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Healthcare workers' perceptions of lean: A context-sensitive, mixed methods study in three Swedish hospitals

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Abstract

As the application of lean in healthcare expands, further research is needed in at least two areas: first, on the role of context in shaping lean and its consequences and second, on how healthcare workers perceive lean. Accordingly, this context-sensitive, mixed methods study addressed how hospital workers' perceptions of lean varied across contexts in three Swedish hospitals. Registered nurses and physicians at the hospitals and across units differing in acuity completed standardized surveys (N=236, 57% response rate) about their perceptions of hospital-wide lean implementation. Perceptions varied by: hospital context, with one hospital's employees reporting the least favorable perceptions; unit acuity, with higher-acuity units reporting more favorable perceptions; and professional role, with nurses reporting more favorable perceptions than physicians. Individual interviews, group interviews, and observations provided insight about these dissimilar contexts and possible explanations for context-specific variability. Findings are discussed with respect to strategies for implementing lean in healthcare; the importance of attending to levels, context, and worker consequences of lean; and directions for future research.

Keywords

Lean healthcare; mixed methods; macroergonomics; Swedish hospitals; worker perceptions

Lean is a tool set, a management system, and a philosophy that can change the way hospitals are organized and managed. Lean is a methodology that allows hospitals to improve the quality of care for patients by reducing errors and wait times. Lean

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is an approach that can support employees and physicians, eliminating roadblocks and allowing them to focus on providing care. Lean is a system for strengthening hospital organizations for the long term—reducing costs and risks while also facilitating growth and expansion. Lean helps break down barriers between disconnected departmental “silos,” allowing different hospital departments to better work together for the benefit of patients.

-Graban, 2012, p.1

1. Introduction

As the opening quote implies, the application of a *lean* approach is widely purported to improve performance in a wide range of industries, including healthcare. Lean is a set of philosophies, principles, and methods for (re)designing organizations to maximize value and minimize waste, thus improving performance (Womack et al., 2007, Liker, 2004). Despite having originated and matured in car manufacturing, lean has been implemented in the service industry, public sector, and product development (Radnor and Walley, 2008, Morgan and Liker, 2006, Womack and Jones, 2005). In healthcare, specifically, there are abundant case summaries of lean implementation globally (Graban, 2012, Miller, 2005, Aherne and Whelton, 2010). In the US, a 2009 survey of hospitals found that over half of responding hospitals (53%) had implemented lean (American Society for Quality, 2009). A recent systematic review identified 33 scholarly studies of lean in healthcare between 1998-2008 (Mazzocato et al., 2010) and another showed a steady annual increase in such studies (Brandao de Souza, 2009).

The dissemination of lean in healthcare has raised a number of questions that research has not yet resolved (Vest and Gamm, 2009, Holden, 2011). The present study of lean in Swedish hospitals is designed to address two major gaps in the literature on lean in healthcare: limited attention to contextual differences and inadequate measurement of workers' perceptions of lean.

1.1. Lean healthcare across contexts

A foundational principle of human factors, and of macroergonomics in particular, is the need to attend to *context*, or those factors and interactions in the sociotechnical work system that occur at levels of analysis beyond the individual (Moray, 2000, Carayon, 2006, Wilson, 2014). For example, Vincent's “seven levels of safety” in healthcare include team, work environment, organization and management, and institutional context factors (Vincent et al., 1998, Vincent, 2010). Recent discourse on *mesoergonomics* has also emphasized examining connections across multiple levels (Karsh et al., 2014). From accumulating evidence, it is known that lean has been applied in diverse contexts, including hundreds of hospitals, clinics, and other units differing in size, location, and clinical function (Graban, 2012, Vest and Gamm, 2009, Brandao de Souza, 2009). However, despite this contextual heterogeneity, there has been almost no systematic research on how lean is implemented across dissimilar contexts within and between organizations (Mazzocato et al., 2010) or whether contextual differences are associated with variability in results (Holden, 2011). For example, Holden (2011) found that among 18 studies of lean in emergency departments, only Dickson et al (2009) compared hospitals implementing lean, although numerous studies mentioned the

importance of factors that hypothetically vary from context to context such as readiness for change and management support. The inattention to context is problematic because healthcare organizations and units can vary considerably and may therefore respond differently to lean (Brandao de Souza, 2009). Furthermore, the nature of lean itself appears to vary considerably from place to place, with its scope ranging from single unit to whole health system, its design ranging from the use of a single lean tool to building a transformational lean culture, and its implementation occurring in both bottom-up participatory and top-down management-driven ways (Poksinska, 2010, Mazzocato et al., 2010). Radnor and colleagues argue that “such variations call for more attention to the ways Lean is translated and implemented” (Radnor et al., 2012, p.366).

1.2. Healthcare workers' perceptions of lean

Another central principle of human factors is the dual goal of improving both human performance and wellbeing (Dul et al., 2012). The dual-goal orientation is strongly embedded in dominant models of human factors in healthcare (Holden et al., 2013, Karsh et al., 2006, Carayon et al., 2006, Carayon et al., 2014). However, in the literature on lean in healthcare, the main—and in almost every case, the only—consequences of lean studied are those on the process and outcome of patient care (Holden, 2011, Mazzocato et al., 2010, Poksinska, 2010). There are few studies that consider the consequences of lean on healthcare workers' perceptions of lean, wellbeing, or working conditions; those that do report either anecdotal evidence or general satisfaction scores from annual employee surveys (Holden, 2011). To our knowledge, no study has quantitatively and systematically assessed workers' perceptions of lean in healthcare. This is a major limitation for two reasons. First, as Poksinska (2010) points out in her review, “the first barrier that needs to be overcome in Lean implementation is to convince staff that Lean can work in a healthcare setting” (p.324). Indeed, at least one recent qualitative study reported some employee resistance to lean in a UK hospital surgical unit (Waring and Bishop, 2010). It is possible that lean's ultimate success is greatly influenced by frontline staff perceptions and acceptance, much as is the case for other healthcare innovations such as new technology (Holden, 2010, Holden and Karsh, 2009). Second, the effect of lean on workers and working conditions has for a long time been of concern in human factors/ergonomics (Genaïdy and Karwowski, 2003, Landsbergis et al., 1999, Delbridge, 2005). This is partly because several studies report that lean increases workload and decreases worker control (Conti et al., 2006, Parker, 2003, Sprigg and Jackson, 2006) or mixed worker effects (Jackson and Mullarkey, 2000).

