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Measuring Lean Management Penetration on the Hospital Nursing Frontline: Instrument Development

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctorate of Philosophy in the School of Nursing

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ABSTRACT

SHEILA SERR ROSZELL: Measuring Lean Management Penetration on the Hospital Nursing Frontline: Instrument Development
(Under the direction of Mary R. Lynn)

Purpose: It is imperative to assure that health care organizations provide excellent care and create value by improving quality while eliminating unnecessary costs. Lean management is a continuous improvement management plan that uses work flow design to produce improvements in quality, safety, cost and productivity; it has been used in manufacturing, service and, more recently, healthcare industries. This study developed and tested an instrument to measure frontline nurse caregivers' perception of the penetration of lean management in hospitals that report using lean strategies.

Methods: The study consisted of three phases. Using the Delphi technique, an on-line survey of experts (*n*=10) and a review of the literature identified domains and subdomains of lean management. Ideas from each domain were formed into items on the Frontline Improvement Thinking (FIT) instrument. The experts also assessed content validity. In Phase 2, nurses assessed the instrument's format, on-line usability of the instrument and content validity. In Phase 3, the instrument was administered to frontline nurses working on units in hospitals that reported using lean methods. Their responses (*n*= 212) provided the data for assessing the instrument's psychometric properties.

Results: Exploratory factor analysis yielded a scale with 75 items in 12 factors. Three domains were identified: organizational, unit and individual areas of improvement.

The 4-factor, 29-item, *FIT Unit* had the highest reliability (α= 0.86-0.94; inter-item correlation range= 0.26-0.63). The 2-factor, 10-item *FIT Organization* was also acceptable (α= 0.87 and 0.79, inter-item correlation range= 0.30-0.72. The *FIT Individual* had less than desired reliability on one factor (α= 0.66) but had acceptable reliability on the other six factors (0.75-0.94; inter-item correlation range = 0.25-0.89). Test-retest reliability estimates were acceptable for the organization and unit based on Pearson's R correlations (0.53-0.77).

Conclusion: In the early stage of development, the FIT instrument proved helpful in describing diffusion of lean management. Sample size and quality were problems, however. Nurses from hospitals with a history of lean quality improvement did not participate in the study and some of the hospitals studied were in the very early phases of lean management. Recommendations include continuing work on measure development by increasing the sample of lean-thinking nurses.

This dissertation is dedicated to my parents, Maynard Leon Serr and Joan Breen Serr. Their love of learning, intensity of focus and continual quest for understanding the world, inspired me to strive for academic excellence. The confusing frustration and pride my father exhibited--choosing the family's stability and comfort over his own goals--finally make sense to me.

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LIST OF ABBREVIATIONS AND SYMBOLS

5S	Sort, straighten, shine, standardize and sustain
α	Cronbach's Coefficient Alpha
AHI	Academy for Healthcare Improvement
AHRQ	Agency for Healthcare Research and Quality
ANOVA	Analysis of Variances
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CITC	Corrected Item to Total Correlation
CNO	Chief Nurse Officer
EFA	Exploratory Factor Analysis
FIT	Frontline Improvement Thinking
IHI	Institute for Healthcare Improvement
IOM	Institute of Medicine
IRB	Institutional Review Board
ISRN	Improvement Science Research Network
JIT	Just-in-time
KMO	Kaiser-Meyer-Olkin test of sphericity
LEI	Lean Enterprise Institute
NHS	National Health Service
QI	Quality Improvement
TJC	The Joint Commission on Accreditation of Hospitals
TPS	Toyota Production System
SPSS®	Statistical Package for the Social Sciences
VSM	Value Stream Mapping

CHAPTER 1

Introduction

Recognition that healthcare systems in the United States are plagued by inefficiency, waste and poor quality control is now widespread. Systemic problems range from avoidable delays in treatment to unsafe practice (Committee on Quality of Health Care in America, 2001). Health care providers anxious to solve problems of efficiency and cost have recently begun turning to an engineering redesign strategy known as "lean management" as a possible solution. Lean management, a comprehensive management system that incorporates work flow design, has produced significant improvements in quality, safety, productivity and cost in both manufacturing and service industries (Migita, 2011; Spear, 2009; Womack, Jones, & Roos, 1991; 1990; Womack & Jones, 1996).

As a strategy for thinking about the work environment and its culture, "lean" is both a philosophy and a set of tools for improving quality and reducing costs by eliminating waste in work processes (Liker, 2004). Hospitals that use lean methods rethink the ways in which units are organized and managed, starting with the recognition that one way to improve patient outcomes is to reduce waste and deliver care more efficiently. For example, hospitals that have adopted lean management practices report near elimination of central line infections and ventilator associated pneumonias, as well as reduced lengths of stay and

shorter wait times for appointments and surgeries (Spear & Schmidhofer, 2005; Spear, 2009; Toussaint, Gerard, & Adams, 2010; Toussaint, & Berry, 2013).

Organizations such as the Institute for Healthcare Improvement (IHI), the Joint Commission (TJC), and Britain's National Health Service (NHS) have pointed to the value of eliminating waste through application of lean concepts. The IHI has encouraged hospitals to use the lean management model to change organizational culture and has pointed to other industries that have instituted the lean approach and achieved continuous learning, continuous quality improvement and innovation, as well as elimination of waste in finances, processes, and patient care (Institute for Healthcare Improvement, 2005).

The Robert Wood Johnson Foundation-funded *Transforming Care at the Bedside* which was based on lean management ideas, demonstrated that with improved work flow, nurses spent less time charting and answering call bells and they identified patient problems faster (Viney, Batcheller, Houston, & Belcik, 2006). The NHS in Great Britain has used lean methods to reduce cost and improve quality (Jones & Mitchell, 2006) and has reported successful implementation of lean management in many settings (Esain, Angel, & Robertson, 2006; Johnson & Jacob, 2006; Jones & Mitchell, 2006). The Joint Commission has advocated for lean methods to address safety and quality goals (Joint Commission Resources, 2006), and the Agency for Healthcare Research and Quality (AHRQ) has pointed to the need for solid evidence on the effects of lean applications in health care to eliminate unnecessary costs while improving quality (Agency for Healthcare Research and Quality, 2009; Helfand & Balshem, 2009).

Although the relationship of lean management to better outcomes has been extensively tested in other industries, studies of lean management in healthcare have

primarily been case studies or rapid cycle quality improvement efforts and have lacked rigorous experimental methods (Kaplan et al., 2010; Mazzocato, Savage, Brommels, Aronsson, & Thor, 2010). Some hospitals have labeled themselves as lean in their public relations campaigns, yet their quality indicators have not reflected better quality than hospitals that did not make the claim. Further, few of the studies have focused on the processes carried out on the nursing unit, the point of patient care.

There are many stages and degrees of lean management in healthcare organizations or nursing units. To determine whether lean management improves the quality, safety, cost and delivery of care, one must quantify the degree of lean penetration. However, there is currently no instrument to measure the magnitude of lean management presence, so it is difficult to show the relationship between lean management and healthcare outcomes. Therefore, this study developed and tested an instrument, Frontline Improvement Thinking (FIT), to measure the penetration of lean management in a hospital nursing unit that uses lean strategies or methods. Using this measure of "leanness," future studies can look at outcomes such as quality, safety, cost and delivery of care and their relationships to the amount of lean in a hospital or other healthcare organization.

Theoretical Framework

Exploratory factor analysis (EFA) was used to develop the FIT instrument. Technically, EFA does not need a research model; its purpose is to generate explanatory theories in order to explain patterns in data (Haig, 2005). However, for this study, it was useful to have a general idea of how lean and diffusion may work together, in order to direct initial expert inputs, item formation, instrument formatting and analysis.

The study was driven by Diffusion of Innovations as an overarching grand theory. At the organizational level, the Toyota Production System (TPS) "House of Quality" was used to describe the philosophy, culture and tools of a lean comprehensive management system. Then, frontline's quality improvement thinking, or "lean thinking," was conceptualized based on characteristics described by Ballé, Beauvalle, Smalley and Sobek (2006), who argue that lean thinking is a "deep framework" of change in thinking about improvement. That is, the heart of lean management is changing the way practitioners look at their work. This change in thinking includes using scientific methods and an improvement mindset every day, in what the authors call the "thinking production system." Concepts from these three models help to explain organizational diffusion of lean management to the frontline.

Diffusion of Innovation

This study used Roger's Diffusion of Innovation to explain how an innovation like lean management diffuses or penetrates down to the frontline of nursing care. Innovation involves the introduction of an idea or behavior--whether a system, policy, program, device, process, product or service--that is new to the adopting organization (Daft, 1995). Rogers described diffusion as "a special type of communication in which the messages are about a new idea" (2003, p. 6). Rogers first described diffusion theory in 1958 (Beal & Rogers, 1958); since then it has been tested in many environments and situations, including health care organizations.

Elements of Diffusion. There are four main elements in the diffusion of an innovation: the innovation, time, communication channels and a social system. *Innovations* have qualities that make them more or less likely to be adopted; these are relative advantage, compatibility, complexity, trial-ability, and observability. Adopters of an innovation learn

about the innovation, consider its merits, decide to adopt, implement the innovation and then confirm or reject the decision to adopt the new idea. Thus, quicker diffusion takes place when the innovation can be tried out without undue distress, when it is low in complexity and when it brings little risk.

The effect of *time*, or the rate of adoption, resembles an s-shaped curve. A sharp increase in the rate of adoption occurs when 16% to 34% of the people adopt the innovation (Rogers, 2003). The first healthcare organization to adopt the Toyota Production System (TPS) Model, Virginia Mason Hospital, started what it called its "lean journey" in 2000. By the middle of the decade a few other systems including ThedaCare, Denver Health, Miami Children's Hospital and Intermountain Healthcare, were using lean engineering and redesign. Because everything that happens in a system, from labs to nursing care to administrative processes such as billing, has waste and can be subject to process management, an organization needs a long time — 3 to 10 years — to implement and sustain lean management. Thus systems that say they are lean may now exhibit the characteristics of innovators or early adopters and this should be considered in measuring leanness.

Communication channels often display a common pattern: first there is knowledge of the innovation; this followed by persuasion, decision, implementation, and confirmation. Communication pathways range from informal and unplanned to formal and planned. The *social systems* in this study were the healthcare organization and its nursing units. Diffusion of lean may differ at each level, and this must be considered in evaluating lean penetration. Variables important in measuring lean diffusion at each level of the social system are briefly described below.

Organization. Organizational structure and capacity for new knowledge are antecedents for any innovation, and lean management is no exception. Diffusion theory's *system readiness* describes a culture that is ready for and conducive to change. Diffusion is related to the organization's openness to change. Leadership, climate, receptive management, clear goals and capacity for collecting high-quality data are influential forces behind a lean innovation.

A sensitive measure of lean should therefore include items that address leadership. Indeed, organizational leadership is key to initiation and sustaining an innovation, as acknowledged in both diffusion theory (Greenhalgh et al., 2004; Rogers, 2003) and the lean research (Emiliani & Stec, 2005; Graban, 2009; Grout & Toussaint, 2010). Successful lean interventions require commitment from leaders and management, and leader visibility and managerial presence on the frontline (Ezzeddine, 2006; Kotter, 2010; Mann, 2009). Although a few studies have reported the initiation of a lean management event by an individual, the vast majority of the lean management research asserts that the qualities of top level leadership make or break a successful transition to a lean organization (Emiliani, Stec, Grasso, & Stodder, 2007).

Unit. At the unit-level, a measure of lean diffusion should include the amount of time dedicated to improvements and the available resources such as coaches, mentors, and spending for developing staff, since all are found to be influences of diffusion (Rogers, 2003). Other unit-level traits include monitoring, feedback, line team decision-making, leader and management presence, training, internal communication and external collaboration.

Social networks, similarity of people within teams, peer opinion, champions, boundary spanners and change agents also influence the extent of diffusion. Thus concepts

in a lean measure should include user involvement, effective knowledge transfer, shared meanings and mission and user-led innovation. Orientation of users, project management, technical support and communication of information contribute to effective innovation diffusion.

Nurses may report that the following reflect of the adoption of lean practices: *kaizen* (a rapid improvement event), value-stream mapping and support services buy-in (e.g., environmental services, central distribution, and patient equipment). Lean concepts that may be seen by nurses on the frontline include elimination of waste, continuous improvement, zero defects, just-in-time deliveries, pull of materials, multifunctional teams, decentralization and managerial commitment to lean production. Factors such as quality leadership, group problem solving, and training and worker empowerment are important for increasing productivity (Boyer, 1996). Psychological safety (Edmondson, 2003) among nurses, especially with the unit manager, may also be associated with diffusion of lean management.

Innovation filters down within the existing culture of an organization to the clinical nursing unit through social networks, marketing, channels of education and communication. This filtering down depends on "purveyors of education" or peers, champions, boundary spanners and change agents (Greenhalgh et al. 2004). Organizational learning and team problem solving are key to changing a top-down structure into one that is focused on the frontline technical core, and to improving the processes to support frontline staff's ability to meet the customer/patient's demands or needs (Argyris, 2002; 2004; Senge, 2006; Tucker et al., 2007). Training as proposed by Shah and Ward (2007), includes educating frontline workers 1) to expect to have materials and information readily available to do their work, on time and correctly and 2) to know what to do if the work system fails. Training should also

include using individual operational failures as triggers for process improvement (Tucker & Spear, 2006).

Individuals. Patterns of diffusion within organizations and between individuals exhibit many of the same characteristics (Rogers, 2003). Rogers gave names to people with certain attributes: there are innovators, early adopters, the early majority, late majority, and laggards or late adopters. Rogers characterized the early "knowers of an innovation" as those with more formal education, higher social status, contacts with a change agent, greater social participation and greater exposure to interpersonal channels of communication. Rogers noted that later adopters are more likely to discontinue innovations than earlier adopters.

Qualities that are linked to adoption include individual needs, motivators, values, goals, learning style and social networks. Other factors affecting adoption and lean thinking include organized documentation of problem-solving, brain-storming, recognition of root causes of the problem, generation of creative improvement ideas, communication, and use of improvement measures. Skills such as problem-identification and scientific problem solving will be adopted at different rates. The qualities described in diffusion theory clearly influence nurses' adoption of lean thinking. Individuals in a lean system often display the traits associated with a deeper level of problem solving; Spear (1999) and many others have recognized that the scientific method is key to success. Thus, items in a measure of lean penetration need to reflect these ideas.

Complexities of Change: Re-invention. Diffusion theory addresses many of the complexities of change and its well tested pathways help direct the introduction in healthcare and diffusion of lean management within health care organizations. One such pathway is re-invention, or the degree of modification by a user. As Voss (1995) observed, lean

management is really just a continuous process improvement on turn-of-the-century time-based studies, combined with business process engineering and other "fads" such as Total Quality Management. A culture of change creates a new culture as an innovation becomes entrenched in the organization. Researchers describe successful innovations within a culture that is receptive to change but is evolving and continually improving (Burton, DeSanctis, & Obel, 2006; Kotter, 2010). This re-invention may make measurement of the lean concept a moving target, so repeated measures may be needed to capture the diffusion of lean management.

Lean Model: House of Toyota

The Toyota Production System (TPS) model describes concepts important to quality management. Often called the TPS "House of Toyota," the model has been recreated and renamed by other lean organizations to establish a framework for organizational direction. A lean organization rests on a foundation of stable, standardized work processes delivered at a pace that minimizes the waste associated with waiting or rushing. Two columns stand on the foundation: building in quality (vs. inspection and re-work) and delivering the right products at the right time at every level of the organization. Central to the model are teamwork and respect for humans' ability to continuously improve and reduce waste. The roof of the house represents the goal of attaining best quality, cost, safety and delivery. The House of Toyota guides the way instrument items need to be viewed. For example, items should capture respect for humans, continuous improvement and outcomes of quality, safety, delivery and cost. This model can serve as a basis for assessing nurses' knowledge of the tools of lean used in a lean organization.

Thinking Production System

Diffusion theory describes the process of getting a lean innovation through the organization and the TPS "House of Toyota" describes the structure of the organization. Ballé, Beauvalle, Smalley and Sobek's (2006) "thinking production system" (lean thinking) can be seen as the outcome or product of a lean innovation. This is a system that engages people in problem solving, in which each person views potential improvement as testable hypotheses. Ballé et al. observed that lean systems are fundamentally systems of training. The training teaches people how to improve performance under the guidance of a mentor. People become aware of problems and note where the system falls short of perfection, then relentlessly pursue the resolution of these problems every day. Ballé described this as a "deep-frame for experiential problem solving."

Variables extracted from Diffusion Theory, the House of Toyota and the Thinking Production System all provide guidance for instrument development. Organizational efforts are key to effective diffusion with an implementation strategy that uses top management to create a climate for implementation. Champions, incentives, manager involvement and recognition are all used to support and spread the innovation. The efforts result in a supportive environment with employees who think about improvement, are aware of problems, have a performance mindset, and solve problems using hypothesis testing, and with leaders who also show improvement thinking to support staff. In the lean tradition, the focus is the customer (patient), who reaps the benefits. Outcomes include improved cost, quality, safety and delivery of care.

Key Assumptions, Variables and Relationships.

