses
- ☐ Feedback from patients or families
- ☐ Feedback from your supervisor
- ☐ Other (please specify)

53. How do you measure patient acuity on your unit?

- ◯ Acuity tool within EHR (electronic health record or patient chart)
- ◯ Hospital-wide computerized acuity tool (separate from EHR)
- ◯ Unit-specific computerized acuity tool (separate from EHR)
- ◯ Hospital-wide paper acuity tool
- ◯ Unit-specific paper acuity tool
- ◯ Informal acuity rating without a tool
- ◯ We do not measure acuity
- ◯ Other (please specify)

Survey (Continued)

54. Please share any other perspectives you have on the nurse-patient assignment process.

Survey (Continued)

Section 6: About you

55. How many years have you been a nurse?

56. What is the highest level of education you have completed?

- Diploma or associate degree
- Bachelor's degree
- Master's degree
- Doctoral degree

57. Please list any certifications you have:

58. How would you describe your hospital?

- Community
- Academic

59. About how many beds does your hospital have?

- 25 or fewer beds
- 26 to 99 beds
- 100 to 199 beds
- 200 or more beds

60. In what state or U.S. territory do you currently work?

Survey (Continued)

Thank you!

Thank you for taking the time to complete this survey!

61. Please provide any feedback or questions for the researchers here:

62. Please provide your email if you wish to be entered into a drawing for a $100 Amazon gift card:

Appendix G
Interview Quotations: Charge Nurse Knowledge of Nurse Strengths

"You do try to look at the nurse's personality to make sure they can handle a tough patient. You don't want to give a very meek nurse, a very vocal, terrible patient. And when you go to a new hospital, you don't know the personalities, and so, all you can do is give it a shot. But, it pays to know your staff."

"I had to make assignments on a completely different unit, that I don't know at all. It was horrible. I don't know the staff. I don't know their strengths or weaknesses. I don't know if they speak any [additional] languages. And they're all relatively new staff, so they are not a very cohesive team. So, it definitely was a huge challenge."
"That charge came in and she was like, 'umm, that person's not good for that one,' and re-did [the assignments]. And I'm like, 'You know them, I don't.' It's definitely a challenge."

"I know my staff very well. So, knowing the experience that the nurse has is helpful. So, if a new charge nurse came on and did not know the staff, it would be a little more difficult."

"I remember that we had several high acuity patients. And, I did feel that there was two nurses on the floor that were newer. I work so closely with them, I know that maybe if I were to give them a full four patients, it wouldn't have gone well. And, I feel as a charge nurse, I need to address that. I shouldn't just say well, they say on the evening shift you can take four patients, that this is what you're going to have to do. It's going to cause anxiety, it's going to cause them to be behind, it's going to be a higher risk of errors. So, I did call in another nurse. I think that's fine for me to do."

"I look a lot at nurse personality traits. Some nurses are better with certain patients than others. Some are better with certain situations."

"A chest tube might or might not be scary depending on how many you see"

"I just know certain nurses can handle certain loads."

"We have some semi-regular folks [float nurses] that I know I can give them just about anything I can throw at them and they'll be just fine. And, then there are others that aren't as familiar with our station, so I will not give them the sickest and the heaviest of the patients, so they can function."

"If there is a patient who speaks Spanish, I will assign a nurse that speaks Spanish. Otherwise, if I know that you don't speak Spanish, it's kind of an extra little acuity tick in my head that you are going to have to have a little bit of extra time with a translator phone to actually provide your care and assessments."

"Knowing staff, knowing their weakness, knowing the staff mix."

Appendix H
Interview Quotations: Participants Thoughts Regarding Computerization of Assignments

"Sometimes I think that computers aren't as smart as people. Or, don't take into account all those extra little things."

"How do you take all of the critical thinking we do in a split second, and put the human factor into it. That's the hardest thing."

"The system is not as smart as I am."