1.3. A context-sensitive study of lean in three Swedish hospitals

To address the gaps identified above, the present study investigated the implementation of lean in three Swedish hospitals. To address prior inattention to context, this study examined differences between the hospitals, as well as unit characteristics and professional roles within hospitals. Hospital, unit type, and role were chosen as the context factors of interest because they represent distinct, recognized divisions ubiquitous in the healthcare domain. These variables are also commonly studied in organization research because they produce variability and prior studies of lean in and outside healthcare have identified differences in how lean is implemented in, adopted, and perceived by workers across organizational, work unit, and professional boundaries. For example, Dickson et al. (2009) found hospital

differences and Mazzocato et al. (2014) found differences between units differing in process complexity. Furthermore, our early qualitative observations of notable hospital, unit, and professional differences at the study sites led us to hypothesize the importance of these three context variables, in particular (Dellve et al., 2013, Dellve et al., 2012, Eriksson et al., 2012).

To address the gap in knowledge about healthcare workers' perceptions of lean, this study assessed physicians' and nurses' early post-implementation attitudes and commitment toward lean, perceptions of the justice of lean implementation, and perceptions of the extent to which lean improved work flow.

Our primary research question was: How do hospital workers' perceptions of lean vary across contexts, namely, across hospitals, unit types, and professional roles? A secondary research question was: What characteristics of lean's implementation account for context-specific variability in workers' perceptions? We hypothesized based on Mehta and Shah's (2005) and Holden's (2011) models of lean that worker perceptions would vary depending on context because in different contexts lean would be differently implemented, for example, using top-down versus bottom-up approaches, using smaller- versus larger-scale projects, and dedicating more or less resources to lean.

Swedish hospitals make for a uniquely appropriate setting to address these research questions. In Sweden, lean has been mandated throughout the public sector, including hospitals. By 2011, 90% of Swedish public hospitals had implemented lean to some degree (Weimarsson, 2011). However, the Swedish government did not mandate specific methods for implementing lean in its hospitals and there is no universal model of lean that can be directly applied (Pettersen, 2009, Hines et al., 2004). Moreover, Swedish hospitals are noted for taking pride in developing their own models of lean (Dellve et al., 2013). Thus, it is likely that how lean is implemented will vary between and even within Swedish hospitals, making them ideal cases for studying variability across contexts.

2. Methods

A “concurrent triangulation” mixed methods design was used (Cresswell et al., 2003), meaning that quantitative and qualitative data were collected concurrently and the two were brought together to guide analysis and interpretation. In particular, quantitative analyses were designed to explain early qualitative observations and qualitative data were used to help interpret findings from the quantitative analyses.

This study used a cross-section of data from a longitudinal study of lean in Swedish small and medium-sized hospitals. Convenience sampling was used to select three hospitals, referred to here as A, B, and C, that were in the early months of implementing lean hospital-wide.

The central source of data used in the study was standardized surveys of registered nurses and physicians involved in lean. The dependent variables were workers' perceptions of lean, and were comprised of survey responses about attitudes toward lean, commitment to lean, perceived justice of lean implementation, and perceived workflow improvement due to lean.

The independent variables were context factors, namely, Hospital (A vs. B vs. C), Unit acuity (higher-acuity vs. lower acuity clinical units), and professional Role (registered nurse vs. physician) of the respondent.

We also gathered rich, triangulated (i.e., multi-source, multi-perspective) data on the context of each hospital, unit type, and professional group, as well the process of lean implementation in each, using face-to-face research interviews with key lean actors and managers, group interviews with staff, and observations.

We selected higher- and lower-acuity units, as defined below, because of the strong possibility that lean may not work equally well in every clinical context or type of care delivery, or alternatively, that lean will be adapted in different ways to accommodate care units differing in their patients, clinicians, and other characteristics (e.g., time pressure, nonlinearity) (Brandao de Souza, 2009). In particular, the high-acuity emergency department (ED) is often selected to be the first hospital unit to undergo lean (Holden, 2011, American Society for Quality, 2009), perhaps because it is the origin of many patient care trajectories (Ben-Tovim et al., 2007). Furthermore, higher acuity units may have the most chaotic and safety-critical processes, and therefore more likely to profit from lean (McCulloch et al., 2010). At the same time, higher-acuity units may already be operating at capacity and new programs such as lean may be disruptive; a “cultural” shift may be necessary before these clinical units accept and participate in lean (Murrell et al., 2011, Toussaint and Gerard, 2010).

Data collection occurred during April to May 2012 (Hospital A, B) and October to November 2012 (Hospital C). The study was approved by the Central Ethical Review Board at Karolinska Institute, Stockholm, Sweden.

2.1. Settings and sample

All three hospitals were publically owned and operated Swedish nonacademic hospitals. Two were medium-sized and one small-sized. They were selected because they were implementing lean hospital-wide during 2012 and agreed to participate in a three-year study. Hospital A had about 100 beds, 700 employees, and served a population of 100,000. Hospital B had about 500 beds, 4000 employees, and served a population of 300,000. Hospital C had about 450 beds, 3000 employees, and served a population of 450,000.

For present analyses, we selected and classified clinical units into two categories of patient acuity: “higher-acuity” and “lower-acuity.” Higher-acuity units were ones that treated patients early in the acute care hospitalization process and included the emergency department (ED), the intensive care unit (ICU), and the acute medical intake and acute surgical intake units that received patients admitted through the ED. Typical patient diagnoses in these units included heart attack, stroke, trauma, and acute abdominal pain (e.g., due to appendicitis). Lower-acuity units were medical and surgical wards that cared for more stable and less urgent/emergent conditions such as complications from diabetes and postsurgical care. One of each clinical unit (ED, ICU, acute-medical, acute-surgical, ward-medical, ward-surgical) per hospital was recruited for the study, except Hospital A had an ICU but no acute care units, Hospitals B and C had acute care units but no ICU, and the

surgical department in Hospital C declined to participate due to other ongoing research and development projects.

Prior experience with process-oriented organizational development (“improvement”) work differed between hospitals: very limited in Hospital A; very extensive in Hospital B; and limited hospital-wide but extensive in some individual units in Hospital C. The surgical clinic in hospital B and the medical clinic and emergency department in hospital C had previous experience working with lean at a unit level.

2.2. Data-collection

A self-administered survey *questionnaire* was distributed to all nurses, assistant nurses, and physicians¹ working either part- or full-time at their hospitals for at least the prior six months. Hospitals A and B elected to distribute a paper questionnaire by mail, while Hospital C chose a web version. In Hospital C, the survey was distributed to a relatively large number of physicians (N=392), compared to other hospitals. The full questionnaire included about 200 items on working conditions; work content; the implementation, use, and perceived impact of lean; and perceived changes in patient and employee outcomes.

