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Applying Lean Principles to Mitigate the "July Effect": Addressing Challenges Associated with Cohort Turnover in Teaching Hospitals

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Abstract
The healthcare system in the United States is comparatively superior to healthcare systems of other countries in terms of advanced and modern technology, drugs used, services offered, and required care. However, hospital management has to face the challenges in the managing of care and addressing safety issues for its patients due to the multiple stakeholders involved such as medical doctors, residents, nurses, diagnostic tool providers, as well as patients. Every year many people lose their lives due to medical errors caused by new employees in hospitals, errors that can be prevented by "mistake-proofing." Similarly, teaching hospitals face an increase in medical errors in the month of July due to cohort turnover, which occurs when trained residents graduate and new ones begin their residency, resulting in increased fatalities and mishaps; this phenomenon is called the "July effect." This sudden changeover of workforce puts the quality of healthcare in teaching hospitals at stake. In this paper, we discuss various reasons behind the July effect and several tools of quality that can be implemented to improve healthcare and increase patients' safety.

Keywords
July Effect, Cohort Turnover, Lean, Healthcare, Teaching Hospitals

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ABSTRACT

The healthcare system in the United States is comparatively superior to healthcare systems of other countries in terms of advanced and modern technology, drugs used, services offered, and required care. However, hospital management has to face the challenges in the managing of care and addressing safety issues for its patients due to the multiple stakeholders involved such as medical doctors, residents, nurses, diagnostic tool providers, as well as patients. Every year many people lose their lives due to medical errors caused by new employees in hospitals, errors that can be prevented by "mistake-proofing." Similarly, teaching hospitals face an increase in medical errors in the month of July due to cohort turnover, which occurs when trained residents graduate and new ones begin their residency, resulting in increased fatalities and mishaps; this phenomenon is called the "July effect." This sudden changeover of workforce puts the quality of healthcare in teaching hospitals at stake. In this paper, we discuss various reasons behind the July effect and several tools of quality that can be implemented to improve healthcare and increase patients' safety.

Introduction

"Cohort turnover" can be defined as replacement of a group of experienced employees with a group of new employees, who can be experienced or inexperienced. It is a threat that many organizations have to deal with. Some organizations have a year-round cohort turnover, whereas others may have a cohort turnover at a specific time of the year. At teaching hospitals, which fall in the latter category, future medical practitioners (i.e., residents) are trained (Kupersmith, 2005; Leeuw, Lombarts, Arah, & Heineman, 2012).

Cohort turnover at teaching hospitals is associated with a drop in the number of highly skilled workers. This leads to a decrease in overall productivity and knowledge as well as an increase in costs of the various operations, mishaps, and fatalities at these hospitals(Phillips & Barker, 2010). Phillips and Barker (2010) found that fatal medication errors increase by 10% in July in counties with teaching hospitals, whereas no such effect is observed in counties without teaching hospitals. Increase in fatalities or mishaps in the month of July due to cohort turnover is described as the "July effect" or "July phenomenon."

Some of the primary reasons that new residents make medical errors in teaching hospitals in early stages of their residency are (i) lack of experience working with patients (Ehlert et al., 2011); (ii) unfamiliar work environments, which includes the pharmacy, equipment, and hospital layout, leading to anxiety (Fletcher et al., 2004; Leeuw et al., 2012; Myers & Bellini, 2012); (iii) frequent paging during patient interaction or data entry; (iv) inefficient handoff or transfer of information (Myers & Bellini, 2012; Riesenberg et al., 2009); (v) long work hours (Fletcher et al., 2004; Peets & Ayas, 2012; Reed, Fletcher, & Arora, 2010); and (vi) lack of supervision, teamwork, and active discussion about errors (Myers & Bellini, 2012; Riesenberg et al., 2009).