Diffusion theory is based on the assumption that an organization can promote change through people by forming pathways to communicate a new idea or information. The theory also assumes that one can identify the idea, the individuals, the pathways and the end characteristics of diffusion. Relationships and key variables documented in the diffusion literature can be grouped as the: influence of individuals, group commitment, complexity of practice, approach to change, factors that enhance or slow change, characteristics of innovations (such as visibility, flexibility, scope and presentation), strategies, monitoring progress, and plan for teaching, implementing and sustaining (Grol, Bosch, Hulscher, Eccles, & Wensing, 2007). These relationships and key variables are important considerations in choosing items for a measure of lean penetration. They also may be considered latent variables, affecting the responses of nurses on the frontline in an organization.

The study reported here also assumed that the nurses on a patient care unit reflect the deepest level of diffusion and a nursing unit is where organizational efforts fully affect patient care. Adoption of lean processes or concepts on a unit and in the organization should be evident to nurses; they should be able to answer the questions on a measurement tool to indicate the diffusion of lean management (i.e., the innovation). Further, diffusion varies and will be reflected in individuals' improvement thinking; on the whole, nurses should reflect the change in their organization. Greenhalgh et al. (2004) suggest that individual-level attributes affect the adoption of an innovation and a group-level of analysis can be used with groups and teams as well as with organizations. Collecting data

at the individual nurse level will produce valid observations about both the unit and the organization.

Summary

In this study, the diffusion framework was used to address the organizational context surrounding lean quality improvement thinking on the nursing unit. Diffusion describes the extent to which education and communication pathways have effectively channeled lean concepts to the unit. In addition, the House of Toyota model was used to guide delineation of the organizational structure and characteristics common to lean programs. Finally, "lean thinking" which asserts that lean management is a thinking process, was used to help assess how much nurses had been educated to recognize and use lean. A measure of lean penetration has the potential to contribute to greater understanding of diffusion theory itself, to organizational change in general and, more specifically, to the introduction of lean management into the healthcare environment.

CHAPTER 2

Background and Significance

There are many approaches to quality improvement (QI), some organizations use a retrospective approach as a type of process control, relying on auditing charts. Others center quality efforts on improving the electronic record assuming that care providers perform the proper care but need a better documentation tool to capture the quality of care. Still other organizations let individual managers identify unit or divisional goals and action plans such as in management by objectives, a popular method where each employee's goals are developed using interactive collaboration. At the most basic level QI is a system of inspection. At the end of a process, the product or patient is rated on some scale of quality. The next level of QI adds a quality control effort, i.e. an attempt to intervene to control the factors that produce quality. The third level of QI is quality assurance with a focus on quality of the end product (or outcome) as it leaves the facility. A fourth level is total quality management where both processes and outcomes are overseen by managers. Over and above these levels are organizational quality improvement initiatives such as lean and Six Sigma which use industrial engineering techniques to focus on reducing waste and variation in processes.

Three approaches have surfaced as chief contenders for the attention of hospital executives: the theory of constraints, Six Sigma, and lean management. The three address system redesign in slightly different ways. The theory of constraints approach focuses on improving throughput volume (Nave, 2002), while Six Sigma focuses on reducing variation

for more uniform process outputs, lean focuses on waste removal to improve flow time. Lean and Six Sigma are now most often seen as complementary programs and are called Lean/Six Sigma. Lean/Six Sigma is recognized as a robust process improvement program which uses a systematic approach to create highly effective solutions (Chassin & Loeb, 2011). Since hospitals often use both programs, this study considered lean and Lean/Six Sigma as one, and called it "lean." Systems re-engineering and design programs like lean management have transformed the quality and productivity of numerous large-scale complex systems. They are also considered appropriate to improve health care delivery. However, to fully understand lean in a hospital, it is helpful to examine the background behind lean management trends in industry, lean management in healthcare, measures of lean management in industry and the state of lean measurement in healthcare.

Lean Management Overview

Lean management has its roots in the early post-World War II period, when American quality improvement (QI) specialists served as industrial consultants for the *Japanese Union of Scientists and Engineers*-sponsored programs. These consultants included W. Edwards Deming, who focused on reducing variation through statistical quality control, and Joseph M. Juran, who focused on quality management. Managers from the Japanese automobile company, Toyota Production System (TPS), used the consultants' recommended QI practices to build a company that was recognized for quality products for many years (Bertel, Rath & Strong 2003). Womack, Jones and Roos (1990) found that TPS-manufactured automobiles were of significantly higher quality than those of other companies and coined the term "lean management" to reflect the differences observed between Toyota's practices and those of other mass producers.

Lean Management Trends in Industry

Lean management is a combination of practices and tools designed to eliminate waste by reducing variation in processes (Womack & Jones, 2005). It is based on a philosophy of long-term continuous improvement, in-depth, root-cause problem solving, efficient process design, and development of people as the only asset that appreciates over time (Liker, 2004; Spear & Bowen, 1999). The term "lean thinking" has come to describe individuals who work to detect waste in the form of time, inventory, motion, waiting, overproduction, over-processing, and defects (Vonderheide-Leim & Pate, 2004; Womack & Jones, 1996; Young & McClean, 2008). Lean methods recognize that waste occurs in any work system; consideration and thoughtful interventions are required to eliminate non-value-added activity.

Managers in lean environments set goals to eliminate waste in the value stream, that is, to reduce time, reduce inventory, reduce cost, and improve efficiency. Lean strategies are based on five principles: 1) identifying value, 2) ordering its production, 3) getting rid of anything that does not contribute to the value, 4) establishing flow, usually one patient at a time or "one-piece flow" and 5) striving for perfection (Liker, 2004; Womack & Jones, 2005). Shah and Ward (2007) define lean production as "an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer and internal variability (p.791)." Outcomes of lean are measured in four broad areas: safety, quality, cost and efficiency of delivery (Liker & Morgan, 2006).

A basic lean intervention is value stream mapping, which follows the transformation of a product or information from the beginning to the end of a process. The value stream is defined as the combination of processes and connectors that are needed to carry out a service or to produce an item. Mapping serves as a visual aid in designing flow or movement, and it

includes how a product (or patient) is changed by procedures and departments (Jimmerson, 2010). In healthcare systems, these maps start out as confusing, intersecting, redundant pathways as the patient is sent for multiple tests, given redundant lab work, or stops in waiting areas. Maps provide a baseline for evaluating processes and eliminating non-value-added activities.

Lean, like any specialty, has a jargon of its own. 'Value-added' processes are those processes which contribute fruitfully to the end product—for which the customer will pay. Lean interventions get rid of "non-value-added" activities or waste and clearly specify activities and connections. A major lean term is 'just-in-time' (JIT), which means that a part arrives at the time when it is needed; JIT reduces wasted time and the defects associated with waiting. Another term is 'one-piece flow', which means working on one part until it is finished so that processed inventory is customer-ready without wasted space for inventory of parts. Kanban is an inventory system that uses cards to signal need for item replacement. A basic lean intervention is 5S (sort and eliminate, straighten, shine, standardize and sustain), which is a system for organizing the workplace. Pull-systems are those that take the cue to start work only when the product is ready, and change-over times (called SMED or single minute exchange of dies) are used to get an object ready for the next stage of processing (e.g., operating or patient room readiness) (Institute for Healthcare Improvement, 2005).

These terms are used to indicate tasks that target processes and are organized to improve efficiency and safety. Lean management strategies include frontline identification of errors, manager involvement at the source of problems, focused quality improvement weeks (called *kaizens* or rapid improvement events) and standard work or activities that are written

down so that others can perform the activity using the same steps. Until work processes are specified, it is difficult to understand what activities produce an outcome (Arnheiter, 2005).

Another broad concept that relates to standard work and process specification is variation. Lean managers often use the tools of Six Sigma to control variation. All processes have variation, called "common cause" variation (Arnheiter, 2005). To understand outcomes and improve quality, the variation must be identified and quantified. Certain actions take place to control variation; for example, special causes can be eliminated or efforts made to reduce the variation. This is the basis for quality improvement, which can be seen as incremental and continuous or as "breakthrough"--that is, a change of greater immediate significance.

In their report for the Agency for Healthcare Research and Quality (AHRQ), Valdez, Ramly and Brennan (2010) noted that system engineering redesign has produced many successes. Manufacturing, aviation and banking have improved many organizations' production lines and transportation networks, reduced waiting times and queue lengths, and achieved 'six sigma quality' in factories. The researchers noted, however, that given the many barriers to change, improvements often only achieve incremental results. While incremental change moves an organization in the right direction, system redesign has the power to create breakthrough change (Valdez, Ramly, & Brennan, 2010). Lean management provides a structure and method for such system redesign.

Lean Management in Healthcare

Care providers often use a craftsman model, seeing caring as an art and designing care for the individual patient as if the provider-patient relationship is the mainstay of

healthcare. This one-to-one, relationship-based care is effective in small or simple healthcare settings; however it often neglects the impact of the organization's structure and processes on patient outcomes (Donabedian, 1976; Grol, 2001; Grol, Bosch, Hulscher, Eccles, & Wensing, 2007). A common concern is that while no one comes to work intending to do harm, the system and its complexities create environments rife with opportunities to make mistakes. Lean management provides a foundation for systems improvement, with a focus on the patient as the one who defines value. Thus, a total systems approach to quality, safety, cost and delivery of care, such as lean management, may provide an effective basis for customized patient care.

The structure of a system and the processes within the system are key in determining outcomes (Donabedian, 1988; IHI, 2005; Spear, 2009; Valdez, Ramly, & Brennan, 2010). Although often referenced, the Donabedian model in which structure and processes create outcomes is often neglected in the daily work of frontline caregivers, producing unintended consequences. The Donabedian model derives from the input-process-outcome (IPO) model, a familiar and fundamental engineering design. The IPO is also the basis of Lean/Six Sigma quality improvement initiatives. In describing Toyota's improvement, Imai (1986) observed that before results can be improved, the process must be improved.

Jimmerson, Weber, and Sobek (2005) found that the roots of operational problems tended to be poorly specified activities, unreliable connections or complex pathways. The Institute of Medicine (IOM) report, *Building a Better Delivery System: A new engineering/health care partnership* (Reid et al., 2005) concluded that the U.S. health care industry does not embrace engineering strategies and technologies, and as a result, it does not achieve the quality, productivity, and performance goals attained in many other industries.

Although adequate resources, such as appropriate nurse-to-patient ratios, are important, simply increasing resources is a poor way to fix performance problems (Kabst, Larsen, & Bramming, 1996). Redesign may be a better way to correct problems of inefficiency such as patient waits, delays in treatment and unsafe practices (Committee on Quality of Health Care in America, Institute of Medicine, 2001).

To envision process improvement in the hospital, Christensen, Grossman, and Hwang (2009) classified healthcare systems and practices in three different categories: 1) the "solution shop" with its complex, innovative processes; 2) "value added process businesses," which transform an input into an output with increased value; and 3) "facilitated networks," which monitor healthcare states including chronic disease management. Initial patient care diagnosis and treatment processes generally fall into the first category. Value added processes often include relatively predictable and repeatable elements for carrying out required patient care. These first two are most applicable to acute care settings and respond best to lean management process improvement efforts. For example, a patient who comes to a nursing floor has some needs that can be addressed at a task or process level, such as setting up the room, getting the equipment and taking vital signs. An unstable patient, however, requires processes like those of the design team in a solution shop. Problem-solving behaviors are less standardized, more flexible and perhaps more creative. Engineering strategies such as lean management are particularly helpful in designing value-added pathways and reducing complexity within a system. With the goal of reducing variation, lean management creates standard work, standard orders, protocols, and pathways to serve most of the patient population; it incorporates engineering methods to target work flow design that

have been shown to be successful in many types of businesses (Spear, 2009; Womack, Jones, & Roos, 1991).

Lean management starts with recognition that a key way to improve patient outcomes is to deliver care more efficiently.

> Lean Thinking is not about influencing the content of those moments when patients and staff are in contact. It is about giving more time for those moments, making them easier to perform and less prone to error, by simplifying sequences, making what has to be done more transparent, removing re-duplicative and unnecessary steps, and making hard to perform steps easier to get right (Bassham, et al. 2007, p. 15).

If reducing waste creates more time for caring, creating an environment of lean thinking should also improve the quality of care. However, it is difficult to determine whether care is improved by lean management. Jha and colleagues (2005) noted that the quality of hospital care in the United States varied widely and individual hospitals varied in performance depending on the indicators and conditions examined (Jha, Li, Orav, & Epstein, 2005). Spear and Schmidhofer (2005) reported that differences between hospitals in the same system prevented cross-system solutions; that is to say, unit-specific context matters when implementing solutions to problems.

The variation in lean management is no different. To find out whether lean management is the reason for better care, a measure of lean is needed to capture the variation that may be responsible for better or worse outcomes. By identifying elements that should be found on a lean unit and comparing them to what is actually present on the unit, a measure of lean penetration could identify gaps in care. Developing such a measure, however, requires insight into both lean and healthcare. The review that follows, therefore, focuses elements of lean management and quality improvement.

Lean Management in Healthcare Research

Case studies of the use of lean management in healthcare are common in the literature; most describe the details of workflow interventions that produce improved outcomes. The case studies tend to use a similar format: 1) they report a problem or some form of waste, 2) apply lean methodology, and then 3) report before and after results. Phlebotomy (Melanson, 2009), pharmacy (Hintzen, Knoer, VanDyke, & Milavitz (2006), lab test quality (Raab, Andrew-JaJa, Condel, & Dabbs, 2006), laboratory operations (Rutledge, 2010), clinics (Lummus, Vokura,& Rodeghiero 2006; Brinton, Casey, & Gonzalez, 2009), emergency rooms (King, Ben-Tovim, & Bassham, 2006; Ng, Vail, Thomas, & Schmidt, 2010), autopsy services (Siebert, 2009), heart quality indicators (Byrnes & Fifer, 2010) and operating rooms (Melanson, 2009; Collar et al.,2012) have all shown improvements with lean management, including reduced wait time, increased capacity and increased patient satisfaction, with continual quality improvement and maintenance of results.

In one case study, Spear (2001) and Kenagy looked at medication administration processes at Deaconess Hospital and showed how using direct observations of activities, connections, and pathways can change and improve an organization, based on lean management principles. Similarly, managers at ThedaCare demonstrated that financial and medical improvements were achievable using lean tools like ‘stop the line’ (stopping work flow and bringing managers to the source to trouble-shoot the problem) and visual management , i.e., the creation of visual aids to see the state of the unit (Grout & Toussaint, 2010).

Organizational Lean in Quality Improvement

Some of the earliest organizational studies of lean management in healthcare came from organizations outside the United States. Chaisiri (2004) described the use of lean management in a hospital in Thailand to create a culture of continuous improvement and process innovation. The outcomes included greater customer satisfaction, increased revenue, a greater number of quality improvement trainers, and more quality improvement visits. Esain and colleagues (2006) found that the NHS could improve invoicing and operating room start times by using lean methods. Leaders in a Netherlands hospital used lean methods to reduce the complexity of hiring personnel with projected financial saving of €36,000 ($47,000) per year. Lean methods saved another €200,000 ($261,000) by managing mechanical breakdowns and irregularities and reducing operating room start times. The desire to gain a competitive edge was an important factor in the hospital's decision to use lean management; and by deploying lean management in small units, one at a time, the hospital overcame barriers to implementation (de Koning, Verver, van den Heuvel, Bisgaard, & Does, 2006).

In the United States, the Virginia Mason Medical Center and the University of Pittsburgh Medical Center Health System have implemented hospital-wide lean management interventions to streamline processes (Furman, 2005; Furman & Caplan, 2007; Nelson-Peterson & Leppa, 2007; Thompson, Wolf, & Spear, 2003). They used the lean concept of elimination of waste through tools such as inventory control, environmental cleanliness (5S), and rapid improvement. The work included 'zero defect' initiatives and implementation of safety programs to improve nursing sensitive outcomes. The results included decreased central line infections and decreased medication safety errors, as well as decreased staff

walking distance, decreased cycle time for the nurses' workflow, decreased call lights, more time spent at the bedside, and less time spent searching and gathering supplies.

Medication administration was studied by Mazur and Chen (2008; 2009). They observed medication delivery, and then devised specific pathways and decision-making to reduce waste in the medication administration process. Furman (2005) and Furman and Caplan (2007) looked at error reporting pathways and 'stop the line' thinking. Nurses devised a Patient Safety Alert System™ "hot line" requiring staff to report errors including near misses, and each report was evaluated immediately by sending the responsible administrator or physician chief to the source of the problem to initiate a review. The initiative increased error transparency and improved safety at Virginia Mason Hospital.

Lean Management on the Nursing Frontline

Frontline involvement has been shown to be essential to lean management's effectiveness (Frndak, 2009; Grunden, 2009; Kim, Spahlinger, Kin, Coffey, & Billi, 2009; Mann, 2009; Tucker, 2006, 2007; Tucker, Singer, Hayes, & Falwell, 2008). In their study of various aspects of process improvement in nursing units, Tucker and colleagues looked at unit-level decision-making (Tucker & Edmondson, 2003; Tucker & Spear, 2006; Tucker, 2007). In 2001, Tucker, Edmondson, and Spear observed nurses before lean, or improvement, thinking had reached healthcare. The researchers found that nurses' most common response to problems was to use techniques that allowed the nurse to continue patient care; however, the nurses ignored the possibility of investigating or changing the causes of the problem.

In 2011, Nembhard and Tucker taught health care staff strategies for effectively changing work processes, such as rapid cycle improvement, root cause analysis, and systems thinking (which the researchers called "induced learning" or "deliberate learning" though it had the characteristics of lean thinking). After teaching the strategies for improvement, the researchers reported improved quality of care and decreased patient mortality in the long term, though not in the short term. They recommended educating frontline workers to expect to have materials and information readily available to do their work, on time and correctly, and to know what to do if the work system fails. Tucker and Spear (2006) noted that using individual operational failures as triggers for process improvement benefitted a hospital. They recommended that managers use lean methods to increase safety through increased visibility of operational failures. Tucker's studies and others demonstrate that improvement thinking can make a difference in health care.