In addition, we conducted individual, face-to-face *interviews* with managers and leaders involved in lean implementation: strategic-level managers (N=7), change leaders (N=19), and all first- and second-line managers in charge of study units (N=21). Topics included previous experiences with improvement work; methods and approaches to implementing lean; contextual and implementation factors related to lean; and goals, outcomes, and future directions. Eleven separate group interviews with staff were held with ED and surgical ward nurses (N=20), physicians (N=10), and assistant nurses (N=15), separately. Group interview topics included participation in lean, perceptions of lean, perceived hindering and facilitating factors for implementation, and perceived outcomes of lean. Furthermore, we conducted *observations* in study units in order to gain familiarity with the units and to obtain visual evidence of how lean was being implemented.

2.3. Survey instruments

Table 1 presents the survey items used to measure perceptions of lean. Respondents also reported their professional roles and were assigned Hospital and Unit designations. The degree of lean visibility was measured with the item, “Do people work with Lean in your department/clinic?” with options of “Yes, in an evident way,” “Yes, in a subtle way,” “No,” and “Do not know.”

2.4. Analysis

Unit and hospital affiliation were verified for each respondent included in the analysis. Responses from registered nurses and physicians in study units and reporting some level of lean visibility were selected for analysis. For each survey item, descriptive statistics were calculated and examined for anomalies. Scales were constructed for multiple-item constructs

¹Physicians at Hospitals A and C did rotations in higher-acuity units rather than being permanently assigned to them.

by calculating a mean with a floating denominator (see Table 1). Due to very low rates of missing data, we did not impute missing data.

To address the primary research question, we carried out four factorial analyses of variance (ANOVA), one for each lean perception variable. The context variables Hospital (3 levels), Unit acuity (2 levels), and professional Role (2 levels) were specified as fixed factors in each model and we estimated a full factorial model of all main effects and interactions. (Note, however, for the three-way interaction there was an empty cell for physicians in high-acuity units in Hospital A). For each model, we calculated the adjusted R-square. Effect sizes were calculated as Cohen's *d* using a pooled variance formula. Alpha threshold was set to $p = 0.05$, although for descriptive purposes we note any p 's < 0.01 . Post-hoc comparisons were carried out with a Bonferroni-corrected alpha threshold. Quantitative analyses were conducted using SPSS v.22 (IBM Corp).

We applied manifest qualitative content analysis (Graneheim and Lundman, 2004) to qualitative data to systematically generate for each hospital and unit descriptions of: the main characteristics of hospital-wide lean implementation strategies; lean tools used; actors involved in lean implementation; processes or projects targeted in work with lean; hindering and facilitating conditions; and future visions for lean. We noted cases of agreement and disagreement among respondents. Multiple analysts were involved in this process, with regular group reviews and discussions. Furthermore, following the quantitative analysis, we conducted further focused rereading and analysis of individual and group interviews to find context and implementation process descriptions matching (or contradicting) and possibly explaining quantitative findings (Cresswell and Plano Clark, 2011).

3. Results

A total of 386 nurses (response rate = 78%) and 166 physicians (response rate = 35%) returned a survey for an overall response rate of 57%. In Hospital A, the response rate was 77% (80% among nurses, 68% among physicians). In Hospital B, the response rate was 79% (81% among nurses, 64% among physicians). In Hospital C, the response rate was 41% (71% among nurses, 29% among physicians). Response rates from higher- versus lower-acuity units were within 4% of each other.

Among all respondents, 236 met inclusion criteria for the present analysis: 170 nurses and 66 physicians. The remainder reported not working with lean, worked on non-included units, or did not respond to a large proportion of analyzed survey items. Table 2 contains information on the distribution of professions, experience, gender, degree of lean visibility, and units for all respondents in the final analyzed sample ($N=236$). There were fewer physician respondents than nurses, and Hospital B yielded only eleven physician surveys. Across all three hospitals, nurse respondents were mostly females (85-89%) and physicians mostly males (62-82%). Although only respondents who reported having worked with lean in their unit were included in the analysis, more respondents reported “subtle” as opposed to “evident” visibility of lean, across all hospitals. In total, about as many respondents were from lower-acuity vs. higher-acuity units, although there was a larger proportion of higher- to lower-acuity unit respondents in Hospitals B and C.

3.1. Variation in lean implementation across hospital contexts

In this section, we discuss similarities between lean implementation across the three hospitals, followed by key differences. All three hospitals were in the early stages of implementing lean and for some their implementation strategies evolved; we describe lean as it was implemented up to the time of the data collection. Appendix A defines some of the tools and concepts mentioned below.

During the study period, the use of lean across hospitals was mainly based on discrete projects. Hospital A's attempt to use lean boards was the only practical example of incorporating lean into everyday improvement work. Hospital-level budgets for lean included salaries for change agents, freeing employee time to participate in lean related projects, and costs of external lean education. Additionally, individual units in all hospitals were expected to “show good will” and contribute time and resources to lean implementation. These similarities notwithstanding, interviews with key actors clearly showed differences in lean implementation strategies at the three hospitals.

Hospital A hired change agents for each clinical unit for a two year term. Change agents held central roles in the implementation of lean. They received ten sessions of lean education and were responsible for educating all employees on lean, usually done through one-hour lectures delivered to each unit. Two managers attended the same ten education sessions and were expected to educate fellow managers. Change agents were also responsible for the implementation of suggestions generated by employees. During interviews, the change agents described having more success working with nurses and assistant nurses to implement smaller-scale changes in their units and less success engaging physicians and managers. Lean projects in Hospital A tended to be smaller and confined to single units, with the exception of two hospital-wide projects on hospital bed supply management and medications. The smaller-scale approach was used because of the perception that Hospital A employees had little prior experience with organizational initiatives such as lean and could learn about lean methods by observing them used in their units. Hospital A was, at the time, unique in using lean boards for regular progress assessment.

The implementation strategy at Hospital B was initiated by the hospital director, a physician who was interested in lean as a model to increase patient flow and decrease costs. Change agents were hired on unlimited-term contracts and, together with lower-level managers, had full-time responsibility for organizational development in clinical units. An external educator—a lecturer from the local university—was hired to conduct an education program on lean for change agents, managers, and physicians, but not for other clinical professionals. Physicians were offered one day of education while managers received the most extensive education. Manager education focused on using lean to improve “acute somatic flow,” a set of patient care processes involving the higher-acuity units that included 50% of the hospital's patients. Not surprisingly, interviews revealed that managers were the ones most involved in lean activities. Physicians and nurses participated in lean activities to the extent that their managers allowed and encouraged them to do so, resulting in unit by unit variability in clinicians' involvement. The main lean methods in Hospital B were value stream mapping at the unit level (used at the start of every project) and an X-matrix at the

management level (see Appendix A for descriptions of these tools). The clinical manager in the surgical clinic was using lean principles prior to hospital-wide implementation.