"One [acuity] '6' can be completely different from another '6' and so, I don't know how it [a computer system] would get that human factor. Because, one '6' could be medically heavy, but more tolerable than another '6' that you are restraining and they are dealing with that. So, I would like them to somehow know the difference between, somehow, magically. That would be big."

"It's hard for a computer to understand the pyscho-social components, especially of people that are sick and hurting, and have been through trauma. I mean, at this point I can't predict, so I don't expect the computer to be able predict, if something was to go wrong. But, it's about the patients that are currently on the floor and all the knowledge that's in my head."

"How would the computer know?"

"It's got to fill the emotional aspect of things too. I don't know how you can make that happen. But, it's people taking care of people."

"How it got the attributes. If it's relying on a nurse to put them in, just from, nurses don't do everything 100% of the time. And then, the computer doesn't know that."
"Nurses don't always document everything."

"Nurses are inconsistent with everything they do."
"The hand written thing is quick and easy, and that's what they do, and the logging is too much for them, it takes 30 seconds, and this only takes 10."
"As much nurse input for whatever is developed the better."

"Epic doesn't know to do that" [group patients by location]
"Teletracking has been told to do that" [group patients by location by adding prefix to room #]

A computer system . . . "It can't factor in everything. Because some things weigh more than others depending on the day. If I've got a bunch of new grads versus not."
"It wouldn't be able to factor in nursing skill set, personality, patient's emotional/personality needs."

"it would be nice if I could customize it myself"

Eye roll at question: Imagine you were asked to develop a computer program that made assignments.
"I don't trust the computers. I'm old school."

Interview Quotations: Participants Thoughts Regarding Computerization of Assignments (continued)

"I wish we had a system like that. Because, I think it would be very helpful. Sometimes having to go into many different areas to try to find out, 'where does this patient best fit in our staffing?' is hard. Because I'm looking at my supervisor charge nurse sheet, what I wrote for that shift, and asking primary nurse how that patient did, I'm looking at the MESH [acuity] tool to see what their acuity is, I'm looking at the shift summary report. So, there is so many different areas where I'm trying to look to determine, 'where should I put this patient?' To have it all in one area would be nice."

"If I had an extra hour back in my day, to take care of my staff and my patients and make sure they had everything they need, I'd be in heaven."

"But, if it could get rid of 20 pieces of paper on my desk, I'd be happy."

Appendix I
Count of Survey Respondents' Shift Worked by Shift Assignments Created For

	Assignment Created For					
Shift Worked	Upcoming Night	Upcoming Day	Same Shift Worked	Upcoming Evening	Other	Total
	LAST Scenario					
Day	47	1	15	12	2	77
Evening	4	5	1	1	1	12
Night	1	34	5		4	44
Other	1				1	2
Total	53	40	21	13	8	135
	HARD Scenario					
Day	41		10	8	1	60
Evening	4	1	2			7
Night	3	28	10		1	42
Total	48	29	22	8	2	109

Appendix J
Count of Survey Respondents' Use of Acuity Systems

Response	*n*	%
We do not measure acuity	24	22
Informal acuity rating without a tool	22	20
Unit-specific paper acuity tool	19	18
Hospital-wide computerized acuity tool (separate from EHR)	14	13
Acuity tool within EHR (electronic health record or patient chart)	13	12
Other (please specify)	7	6
Unit-specific computerized acuity tool (separate from EHR)	4	4
Hospital-wide paper acuity tool	3	3

Respondent comments about acuity systems:

We have [brand name] recently and a unit acuity tool that no one fills out so neither are used
We had a tool that is missing so now it is more subjective
We have acuity measures in the EHR but it does not factor into staffing yet as they are not entirely accurate.
We have specifics in marking our patients of higher acuity as Stepdown patients which would make 1 stepdown patient count as 2patients in an assignment. So, in an assignment a RN may only have 4 patients if she has 1 stepdown patient and etc.....
Daily rounds with nurses
High medium or low
Acuity is measured but I don't have access to that program.