Other nurse researchers have implemented A3 problem-solving, a legal-sized paper tool developed by Toyota to detect and correct problems. The A3 guides frontline staff through the processes of problem-solving, the sections help focus the problem by providing space to map the process, collect data, consider constraints and find solutions (Jimmerson, Weber & Sobek, 2005; Sobek & Jimmerson, 2004; 2006). Jimmerson et al. noted A3 implementation issues including 1) a need to establish a coaching network to help with the tool, 2) problems in gaining management support and 3) making the time to problem solve. Jimmerson (2005) piloted a 2-year nursing quality improvement program using lean principles at Intermountain Healthcare, and identified three factors in success: 1) participants' ability to see waste in daily activities, 2) frontline staff's involvement and

enthusiasm for making improvements, and 3) a common template such as the A3 to facilitate communication.

In a systematic review of the literature, Delliframe, Langabeer and Nembhard (2010) looked at lean management's research to determine whether the research supported Lean/Six Sigma as evidence-based management. Of the 34 studies included in the review, only 11 conducted any statistical analysis to test for significant improvements. The authors concluded that there is little solid evidence of the effectiveness of Lean/Six Sigma; current trends in evidence-based management are based on conceptual arguments rather than empirical research. Measuring outcomes associated with lean programs would help to provide solid evidence of effectiveness.

In another systematic review of the organizational quality improvement (QI) literature (including lean management as a method), Kaplan et al. (2010) identified important elements for successful programs: 1) top management leadership, 2) organizational culture, 3) data infrastructure and information systems, and 4) number of years involved in QI. Other factors identified included physician involvement in QI, microsystem motivation to change, sufficient resources for QI, and QI team leadership. The authors concluded that our understanding of the elements of success would be enhanced by a practical conceptual model, clear definitions of contextual factors and well specified measures.

Mazzocato, Savage, Brommels, Aronsson and Thor (2010) sought to identify which contexts (mechanisms) produced which results in lean management. Common components of lean programs included methods and tools to understand and organize processes, manage change and solve problems. Outcomes included time-savings, timeliness of service, cost reductions, productivity enhancements, reductions in errors or mistakes, improved staff and

patient satisfaction and reduced mortality. The authors concluded that the field of lean management is "not yet mature enough for a realist view"; thus, conducting research which focuses on particular aspects such as management's role or learning may prove helpful in realizing the potential benefits of lean.

Measurement instruments used in lean studies

An early attempt to evaluate the degree of leanness of manufacturing firms was documented by Karlsson and Ahlstorm (1996), who used nine elements of lean to assess changes taking place in the workplace while introducing lean production: elimination of waste, continuous improvement, zero defects, just in time deliveries, pull of materials, multifunctional teams, decentralization, integration of functions and vertical information systems. The researchers concluded that the importance of measuring lean lies in assessing the direction of change, not the actual values of change. The study was observational and exploratory and did not use a standard survey tool; however, the findings became the basis for other measurement studies.

Boyer (1996) added a measure of managerial commitment to the assessment of lean production by Karlsson and Ahlstorm. Leaders were asked about the firm's commitment to just-in-time and commitment to total quality management. Boyer called this *infrastructural support*; it viewed quality leadership, group problem solving, and training and worker empowerment as contributions to increased productivity (Boyer, 1996). Soriano-Meier and Forrester (2002) expanded on the Karlsson and Ahlstorm and Boyer models, by triangulating the findings with factory data and interviews to assess the adoption of lean production principles in the ceramics industry. Soriano-Meier and Forrester measured factory degree of adoption and degree of leanness at two points, 3 years apart. They defined *degree of leanness*

as the mean value of the nine variables in the Karlsson and Aalstrom (1996) and Boyer models (1996). Managerial commitment to just-in-time, total quality management, and investment in supportive infrastructure were found to be positively related to actual lean changes and performance. The alpha values of their items were very high: quality leadership (α= 0.79), group problem solving (α= 0.92), training (α= 0.71), worker empowerment (α= 0.81), elimination of waste (α= 0.85), multifunctional teams (α= 0.77), continuous improvement (α= 0.72), decentralization (α= 0.70) and vertical information systems (α= 0.70). All were positively related to actual lean changes and performance.

Recently, Chauhan and Singh (2012) used the Soriano measure to identify lean parameters and examine the weight of their contribution to lean manufacturing. The researchers' 53-item survey did not include Boyer's management factors, however. The authors used three experts to weight the parameters in the Soriano instrument. To examine relationships between the nine factors, Pearson's correlations were calculated. All were positive, showing that changes in any one category affected the others. Just-in-time delivery had the highest correlation (R= 0.92) and vertical information systems the lowest (R= 0.59). The items were worded for a factory with terms like scrap, machines and gages, but the concepts relate to any lean organization.

Measures that use self-assessments for data contain subjective information and may not accurately describe a particular institution. Therefore, Wang, Hyun, Harrison, Shortell, and Fraser (2006) developed a measure of leanness that quantified the leanness level of a manufacturing system based on benchmarks of ideal leanness obtained from historical data. Cost, time and value were the input-output variables, and benchmarks were determined for individual value streams. Each indicator was scored 0-1; as a unit, area or organization

became leaner, the scores grew closer to 1. The researchers found that as one area became leaner, it created disorder in other units that fed into the lean unit; the other units lost productivity until they too used lean methods to integrate into the larger system. While the idea of leanness benchmarks is interesting, the researchers found that the effectiveness of their leanness measure was limited in complex environments because historical data were inaccurate or hard to find. After an intensive analysis of the literature, Shah and Ward (2007) developed a measure which included 48 items to represent lean production. They looked at terminology and how it had changed in lean production in an attempt to find words to represent the aspects of lean production that eliminate or minimize variation. The authors then pilot-tested their instrument using exploratory factor analysis. A corrected item to total correlation (CITC) score was calculated for each item to assess item reliability. Of the 48 items, 6 had CITC values below 0.30 and were removed. Of these six items with low values, 5 were items that were reverse-coded. Ten factors were identified: 1) regular performance feedback to suppliers, 2) JIT delivery of supplies in the right quantity at the right time in the right place, 3) JIT production with a "pull" signal to start production, 4) supplier involvement in the production process, 5) focus on customers and their needs, 6) mechanisms that enabled continuous flow of products 7) set-up time reduction to minimize process downtime between product changeovers, 8) total productive/preventive maintenance to ensure availability of equipment, 9) statistical process control to ensure that each process was defect free, and 10) employee involvement in problem solving with cross-functional roles. All items had significant loadings on their respective factors; the percent of variance explained ranged from 53 to 79%. Cronbach's alphas for each of the factors ranged between 0.73 and 0.86, indicating internal consistency.

Although Shah and Ward's lean production model was not directly related to healthcare, the definitions, factors and items may contribute conceptually to the measurement of lean diffusion, especially the focus on customers, availability of equipment, defect free services and employee involvement. That is, a modified measure like Shah and Ward's may be used to determine whether patient care units are supplied with the right amount of materials, focused on the patient as a customer, and can get patients moving--to their appointments or in admission and discharge processes--in a continuous flow, with room and equipment readiness, care that is error-free, and with employees engaged in improving the processes and solving the problems they know best.

Another health care measure was developed by Mazur, Chen and Prescott (2008) to quantify problem solving after implementation of Toyota's A3 tool with value stream mapping and root cause analysis. Based on literature reviews, focus groups and unstructured conversations on scientific problem solving, this instrument also included concepts that may be pertinent to measuring the degree of lean on a nursing unit. The instrument included 16 items with 8 factors: memorizing through organized documentation, distilling and grouping information, brainstorming, recognizing root causes of a problem, generating creative improvement ideas, communicating, systems thinking and selecting improvement measures. Since problem solving and the scientific method are keys to TPS success, a nursing unit that uses more of the scientific method--as taught in TPS--should reflect more lean thinking.

Mazur, McCreery and Rothenberg (2012) created a 10-item instrument with 5-point responses based on double-loop learning (Argyris, 1976; 2002) and lean thinking (Womack et al, 1990). The instrument was based on the literature. The researchers also used two subject matter experts to help create the tool; a third examined the objectives and items. Then

three key hospital employees gave opinions and feedback on the instrument. The measure included three factors: a 3-item "knowledge application" (α= 0.91), a 4-item (α= 0.78) "reflection and internalization" and a 3-item (α= 0.78) construct called "commitment." The lean intervention's objective was to measure how much frontline healthcare professionals change over time from a "reactive fixer of problem symptoms" (single-loop) to "root cause problem-solver" (double-loop) learner. The measure's items and constructs can serve as guides to developing items on lean thinking.

Recently, Puterman and colleagues (2012) developed a lean healthcare program evaluation to assess the success of interventions like rapid improvement events and *kaizens*. Components of the evaluation included efficiency gains, quality and safety improvements, staff engagement enhancements and financial and resource inputs. Because the evaluation applied a time series regression model to inputs from administrative data systems, staff-collected forms, and patient quality and safety data, the researchers claimed to have statistical rigor. The researchers did not, however, report on the results of the healthcare program, nor did they elaborate on the findings associated with their suggestions. However, their concepts may be of use in developing nursing measures and perhaps evaluation of hospital improvements with the Puterman team's method may triangulate with data from a nursing instrument to verify the validity of a newly developed measure.

Summary

Lean, a form of quality improvement in healthcare is receiving increased attention in healthcare. Case studies and quality improvement projects using lean management elements are common in the healthcare literature. However, the connections of lean management to hospital improvements in quality, safety, cost and delivery have not been clearly established.

Measuring the amount of lean diffusion in hospitals is the first step toward connecting the amount of lean management quality improvements with outcomes. While there are academically sound measures of lean in other industries, there is no measure in healthcare that targets lean improvements in hospitals or nursing units, the point of customer contact.

CHAPTER 3

Methods

To measure lean penetration in patient care units, nurses in hospitals were recruited to report on the status of lean on their unit. To obtain this feedback, a comprehensive questionnaire was created to measure the amount of lean in the hospital. Instrument development included domain identification, item generation, assessment of content validity, response formatting, pilot testing and field testing of the instrument, and analysis of the instrument's psychometric properties. The process was carried out in the three phases described below.

Phase 1: Domain identification and item generation.

Empirical indicators, constructs and attributes found in an extensive review of the literature, as well as input from an expert panel were used to develop items for measuring lean diffusion in a nursing unit. The process included: 1) identifying all possible relevant constructs, 2) analyzing existing measures for items that were applicable to the new instrument and 3) verifying the domains and items with experts.

Step 1: Review of the literature. An extensive literature review was used to examine the characteristics of lean management, lean thinking and quality improvement that may be seen on a nursing unit. Lean improvement tools (such as 5S, value stream mapping, *kaizen*, and Six Sigma) were examined along with leadership involvement, presence of teams, resource availability, characteristics of learning organizations, quality improvements, change management and other constructs suggested by experts such as zero defects or A3. In

addition the following websites were queried for information on the latest research on lean in healthcare: Institute for Healthcare Improvement, the Agency for Healthcare Research and Quality and the Robert Wood Johnson Foundation. Pub Med, Nursing and Allied Health databases (CINAHL), ISI Web of Science, articles and dissertation abstracts and Business Source Premier (BSP) were queried using the terms: "lean management," "lean thinking" and "time-based management." The search also included MeSH terms "Quality Improvement" and "TQM." Google Scholar sites were queried using the terms "TPS," "lean management" and "lean hospital." Bibliographies and reference lists were examined for additional citations.

Because the literature on lean management in healthcare first appeared around 2000 when Virginia Mason Hospital started working with Toyota, a 20-year limit was set for the review (1993-2013). The search included only English-language publications. Titles and abstracts of the articles identified were scanned for reports of lean management, especially organizational goals, leadership, management and frontline roles, or use of lean management strategies such as value-steam-mapping, *kaizen* or rapid improvement events, just-in-time (JIT), one-piece flow, *kanban*, and 5S.

Step 2: Analysis of other lean measures. Measurement tools were retrieved from a review of the operations management literature using the sources noted above. The search included the terms "operations management," "TPS," or "lean management" and "measur*," "instrument," or "tool."

Step 3: Expert opinion. To gather opinions on how to measure the degree of lean management diffusion, modified Delphi methods (Dalkey & Helmer, 1963) were used. The Delphi method uses a panel of experts to gain consensus. By definition, it "is a group process involving an interaction between the researcher and group of identified experts on a specified

topic" (Yousuf, 2007). Unlike other data gathering and analysis techniques, the Delphi method uses multiple iterations to develop a consensus of opinion on a specific topic; that is, it draws on the insights of many experts rather than a single principal investigator's judgment and discretion (Hsu & Sandford, 2007). The method does not require face-to-face interaction as in interviews or focus groups. It is used when there is lack of empirical data in an area and experts are located in different locations and settings. McKenna (1994) advised the Delphi technique should be used when opinions and positions would benefit from subjective judgment and when convergence on a collective agreement is desired. Thus, the Delphi method was considered appropriate for investigating lean management in healthcare, a relatively new field of study where concepts have not been fully identified or defined.

Setting clear standards for selection of a Delphi panel is important as are expert's qualifications, as representatives of their professional group and with sufficient expertise, knowledge and experience. Experience is especially important in those without academic or a professional association's credentials. Published research has been the main criterion for judging expertise in several Delphi studies (Baker, Lovell, & Harris, 2006). Since heterogeneity of panelists and objectivity in opening round materials are essential to a successful Delphi technique (Lynn, Layman, & Englebardt, 1998), the goal was to obtain a purposive sample of at least five and not more than ten panelists. Experts from the lean health care field were called upon to cast light on lean management diffusion and lean thinking. Since panelists were consultants and were not being studied, IRB review of this portion of the study was not required.

Three rounds of expert questioning occurred in Phase I and are described below.

Round 1. The first round included open-ended questions posed to the experts about the content area. After experts responded to a recruitment email, they were sent an electronic link and asked the following questions:

> If you were a lean management consultant and had to write a report on improving cost, quality, safety and delivery on a nursing unit, what are the most important elements you would consider? In other words, what factors do you think represent lean or lean thinking?
>
> How would a nurse's actions differ on an 'advanced' lean unit versus those on a unit that has no lean influences?
>
> Some nursing units look like they use the tools of lean—e.g. visual cues, 5S, inventory management, *kaizen*/rapid improvement events but do not show significantly better quality care compared to like organizations. What factors do you think might explain this?
>
> Do you wish to say anything else that may help understanding the amount of lean or identifying 'lean thinking' on a nursing unit?

The panelists' responses and ideas from the literature are in Appendix 1.

Round 2. The panelists' responses from Round 1 served as a basis for Round 2's structured questionnaire, as described by Hsu and Sandford (2007). Researcher-collated responses were sent back to the experts after the ideas were analyzed for redundancy and clarity. Panelists were asked to comment on ideas that would expose areas of controversy and provide more insight scales without compromising significant measurement precision (O'Muircheartaigh, Krosnick & Helic, 2000).

The 5-point scale was devised using three anchors, Not Relevant to Lean, Moderately Relevant to Lean, and Fully Relevant, with arrows (=>) to indicate progressively greater

relevance to lean at numbers 2 and 4. Instructions to the experts were as follows:into experts' answers. Panelists were asked to rate each construct on a 5-point Likert scale (from Not Relevant to Lean to Fully Relevant to Lean). The 5-point scale was used because scales with a neutral midpoint tend to produce data of higher reliability and validity than scales without midpoints and it is more parsimonious than 7-point or 10-point

> The statements from the first round have been reviewed and redundant statements eliminated. Also, because the eventual instrument was administered to nurses with differing levels of knowledge, especially about the "jargon" of lean management, much of the lean terminology has been changed to reflect more commonly used words like "problem solving" or "change." The A3 is described as a written plan of problem-solving.
>
> The statements that follow have been grouped using labels that may or may not persist. But they were chosen to help with formatting, specifically keeping items addressing similar ideas on a single page in what follows. Each section has a comment section to help identify items that may be awkward or unclear. Additional ideas or thoughts are welcome.
>
> What I am asking you to do now is review each statement below and, using the five point scale, indicate how relevant the statement is to lean thinking for a frontline staff nurse.

To analyze the responses, items were ranked by the descending median of the experts' responses. Numerical dividing points were selected to make it easier to read the on-line version of the next round's survey and to help the experts see how their responses fit, so that they could advocate for a particular idea. For example, if experts wanted value stream mapping to be higher, then their comments could reflect that line of thinking. The experts' suggestions were used to reword items, or to simply re-consider and give ideas back to the experts for more feedback.

Round 3. In Round 3, the experts were asked to give feedback on the collated results from Round 2. They were asked to rank items according to how important they were as components of lean diffusion and whether the items were meaningful, clear and

unambiguous, not redundant or confusing. The items were arranged by degree of consensus; that is, the questions with the highest sum totals and highest median were first, the lowest last. Experts were asked to rank each on a 4-point scale. Instructions were as follows:

> Please respond to each of the following items as to whether the item is relevant to lean thinking, clear and unambiguous, using a 1 to 4 response scale:
>
> 1 = an item that either clearly does not belong or is not easily edited to be retained.
> 2 = an item in serious need of being revised and should be eliminated.
> 3 = an item that is relevant but is in need of minor editing.
> 4 = an item that is relevant and sufficiently clear and succinct.
>
> Please comment on how you could improve wording or content.