Hospital C implemented lean by forming groups of clinicians and assigning each to work on improving a preselected core clinical process. Each working group was governed by a top-level manager who was called the “process owner” and a clinically active physician who was called the “process leader.” Each group received support on how to implement lean from centralized change agents who had received a year of extensive education in Six Sigma and were supported by outside consultants. No one besides the change agents received any education on lean and unit managers and clinicians outside of the working groups were less involved in lean implementation. Accordingly, interviewees described difficulty diffusing the solutions created and piloted by working groups to other clinicians. Some managers in Hospital C were working with lean-inspired methods in their clinics but this was not integrated into the hospital-wide lean initiative. The main lean method used in Hospital C was value stream mapping, which was used at the start of every project.

The higher-acuity units in Hospitals B and C, tended to have more experience with prior process development work and were more enthusiastic about improvement opportunities aimed at improving acute patient flow and cooperation across units; this was not the case in Hospital A, where prior process redesign experience was low across all units and projects tended to not cross unit boundaries. Lower-acuity units tended to be more variable in their engagement with lean, often depending on the disposition of the unit manager.

Table 3 summarizes key hospital differences in context and lean implementation.

3.2. Workers' reports of their perceptions of lean

Responses on individual survey items are presented in Figure 1 on the original response scale, aggregated across all hospitals, units, and professions. On the whole, about 25-55% of respondents indicated “high” or “very high” attitudes, perceived justice, commitment, and perceived flow improvement versus about 15-35% who responded “low” or “very low.” Thus, favorable perceptions of lean were more common, but there was a subset with unfavorable perceptions. Responses on attitude items tended to be more favorable than those on other items. For perceptions of flow improvement due to lean, the proportion of high, medium, and low responses were roughly equal. However, as reported below, workers' perceptions varied across levels of the three context variables: Hospital, Unit acuity, and professional Role.

Context variables associated with workers' perceptions of lean—Table 4 reports workers' reported perceptions of lean divided by hospital, unit acuity, and professional role. Below we report multivariate analyses testing the association between these three context variables and worker attitude and commitment toward lean, perceived justice of lean implementation, and perceived improvement in flow due to lean.

3.3.1. Attitude toward lean: The omnibus ANOVA model for Attitude was significant ($F(10,223)=10.50$, $p = 0.01$), with context variables (Hospital, Unit, Role) explaining 29% of variance in attitude scores. There was a significant main effect for Hospital ($F(2,223)=4.88$,

p 0.01), such that Hospital A had lower attitude scores ($M=2.99$, $SD=0.87$) than either Hospital B ($M=3.54$, $SD=1.02$) or Hospital C ($M=3.77$, $SD=1.05$). The effect size of Hospital was large ($d=0.59$ for A vs. B, 0.81 for A vs. C). The main effect for Role was also significant ($F(1,223)=6.28$, $p = .01$) and large ($d=0.60$), such that nurses reported higher attitude scores ($M=3.57$, $SD=0.96$) than physicians ($M=2.97$, $SD=1.08$). There was also a significant main effect for Unit acuity ($F(1,223)=20.07$, $p = 0.01$) and this effect was also large ($d=0.73$). Attitudes in higher-acuity units ($M=3.71$, $SD=0.97$) were higher than those in lower-acuity units ($M=3.00$, $SD=0.96$). However, these Unit acuity differences were only present in Hospitals B and C, indicated by a significant Hospital by Unit acuity interaction ($F(2,223)=10.36$, $p = 0.01$). More precisely, (1) attitude scores were average across all hospitals' lower-acuity units, (2) attitude scores in the higher-acuity units at Hospital A were also average (i.e., no difference from lower-acuity, $d=0.03$), and (3) in Hospitals B and C, the attitude scores in higher-acuity units were about one point above average ($d=0.85$ in Hospital B, 1.31 in Hospital C). Lastly, there was a significant Hospital by Unit by Role interaction ($F(1,223)=4.25$, $p = 0.05$), indicating that nurses in lower-acuity units had more positive attitudes than physicians in those units, but only in Hospitals A ($d=1.07$) and B ($d=1.12$), and not in Hospital C ($d=0.17$). There were no other significant interactions.

3.3.2. Commitment toward lean: The omnibus ANOVA model for Commitment was significant ($F(10,224)=8.41$, $p = 0.01$), with context variables (Hospital, Unit, Role) explaining 24% of variance in commitment scores. There was a significant main effect of Hospital ($F(2,200)=6.75$, $p = 0.01$), such that commitment scores in Hospital A ($M=2.56$, $SD=0.88$) were lower than those in both Hospital B ($M=3.17$, $SD=1.14$) and Hospital C ($M=3.36$, $SD=1.06$). The effect size of Hospital was large ($d=0.61$ for A vs. B, 0.83 for A vs. C). There was also a significant and large ($d=0.84$) main effect of Unit acuity ($F(1,200)=9.14$, $p = 0.01$), such that commitment scores were nearly one point higher in higher-acuity units ($M=3.45$, $SD=0.99$) than in lower-acuity units ($M=2.61$, $SD=1.00$). However, as with attitude scores, commitment score differences between units were found only in Hospitals B and C, indicated by a significant Hospital by Unit acuity interaction ($F(2,200)=3.88$, $p = 0.05$). In Hospital A, commitment scores were slightly below average in both types of unit ($d=0.05$). In contrast, in Hospitals B and C, commitment scores were above average in higher-acuity units and below-average in lower-acuity units ($d=0.71$ in Hospital B, 1.11 in Hospital C). There were no other significant main effects or interactions.

3.3.3. Perceived justice of lean implementation: The omnibus ANOVA model for perceived Justice was significant ($F(10,219)=3.52$, $p = 0.01$), with context variables (Hospital, Unit, Role) explaining 10% of variance in justice scores. There was a significant main effect for Unit acuity ($F(1,198)=5.89$, $p = 0.05$), such that justice scores in higher-acuity units ($M=3.24$, $SD=0.76$) was higher than in lower-acuity units ($M=2.81$, $SD=0.84$). This main effect was of moderate size ($d=0.54$). However, once again, there was a significant Hospital by Unit acuity interaction ($F(2,198)=5.42$, $p = 0.01$). As with attitude and commitment scores, the significant interaction means there were no Unit differences in Hospital A ($d=0.02$) because justice scores were average in both unit types. At Hospitals B and C, higher-acuity units had justice scores somewhat above average, while lower-acuity units had somewhat below average justice scores ($d=1.10$ in Hospital B, 0.71 in Hospital C). There were no other

significant main effects or interactions. At Hospitals B and C, higher-acuity units had justice scores somewhat above average, while lower-acuity units had somewhat below average justice scores ($d=1.10$ in Hospital B, 0.71 in Hospital C). There were no other significant main effects or interactions.