Appendix K
Survey Respondents' Comments

Acuity

"It's horrible for the nurses and patients that we do not factor acuity into it."

"My hospital system doesn't utilize the care value system to its full capability. We input names for assignments but don't base assignments off the acuity."

"I have brought up acuity assignments before, but staff seems to rely more on receiving same patients back for quicker report, walking less, and their own perspective. We simply do not have the resources at my hospital and I feel like the acuity is so high on too many occasions that I have often wanted to put in my two weeks. There is also a good chance on nights we have no CNA. I feel this is an important part of nursing and a system should be used by every hospital."

"I balance the complexity of care (acuity), match with the RN who will provide safe and quality care; the number of ancillary staff; we can benefit from an acuity system."

"An acuity tool would be very helpful!"

"acuity tools still do not tell the story of patient acuity or what is happening on a unit."

"Acuity tools work to an extinct on our floor but what I have seen works the best is rounds daily with the nurse and care mangers. You then know most important information about the patient. This help me with assignments the most. When knew patients come to floor, talking with the nurse is best the way. We still use an acuity sheet but not faithfully."

"Would like to see research on acuity systems"

Difficulty

"It's [very] difficult"

"Can be time consuming with paper form, we try to limit staff members from switching patient assignments once they've been made or to speak with Charge Rn before any changes are made"

"Patient throughput at the times in trying to make assignments makes it very difficult. (Admissions/ discharges)"

"Previous hospital: only RNs, only 07-19 shifts, assign sections of 4 beds, assign for own shift... very easy. New hospital: multiple shifts (7-13, 7-15, 7-19, 11-19, 11-23, 19-03, ...) , support staff, high sitter use often pulling support staff off floor, mix of LPNs and RNs, assignments spread out (random rooms), elevated pt turnover, unit layout 2 sided, staff tensions, no acuity tool, not updated pt list, making assignments for next shift.. while holding full pt load: very challenging"

"Used acuity tool in the past that was not reflective of task and effort of staff.. staffing takes too long to determine staff numbers and makes changes frequently causing delay in assignments being made.. on days discharges heavily skewed to one nurse lead to too many admissions.."

Survey Respondents' Comments (Continued)

"We have found that acuity varies, depending on what shift is caring for the patient. For instance, a day shift RN may have a lot of meds and wound care to do, making the patient a level 3 acuity, but for the night shift, that patient may be rated a level 2."

"It is difficult and requires frequent changes throughout the shift due to changes in staffing and patient condition."

"It can take a lot of time making sure patient assignments are fair for the nurses. Patient safety and clinical effectiveness is the most important"

"No matter what you do, you will NOT make all staff nurses happy."

"I wish there was a better way to assign pts in by acuity, distance and what is safest for patients. sometimes it is impossible to assign by acuity and distance."

"For me, it is almost the hardest thing I do all shift. Trying to be fair yet provide patients with quality, safe care."

"Although we have access to EPIC, there is not enough time to go through each chart to consider more than a few acutity characteristics."

Goals/factors/process

"Know the kind of patients (level of care) Be smart and allow or give yourself enough time to do it."

"There are so many things to consider but knowing the patients is key. Patients are different in person than what is said on paper. It helps to lay eyes on them."

"Really try and be fair and have rationale for your assignments if necessary. Meaning, divide up tele pts, isolation pts, confused pts. and make the load as equal as possible."

"we have a wide range of nursing experience. We try to make sure that the less experienced nurses have opportunities to learn/grow without overwhelming them and that the most experienced nurses are not always given the toughest assignments. On shifts with mostly inexperienced nurses we will lower the patient to nurse ratio by one to ensure best patient care."

"On our unit we find it best to assign our nurses in teams. Within a 12 room span we assign to RN's and and NA as a team. All three work to back up each other to meet our patients needs and to keep them safe while in our care."