Consensus was determined using Lynn's (1986) two-stage process for establishing content validity. Her 4-point content validity index requires items to achieve 0.80 agreement by this number of experts. That is, eight of the ten experts needed to rank an item with a response of 3 or 4.

Phase 1: Results

Experts with knowledge of lean management in a healthcare environment were referred to the researcher by academic advisors, were known through publications in the field, or were known to the researcher through contacts from the Lean Healthcare Summit. Ten agreed to help generate content for the measure. They included quality improvement leaders who had initiated and sustained lean programs, and nursing quality and research directors of lean programs and lean consultants in the healthcare industry.

Table 1. Expert Panel for Phase 1

Name	Role
Mark Graban	CIO of KaiNexus and author
Ron Wince	CEO of Guidon Performance Solutions
Dr. Cindy Jimmerson, RN, PhD	CNO of Lean Healthcare West and author
Dr. Susan Sheehy, RN, PhD	Lean Healthcare Eastern consultant
Dr. Marianne Jackson MD, MPH	University of North Carolina
Heather Grant, RN, MSN	Rex Hospital Quality Director
Dr. Sallie Davis-Kirsch, RN, PhD	Seattle Children's Hospital
Dr. Linda Latta, RN, PhD	Seattle Children's Hospital
Cindy Loughman, RN, Quality Specialist	Pittsburgh Regional Health Center

Round 1. Within 2 weeks of recruitment, the first link to the online survey reached the panelists. All returned their responses within a week. Their responses were qualitative in nature so were analyzed by looking at descriptions of lean management and lean thinking, including both common and unique characteristics. In general, experts answered from the perspective of their particular specialty. For example, consultants to hospitals tended to focus on organizational philosophy, support and leadership. Nurse consultants who work with A3 problem-solving (a tool used to guide lean efforts) focused on communication and individual efforts; quality improvement leaders discussed education and ways to disseminate information; and consultants talked about leadership and the environment.

Preliminary qualitative analysis of expert responses to the open ended questions revealed that the responses could be roughly categorized as 1) awareness of work processes, 2) elimination of waste, 3) use of a scientific method for problem solving as part of everyday

work, 4) presence of an education system for training, development and support for everyone in the organization, 5) frontline employee involvement and empowerment, 6) a mindset or understanding of improvement with an acceptance of lean methods, 7) presence and support of leaders and managers, 8) use of TPS tools for improvement and, specifically, 'stop-the line' for errors, 9) an organizational culture or environment for improvement, 10) use of appropriate metrics, 11) value for the patient as customer, 12) organizational incentives and benefits. The answers to the questions were used to form items for the second round of the survey. There were 121 responses that were considered unique and applicable to lean management. To these, 76 ideas from the review of the literature were added. The ideas are summarized in Appendix 1.

Using content analysis, the 197 ideas were further analyzed and formatted into 132 items to be used on the survey; each idea was written on a Post-It® note and then placed on a wall with the other ideas. The ideas were grouped together and rearranged until concepts were identified. This process exposed redundancy and provided a basis for grouping items on the instrument. The ideas were then organized by topic to ease the burden on experts and to promote clarity of thought. Because lean thinking seemed to have three broad components--the organization, the unit and the individual, items were developed using three different stems, or lead-ins to the item. The three stems were, "A nurse on a patient care unit would:," "On this patient care unit:" and "In this organization:" For further clarity, the items were sub-grouped as elimination of waste, processes, mindset, problem solving, patient focus, a lean unit and organizational characteristics. The resulting survey was used to elicit responses in Round 2.

Round 2. Although the plan was to send the second survey link 2 weeks after the initial feedback, analysis took longer than expected. The items were sent out a month later and it took longer to obtain panelists' responses. Expert ranking on the 5-point scale of relevance to lean was collated in this round. The item medians ranged from 1.0 to 5.0. Lower ranked responses were carefully considered, with a decision made to eliminate, leave for further comment or reword the items.

A total of 118 items were then reformatted into a 4-point scale; 24 items were eliminated due to a low ranking of relevance to nursing or redundancy of content. The electronic survey included text areas after each section so that panelists could add comments to help the researcher understand the panelists' numerical responses.

Round 3. In Round 3, the experts were sent the link to the 118-item survey. A 2-week turn-around was achieved, though some experts reported that they were especially busy with conferences and end-of-school activities. All 10 of the experts responded to at least one section of the Round 3 survey; however it was unclear why some skipped sections or did not finish, for reasons not given. All questions had at least eight responses, often from eight different experts. In the end, however, there was a remarkable sense of agreement on what ideas were relevant to lean. Experts gave seventeen questions a perfect 4. These questions touched on every categorical subdivision found in Round 2: mindset, waste, patient focus, and problem solving, as well as unit and organizational characteristics.

Although Round 3 was initially designed to determine relevance as well as formatting of the survey, in Round 3 the 118 items were also subjected to content validity assessment using Lynn's (1986) recommendations. Items with less than a 0.80 agreement (that they were a 3 or 4) were revised or eliminated (Lynn, 1986). Panelists clarified the information

and gave judgments about the 118 statements, specifically, the whether statements should be included as a component of lean penetration to the nursing unit. After the responses were analyzed, the items were formatted for administration to nurses in the Phase 2 pilot test.

Phase 2: Peer Review and Pilot Testing

The aims of the second phase were to establish content validity and to ascertain the readability, clarity, and understanding of the survey items. IRB approval was obtained to carry out this phase. Nurses from local hospitals that used lean methods as improvement methods were asked to evaluate the items. Quality directors and nurse managers were contacted for names of nurses who knew lean management. These nurses were then contacted by email to determine their interest in participating

Nurses gave feedback in four ways: 1) web survey to evaluate relevance to their practice, 2) web survey to determine whether the content captured lean, 3) web survey to evaluate electronic characteristics including ease of access and appearance of the measure, and 4) focus groups to evaluate reading and formatting plus applicability of lean to the clinical unit. The intent was to identify how well the items described an ideal unit and how relevant the items were to practice. Two surveys with the same 116 items but with two different sets of instructions were administered using a 4 or 5-point Likert Scale. The instructions read as follows for the 4-point clinical relevance survey:

> Review each statement below and, using the 4-point scale, indicate how relevant the statement is to lean improvement thinking for a frontline staff nurse.
>
> 1=Not relevant to lean or improvement thinking
> 2=Unable to assess or in need of so much revision that it would no longer be relevant
> 3=Relevant, but needs minor revision
> 4=Very relevant and succinct.

Instructions for the 5-point content analysis survey were:

> You are to review each statement below and, using the 5-point scale, indicate how much the statement describes the lean/ improvement in your work situation.

Respondents were asked to rank the items strongly disagree (SD) to strongly disagree (SA).

An electronic version was created for on-line use and a paper version for focus groups. Two groups (one web group and one focus group) used the clinical relevance survey and two used the content analysis survey. After nurses agreed to participate, two web groups were given a copy of the survey's electronic link in a second email message. One received the content survey, and the other received the relevance survey. The nurses who responded by web survey were given a gift card via electronic link.

Two additional groups of nurses were asked to participate in a 2-hour, face-to-face session to assess the survey. One group filled out a paper survey for content analysis, the other filled out a survey of relevance. Nurses were then asked about the overall set of items, whether they thought the items measured the amount of lean on the unit and whether they thought anything was missing. Nurses' responses served as a basis for a final revision to simplify and clarify content before administering the measure for psychometric analysis. For their participation, the groups were served lunch and were given a gift card.

Phase 2: Results

The participants in Phase 2 included frontline nurses from hospitals in the southeast United States. The first group of nurses (n=5) was surveyed electronically. They worked in a 660 bed small city hospital. In the third year of their lean management program, the hospital had a Lean Six Sigma nurse champion and was supported with students and faculty from a near-by university.

The second group of nurses (*n*=8) participated in a focus group. These nurses were from a 145 bed county hospital that had introduced lean methods about three years ago with teaching on tools and methods. As new nurses were hired, they were given a short teaching session in their orientation program.

A second focus group, consisted nurses (*n*=10) from an academic medical center. The 804-bed hospital had a newly formed organizational lean management initiative, but had a history of teaching nurses QI through department-based programs. Nurses were from one surgical unit that had two Six Sigma Green Belt projects in motion; the manager was fully invested to dedicating time and resources to the project.

Nurses (*n*=2) from a regional 335-bed hospital also participated by filling out the electronic survey. The nurses reported having 2-4 years of training; the hospital itself had two years of lean management experience. The hospitals, number of participants in the pilot study and data collection method are summarized in Table 2.

Table 2. Phase 2 Pilot: Participation and Survey Distribution

	Hospital Beds	Hospitals' Length of Lean Program (years)	Nurses (*n*)	Content (5-point scale)	Relevance (4-point scale)	Electronic Characteristics (5-point scale)
Focus Group 1 (Paper)	145	3	8	x		
Focus Group 2 (Paper)	804	1	10		x	
Electronic Survey 1	660	3	5	x		x
Electronic Survey 2	335	2	2		x	x

The nurses that participated in the pilot study reported an average of 2.8 years (range 1-20) of work experience with an average of 1.4 years (range 1-4 years) of process improvement experience. They worked on units that had carried out lean methodologies for an average of 1.1 years. All the nurses reported that they had attended a course on lean quality improvement or Six Sigma methodology and had participated in a lean rapid improvement event or kaizen. Two groups completed analysis of clinical relevance using the 4-point formatting. Two groups received a survey with 5-point formatting for content analysis. Revising the survey was an iterative process with comments used to make revisions in the next version administered.

Focus Groups. The nurses who participated in focus groups evaluated the content, relevance, formatting and usability of the survey by using the paper formatted copy. These nurses were instructed to go through the survey and take notes on questions or problems they might encounter with items and formatting. They gave both verbal and written feedback and discussed the wording of the survey's instructions, response scaling and items. The researcher guided the group through each question, taking notes and delving into comments and concerns about each item. The comments from the first focus group were included in the second group's session so that the feedback could be checked for accuracy and commonality of opinion on the items. For data integrity, the researcher recorded the sessions to assure that the nurses' comments were preserved.

Electronic assessment. Ten nurses accessed a Survey Monkey site via electronic link. The first five nurses to take the survey assessed lean management content and electronic characteristics. They commented on occasional unclear wording, a repeated item and the difficulty of assessing content on-line. That is, they were unsure whether to report on how

their unit actually performed or how a unit should perform. The items' wording was corrected before sending out the next electronic survey.

Although generally the nurses thought the instructions were clear, the rating scale appropriate, and items straight-forward, many suggestions were made to simplify and clarify wording. Of these, the most helpful comments pointed out that items often had two parts and should be divided into two questions. Other comments were on wording items negatively. It appeared that nurses missed the "no" or "not" when reading the item; responses therefore varied widely on the negatively worded items. Seven items were deleted and minor revisions to item wording were made when the nurses' suggestions seemed reasonable. One nurse thought the Qualtrics® web site had better appearance and security. After further evaluation, it seemed appropriate to change the survey's site from http://surveymonkey.com to http://software.unc.edu/qualtrics/.

Readability tests. As an additional test of readability, two tests were used to evaluate the survey. The survey items were entered into software found at the Readability Formulas webpage: http://www.readabilityformulas.com/free-readability-formula-tests.php. The readability tests included the two following measures plus a combined score.

- The Flesch-Kincaid Grade Level and Flesch Reading Ease Score were used to gain estimates of document comprehensibility. The Flesch-Kincaid Grade Level is an index that computes the years of education required to comprehend a document. It can be calculated using the following equation: (0.39 × Average Sentence Length) + (11.8 × Average Syllables per Word)-15.59.

- The Flesch Reading Ease Score figures difficulty of comprehension on a scale of 0 (very complex) to 100 (extremely simple); it is calculated by using the equation 206.835-(1.015 × Average Sentence Length)-84.6 × Average Syllables per Word. (http://www.readabilityformulas.com/free-readability-formula-tests.php.).

Assessment of readability indicated that the measure had an eighth grade reading level, i.e., it was fairly easy to read for those 12-14 years old. The results showed that the wording of items was appropriate for nurses who had at least an Associate Degree.

The revised survey was named the Frontline Improvement Thinking (FIT) measure and is shown in Appendix 2. Further formatting for the Qualtrics.com website was done to finalize the survey for use in Phase 3.

Phase 3: Field testing and factor analysis methods

The minimum sample size for this study was 300 participants, as recommended by Pett, Lackey and Sullivan (2003). Nursing directors and researchers from hospitals that reported using lean management were asked to distribute an electronic link to their nurses. Directors and researchers were contacted personally at conferences, by phone or by email and given details of the study prior to sending out the first survey link.

Nurses who agreed to participate followed an electronic link to a password-protected website that contained the FIT survey. Frontline nurses were self-identified using criteria set forth in the instructions to the survey (Appendix 2); only those involved in direct patient care were asked fill out the survey. They were asked to complete the on-line survey at a convenient time and location and were given two weeks to do so. A reminder was sent out after 5 days. Test-retest reliability was assessed by sampling a group of 35 nurses who had

indicated their willingness to participate again. They were queried 2 weeks later using the same instrument. An anonymous code was used to link the two administrations (Damrosch, 1986).

Assessment of psychometric properties. Factor analysis and reliability assessment were done using SPSS® v.19 statistical software. The Kaiser-Meyer-Olkin (KMO) was used to determine sampling adequacy and to determine whether factors were identifiable. Acceptable values were used per Kaiser's (1974) recommendation; he described KMOs over 0.90 as "marvelous," 0.8-0.9 as "meritorious," and 0.7-0.8 "middling," 0.6-0.7 "mediocre" and 0.5-0.6 as miserable. Bartlett's Test of Sphericity was used to test the null hypothesis that there was no relationship among items, an initial test of whether the matrix should be analyzed. A Scree plot (a graph of eigenvalues) was used to estimate the number of factors to be extracted. The "elbow" in the Scree plot was used to determine the number of factors to be rotated. Principal axis factoring (PAF) was chosen as an extraction method to avoid overestimating the number of factors or the item loadings on factors, a common problem with principal components analysis (Costello & Osbourne, 2005). Data was rerun three times using numbers above and below the predicted breakpoint or 'elbow,' as suggested by Costello and Osbourne (2005).

To attain the most interpretable factor structure, oblique and orthogonal rotations were used, and the clearest solution was selected. Initial item loadings for item retention were set at a minimum of 0.35 with at least 0.15 difference in cross loadings (Costello & Osbourne, 2005). After evaluating and refining the factors, reliability was assessed focusing on internal consistency (Pett, Lackey, & Sullivan, 2003). Test-retest assessment included Pearson's correlations and Kappa statistics to examine factor stability; a Kappa greater than

0.5 or a Pearson correlation of 0.7 were used to define stability (DeVellis, 2003). Both Pearson and Kappa were used because Pearson Correlation is subject to chance agreements and Kappa corrects for this; both range from -1 to +1. Analysis was based on kappa ratings as follows: <0.2=poor, 0.2-0.4=fair, 0.4-0.6=moderate, 0.6-0.8=good and 0.8-1.0=very good, using Knapp's (1995) suggestions to determine the values.

To assess internal consistency Cronbach's alpha coefficient was calculated for each factor. This coefficient represents the proportion of total factor variance that can be attributed to a common source (Pett, Lackey, & Sullivan, 2003). Because the instrument was in the first stage of development, alpha values greater than 0.7 were considered acceptable. The factors were interpreted and named, and the instrument finalized.

CHAPTER 4

Results

This chapter describes the findings from the final phase of FIT instrument development. Included are the results of field testing sampling, demographics, factors, and psychometric analysis.

Phase 3: Field testing and factor analysis results

Sampling. Sampling for field testing was more difficult than expected. A letter of recruitment to CNOs brought in no responses, so the researcher sent emails accompanied by a phone call to the CNO's administrative assistants. Two CNOs answered with negative responses, three did not answer. Next, quality directors and nurse researchers were contacted. Recruiting participants at a lean conference brought in additional responses, for a total of responses (*n*=212*)* from five hospitals that used lean management methods. Additionally, scattered responses from 61 nurses from 61 different hospitals also completed the survey. Another 300 responded to a social media request from nurse.com. Many of the respondents, however, failed to answer the questions on demographics. Consequently, 361 responses were considered but not used because they did not "behave" like the locally collected data, they were from at least 64 institutions and individual responses did not allow for a broad organizational assessment of lean. The 212 complete responses from groups of nurses at various levels of lean hospitals fell short of the initial goal of 300 subjects; however sampling adequacy assessments for these data were good.

Five hospitals were included. The Hospital A is a 110 bed community hospital in the southeast with a lean management program that had been effect for two years. The hospital had funding and training to step up their program, so nurses were undergoing education in lean management methods. The Hospital B is a 925-bed academic medical center in an industrial area of the Midwestern U.S. Units incorporated lean methods before lean became an organizational priority and initiative; it used lean techniques about 4-5 years. Hospital C is the same 660-bed city hospital used in the pilot study which used lean for about 2 years. It is associated with a state university and had a nurse who was a Lean/Six Sigma champion. The Hospital D is a 478-bed facility located in the Midwest and served patients from a multi-state region. It initiated a lean program about 3-4 years ago. The organization is rapidly acquiring local hospitals so the current state of education and deployment was in flux. Hospital E is an academic medical center in the southeast, an 880-bed facility which is launching an organizational lean Six Sigma program. The demographics of the 212 participating nurses are detailed in Table 3.