3.3.4. Perceived flow improvement due to lean: The omnibus ANOVA model for perceived Flow Improvement was significant ($F(10,223)=8.42$, $p=0.01$), with context variables (Hospital, Unit, Role) explaining 27% of variance in perceptions of improved flow resulting from lean. There was a significant main effect of Hospital ($F(2,223)=7.96$, $p=0.01$). Flow improvement perceptions were lowest in Hospital A ($M=2.49$, $SD=0.90$), compared to Hospital B ($M=2.93$, $SD=1.05$) and Hospital C ($M=3.35$, $SD=0.88$). The magnitude of these differences were moderate ($d=0.46$ for A vs. B) to large ($d=0.83$ for A vs. C). There was also a small-to-moderate but significant difference between Hospitals B and C ($d=0.38$). A significant main effect of Unity acuity ($F(1,223)=11.12$, $p=0.01$) indicated greater perceptions of lean related flow improvements in higher-acuity ($M=3.25$, $SD=0.74$) versus lower-acuity units ($M=2.81$, $SD=0.84$), a moderate-to-large effect ($d=0.56$). The main effect of Role was also significant and moderate-to-large ($F(1,223)=9.04$, $p=0.01$, $d=0.59$), with nurses reporting higher perceived flow improvements due to lean ($M=3.08$, $SD=1.04$) compared to physicians ($M=2.45$, $SD=1.11$). However, these latter two main effects are qualified by significant Hospital by Unit ($F(2,223)=10.70$, $p=0.01$) and Hospital by Role ($F(2,223)=4.04$, $p=0.05$) interactions. Unit acuity differences, as in the three other ANOVA models, were restricted to Hospitals B and C, where the below average scores in lower-acuity units were significantly different from the above average scores in higher-acuity units ($d=1.00$ in Hospital B, 1.02 in Hospital C). In Hospital A, scores in both units were about the same ($d=0.10$). On the other hand, role differences were found in only Hospitals A and B, but not C. In Hospital C, both nurses and physicians had average or half a point above average scores on perceived flow improvement (i.e., no significant difference despite an effect size of $d=0.39$). In contrast, physicians in Hospitals A and B had scores nearly a full one point below average, while nurses in those hospitals had approximately average scores, corresponding to large effects ($d=0.77$ for Hospital A, 0.94 for B). There were no other significant effects.

3.3. Further investigation of Hospital A

Because the model results described above revealed unique patterns of worker perceptions of lean in Hospital A, we provide further description of Hospital A and summarize data from interviews and observations in Hospital A that help to understand its unique context. Compared to the other two hospitals, Hospital A was of smaller size and located in a smaller town. Interviewees at Hospital A described that it had overall little maturity doing process-oriented organizational development (or “improvement work”) with physicians and nurses. Instead of developing clinicians' competence in this area, the hospital hired change agents to implement lean. The change agents were described to play a critical mediating role in improvement work because they interpreted the work design problems and suggested solutions communicated to them by clinicians. The change agents were also hired for a limited term.

Additionally, unit managers expressed that they either did not receive enough training on lean or they did not have sufficient time for improvement work. Similarly, in observations, clinicians were not seen to take active roles in lean activities and some clinicians commented that they had insufficient knowledge about how to implement lean. This was corroborated by interview statements that there were few champions for lean besides the change agents.

Individual and group interviews with physicians—including two senior and influential physicians—also revealed some support for lean as a concept but criticism of how lean was implemented in practice. Physicians were particularly dissatisfied with their lack of control over managerial decisions about lean, the hospital's dismissal of some improvement suggestions as too costly, and projects not being sustained. Two interviewed managers attributed physician resistance to the smaller Hospital A attracting individuals with little interest in organizational development.

Finally, as described above, compared to Hospitals B and C, Hospital A attempted smaller-scale improvements within each unit, had a lesser focus on end-to-end flow within the hospital, and did not systematically use value stream mapping techniques.

4. Discussion

In this context-sensitive, mixed methods study of lean in three Swedish hospitals, there were several notable findings concerning variability in worker perceptions of recent lean implementation. While some individuals perceived lean positively, including nearly a third reporting that they perceived substantial workflow improvements, there were many others with unfavorable experiences. Variability in perceptions did not reflect merely different individual reactions but varied depending on context, namely, the respondent's hospital, unit, and role. These three context variables accounted for between 10-29% of the variance in perceptions of lean.

4.1. Hospital differences

Respondents from Hospital A responded least favorably to lean. Neutral or worse perceptions of lean were found across units in this hospital. While attitude, commitment, and justice perceptions did not differ between hospitals B and C, respondents in Hospital C had the most favorable perceptions of lean related work flow improvements. In Hospitals B and C, those in higher-acuity units—the emergency department and downstream acute care units—reported especially favorable lean perceptions. Nurses across hospitals had a more positive attitude toward lean and perceived more strongly that lean improved workflow.

Clearly, compared to the other study hospitals, Hospital A was a unique case of lean implementation and a stellar example that “context matters.” The design of our study was such that we could further investigate *how* context mattered. We had at our disposal rich data on each hospital's and their units' contexts and how lean was translated for that context. Our quantitative results are therefore interpretable in a way that is only possible through mixed methods (Cresswell and Plano Clark, 2011) and careful researcher attention to the actual way in which an intervention is implemented (Øvretveit, 1998). In this case, we

learned that Hospital A was smaller, generally inexperienced with organizational development efforts, and appeared to attract staff for whom such efforts were not of great priority. Moreover, the hospital implemented lean in a unique way. Unlike Hospitals B and C, Hospital A hired temporary change agents to be in charge of mostly smaller-scale projects within separate units. Hospital A clinicians lacked direct training on lean, control over the nature of improvement projects, and management support to take the time to participate in lean. Our findings about the nature of clinician participation at Hospital A are important not only because of the general benefits of participation in improvement projects (Brown Jr., 2002), but also because there are several ways to design participation and not every way will be equally successful (Haines et al., 2002). Accordingly, in a study of 28 Swedish industrial companies implementing lean, Brännmark and Holden (2013) showed that the most favorable worker perceptions were not associated with the “most” participation but rather with a specific “package of participation,” namely, participation in stable continuous improvement groups.