"Based on the nurses information during their shift"

"I always aim for nurse and patient preference in assigning to assure quality and safe patient care. I believe happy nurses who have adequate time to make sound decisions make for the happiest and safest patients."

"Fair assignment on all aspect like acuity, skills and safety."

Survey Respondents' Comments (Continued)

"Continuity of care is the most important factor to me. Having patients that are known by staff help with the flow of the unit. Of course, there are times when the acuity load of a nurse needs to be split even if it influences continuity of care. The difference of having proper staff to help with answering call lights and turning/cleaning patients plays an important factor. I see nurse burnout happen sooner when a continual breakdown of assignments cause them to have difficult days everyday."

"We have pre-assigned rooms in an assignment that a nurse can be assigned to for months, while this takes some stress off making the assignment the night shift have to always make adjustments based on staffing or nurse preference or competency or at times patient or family preference. In other words, the process is not static and nurses need to be open to unplanned adjustments during any given shift."

"[Balancing] workload and competency is the most important thing to me. Because the unit is large, I need to spread out my experienced nurses so all the strong are not on one end."

"I always ask all of the nurses/CNAs about the acuity of the patients and their workload. When I make the assignment, I make sure to fairly distribute the acuity. I also fairly distribute isolation pts, telemetry patients, and possible patients being discharged. It is still difficult to distribute the patients especially when the unit is short-staffed."

"We have certain things a nurse can't have 2 of if at all possible: cystic fibrosis, trachs, comfort Care, confused, ivda"

"I think an EHR acuity tool would be great. We tried a paper based tool before and the nurses said it took too much time to complete, even though it was supposed to help with assignments. It is also challenging to make the assignment for the CNAs, because a difficult/heavy pt for an RN may be different than a difficult/heavy pt for a CNA, so it is important to take this into account."

"Well, I would like to see and acuity system that takes into consideration, age, mobility, swallowing, oxygen, psychological need, hours to care (bathing etc)"

"Interested to learn how others do Nurse-Patient assignments"

Computer

"I don't think a computer program should make assignments as there are too many comexities and decisions that have to be taken in account as things change."

"We have tried different acuity tools, team assignments with RN and CNA but so far nothing has shown an improvement over experienced judgement"

"patient assignment is more than just giving a set number of patients/acuities to nurses. Nurse skill, experience, patient needs, and nurse/patient requests are important to try and honor. That is why we stopped using the EHR assignment porgram because it was unable to staff incorporating human traits."

"Looking forward to seeing if a successful computer program could be developed!"

Survey Respondents' Comments (Continued)

Staffing

"Will this be use to aid to standardize nurse-patient ratio?"

"Need better staffing ratios"

"Staffing shortages on a specialty unit (burn, trauma, neurosurgery, and epilepsy monitoring) make it difficult to create safe, fair assignments. Charge is often in staffing. The unit remains at capacity, making it difficult to group specialty populations. Rn s that work solely on this unit often have to complete tasks resource nurses are not trained to complete such as burn dressings."

Comments

"Great survey"

"This is a good research study and good learning tool for nurses who will have the opportunity to make assignments."

"Well written survey, I am pleasantly surprised."

Appendix L
Survey Respondents' Location of Employment

State of Employment	*n*	%
California	10	9
Illinois	10	9
Pennsylvania	9	8
Tennessee	7	7
Indiana	6	6
Missouri	5	5
North Carolina	5	5
Florida	4	4
Kentucky	4	4
New York	4	4
South Carolina	4	4
Texas	4	4
Virginia	4	4
Maryland	3	3
Michigan	3	3
Wisconsin	3	3
Colorado	2	2
Georgia	2	2
Kansas	2	2
Massachusetts	2	2
Minnesota	2	2
Nevada	2	2
Washington	2	2
Arizona	1	1
Arkansas	1	1
Delaware	1	1
Iowa	1	1
Nebraska	1	1
New Jersey	1	1
New Mexico	1	1