Table 3. Demographic Data of Nurses and Their Units

Hospital	Nurse Responses	Worked as Nurse (yrs.)	Individual Nurse Experience with Lean or QI (yrs.)	Lean Methods used on hospital work unit (yrs.)
	n=	Mean (SD)	Mean (SD)	Mean (SD)
Hospital A	10	13 (1.4)	3 (0)	3 (0)
Hospital B	24	18.5 (13)	7.2 (8.5)	6.3 (8.5)
Hospital C	12	13.6 (14.8)	3 (3.0)	7.8 (5.6)
Hospital D	20	15 (13.4)	5.8 (9.2)	7.3 (4.7)
Hospital E	146	12.7 (9.9)	6.2 (8.1)	4.1 (5.3)
Total	212			

Assessment of structure and reliability. Both orthogonal and oblique rotations were examined. Traditionally, orthogonal rotation has been used but it assumes that factors are not correlated with each other. In studies with humans, factors are more likely to be correlated; consequently, an oblique rotation, which maximizes loadings for correlated factors, was the better choice for this analysis.

The pattern matrix was examined for factor/item loadings. Interpretability was determined by looking for common themes or patterns in items, especially ideas suggested in the review of the lean and quality improvement literature. As expected, the most interpretable factor structure was obtained with an oblique rotation, demonstrating that there was some correlation among the factors being rotated (Pett, Lackey & Sullivan, p. 150). Minimum item loadings for retention, i.e. the Pearson correlation between the variable and the factor, were initially set at 0.35, with at least 0.15 difference in cross loadings (Costello & Osbourne, 2005). Although this minimal loading is adequate for exploratory analysis, each factor had many items with considerably higher loadings, so a 0.40 minimum loading was used to select the final items. The result was a 12-factor, 75-item instrument which covered the organization, unit and individual.

Organization. The first 12 items in the measure addressed the organization. The section's KMO= 0.86 (meritorious) and Bartlett's Test of sphericity $p<.001$ showed that sampling was adequate, factors were identifiable and the matrix could be analyzed. The "elbow" in the Scree plot indicated that there were two factors to be rotated, so data were rerun three times using one, two and three factor rotations.

With a two-factor solution, two items did not load according to the pre-set criteria so they were eliminated. Factor 1 was named *Learning Organization*. It included five items

such as “Everyone in the organization is encouraged to get training on improving processes” and “There are many opportunities to learn about process improvement.” The Cronbach’s alpha reliability estimate was α= 0.87. The inter-item correlation range= 0.44- 0.72. (Kappa= 0.28 and Pearson’s R= 0.61). Despite low reliability estimates, internal consistency was high and the items’ content appeared to fit together well.

The second factor, *Frontline Involvement*, included five items such as “Leaders of the organization include frontline staff like me, when needed, to problem-solve.” Cronbach’s alpha was α= 0.79 (inter-item correlation range= 0.30- 0.65; Kappa= 0.37; Pearson’s R= 0.68). The two factors explained 55.2% of the total variance. Despite relatively low test-retest reliability scores, the internal consistency fell well above the 0.70 Cronbach’s alpha expected for a measure in the early stages of development. The factors, items and loading are reported in Table 4.

Table 4. Abbreviated Text and Factor Loading for Organizational Factors

	Loadings by Factor	
	1	2
Everyone is encouraged to get training.	.99	
Nurses are expected to attend classes.	.73	
There are many opportunities to learn.	.72	
Everyone has access to a coach.	.59	
Everyone identifies opportunities	.55	
Leaders of the organization include frontline staff like me.		.75
Nurses who best know the processes are involved in solving the problem.		.57
A hospital leader comes to the unit to help understand the problem.		.52
Organization stresses change is important.		.52
Mission of the organization helps guide change.		.48

Unit. The next section of the instrument focused on the nurse's experience with lean improvement thinking on the nursing unit. Sampling was adequate as determined by the KMO= 0.92 (marvelous) and Bartlett's Test of sphericity ($p<.001$). The "elbow" in the Scree plot indicated that there were four factors to be rotated, so data were rerun three times using three, four and five factor rotations. The four-factor matrix proved to best capture the essence of the lean unit, describing 54.5% of the variance, with loadings that met the pre-set criteria. Eleven of the 40 items were eliminated.

The 9 items of Factor 1 centered on *Manager Support*, including: "My manager is receptive to new ideas," and "Staff meetings are efficient and focused." For this factor, α= 0.94 and inter-item correlation range= 0.41- 0.76, which are acceptable values for an exploratory analysis. The high alpha meant that items had a great deal of internal consistency. Test-retest reliabilities were fair, but acceptable (Kappa= 0.31; Pearson's R= 0.70). The items fit well, all having managerial content.

Seven items encompassed the concept of *Mentoring* (Factor 2), including "There is an education program to teach nurses about process improvement," and "There are people available to help me recognize ways that errors might occur in my work" (α= 0.91; inter-item correlation range= 0.46- 0.72; Kappa= 0.28; Pearson's R= 0.66). Despite the relatively low test-retest reliability scores, the internal consistency Cronbach's alpha of 0.91 was highly desirable for a 7-item factor. The items fit loosely around mentoring or education on the unit and were different from the organizational learning factor.

Factor 3, called *Patient Centered Focus*, contained 11 items including "The patient care on my unit is performed in a systematic way," "Most staff (nurses to housekeeping) recognize that what they are doing is for the patient" and "The nurse is usually able to give

the patients what they want, when they want it, in the way they expect it, as long as safety is not compromised" (α= 0.88; inter-item range= 0.26- 0.63; Kappa= 0.30; Pearson's R= 0.53). Once again, Cronbach's alpha was high and test-retest reliability fair. Since lean management's philosophy prioritizes process improvement for the customer, these 11 items may prove to be some of the most important items for nurses.

The fourth factor embraced *Visual Management* with its two items "Statistics on falls, central line infections and other quality indicators are displayed for staff to see" and "Charts and data are displayed so that staff knows how improvements are progressing" (α= 0.86 and inter-item correlation= 0.76; Kappa= 0.5; Pearson's R= 0.77). This factor had a high Cronbach's alpha as expected with a two-item factor. Its test-retest reliability was the highest of all the factors, which may mean that units were aware of the need to post their results to gain nurse buy-in and to involve nurses in quality improvement. Factors, items and loadings are shown in Table 5.

Table 5. Abbreviated Text and Factor Loading for Unit Factors

	Loadings by Factor			
	1	2	3	4
Unit manager's attitude helps get everyone involved.	.87			
Manager follows-up to finds ways to make improvements work.	.82			
Manager encourages new ways of doing things.	.80			
Manager is receptive to new ideas.	.78			
Manager creates new ways of seeing the problem.	.77			
Manager comes to help look for the causes of the problem.	.73			
Staff meetings are focused.	.73			
Manager identifies “work-arounds.”	.67			
Manager asks staff to use a written plan.	.62			
Instructors help me recognize errors in my work.		.77		
Education program teaches nurses.		.64		
Person available to coach staff.		.62		
Nurses worked on at least one improvement project.		.62		
People help me recognize that errors.		.55		
Designated person who helps work through problems.		.53		
There are ways to measure time spent in patient care.		.50		
Supplies are in a designated place.			.71	
Patient care is performed in a systematic way			.68	
Nurse is able to give the patients what they want.			.65	
Patient care is a team effort.			.61	
Equipment is kept in a designated place.			.59	
Stocks of supplies are sufficient.			.58	
Supplies needed to do the work.			.56	
Cleanliness and order are monitored.			.53	
Nurses have the authority to address problems.			.51	
Nurses participate on a team that improves patient care.			.49	
Staff recognizes that what they are doing is for the patient.			.48	
Statistics on quality indicators are displayed.				.76
Staff knows how improvements are progressing.				.70

Individual. The third section of the measure addressed individual nurses. KMO= 0.88 (meritorious) and Bartlett's Test of Sphericity $p<.001$ demonstrated that sampling was adequate, factors were identifiable and the matrix could be analyzed. The Scree plot suggested seven components. However, the clearest, most interpretable factors were revealed when six factors were formed from a 36-item scale.

Factor 1, *Takes action,* included 9 items, such as "I know that is important to confront problems, not ignore them" and "I think that to improve care, a nurse must continually think of different ways to perform better care (α= 0.88 and inter-item correlation range= 0.26-0.65; Kappa= 0.33; Pearson's R= 0.35). Cronbach's alpha was highly acceptable, the test-retest reliabilities only fair. The factor items describe a nurse who not only thinks about care and the problems, but takes action to improve care.

Factor 2, a 12-item factor, *Solves problems,* included such items as "I identify ways to eliminate waste in patient care," "Find ways to increase time with the patients" and "Use problem-solving to remove obstacles to providing optimum patient care" (α= 0.91 and inter-item correlation range= 0.25- 0.66; Kappa= 0.33; Pearson's R= 0.46). The high Cronbach's alpha is exceptional for a 12-item factor. The items included some of the lean thinking elements that are important in a system that has been changed by lean management. Test-retest reliabilities were fair.

Factor 3, *Reduces Variation,* loaded on 2 highly-correlated items: "I do not think that it is important to perform care in a similar manner to other nurses in the organization" and "I do not think that it is important to perform care in a similar manner to other nurses on the unit." (α= 0.94 and inter- item correlation= 0.89; Kappa= 0.17; Pearson's R= 0.28). The 2-item factor had a high Cronbach's alpha but low test-retest reliability. Despite, or perhaps

because of, the negative wording, these 2 items held together with each trial rotation. They seem to indicate that nurses are aware of variation in care.

Factor 4, *Uses Improvement Tools*, included 3 items such as "I solve problems using a methodical written, approach to communicate the ideas" (α= 0.75 and inter-item correlation range= 0.42- 0.60; Kappa= 0.17; Pearson's R= 0.38). Cronbach's alpha was over the 0.70 minimum set for factor on a new instrument. Test-retest reliability was poor.

Finds Opportunity, Factor 5, included 2 items: "I find opportunities to improve how I provide care every work-day" and "I compare the way I perform care to how my co-workers perform care" (α= 0.66 and inter-item correlation = 0.5; Kappa= 0.27; Pearson's R= 0.38). Factor 5 was the most troublesome factor, the low Cronbach's alpha did not get better with a 4 or 7-factor solution. The items made the most sense conceptually with a 5-factor rotation. Though each of the two could have been split with Factor 1 (Take action) and Factor 3 (Reduce Variation), the responses from the nurses did not indicate that split.

Factor 6, *Mindset for Change*, included 8 items such as "I think that process improvement work can cause positive change to occur" (α= 0.84 and inter-item correlation range= 0.26- 0.59; Kappa= 0.32; Pearson's R= 0.39). This factor was another important reflection of lean thinking. Cronbach's alpha was acceptable and the items described the concept appropriately. Test-retest reliability continued to be fair. The items and loadings for the Individual FIT factors are found on Table 6. A summary of the psychometric data for all factors can be found on Table 7.

Table 6. Abbreviated Text and Factor Loading for Individual Factors

	Loadings by Factor					
	1	2	3	4	5	6
Need to look for ways to improve patient care.	.68					
I can decrease cost of care by using the needed supplies.	.67					
Important to confront problems, not ignore them.	.55					
A nurse must think of ways to perform better care.	.55					
Make sure care is error-free.	.51					
Inform the patient of the expected routine.	.51					
Plan that is carried out, analyzed and improved.	.48					
Important to find out why the system created an error.	.45					
Look at the process start to finish before finding solution.	.43					
Identify ways to eliminate waste.		.79				
Reduce waste in wait time and over-processing.		.69				
Increase time with the patient.		.68				
Address issues before an error occurs.		.68				
Eliminate delays, errors and inappropriate procedures.		.63				
Remove obstacles to optimum patient care.		.61				
Make patient care safer.		.59				
Everything is done with a patient focus.		.57				
Continually find ways to make patient care better.		.52				
Call managers (stop-the-line) during a shift.		.51				
Look for ways to keep from searching.		.50				
Start the plan for discharge on the day of admission.		.47				
Perform care like nurses in the organization.			.93			
Perform care like nurses on the unit.			.93			
Sketch out a diagram of how it is currently carried out.				.71		
Map what actions occur during patient care.				.57		
Use methodical, written, approach to communicate .				.51		
Find opportunities to improve care.					.63	
Compare care to how co-workers perform care.					.44	
Save time when problems are worked on as they occur.						.73
Ask "what would it take to…"						.62
Know to ask “why” to get to the root cause.						.60
Process improvement work can cause positive change.						.49
If I use a “work-around” I must return to the issue.						.48
Follow-up on audits is important to improving care.						.46
Know how other units carry out their work.						.46
Change is needed to improve care.						.43

Table 7. Summary of Psychometric Data for All Factors

FIT Section	Number of Items	Factor Name	Cronbach's Alpha	Inter-item Correlation	Kappa	Pearson's r
Organization						
	5	Learning Organization	.87	.44- .72	.28	.61
	5	Frontline Involvement	.79	.30- .65	.37	.68
Unit						
	9	Manager Support	.94	.41-.76	.31	.70
	7	Mentoring	.90	.46- .72	.28	.66
	11	Patient Centered Focus	.88	.26- .63	.30	.53
	2	Visual Management	.86	.76	.50	.77
Individual						
	9	Takes Action	.88	.26- .65	.33	.35
	12	Solves Problems	.91	.25- .66	.33	.46
	2	Reduces Variation	.94	.89	.17	.28
	3	Uses Tools	.75	.42- .60	.17	.38
	2	Finds Opportunities	.66	.50	.27	.38
	8	Mindset for Change	.84	.26-.59	.32	.38
Total	75					

CHAPTER 5

Discussion

This study was designed to create a comprehensive assessment of lean management in a healthcare organization so that a researcher or administrator could measure how much "leanness" is in an organization. Lean management and associated lean thinking are complex; they have been clearly described by experts, but are difficult to capture and measure. Like many management models, lean management evolves as an organization matures. Each section of the 75-item FIT measure was found to encompass several diffusion concepts. The instrument included items in three dimensions: the organization, patient care unit and individual nurse thinking. The measure of a lean healthcare organization included 12 factors: *Learning Organization*, *Frontline Involvement*, *Manager Support*, *Mentoring*, *Patient-Centered Focus*, *Visual Management*, and an individual nurse who *Takes Action*, *Solves Problems*, *Reduces Variation*, *Uses Tools*, *Finds Opportunity*, and has a *Mindset* for change.

Diffusion and Lean Thinking

Diffusion of Innovation Theory helps describe how an organization integrates lean methods through its leaders, managers, and educators to the frontline. The FIT Organization dimension fits with two constructs or characteristics of diffusion theory: an *educational system* that supports continual improvement and involvement of frontline nurses as *change agents*, to make decisions in their area of proficiency. Other measures of lean have included similar constructs, specifically Mazur et al.'s (2012) Lean (single/double loop learning)

thinking measure, and the Boyer managerial commitment scale whose *infrastructural support* factor included training and employee empowerment. The FIT Unit section incorporates diffusion theory's description of the *social system*: the unit manager's support, availability of mentor/coaches, display of data so that progress is visible, and a focus on the patient as the customer, i.e., receiver of improvements. The unit factor also has characteristics described in diffusion theory's *communication channels* where knowledge, persuasion, decision, implementation, and confirmation directly affect penetration to the frontline. The FIT Individual section has items that parallel ideas described in Ballé's (2006) lean thinking paradigm. This section's factors identify nurses who take action, use a scientific method to problem-solve, know how to reduce variation in care processes, can use tools of lean, recognize opportunities for improvement and have a mindset for change.

Time in Diffusion of Leanness

Time, as an element of Diffusion of Innovation, was found to be an elusive concept. The s-shaped time curve of diffusion predicts that the early adopters, the first 16% to 34% of the people in the organization, need the leadership and resources to spread the innovation to others. The more acceptance of the innovation there is the more evidence of the innovation's presence should be found over time. Consequently, the longer an organization participates in lean programs, the higher the FIT scores should be.

Although beyond the original intent of this study, the five hospitals were evaluated for their scores on leanness to shed further light on diffusion. To do this, the length of lean programs (years) was compared to hospital scores (Appendix 3); the hospital with the highest scores was ranked 1 and the lowest scores ranked 5 on each factor. Surprisingly, there was not a direct relationship between time and diffusion, rather, other issues moderated the

relationship. For example, the hospital (C), with 2 years of lean had the highest organizational factors scores. The hospital's enthusiastic nurse champion in the quality department, who worked with industrial engineers from a near-by university seemed to be an important piece of their high rankings. The individual FIT factors *Takes Action* and *Mindset for Change* were the highest of all the hospitals.

The second newest lean program (Hospital A) produced comparable second-place FIT organizational scores. Individual FIT scores *Solves Problems, Reduces Variation, Uses QI Tools and Finds Opportunities* were the highest of all the nurses. In this study, then, nurses in hospitals with about two years of lean report the highest Organizational and Individual FIT scores. The hospitals may be at the 16% to 34% tipping point where lean could either diffuse throughout the organization, or subside, depending on the resources provided.

The longest program (4-5 years), Hospital B, was predicted to be the "leanest." However, nurses rated the organizational and unit FIT factors the lowest of the 5 hospitals, with a mean of 3 (neither agree nor disagree). Perhaps this was because it is harder for large organizations to keep up with employee turnover or resources during the economic downturn or direct financial benefits are not seen in frontline improvement programs so limited resources are directed to high yield measures. Alternately, the layers of administration in a large organization may make it hard to impart the personal touch needed to reach the unit level to gain frontline involvement. The second longest program (3-4 years) had the second lowest nurse ratings in the Organizational FIT and the lowest Individual FIT scores. It appears the lean program lost momentum as the system turned its focus to acquiring other hospitals. Clearly, lean and organizational priorities are essential to sustaining improvements.