The nature of lean implementation Hospital A appeared to create negative impressions of and lack of participation in lean among high-ranked and influential clinicians, particularly physicians. To the extent that their influence was even greater because of the hospital's smaller size, these powerful individuals' initial reactions may have considerably stymied the diffusion of lean (Rogers, 1995). Hypothetically, initial positive reactions and successes with lean could also have diffused quickly through the hospital. In any case, the potentially crucial role of champions and opinion leaders (Kahn, 2004) in the initial acceptance and sustainability of lean, particularly in smaller hospitals, is a phenomenon that could be further explored.

4.2. Unit acuity and professional role differences

The finding that higher-acuity units responded more positively to lean than lower-acuity counterparts is interesting for two reasons. First, it speaks to the potentially greater value of standardization and better flow due to lean in clinical contexts where the baseline work is fast-paced, high-volume, multi-agent, and highly susceptible to flow disruptions (Cosby and Croskerry, 2009). These units, particularly Swedish emergency departments, are often under pressure to improve efficiency without additional resources. They are highly interdependent with other units, particularly ones along the acute care pathway, and cannot completely control patient flow. This is especially evident in emergency departments, which receive a steady stream of patients but often are slow to admit them to the hospital due to bed shortages in downstream units. Not coincidentally, emergency departments are often the first hospital units to “go lean” and demonstrate consistently positive results (Holden, 2011, Ben-Tovim et al., 2008, American Society for Quality, 2009). Consistent with our findings, a recent study of emergency departments in three Swedish hospitals found that the department whose triage was designed according to lean principles had the lowest length of stay, fewest patients leaving without treatment, fewer readmissions, and lower mortality (Burström et al., 2012). In an interview study, Timmons et al. (2014) found that staff at an ED in the UK strongly supported and participated in lean activities and speculated that this was because lean could provide ED workers a much-needed professional identity.

A second implication of unit differences is that important sources of variance can be located at “meso” levels, i.e., ones between individual and organization (Hackman, 2003). This is only possible when the organization does not impose strict top-down control over the unit and when individuals within the unit are somehow influenced toward similarity (Klein et al., 1994, Klein et al., 1995). In this case, in Hospitals B and C, unit managers and clinical leaders had varying prior experiences working with approaches such as lean and were given some control over the implementation of lean. For example, in Hospital B, managers received a lot of training and had discretion over how much to involve their physicians and nurses in lean. Hospital C had several managers who had extensive prior experiences using lean in units within their clinics. Thus, in those two hospitals, unit differences may have reflected the influence of unit management, similar to work by Zohar (Zohar and Luria, 2005, Zohar, 2000) showing that safety climate is most strongly dictated at the meso level of the work group because of the strong influence of the work group supervisor. In contrast, in Hospital A, where managers had little discretion over the work done by hospital-level change agents, there were no unit differences. It still remains to be seen whether in fact unit-level effects were due to managers and, if so, whether managers had influence through support and commitment to lean, actual personal involvement in lean (Bateman, 2005), or both. There are other units of analysis that could be incorporated into future studies of lean in healthcare. For example, Hospital C used self-contained working groups and important variance could be associated with membership in such groups, regardless of unit or profession. To this point, another recent lean healthcare study suggested that a team-based lean project in a hospital information technology department may have “resulted in an uncommonly motivated, resource-rich team of ‘elites’” that experienced uncommon success (Holden and Hackbart, 2012, p.200).

A noteworthy finding in the study was that while nurses on the whole had more positive responses than physicians for two out of four lean perceptions constructs, this finding was not consistent across all unit types and hospitals.

4.3. The importance of studying context

In his final paper in this journal, John Wilson (2014) urged the ergonomics/human factors (E/HF) community to contemplate that “everything that people do and everything that E/HF studies, improves and implements, takes place in a context” (p.7) and, more provocatively, that a study that fails to consider context “is, in fact, not E/HF at all” (p.6). In this study, attention to context clearly revealed that lean is not identically implemented or perceived across hospitals, units, or professional roles.

While the importance of context is perhaps not surprising—and is indeed consistent with at least one other recent study of healthcare quality improvement efforts across contexts (Øvretveit et al., 2012)—ours is one of the first study to systematically compare workers' perceptions of lean across healthcare contexts. The literature on lean in healthcare is rich in case studies within single organizations or units, including detailed analyses of celebrated lean implementers such as Virginia Mason Medical Center (Kenney, 2011) or ThedaCare (Toussaint and Gerard, 2010, Holden and Hackbart, 2012). While these cases provide excellent retrospective insights and principles into implementing lean in healthcare

(Toussaint and Berry, 2013), they do not offer the type of study design necessary to scientifically assess contextual differences or link them to outcomes (Vest and Gamm, 2009, Klein and Kozlowski, 2000). In addition to mixed methods studies such as ours, which captures comparable data through a standardized survey across hospitals, units, and roles, while qualitatively assessing differences between these contexts, we recommend the use of multiple case study methodology in combination with the Realistic Evaluation framework (Pawson and Tilley, 1997). The Realistic Evaluation framework guides an analysis of how specific interventions (e.g., a participatory approach to lean) interact with specific contextual factors (e.g., workers with strong prior experience with improvement work) to trigger hypothesized mechanisms (e.g., worker engagement in everyday problem solving) that result in outcomes (e.g., happier workers, fewer defects). This framework has been applied to study lean in healthcare in a limited fashion (Holden and Hackbart, 2012, Mazzocato et al., 2012, Black, 2009) and can be highly productive when applied to a study of multiple hospitals and units differing in context.

Regardless of the framework used, we urge human factors researchers and investigators of lean in healthcare alike to begin specifying hypotheses about hospital and unit differences and other multilevel phenomena such as the spread of influence and innovation across intra- and inter-organizational boundaries (Waterson, 2010, Karsh et al., 2014, Holden, 2012). We also urge researchers to consider how lean and other healthcare interventions such as new technology both transform and are transformed by the sociotechnical system where they are introduced (Radnor and Walley, 2008, Holden et al., 2011). In a manner of speaking, “no two leans will look alike” and, conversely, an entity pre- and post-lean may experience contextual changes (Mazzocato et al., 2010, Radnor et al., 2012). To be concrete, Hospital A began to work with lean having little experience with similar change programs. This shaped the manner in which they implemented lean. However, by virtue of having implemented lean, the hospital gained experience and thus effectively changed the “experience” aspect of its context, potentially paving the way for future success with lean. Dynamics like these are challenging to assess but may hold the key to understanding organizational change.