Additionally, it was thought that a pattern of lean diffusion would be seen from FIT organization to unit to individual; scores would increase showing penetration from top leadership to individual nurses as the hospitals became leaner. If nurses rated the two FIT Organization factors on the low end of the scale, the hospital would probably also be low on the rest of the factors. The unit would be the next area of innovation spread or penetration. Nurses on a unit with an involved, knowledgeable manager would more quickly learn and adopt lean thinking. A manager who provides time and resources for improvement events would affect the amount of lean thinking conducted by the unit nurses, especially problem solving and visual management. Unit scores would be moderate to high only if the organizational scores were high. Finally, the FIT individual section would reflect the last stages of lean penetration. Individual nurses would score high only if the organization and unit scores were also high. However, the ranking within the hospitals did not follow that pattern. The same pattern of high/low scores was found in nine of the 12 factors at all levels. The three exceptions were *Visual Management, Takes Action, Uses Tools* where Hospitals B and D showed strength.

Although the organizational diffusion did not follow the expected pattern of organization to unit to individual, it may be that the diffusion is more iterative or circular. It may be that organizational mission and leadership start the process, then individual nurses become more important as mentors or coaches, or unit managers influence the individual nurses more than leadership. Leaders then reward individual nurses or units to create spread. With organizational initiatives many factors come into play, for example, perhaps in this case a piece of diffusion that may not have been captured in the measure is a concept called valence, or "what's in it for me?" or a similar idea, "what's in it for my patients?" Further use

and research of the measure may elucidate the issues surrounding diffusion. Lean management takes 3-7 years to build and sustain improvements; it may be that the hospitals in this study may not reflect diffusion throughout the organization. Nevertheless, as explained earlier, exploratory factor analysis and instrument development may be guided by theory, but does not depend on theory for its integrity.

Time, Individual Experience and Leanness

As another way of looking at time, lean experience of the individual and of the unit and leanness was examined. Though the original thought was that leanness would increase with time, there is little correlation with amount of lean experience of the individual or the unit (Appendix 4). *Uses Tools* was the only factor that correlated significantly (p=0.4) with the number of years the unit worked with lean or other process improvement. The Phase 2 nurses' focus group comments shed light on this finding; though they see problems and know the lean concepts and tools, the nurses do not think they know how to take action or turn problems into opportunities for improvement.

The years worked as a nurse had three significant negative correlations. FIT factors, *Learning Organization* and *Frontline Involvement* (organization), as well as the *Visual Management* (unit), which suggests that the more experience a nurse had, the less the nurse reported training, coaching, and leadership requests to participate in problem solving. It appears that organizations surveyed focused teaching on the less experienced nurses, perhaps in orientation or internship programs. Alternately, younger nurses may accept lean philosophies and training while older nurses fail to recognize or incorporate the learning into work practices. Less experienced nurses also reported more evidence of visual management

in the form of charts and graphs. Perhaps more experienced nurses had higher expectations or the status of previous improvement efforts was not apparent to them.

The individual's own experience with process improvement programs was significantly negatively correlated with *Frontline Involvement* and *Mentoring*. That is, the more experience nurses had, the less they reported participating in problem solving that affected them. It is possible that once nurses undergo training, they lack direction in identifying projects. As enthusiastic beginners of lean management, they still need coaching and direction to maintain the momentum. It could be that lean appears exciting and challenging when first introduced. Because it requires a lot of effort, nurses find they no longer have interest or energy for the hard work. *Mentoring* addressed unit education programs, coaching and improvement projects; nurses with more lean experience reported less of these programs and projects. Perhaps expectations rise as nurses work with process improvement, so there would be a sense that there are not enough programs, projects and coaches to meet the demand. It is also possible that the institution loses its focus or emphasis on lean and rewards and recognition for lean improvement efforts diminish.

Because lean management takes a long time, the one point-in-time correlation may not fully describe time's effect. Roger's demonstrated that there was not a linear relationship between time and diffusion as evidenced by the s-shaped curve. Consequently, using correlations may not be the best method of statistical analysis. To more fully understand an organizational state over time, serial administration of the FIT measures in the same organizations is suggested.

Between-hospital analysis

Comparing the factor means across the five hospitals proved interesting. An analysis of variances (ANOVA) was performed comparing of hospital means (Appendix 4). The Organizational FIT and Unit FIT factors all were significantly different between hospitals, suggesting that one could determine differences in the hospitals' lean programs. However, the Individual FIT factors revealed no significant differences. This may be because nurses rate high on the individual section only after they are taught to see processes, feel empowered to act and know the tools of improvement. Because incorporation of lean thinking into the frontline nurses' daily routines takes the most time, the scores on the factors in the individual section should be low or inconsistent in the early stages; the hospitals studied may have all been in early stages.

The hospitals differed significantly on the organizational factors *Learning Organization* and *Frontline Involvement* and on the unit level *Manager Support*. The three factors showed a similar significant difference in mean responses. Conversely, Hospital C ranked highest on organizational factors, *Learning Organization* and *Frontline Involvement* and on the *Manager Support* (unit), *Take Action, and Mindset for Change* (individual) ; perhaps because the hospital was in the second year of their journey and had had a year of lean training for the staff. The nurses knew the terminology and the ideology and had a strong feeling about the organization's mission and goals.

Visual management, having displays and charts on quality indicators, showed significant difference between hospitals. The highest, Hospital D, was low on all other factors; this demonstrates that visual management or display of quality indicators was a valued take-away from their quality improvement program.

The nurses in the hospitals did not rank themselves significantly different on the other six factors, perhaps demonstrating that individual lean thinking and unit efforts are relatively consistent with the current state of lean hospitals. While this analysis is beyond the scope of an exploratory study, it does show how the FIT measure may be used to compare and contrast hospitals.

Validity and Reliability of the Instrument

This study used information from three sources to investigate the structure underlying the items related to lean management: subject matter experts, qualitative and quantitative data from knowledgeable frontline nurses, and data from frontline nurses.

Content Validity. Content validity is established when experts judge that a sample of content accurately captures and measures a domain. A particular strength of the study is the type of panelists used and their substantial inputs. High-level lean experts were recruited from consulting, administration, nursing and medical practice, quality improvement and research arenas. The experts' input confirmed that the researcher's conceptual framework was reasonable and could serve as a starting point for measuring lean. The panelists' descriptions of lean management encompassed not only physical features on the unit but also thinking patterns that frontline nurses would demonstrate in a lean unit. Additionally, expert panelists depicted a lean organization of leaders who communicated the vision and mission of patient-centered, waste-free care. They described managers who were involved and informed enough to stimulate new ways of thinking about processes and doing the work. Finally, the experts discussed the availability of educators and resources to support improvement ideas.

The experts said individual nurses in a lean hospital would know how to draw a process map and use it to find new ways to increase time with the patient. The nurses would look for things that unnecessarily cost the patient money, time, and physical comfort—i.e., anything described as 'waste' in lean thinking. Additionally, nurses would describe the unit as efficient; it would have processes in place to provide readily available supplies and maintain functioning equipment. Nurses would have time to work on creating value for their patient-customer.

As the panelists' ideas progressed through the three rounds, lean jargon proved troublesome. Since lean is a relatively new concept, nurses may know the ideas, but not the terminology. To address the concerns of the experts, lean terminology was placed in parentheses to explain an item. For example, one item read: "I know to inform the patient… of the expected routine (standard work) for the day."

The sheer magnitude of ideas the experts presented for consideration presented a challenge. The main goal of the first phase of instrument development and testing was to attain data saturation, but a long list of items creates a burden for experts. The focus groups and electronic responses of nurses in Phase 2 provided a vast amount of information that helped with item revision by explaining how and why the data grouped as it did. Nurses said the measurement tool generally asked the right questions. However, because the nurses had to answer questions in a way that reflected their unit's current condition, some items may have had lower scores than had the nurses not been asked to describe their particular unit. The face-to-face discussions of the focus groups helped bring the problem to the surface so that it could be clarified. A specific example was seen with the item (unit level) "Medication errors and near-misses are always reported and investigated." Nurses said they knew about

medication error-reporting and the organization had a system of reporting, but the culture of the organization and unit was that near-misses would never get reported, and only major errors were formally documented. Consequently the content was ranked highly relevant, but when asked the question for "lean penetration," the item had low Likert scores so was eliminated.

The focus groups also shed light on lean thinking within particular organizations in a way that was not exposed in the electronic surveys. Because the nurses were grouped by hospital, the discussions often surrounded hospitals' practice, their education systems, their orientation to lean management and leadership's role in establishing a culture of quality improvement. The discussion helped identify how much lean management was used. For example, some nurses reported that the hospital practiced lean management; however, the organization did this by teaching lean tools for quality improvement in the nurses' orientation program. The nurses did not see it in other ways on the unit, with continuing education, or in nursing competencies.

In the pilot testing, nurses tended to agree that in ideal settings, there would be no waste, resources would be plentiful, and there would be zero defects in care. They generally reported that they had a basic knowledge of lean and its associated skills. However, they felt that their lean education left them in a quandary about how to use the tools, see opportunities, prevent cross-system errors, eliminate waste, conduct experiments and generally benefit from lean thinking. These comments and concerns by nurses explained why certain items dropped out when submitted to exploratory factor analysis (EFA).

Reliability. Nurses who took the FIT survey instrument were asked to give their email address so that the same survey instrument could be re-administered. Test-retest

reliability assumes that the test-taker and the construct remain the same, so differences in values are related to common error (Pett, Lackey, & Sullivan, 2003). The kappa and Pearson's R correlation were used to help determine reliability or stability of the instrument. Furthermore, the study reported the Cronbach's coefficient alpha, the average of all possible split-half reliability coefficients (Pedhazur, 1991; Pett, Lackey, & Sullivan, 2003). The reliability estimators used in the FIT study had both advantages and disadvantages. Though alphas were acceptable for a new instrument, kappas and Pearson correlations were low. The assumption of kappa statistics is that the data are nominal or categorical (Feinstein & Cicchetti, 1990) appropriate for an item-level Likert scale. The kappas in this study ranged from 0.17-0.37, making them "fair" at best. In contrast, Pearson's product moment (Pearson's R) assumes that the data is continuous--appropriate because Likert data are treated like continuous data at the total (factor) score level. Values ranged from 0.28 to 0.70, with the lowest scores in three of the factors identified in the individual FIT.

Because the 118-item survey instrument took about 20 minutes to complete and "individual" items were placed in the middle of the survey instrument, raters may have experienced test fatigue with resulting inconsistency of responses. Other explanations may be that individual nurses may not have considered their lean skill level prior to taking the FIT survey, or that the items in the measure were not those they typically thought about during patient care. The 2-week period between survey instruments allowed them to consider how they thought about lean problem-solving and opportunities for improvement. Consequently, their scoring would be expected to be different on the re-test.

Although the instrument's poor stability is a weakness, this weakness may be related to methods--sampling a population that is over-surveyed, offering inadequate incentives, and

being a student-led study. There are many reasons for getting a smaller than desired sample size. Some nursing research directors said they do not take a risk with unknown researchers; they commented that they rarely hear about the results from student researchers. Additionally, one director thought instrument development studies are especially prone to failure. Furthermore, several hospital committees said they protected their nurses from the inundation of surveys coming from outside their system. Thus, stability is only a minimal limitation. The successful completion of this study now presents an enormous opportunity to gain a larger sample size which would increase the psychometric value of the instrument.

Criterion-related validity. One form of validity is criterion-related validity, which is assessed by comparing the performance of operationalization of the (leanness) concept against some criterion. Because hospitals use lean in many ways, in different parts of their structure—such as quality or operational efficiency departments – there is a wide variation in what makes an organization lean. In addition, hospital databases tend to be treated in a highly confidential manner. It was therefore difficult for the investigator to use 'leanness' as a known entity to triangulate the data.

Moreover, since there is no publically accessible database that tells which hospitals use lean management, it was difficult to identify hospitals. There are vast differences in hospitals that called themselves lean. Consequently, the following investigator-imposed "rules" were used: 1) hospitals that had published their findings or were described by lean groups such as the James Womack group, Lean Enterprise Institute (LEI) the organizations with the most 'leanness', 2) Also, if a hospital had a lean training institute (in the TPS tradition) the hospital was considered very lean. 3) A lean hospital would be one represented at conferences such as the Lean Transformation Summit, the Improvement

Science Research Network (ISRN), the Academic Institute for Improvement (AHI) and the Institute for Healthcare Improvement (IHI). Thus, the researcher sent letters to CNOs from these hospitals, presented posters and recruited at conferences to find the hospitals that were presenting programs on their lean improvements. Despite these efforts, in the end local and personal references proved to be the most fruitful sources of lean hospitals and their nurses.

Even after lean hospitals were identified, nursing research directors and committees had policies and procedures that were hard to find, let alone overcome. IRBs presented yet another barrier. Each hospital and university had a different method of application; some required only the original research approval from the investigator's IRB, while others required a local contact to be co-investigator. It was also difficult to get information out to the nurses. Ideally, an electronic newsletter or web page with the link brought nurses to the study's survey. However, even some large hospital systems that put out the link got no responses from their nurses. An especially frustrating experience occurred when a hospital website was spammed and that survey link received hundreds of responses with unusual emails sent within minutes of each other, similar to the spamming of the nurse.com website.

Eliminated Items

In the factor analysis, 36 items were eliminated. One organizational item that did not make it into the final FIT survey was "There is not a system of reporting unsafe practice." A great majority of the nurses, 83% (*n*=177), reported that they strongly agreed or agreed that there was not a system to report unsafe practice. Likewise, the unit item, "Medication errors and near-misses are always reported and investigated" was deleted. A lean hospital that seeks to measure quality would want to have a system to make errors transparent. However, in this exploratory effort, analysis focused on shared variance--that is, whether or not an item

was strongly agreed upon, what was important was that it shared the same characteristics in describing a concept. This particular item shared less than 0.21, below the 0.35 cutoff. Another organizational item was "The nurse champions for change are rewarded and recognized," which loaded almost equally on both frontline involvement and organizational learning, so though recognition is important in lean management, the item was eliminated.

In general, the nurses thought traits of their unit managers were important in a lean organization. Curiously, the one item that addressed psychological safety, "I feel comfortable reporting errors to the unit manager," did not factor high enough to be included. Yet, 168 nurses (84%) who answered the question indicated that they strongly agreed or agreed that they felt comfortable. However, because the item loaded on three factors, it was eliminated.

Systems thinking is another concept described in the quality improvement literature, so two items were included in the survey; one fell out. The individual nurse item, "I think it is important to find out why the system, not the person, created an error," held together with the "Take action" factor, but a second item "I understand that a system, not an individual, is the source of many problems," was discarded because it loaded on four factors.

One way of thinking about improvement is a concept called "The Five Why's." To get at the root cause of a problem, one asks why five times, to work beyond a seemingly obvious answer. Several items addressed the "why" concept, including "Ask why work is done as it is currently carried out," "Repeatedly ask 'why'—for example, why inventory is stored here, why we care for patients in this way." Two items were kept, but three were discarded. On face value, one would think the items would have held together as a factor; but, again, they shared variance with others.

Strengths and Limitations

Two limitations of the study, discussed above, were difficulties identifying lean hospitals and attaining a large enough sample. In retrospect, another limitation may have been the decision to develop a scale (reflective perspective), as opposed to an index (formative perspective), to describe latent variables. Each uses different procedures for retaining or excluding items (Diamantopoulos & Siguaw, 2006). Because scale development is widely described in the organizational literature but index formation has been relatively ignored, the decision to use a scale was one of default rather than calculated reasoning. Diamantopoulos and Sigauw (2006) suggest that the scale versus index decision does not affect error in a study except in making decisions on item retention. In index construction, items are retained as long as they have distinct influence on latent variables; low correlations are expected. In contrast, scale correlation matrices group like items together so high correlations are preferred (Bollen, 2006; Diamantopoulos & Siguaw, 2006; Fayers & Hand, 1997). Consequently, this may have contributed to lower test statistics than desired. Further exploration of how items are dropped or retained may be warranted.

The strengths of the study included the expert panel and the pilot study feedback which captured a range of nursing related lean and diffusion concepts. Another strength of the study was the idea itself; this was the first-attempt to develop a lean management hospital measure. Typically consultants in the private sector have used their own proprietary formulas and methods for assessing organizations. This study places assessment and measuring in the public and academic domain. Measuring lean hospitals in a systematic way can pave the way for further lean research. By discerning what the constructs of lean management look like on

the frontline, investigators and administrators can measure the progress of their programs or the current state of lean management.

Future studies based on the FIT measure could use the concept of "going to the gemba" (workplace), an idea taken from lean methodology, to observe why the scores on the measure are what they are. As a leadership initiative, this technique would use the "five whys" to ask the nurses about the specific FIT items. For example, why the nurses report having/not having champions, mentors, managers that support them or why they do/do not carry out improvements.

Additionally, size of the hospital appeared to affect leanness. The smaller hospitals had higher organizational scores than the larger ones. More research is needed on the relationship, and it is one way the FIT measure can be used in future research. Further study is also needed on such mitigating influences such as the resources available for sustaining lean programs, the effect of nursing turnover and presence of lean in orientation programs for new nurses. The instrument can be used to address these issues.