4.4. The importance of studying workers

The pursuit of safer, higher quality, and more efficient healthcare delivery can benefit from greater attention to the health, safety, wellbeing, working conditions, and perceptions of healthcare workers. Apart from being an important goal in itself (Lucian Leape Institute, 2013), these worker outcomes may influence patient care outcomes including patient safety (Fahrenkopf et al., 2008, Kirwan et al., 2013, Carayon et al., 2013). In studies of lean in manufacturing, a majority of studies reveal a negative effect of lean on workers, suggesting that lean heightens the work pace, increases workload, decreases job autonomy and skill discretion, and generally produces more stressful working conditions (Hasle et al., 2012, Landsbergis et al., 1999). Whether this is true of lean in healthcare is not possible to tell because of the dearth of rigorous research on the consequences of lean on healthcare employees (Holden, 2011).

At the same time, what evidence there is points to the potential for positive effects of lean on healthcare workers through worker empowerment and control over working conditions,

increased opportunity to spend time on direct care and other more satisfying aspects of work, and the reduction of working conditions such as unnecessary physical exertion (Spear, 2005, Poksinska, 2010, Holden, 2011). The present study demonstrates largely positive (though variable) worker perceptions of lean and we would hypothesize that these are correlated with positive employee outcomes such as worker wellbeing. More work will be needed to test this and other hypotheses about the relationship between lean and worker perceptions, working conditions, and worker outcomes. One preliminary observation, based on the present study and extant literature, is that in both healthcare and Sweden there is a tendency, at least in published reports, to involve workers in lean change efforts and to explicitly concentrate on respect for and empowerment of workers. This is not inconsistent with lean in general, which after all tends to promote a respect for workers (Liker, 2004), but may be particularly emphasized in healthcare and Swedish contexts due to structural and historical factors such as the support of lean by charismatic healthcare leaders (Toussaint and Gerard, 2010, Kenney, 2011, Graban, 2012) or the power of unions and pursuit of healthy workplaces in Sweden (Johansson and Abrahamsson, 2009, Poksinska et al., 2010). This contention, too, requires further research.

4.5. Limitations

We note a number of methodological issues. First, the study was cross-sectional and limited in its ability to draw causal inferences, although in this case it is logical to believe that context influenced perceptions, not the reverse. However, in this design, it was not possible to test specific claims such as that high levels of frontline staff participation actually *caused* more favorable perceptions. Our ongoing data collection in this longitudinal study will permit stronger statements regarding causal mechanisms. Second, the present study assessed only worker perceptions of lean-related improvement and then only of flow and not downstream outcomes such as patient quality or safety. Again, our broader study, which is designed to collect both objective performance data and worker perceptions of quality, safety, and other outcomes, will permit us to address this limitation in future analyses. Third, in using ANOVA we assumed more than ordinal properties of our dependent variables (worker perceptions); while this is a debatable decision, our findings did not change when the models were analyzed using ordinal logistic regression. Several of our dependent variable measures were also single items, which is not optimal in some cases, but appropriate when the construct is distinct and unitary (Nagy, 2002, Wanous et al., 1997). Fourth, despite our relatively high response rate and thorough approach to recruitment, we did not achieve balanced cell sizes across the conditions of our three context variables. While not ideal, this is a typical challenge of organizational field research such as ours, in which voluntary questionnaires were administered to busy employees (Holden et al., 2008). The combination of focusing on nested levels of context (e.g., the three-way Hospital by Unit by Role interaction in this study) and the difficulties of field research recruitment poses an important challenge for future research seeking to obtain multilevel data within time and resource constraints. Fifth, one could question whether our study is able to conclude about the effect of lean on worker perceptions, given that lean was not implemented identically across contexts. This is true, and in fact is the point of the present study, which investigated the effects of different forms (or “bundles” (Shah and Ward, 2003)) of lean in different

contexts. Further research should similarly seek to elucidate the specific effects of implementation-context configurations (Mazzocato et al., 2012).

5. Conclusions

If researchers and practitioners acknowledge what Wilson (2014) called “the primacy of context” (p.7), then they must continue to examine how lean implementation and the impact of lean vary across settings, at higher (regional, hospital) and lower (unit, role, team) levels of analysis. Our study confirms that context matters and sheds some light on how specific lean implementation strategies in specific contexts influence employees' initial perceptions of lean. Future research on lean in healthcare should also examine national differences, given that hospitals and clinics all over the world are implementing lean but likely under different conditions and constraints. A second essential future direction is to use rigorous designs, measures, and analyses to understand how lean impacts healthcare workers, for better or for worse, as well as demonstrate why lean's impact on workers is an important outcome. Lastly, while the literature on lean in healthcare has grown in volume and has unearthed several excellent success cases, the next step in the evolution of research on lean in healthcare must be to go beyond confirming success and move into the realm of explaining, predicting, and replicating success. This will require careful theory building, hypothesis testing, and attention to both patient and worker outcomes: in short, a more principled, scientific, and human factors-based approach to understanding lean healthcare.

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Appendix A

Definitions of lean tools and concepts used in study hospitals

Tool or concept	Definition
Lean board	A structured physical board where ongoing improvement efforts and progress are visualized and tracked. The goal is for meetings to be held around the lean board.
Change agent	An individual with lean methods skills assigned by top management to support and promote the implementation of lean.
Value stream mapping	A technique for diagramming and analyzing the flow of material and information.
X-matrix	A document used by management for visualizing goals, indicators, and status relative to goals.
Process owner	The individual responsible for the results of the redesign of a specific process.
Process leader	The individual with clinical process expertise responsible for the progress of the redesign of a specific process.
Six Sigma	A quality management approach using a cyclical redesign process and statistical methods to manage defects and process variability.

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Highlights

- Hospital workers' perceptions of lean vary by hospital, unit, and role.
- Perceptions in Hospital A were unique compared to those in Hospitals B and C.
- Higher-acuity units typically reported more favorable perceptions.
- Nurses typically reported more favorable perceptions than physicians.
- Implementation differences explained some of the context-specific effects.

Figure 1.

Reported attitude and commitment to lean, perceived justice of lean implementation, and perceived workflow improvement from lean, aggregated across hospitals, unit types, and professional roles.

Table 1

Lean perception items.