Conclusion

The importance of assessing the state of quality improvement thinking in nurses cannot be overemphasized. Change in practice is not easy and the need for change is not always obvious. Comparing hospitals helps leadership see where their organization ranks in overall performance. Comparative data often serves as a stimulus for poorly performing hospitals or units to improve outcomes. Evaluating units within the hospital identifies areas to focus resources and programs for team alignment with organizational strategic priorities. Tracking changes in unit performance after implementation of a lean intervention may give insight into quality of care. Understanding the individual nurse's thinking provides a way to

identify mentors and coaches as well as change agents. Measures are a means for encouraging improvement or may be tools for monitoring performance. The FIT instrument has the potential to provide such a service to hospital leadership.

Measuring the success of a lean improvement program requires picking an environment at a point in time, and 'taking the temperature' of the conditions at that point. One way of measuring is to find the person who makes contact with the organization's final 'product'—the patient—to see if the organization's lean management, or other quality improvement, initiative has reached the point of care. Since nurses are at the hub of patient care activities, asking nurses who have contact with the customer to report on improvements gets at the essence of lean philosophy, i.e. to provide value as defined by the customer. Because this instrument incorporates widely used quality improvement terminology, it can be used to assess not only lean management, but also the current state of general quality improvement. Each item and factor addresses key elements of improvement thinking; consequently a score on an item or factor gives ideas about specific opportunities for enhancing quality efforts. Scores on the items provide a focus for educational programs. A baseline assessment followed by yearly assessments may help organizations or units enact strategies that ensure improvement efforts are sustained. The FIT instruments addresses the organization, unit and individual levels and is an early effort to capture the quality of leanness and, by extension, lean penetration to the frontline.

Appendix 1. Ideas from Literature and Experts

#	Experts' Response (121)	Literature (76)
1.	The degree to which processes are internalized is critical to adoption of lean strategies.	The starting point of lean initiatives could be: Value stream mapping, lean baseline assessment, mass training, the basic building blocks of lean, and a pilot project, change management, analysis of internal overall equipment effectiveness and losses.
2.	Ownership of the process (involvement/participation) is important.	Steps: Assess current state, determine target state, stabilize the operations, optimize the opportunities, and institutionalize the lean approach.
3.	Desired result would be that delivery of care is safe, reliable and happening with continuous flow.	Lean is quality improvement through building in quality 100% at the process rather than inspecting it in later.
4.	On a lean unit, nurses would think in a more systems way, to identify processes and be ready to work on a team to improve the process.	Design work to capture existing knowledge and building in tests to reveal problems.
5.	Improvement starts with value stream mapping the current state of a process then analyzing the current state.	Optimizing the performance of an individual are is insufficient; the entire process flow between units must be improved for sustained performance.
6.	An A3 must include every department involved, not more silos or pointing fingers.	Steps: Specify value, identify the value stream, establish flow, respond to demand (pull) and pursue perfection.
7.	It is important to map out the processes	Rule-based methods are powerful to reliably deliver best practices. Judicious process improvement, by elimination of waste, frees time and resources for decision making, reflection and discovery of unique patient goals central to excellent patient care.
8.	It is important to identify the process for maintenance or accountability, for auditing and continued observation and data collection.	

#	Experts' Response (121)	Literature (76)
9.	Need a standard method of addressing problems in everyday work, not just in kaizen or rapid improvement events.	
10.	Identify where variation exists	
11.	Standard work drives out waste and errors—a specific approach is needed.	
12.	Nurses are lean thinking if they are aiming to remove waste	The longer an article (patient) is in the process and the more it is moved about, the greater is its ultimate cost.
13.	5S can help drive out waste sorting, weeping, simplifying, standardizing, sustaining.	There are conceptual and operational benefits of framing the problem as "too much waste" rather than "too little efficiency"
14.	Kaizen and other activities may be alive and well, but the true drivers of waste are left untouched because they are harder to do.	Cost reduction through waste elimination: anything other than the minimum amount of equipment, materials, parts and working time absolutely essential to production are merely surpluses that only raise cost
15.	Elimination of waste in all forms: wait time, duplication, overstock, processed with no value added; think about elimination of waste in its broadest application.	Collapsing the lead time closer to the actual processing time by squeezing out non-value adder time and tasks results in both cost and time reductions.
16.	Removal of waste is the first and foremost principle of lean thinking	Lean production focuses on continuously transforming waste into value from the customer's perspective. It provides a rigorous systematic approach to process improvement, error-proofing and waste reduction.
17.	Nurses and leaders start seeing all steps in their process in term of wastes, then work to remove waste.	Do not tolerate waste but learn to recognize and relentlessly pursue value.
18.	Finding waste frees nurses to focus on quality care.	Inventory is not an asset, but a cost or waste

#	Experts' Response (121)	Literature (76)
Use of Scientific Method for Problem solving as part of everyday work.		
19.	Lean production focuses on continuously transforming waste into value from the customer's perspective. It provides a rigorous systematic approach to process improvement, error-proofing and waste reduction.	Less about "leaning out" every process, more about seeing problems, solving them the right way increasing the intellectual capacity and skill of all members
20.	Do not tolerate waste but learn to recognize and relentlessly pursue value.	Use the proven plan-do-check-act methodology for deploying improvements-- both incremental and breakthrough.
21.	Inventory is not an asset, but a cost or waste	4 main points of deployment: Identify problems, solve problems, develop the individual, establish a system of training
22.	Identify the issue rather than complaining	Identify problems
23.	Develop countermeasure and implementation plan	Solve problems
24.	Test and follow-up plan	Develop the individual
25.	Use problem solving to remove and obstacle or threats in the work	Establish a system of training
26.	Have a scientific approach to implementing changes: test incrementally.	Every employee works on problem solving with guidance of a coach.
27.	Willing to undertake real-time root cause analysis of waste and errors, coincident with a determination to find a process answer, not a person as the cause.	Confronting problems is strongly embedded
28.	The nurse who recognizes an obstacle to safe, continuous flow of work would stop, use a standardized method to devise and test a better way to work, instead of working around the obstacle or reporting a problem to someone else to fix.	Managers learn not to work-around a problem with a quick fix and instead sort out the fundamental issue.
29.	Mis-dosing should never occurs and near-miss opportunities would be visible tracked in the pursuit of problem-solving	Improvements are not immutable fixes but experiments that can be revisited and adjusted as the work flow indicates.

#	Experts' Response (121)	Literature (76)
30.	Nurses question the process; they constantly ask "why"-why are we ordering so much why is inventory stored here, why do we care for patients in this way.	Creativity before capital, include team brainstorming of ideas
31.	Nurses are proactive in solving problems	
Training		
32.	Leaders are fully trained and supportive	Strategic aim: empower senior nurses and ensure they have the appropriate knowledge and expertise
33.	Lean education and training for frontline workers.	System of training where every manager has a coach who, in turn, coaches the frontline.
34.	Lean instructors have to dig much more deeply into how information is managed and mistake-proofing promoted	Implementation of lean thinking at the organization level can be achieved by strategic training of relevant staff members.
35.	Lean trainers need to take the time to make the deep connection between beliefs and actions—if I believe it will make a difference, I am much more likely to engage in the activity	Education and training in lean thinking should be measured according to 'belt' levels.
36.	Being educated in Lean thinking creates an awareness of work arounds, do-overs, and things that get in the way of doing the very best work we can to deliver the very best care we can.	Deploying...is about how many managers, supervisors and team leaders have been trained by a sensei and can start training people on their own.
37.	Standard training for all is required	Less about "leaning out" every process, more about…increasing the intellectual capacity and skill of all members
38.	Lean systems require training and involvement of all personnel-in particular those closest to patient care.	Make it evident who is championing the program.
39.	Lean coaches should be available to everyone	
40.	Super-user staff coaches are helpful.	
41.	Frontline involvement/ empowerment	

#	Experts' Response (121)	Literature (76)
42.	Lean thinking can occur in any area of the healthcare organization by any worker, from administration to frontline staff	The real work begins when the new process knowledge is disseminated throughout the organization and when frontline workers, under the guidance of a coach begin to call the shots on what to improve
43.	Lean has to include participation from those doing the work	
44.	All work design is done as a response to or in anticipation of a problem by the people who do the work.	
45.	Frontline workers being given the authority to identify problems and address them in the course of everyday work	
46.	Frontline identification of barriers to delivering excellent patient care and eliminating those barriers	
47.	The (frontline) nurse on an advance lean unit would initiate problem solving work as s/he sees necessary	
48.	Small savings add up in a day, allowing the nurse to spend more time with patient, paperwork, or simply reduce his/her stress level.	
49.	Nurses on lean units feel empowered to make small changes without checking with their boss and to make suggestions regarding improvements.	
Mindset or understanding		
50.	Recognizing work-around and "the way we have always done it" and addressing them head-on.	The lean improvement perspective has stimulated multiple innovations and has provided the discipline to implement others.
51.	Where "good enough" never is	Core values: empowering workers, maximizing efficiency, heeding customers, rigid adherence to quality and standards, evolution, innovation, asking why.

#	Experts' Response (121)	Literature (76)
52.	Lip service is given to PDSA; too many treat Kaizen events as a one-time fix without incorporating the deep understanding of continuous improvement through testing.	A cocktail of factors are needed for lean success
53.	Lean thinking requires asking "what would it take to…?" rather than a negative complaint.	Lean is a developed practice, not a theoretical philosophy or set of tools. Not a codified body of knowledge; it's the cumulative behavior and experience of the people who practice the system.
54.	Lean has to become a new way of thinking and approaching work processes. It becomes the work rather than layer on top of previous work processes or "ways of thinking"	Health care and TS share the challenge of producing highest quality products (clinical outcomes) within an environment of constrained resources, managing complex business operations, assuring safety and satisfaction of both workers and customers (patients). Both industries need highly reliable systems that ultimately lead to higher quality and greater safety, efficiency and appropriateness.
55.	Lean is not another "thing" nurses do. It is only effective when it is recognized as a way to think and look at work differently, all the time, every day, in every kind of work.	Lean thinking requires continuous elimination of waste or non-value-added elements from processes so that customers or patients are given ever greater value.
56.	Changed thinking includes demanding a higher reliability in our work, taking time to notice or "see" inefficiencies and errors so they don't happen over and over.	5 principles of lean: identification of customer values, management of the value stream, developing a flow production, using pull techniques, striving for perfections.
57.	There must be an understanding of lean philosophy and methodology and Value stream mapping that will help to organize efforts (i.e. when to use which tools) to get from the current state (which everyone deeply understands) to a future state (what everyone wants it to look like)	Application of lean thinking in health care lies in eliminating: delay, repeated encounters, errors and inappropriate procedures.

#	Experts' Response (121)	Literature (76)
58.	Lean is not a toolbox, but a concept and better way to look at work that can be applied to everything they do for truly continuous improvement.	Build the performance mindset: establish the standard method, track performance, make problems visible, teach basic work analysis, develop employees through solving problems or improvement tasks
59.	People get bogged down in the debate of methodology versus principles. Presence of lean tools does not mean you are lean.	A facility that embraces lean thinking views every employee as an asset.
60.	Lean is methodical and comprehensive, not a quick fix. It is incremental change leading to the ideal state.	Lean thinking is the practice of starting, not with a potential solution, but with the development of a detailed understanding of how a complex process works.
61.	When a unit becomes Lean, nurses suggest A3s indicating they understand the value of the methodical lean approach.	Lean includes developing within each employee a "kaizen consciousness."
62.	Lean requires establishing the belief in personal control, social norms and organizational support.	Lean is a never-ending journey.
63.	A key concept is to deeply understand the current condition before making changes.	Lean has a major strategic significance through its implementation, HR implications, general approach to suppliers, universal conviction as tactics rather that philosophy.
64.	Everyone in the organization should understand the lean philosophy and methodologies.	
Management and Leadership		
65.	Changes might not be perfect, but need modification. This requires flexibility, compromise, follow-up, persistence of staff and leadership.	Leaders move away from rigid command and control, away from "project by project' increments and toward arming frontline workers with the tools they need to improve their work every day.
66.	If management puts visual cues and demand flow inventory systems in place, they must be used by the staff to be effective.	Promote lean leadership at all levels (observed by the number of lean metrics at all levels).
67.	Leadership at hospitals struggles to free nurses to engage in the improvement process.	While leaders set the vision, priorities, processes and measures, the real action occurs on the frontline of care, not in the C-suite.

#	Experts' Response (121)	Literature (76)
68.	While many leaders accept vacation, PTO, they are less accepting of paying nurses to find opportunities for improvement.	A strictly top-down approach would be at odds with a more nuanced lean approach, which is led from the top down, but relies heavily on frontline feedback to adjust direction (bottom up)
69.	Leadership must help nurses understand what is in it for them. Link it to local win-win.	Leaders...emphasize the importance of creating an organizational culture that is ready and willing to accept lean thinking.
70.	Middle management understanding of lean is important.	Managers must have discipline to learn, practice correct behaviors, to understand the system-level implications of their actions, and unlearn political behaviors.
71.	A lean champion at the administrative level is important.	Managers become mentors and coaches, helping bridge organizational boundaries
72.	Administrative involvement and buy-in is important.	Top management and leadership support at both national and organizational levels is critical to achieving successful and sustainable improvements of any kind.
73.	Adoption of lean requires that managers use lean principles to run staff meetings, and evaluate performance.	Senior nurses who are involved in targeted or problem areas are in the best positions to initiate, implement and achieve such improvements.
74.	Lean principles must be incorporated into leader standard work.	Senior managers must recognize that organizations are a compilation of operations and processes that ultimately deliver value to a customer in the form of a product or service.
75.	If lean principles are used to run staff meetings, evaluate performance, to coach on a daily basis, and are incorporated into leader standard work, then there is a chance at real adoption of the new system.	Lead by developing knowledge in work design and testing, swarming and solving problems and sharing new knowledge at every level.
76.	The degree to which managers embrace lean and get their staff on board makes a huge difference.	
77.	No difference in outcomes will occur if there are cynical leaders who do what is necessary to play the game, but have no commitment to the philosophy.	

#	Experts' Response (121)	Literature (76)
78.	A nurse on an advanced lean unit would use the word "we," not "they," when referring to leadership.	
79.	Managers promote "unroofing" of problems by requesting A3s or similar and having mechanisms for scheduling teams to make improvements.	
Stop-the-line		
80.	Willingness to stop-the-line is one of the most important behavioral factors	Swarm (stop the line) and solve problems to create new knowledge.
81.	The nurse would stop the line and know someone would respond immediately on a lean unit.	The commitment to producing zero defects led to a stop the line policy in which production stops when a defect or delay is detected to prevent customer or coworkers from experiencing adverse consequences.
82.	Lean thinking nurses would stop the line, find the root cause, and determine how to prevent a problem from happening again.	Improving performance is the first goal, not implementing tools for the tools' sake.
83.	Unless the nurse is looking for needed supplies in a critical event, and can find it now because of 5S, I do not see these tools greatly impacting quality of care.	Lean thinking builds directly on the PDCA cycle of CQI but adds tools to identify and transform waste, supplies, metrics of timing and resources and most important, focuses intently on the creation of value as defined by the customer
84.	Too many units focus on tools without taking on the hard work of developing a culture of high expectations.	Critical tools include rapid process-improvement workshops, Kaizen events and the patient safety alert system, among others.
85.	Focus on tools without the commitment to changes in thinking is discouraging.	
86.	On a lean unit ideas for kanban, inventory control, visual cues, reliable handoffs, and easily identified standard work would be forthcoming regularly.	
87.	Tools are ineffective if placed on the unit by outsiders, without commitment on the part of staff.	

#	Experts' Response (121)	Literature (76)
88.	Labels on drawers and cabinets indicate lean thinking, but are not a good measure of spread—non-lean units can label.	
89.	Standard lean implementation is tools-based; staff needs to know why and when they work.	
90.	Having tools in place does not assure compliance or mean waste has been removed.	
91.	Lean is an entire package; understanding + tools.	
92.	Lean tools do not have a direct impact on quality of care; they improve efficiency.	
Environment/ Culture		
93.	On a lean unit, items would be at hand. The nurse would not have to leave the patient room to get supplies; she would enter the room with them in preparation.	Create an environment where people have to think which brings with it wisdom and this wisdom brings with it kaizen (continuous improvement).
94.	Everyone in the organization needs to know results of work being done; a report out mechanism assures this dissemination.	Nurture a learning environment
95.	A culture of high expectations such as being willing to call out mistakes, errors, omissions, redundancies.	Internal capability needs to be developed in organizations which will help develop a 'systems thinking' culture that is required for continuous improvement.
96.	The appearance of anticipating a patient need is achieved by having a solid system in place.	Need to have a culture change from "the way we do things here." To that in which observation, inquiry, improvement and teamwork in pursuit of quality become automatic.
97.	Nurses need to understand their "helping" culture leads to errors-it takes over a small fraction of a process and safeguards are removed.	Culture requirements: Make decisions at the lowest level, clarity of vision—and indication of what the organization believes it will look like once the transformation is complete. Ensure there is a strategy of change where the organization communicates how the goal will be achieved.
98.	Culture has to change so fear does not dictate actions.	

#	Experts' Response (121)	Literature (76)
99.	Too many hospitals, even those using lean tools, are afraid to show their problems.	
100.	To measure lean thinking, ask nurses how many improvement projects they suggested, are involved in now and in the past year	Improve customer service by reducing response time
101.	Ask nurses how their manager responds when they bring a new idea forward	How can I please my customer by delivering to them exactly what they want, exactly when they want it, in the right quantity at the highest quality and the lowest cost?
102.	See whether problems are tackled by committees and task forces or in rapid improvement events	
103.	Measure how many problems are analyzed using A3 thinking: an analysis of the problem and an offer of countermeasure or solution.	
104.	Data provided back to the staff reinforce gains from the new systems—data from patients, How did the new system make a difference for patient?	
105.	Let a unit set its own goals and standards	
106.	Lean is best measured by behaviors and actions that the staff demonstrate on a daily basis	
107.	Specific order of measures: Safety, Quality Delivery, and Cost. This reinforces the real focus.	
108.	Face-to-face time nurses spend with patients as a percentage of total hours worked.	
109.	Other metrics: involuntary overtime hours, on-call hour, patient outcomes.	
110.	It is important to identify meaningful metrics.	
Value for the patient as customer		
111.	Customers desire nurses who care, who seem to anticipate every need and who reassure them.	The customer is "that individual that monetarily pays for the product or service.

#	Experts' Response (121)	Literature (76)
112.	On a lean unit, patients would know who their nurse is, when that nurse will be in the room (frequency) and the expected routine (standard work) for the day.	Systematically and continuously focus on the customer.
113.	Improvements are patient-centered, not benchmarked.	Work must focus on customer needs. Give workers tools to address problems. Address problems one by one. Support a blame free workplace. Teams that apply scientific method to test work design, provide workers with a help chain up to and including managers.
114.	Nurses are thinking lean if everything they do is for the patient	Value added expenditure of resources from the customer's viewpoint. Give customers what they want, when they want it, where they want it, at competitive price, in the quantities and varieties they want, of expected quality.
115.	Getting nurses to see that what is being done is for the patient's benefit is one of the most important factors in lean thinking.	
116.	Staff in a hospital, from nurses to housekeeping, remembers that what they are doing is for the patient, the steps they take and outcome they reach are likely to be more desirable and meaningful.	
117.	Lean is a team effort with the entire team working toward ideal patient care.	
Incentives/Benefits		
118.	Find incentive and reward systems for staff participation.	Promote lean thinking: make staff members aware, and gain their approval, of its potential benefits
119.	Paid time to apply the principles is important	
120.	Financial support to implement the new lean ideas is important.	
121.	Cost is an outcome…this is not a motivational concept for improvement.	

Appendix 2. FIT Survey and Instructions

Dear Colleague:

Because we are concerned with the current state of health care delivery, we are conducting a research study focused on how nurses change the processes that improve patient care in the hospital setting. We have identified hospitals that are known for their lean management improvement initiatives and are hoping to identify over 300 nurses that would be interested in participating in the study by completing this on-line questionnaire.

This on-line questionnaire asks you to evaluate how the hospital, patient care unit and nurses use lean management improvement thinking or how they find it in their environment. It will take about 25 minutes to complete the questionnaire and your answers are anonymous.

If you are currently working in a hospital and provide direct patient care, please follow the internet link below by clicking on the link to find the survey. Viewing the survey does not commit you to completion of the questionnaire. You may stop at any time.

At the end of the questionnaire there is a section to create a unique identifier if you would be willing to answer this same survey a second time. This would help with the assessment of reliability of the questionnaire.

After you submit the questionnaire, there will be an opportunity to receive a $15 gift card electronic link when you enter your email address. The email address will be kept separate from the survey data.

Thank you for considering participation in this study.

Sincerely,

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Mary R. Lynn
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FRONTLINE IMPROVEMENT THINKING

Lean management, a type of continuous quality improvement that uses work flow re-design, is one method of improvement that shows promise for health care.

To better understand improvement thinking, it is helpful to know how nurses use lean management or how they find it in their environment.

Review each of the following statements and, using the 5-point scale, indicate the extent to which these items are descriptive of you in your work situation or in your workplace.

Use the following scale when responding to the items:

If you	*strongly disagree*	the item is descriptive of your work or your work situation, circle SD.
If you	*disagree*	the item is descriptive of your work or your work situation, circle D.
If you	*neither agree nor disagree*	the item is descriptive of your work or your work situation, circle N
If you	*agree*	the item is descriptive of your work or your work situation, circle A.
If you	*strongly agree*	the item is descriptive of your work or your work situation, circle SA.

The following statements describe the <u>organization</u> in which I work:

1.	The mission of the organization helps guide change.	SD	D	N	A	SA
2.	The organization stresses that change is important.	SD	D	N	A	SA
3.	A hospital leader comes to understand the problem.	SD	D	N	A	SA
4.	Leaders include frontline staff like me… to problem-solve.	SD	D	N	A	SA
5.	Nurses who know the processes are involved.	SD	D	N	A	SA
6.	There is not a system of reporting unsafe practice.	SD	D	N	A	SA
7.	Champions for change are recognized and rewarded.	SD	D	N	A	SA
8.	Expected to attend classes … to improve processes.	SD	D	N	A	SA
9.	Need to identify opportunities for improvement.	SD	D	N	A	SA
10.	Encouraged to get training on improving processes.	SD	D	N	A	SA
11.	Have opportunities to learn about process improvement.	SD	D	N	A	SA
12.	Everyone has access to a coach	SD	D	N	A	SA

As a nurse on a patient care unit I:

13.	Understand that a system, is the source of many problems.	SD	D	N	A	SA
14.	Ask "what would it take to…" rather than complain.	SD	D	N	A	SA
15.	Change is frequently needed to improve care.	SD	D	N	A	SA
16.	Important to know how other units carry out their work.	SD	D	N	A	SA
17.	Understand that thinking…opens up new ways of solving it.	SD	D	N	A	SA
18.	I can save time …if problems are worked on as they occur.	SD	D	N	A	SA
19.	… not important to perform care similar to nurses on unit.	SD	D	N	A	SA
20.	… not important to perform care similar to other nurses in the	SD	D	N	A	SA
21.	…compare it to the protocol to see if there is a discrepancy.	SD	D	N	A	SA
22.	… if “work-around” find a permanent solution.	SD	D	N	A	SA
23.	Savings of time add up to allow time with the patient	SD	D	N	A	SA
24.	Feel comfortable reporting errors to the unit manager.	SD	D	N	A	SA
25.	Know that it is important to include other departments	SD	D	N	A	SA
26.	Follow-up on audits is important to improving care.	SD	D	N	A	SA
27.	Ask “why” repeatedly to get to the root cause	SD	D	N	A	SA
28.	Process improvement work can cause positive	SD	D	N	A	SA
29.	Procedures to describe nursing work processes	SD	D	N	A	SA
30.	Look at how care is currently delivered and make it better.	SD	D	N	A	SA
31.	Find opportunities to improve care every work-day.	SD	D	N	A	SA
32.	Identify ways to make patient care safer.	SD	D	N	A	SA
33.	Compare care to how my co-workers perform care.	SD	D	N	A	SA
34.	Sketch out a diagram of how it is currently carried out	SD	D	N	A	SA
35.	What actions and “hand-offs” occur during patient care.	SD	D	N	A	SA
36.	Ask: 'How else the work could be done?	SD	D	N	A	SA
37.	Ask “why” work is done as it is currently carried out.	SD	D	N	A	SA
38.	Am able to carry out improvements on the nursing unit.	SD	D	N	A	SA
39.	Work on quickly-fixed problems	SD	D	N	A	SA
40.	Understand that process analysis improves the care I give.	SD	D	N	A	SA
41.	Uses process analysis forms (such as A3 forms).	SD	D	N	A	SA
42.	Look at the process from start to finish	SD	D	N	A	SA
43.	Call managers to an area (stop-the-line) during a shift.	SD	D	N	A	SA

As a <u>nurse</u> on a patient care unit I:

44.	Remove obstacles to providing optimum patient care.	SD	D	N	A	SA
45.	Improvement of care requires a plan	SD	D	N	A	SA
46.	Confront problems, not ignore them.	SD	D	N	A	SA
47.	Continually think of different ways to perform better care.	SD	D	N	A	SA
48.	Find the cause of a problem or error as soon as it happens.	SD	D	N	A	SA
49.	Find out why the system, not the person, created an error.	SD	D	N	A	SA
50.	Am aware of 'work-arounds', 'do-overs'	SD	D	N	A	SA
51.	Continually find ways to make patient care better.	SD	D	N	A	SA
52.	Do not know what other units are doing to improve care.	SD	D	N	A	SA
53.	Use a methodical, written, approach to communicate	SD	D	N	A	SA
54.	Ask “why”- for example why we care for patients in this way.	SD	D	N	A	SA
55.	Patient satisfaction scores measure value-to-the-patient.	SD	D	N	A	SA
56.	Understand that everything I do is done with a patient focus.	SD	D	N	A	SA
57.	Inform the patient of (frequency) and routine	SD	D	N	A	SA
58.	Change of thinking to make care error-free.	SD	D	N	A	SA
59.	Need to look for ways to improve current patient care.	SD	D	N	A	SA
60.	Look for ways to keep the patient from waiting.	SD	D	N	A	SA
61.	Return over-stocks of supplies back to central distribution.	SD	D	N	A	SA
62.	Eliminate things that cause delay, repeated encounters, errors and inappropriate procedures.	SD	D	N	A	SA
63.	Transportation, inventory, motion, and waiting can be targeted for improvement.	SD	D	N	A	SA
64.	Keep from searching or going back for needed items.	SD	D	N	A	SA
65.	Reduce waste in wait time, duplication, overstocking and over-processing	SD	D	N	A	SA
66.	Eliminate waste in patient care.	SD	D	N	A	SA
67.	Increase time with the patient.	SD	D	N	A	SA
68.	Start the plan for discharge on the day of admission	SD	D	N	A	SA
69.	Decrease cost of care by using only the needed supplies.	SD	D	N	A	SA
70.	Address issues that produce errors before error occurs.	SD	D	N	A	SA

The following statements describe the nursing care unit on which I work:

71.	The right supplies are in a designated place.	SD	D	N	A	SA
72.	Supplies needed to do the work are easily accessible.	SD	D	N	A	SA
73.	Most nurses participate on a team	SD	D	N	A	SA
74.	Most nurses worked on a number of improvement projects	SD	D	N	A	SA
75.	Work can be accomplished in a non-rushed manner.	SD	D	N	A	SA
76.	Able to give the patients what they want, when they want it, in the way they expect it,…	SD	D	N	A	SA
77.	The patient care is performed in a systematic way.	SD	D	N	A	SA
78.	There is a designated person to work through problems.	SD	D	N	A	SA
79.	There is time set aside for teams to problem solve.	SD	D	N	A	SA
80.	Education program to teach about process improvement.	SD	D	N	A	SA
81.	Instructors help me recognize errors might occur	SD	D	N	A	SA
82.	People available to help me recognize errors in my work	SD	D	N	A	SA
83.	Person available to coach staff in improving care processes.	SD	D	N	A	SA
84.	Stocks of supplies are sufficient for optimal patient care.	SD	D	N	A	SA
85.	Staff recognize that what they are doing is for the patient.	SD	D	N	A	SA
86.	Patient care is a team effort	SD	D	N	A	SA
87.	Nurses have the authority to address problems	SD	D	N	A	SA
88.	The problem-solving work my unit does improves quality	SD	D	N	A	SA
89.	There are ways or tools to measure how much time is spent in patient care.	SD	D	N	A	SA
90.	Experienced nurses help teach formal problem solving to other nurses.	SD	D	N	A	SA
91.	There are resources available to solve the problem.	SD	D	N	A	SA
92.	There is time built into the unit staff's schedule to work on improvement and problem-solving issues.	SD	D	N	A	SA
93.	The equipment is kept in a designated place.	SD	D	N	A	SA
94.	My unit manager identifies work-arounds and helps solve them.	SD	D	N	A	SA
95.	My unit manager encourages new ways of doing things.	SD	D	N	A	SA
96.	My unit manager's attitude helps get everyone involved in change.	SD	D	N	A	SA

The following statements describe the nursing care <u>unit</u> on which I work:

97.	My manager asks staff to use a written plan to solve unit problems.	SD	D	N	A	SA
98.	Nurses do not communicate to their manager using problem-solving with written forms (such as A3s or PDCAs).	SD	D	N	A	SA
99.	When called as a result of a problem being identified, my manager comes to help look for the causes of the problem.	SD	D	N	A	SA
100.	Whenever my manager helps with a critical problem, s/he creates new ways of seeing the problem.	SD	D	N	A	SA
101.	My manager is receptive to new ideas.	SD	D	N	A	SA
102.	Staff meetings are efficient and focused.	SD	D	N	A	SA
103.	If a new way of doing things does not work, my manager follows-up to finds ways to make it work.	SD	D	N	A	SA
104.	The equipment is kept in working order.	SD	D	N	A	SA
105.	Medication errors and near-misses are always reported and investigated.	SD	D	N	A	SA
106.	Cleanliness and order are monitored.	SD	D	N	A	SA
107.	There are labels where supplies and equipment are kept.	SD	D	N	A	SA
108.	Statistics on falls, central line infections and other quality indicators are displayed for staff to see.	SD	D	N	A	SA
109.	Charts and data are displayed so that staff knows how improvements are progressing.	SD	D	N	A	SA
110.	Nurses know how previous improvements are working to improve care.	SD	D	N	A	SA

Demographics:

Please describe your experience.	
1 How many years have you worked as a nurse?	
2 How many years have you worked with lean methods or other process improvement programs?	
3 Approximately how many years has your unit worked with lean or other process re-design improvement methods?	
4 Describe your unit: (drop-down)	Clinic, OR, Pre/Post-op, Rehab, Medical or Surgical Care, Labor and Delivery, other (write in)

If you are willing to be re-contacted to help with the assessment of reliability, please complete the following question which will help us link your responses from the first and second time you completed this survey. You are the only person who knows the answer to these questions.

First letter of your mother's first name: __

First letter of your father's first name__

Number of older brothers__

Number of older sisters__

Your name begins with letter in first half of alphabet (=1) or name begins with a letter in the second half of the alphabet (=2)___

Month of birth__

Born in an even/odd-numbered year (0=even, 1=odd)___

First letter of your middle name___

Thank you for helping with this project to develop a measure of lean management. If you have questions, please contact me.

Sheila Roszell, MSN, RN-BC
Doctoral Student
UNC-School of Nursing
sroszell@unc.edu

If you would like a gift card link for $15, you may enter an email address below. The email will not be shared or used in any other way. It will be kept separate so there will be no connection with your answers. Note: "Yes, No" multiple choice question, then redirected accordingly on the electronic version.

Email Address:	

Appendix 3. Comparison of FIT Factors and Hospital Ranking of Scores

	Hospital Lean Experience (yrs.)				
Factor	A (2 yrs.)	B (4-5 yrs.)	C (2 yrs.)	D (3-4 yrs.)	E (1 yr.)
Learning Organization	2	5	1	4	3
Frontline Involvement	2	5	1	4	3
Manager Support	3	5	1	4	2
Mentoring	2	5	1	4	3
Patient Centered Focus	1	5	2	4	3
Visual Management	4	5	3	1	2
Take Action	3	2	1	5	4
Solve Problems	1	4	2	5	3
Reduce Variation	1	3	4	2	5
Use Tools	1	3	4	5	2
Find Opportunities	1	3	2	5	4
Mindset for Change	2	4	1	5	3

Appendix 4. FIT factors and Correlations with Experience

Factor		Yrs. worked as a nurse?	Yrs. worked with lean methods or other process improvement programs?	Yrs. unit worked with lean or other process improvement methods?
Learning Organization	R	-.21*	-.16	.03
	Sig.	.04	.10	.41
	n	74	67	58
Frontline Involvement	R	-.27**	-.30**	-.16
	Sig.	.01	.01	.12
	n	74	67	58
Manager Support	R	-.14	-.17	-.03
	Sig.	.12	.08	.42
	n	74	67	58
Mentoring	R	-.15	-.23*	-.02
	Sig.	.10	.04	.43
	n	73	66	58
Patient Centered Focus	R	-.11	-.05	.02
	Sig.	.19	.34	.46
	n	73	66	58
Visual Management	R	-.22*	.03	.18
	Sig.	.03	.40	.09
	n	74	67	58
Takes Action	R	.15	-.02	.04
	Sig.	.11	.42	.37
	n	74	67	58
Solves Problems	R	.16	-.00	.07
	Sig.	.08	.49	.31
	n	74	67	58
Reduces Variation	R	-.19	-.15	-.04
	Sig.	.05	.12	.38
	n	74	67	58
Uses Tools	R	.17	.15	.24*
	Sig.	.07	.12	.04
	n	74	67	58
Finds Opportunities	R	.04	-.02	-.09
	Sig.	.37	.43	.26
	n	74	67	58
Mindset	R	.05	-.08	-.03
	Sig.	.34	.26	.42
	n	74	67	58

Appendix 5. Differences in Factor Means Between Hospitals

Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Learning Organization	10.46	4	2.61	4.55	.002
Frontline Involvement	8.04	4	2.01	4.00	.004
Manager Support	14.06	4	3.52	6.22	.000
Mentoring	6.19	4	1.55	2.13	.079
Patient Centered Focus	5.98	4	1.49	4.04	.004
Visual Management	13.55	4	3.39	4.12	.003
Take Action	.65	4	.16	.95	.432
Solve Problems	.89	4	.22	1.02	.396
Reduce Variation	2.89	4	.72	.74	.565
Use Tools	1.93	4	.48	.84	.499
Find Opportunities	1.31	4	.33	.94	.442
Mindset for Change	.61	4	.15	.94	.442

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