Construct	Items (translated from Swedish)	Cronbach's alpha ¹
Attitude toward lean	<ul style="list-style-type: none"> To what extent do you think Lean is a good idea? To what extent do you like to work according to Lean? 	0.91
Commitment to lean ³	<ul style="list-style-type: none"> To what extent are you interested and committed to work with Lean? To what extent is Lean important to how you perform your work? 	0.84
Perceived justice of lean implementation ⁴	<ul style="list-style-type: none"> To what extent do you think the way that Lean was introduced at your hospital was done in a right and proper way? To what extent were employees at your hospital treated in a fair way in the implementation of Lean? 	0.81
Perceived flow improvement due to lean ⁵	<ul style="list-style-type: none"> To what extent has your work with Lean contributed to better workflow? 	-
Response scale:	Very low/None, Low, Medium, High, Very high	

¹ Calculated on present study data.² Based on standard items for attitude measurement (Ajzen, 2002).³ Adapted from Cook and Wall (1980).⁴ Adapted from Greenberg (1994).⁵ Developed based on Mazzocato et al (2012).

Table 2

Sample demographics.

	Hospital A (N=96)	Hospital B (N=57)	Hospital C (N=83)	Total (N=236)
Professions				
RN	67 (70%)	46 (81%)	57 (69%)	170 (72%)
MD	29 (30%)	11 (19%)	26 (31%)	66 (28%)
Years in profession				
< 2	8 (8%)	2 (4%)	11 (13%)	21 (9%)
2-7	28 (29%)	19 (33%)	31 (37%)	78 (33%)
8-14	16 (17%)	12 (21%)	25 (30%)	53 (22%)
>14	44 (46%)	24 (42%)	16 (19%)	84 (36%)
Sex, females				
RN	60 (89%)	39 (85%)	51 (89%)	150 (88%)
MD	8 (28%)	2 (18%)	10 (38%)	20 (30%)
All	68 (71%)	41 (72%)	61 (73%)	170 (72%)
Visibility of lean				
Lean is evident	35 (36%)	21 (37%)	32 (39%)	176 (37%)
Lean is subtle	61 (64%)	36 (63%)	51 (61%)	148 (63%)
Hospital Units				
<u>High-acuity</u>				
Acute-ED	18 (19%)	15 (26%)	29 (35%)	62 (26%)
Acute-ICU	25 (26%)	0 (0%)	0 (0%)	25 (11%)
Acute-Medical	0 (0%)	1 (2%)	26 (31%)	27 (11%)
Acute-Surgical	0 (0%)	20 (35%)	0 (0%)	20 (8%)
All high-acuity	43 (45%)	36 (63%)	55 (66%)	134 (57%)
<u>Lower-acuity</u>				
Ward-Medical	25 (26%)	7 (12%)	20 (24%)	52 (22%)
Ward-Surgical	28 (29%)	14 (25%)	8 (10%)	50 (21%)
All low-acuity	53 (55%)	21 (37%)	28 (34%)	102 (43%)

RN=registered nurse, MD=physician, ICU=intensive care unit, ED=emergency department

Table 3

Context and process of lean implementation, by hospital (at time of data collection, 2012).

	Hospital A	Hospital B	Hospital C
Implementation context			
Size	Small	Medium	Medium
Prior work with organizational development	Limited	Extensive	Extensive in some units but limited hospital-wide
Implementation process			
General initial approach	Individual projects and daily use of lean boards	Individual projects	Individual projects
Scope of improvements	Mainly confined to single units	Acute somatic flow (a cross-unit process)	Preselected (often cross-unit) clinical processes
Central actor(s)	Change agents	Hospital management team, change agents, lower-level managers	Team, "process owner," "process leader"
Change agent, term of hire	Two-year contract, one for each multi-unit clinic	Unlimited term, both clinic-level and central core of change agents	Unlimited term, central core of change agents
Change agent, role	Implement employee suggestions, educate employees	Clinic-level change agents work with lower-level managers to implement change	Support improvement teams, as needed
Nature of lean education	Change agents and two managers received education, then gave lectures to staff and manager colleagues	University lecturer, extensive education for managers, one day for physicians, written materials for change agents	Change agents received education
Employees engaged	Primarily nurses and assistant nurses, some lower-level managers	Primarily managers, clinician involvement varied by unit	Primarily teams of clinicians, top-manager "process owner," physician "process leader"
Key lean tools used ^a	Lean boards	Value stream mapping, X-matrix	Value stream mapping

^aSee Appendix A for definitions of these tools

Table 4

Mean (standard deviation) attitude, commitment, perceived justice, and perceived flow improvement scores* by Hospital, Unit acuity, and professional Role.

	Hospital A		Hospital B		Hospital C	
	Higher-acuity units	Lower-acuity units	Higher-acuity units	Lower-acuity units	Higher-acuity units	Lower-acuity units
Attitude toward lean (N=234)						
Nurses	3.01 (0.73)	3.49 (0.88)	3.83 (0.71)	3.35 (1.06)	4.19 (0.96)	2.91 (0.56)
Physicians	-	2.57 (0.84)	3.93 (1.53)	2.22 (0.86)	4.07 (0.63)	3.06 (1.00)
Both	3.01 (0.73)	2.98 (0.97)	3.84 (0.84)	3.03 (1.11)	4.17 (0.91)	3.00 (0.85)
Commitment to lean (N=235)						
Nurses	2.50 (0.81)	2.83 (0.94)	3.42 (0.89)	3.03 (1.17)	3.75 (0.93)	2.54 (0.82)
Physicians	-	2.29 (0.84)	3.70 (1.72)	1.83 (0.82)	3.55 (0.68)	2.76 (1.15)
Both	2.50 (0.81)	2.54 (0.92)	3.46 (1.02)	2.69 (1.20)	3.72 (0.89)	2.68 (1.02)
Perceived justice of lean implementation (N=230)						
Nurses	3.15 (0.71)	3.33 (0.67)	3.39 (0.64)	2.60 (0.57)	3.23 (0.73)	2.82 (0.84)
Physicians	-	2.70 (0.93)	3.30 (1.40)	2.33 (1.25)	3.28 (0.87)	2.65 (0.72)
Both	3.15 (0.71)	2.98 (0.87)	3.37 (0.76)	2.52 (0.80)	3.24 (0.74)	2.71 (0.76)
Perceived flow improvement due to lean (N=234)						
Nurses	2.54 (0.71)	2.96 (1.00)	3.35 (0.91)	2.60 (0.74)	3.76 (1.01)	2.36 (1.21)
Physicians	-	2.03 (0.86)	2.80 (1.48)	1.67 (0.82)	3.44 (1.01)	2.82 (1.07)
Both	2.54 (0.71)	2.45 (1.03)	3.28 (1.00)	2.33 (0.86)	3.71 (1.01)	2.64 (1.13)

* On 5-point scale, 1=Very low/None, 2=Low, 3=Medium, 4=High, 5=Very high