Cohort Turnover and Various Causes for Cohort Turnover

Cohort turnovers can be divided into two types: voluntary and involuntary turnover (Patrick L. O'Halloran, 2012). Voluntary turnover is a turnover when an individual quits due to his or her own personal choice. This can happen when the employee (i) is offered a better job elsewhere, (ii) is offered a higher salary elsewhere, (iii) is offered a better work environment elsewhere, (iv) experiences feelings of powerless in the organization, (v) experiences high job pressures, and/or (vi) quits for personal reasons. This type of turnover is observed throughout the year (Kwon & Rupp, 2013; Ongori, 2007). Involuntary turnover occurs when an employer terminates an employee due to (i) downsizing of the organization, (ii) the employee's substandard performance, (iii) the end of a seasonal job, and (iv) retirement (Hong, Wei, & Chen, 2007; O'Halloran, 2012). In most cases involuntary turnover is initiated by the employer. According to many researchers, the rate of voluntary or involuntary turnover depends directly on the employee's relationship with the organization and his or her level of performance (Hong et al., 2007; Hurley & Estelami, 2007; Van Dick et al., 2004). High performers are more likely to have many employment opportunities and, therefore, are more likely to cause voluntary turnover, whereas very low performers are asked to leave as they cannot achieve the organization's expectations, giving rise to involuntary turnover (Biron & Boon, 2013).

Collective turnover is a kind of involuntary turnover that is seen in teaching hospitals (Huckman, Song, & Barro, 2014)"abstract":"Nearly all managers must deal with the consequences of employee turnover within their organizations. Despite the importance of this issue, several authors have observed that academic attention has been disproportionately focused on the causes rather than consequences of turnover. To investigate consequences more closely, the authors of this paper focus on the effects of turnover in a particularly high-stakes setting: teaching hospitals. Specifically, the authors examine the effects on productivity of cohort turnover-the planned simultaneous exit of a large number of experienced employees-in this case, medical residents and fellows-and a similarly sized entry of new residents and fellows. Typically, at (or slightly before. Such turnover happens when members of a group leave the workforce once their commitment has been fulfilled and they move on to the next level in

their career (Huckman, Song, & Barro, 2014). Collective turnover depletes an organization's performance due to the sudden reduction of "quality and quantity of employee knowledge, skills and abilities" (Nyberg & Ployhart, 2013). This type of turnover can reduce human capital resources, lower stock prices, and affect the overall unit's performance (Nyberg & Ployhart, 2013).

A teaching hospital experiences a negative impact due to collective involuntary turnover. In most organizations, the rate of involuntary turnovers usually is dependent on the performance and relationship of the employees with the organization. However, in teaching hospitals the turnover doesn't depend on the level of residents' performance or their relationship with the organization; the residents have to move on to new positions once they have successfully accomplished the various tasks required and progress further in their new assignments. This periodic turnover can also be observed in political administration and the military (Huckman et al., 2014; Young et al., 2011)"abstract":"Nearly all managers must deal with the consequences of employee turnover within their organizations. Despite the importance of this issue, several authors have observed that academic attention has been disproportionately focused on the causes rather than consequences of turnover. To investigate consequences more closely, the authors of this paper focus on the effects of turnover in a particularly high-stakes setting: teaching hospitals. Specifically, the authors examine the effects on productivity of cohort turnover-the planned simultaneous exit of a large number of experienced employees-in this case, medical residents and fellows-and a similarly sized entry of new residents and fellows. Typically, at (or slightly before. In this paper, the authors have identified challenges that are caused by cohort turnover in teaching hospitals and have employed lean principles to mitigate those risks.

Effects of Turnover on Organizations

Cohort turnover results in increased operational costs. These costs are of two types: (i) direct costs, such as recruitment, job training, and temporary staff ; and (ii) indirect costs, such as loss of organizational knowledge/memory, reduced productivity, pressure on the remaining staff, reduced customer satisfaction, and quality of service (Biron & Boon, 2013; Ongori, 2007). The most prominent direct effect on an organization is reduced customer satisfaction, which consequently reduces an organization's profitability and customers' loyalty (Hurley & Estelami, 2007). In the case of teaching hospitals, cohort turnover can reduce the quality of care for patients, affecting customer satisfaction and increasing the risk of mishaps.

Literature Review

Lean Thinking

Lean thinking is not just implementation of a set of tools; it is a system that requires thinking and thorough understanding. Simply, lean thinking can be defined as a thought process for improvement, with the principle "to do more with less" (Stone, 2012). For example, using lean thinking, Toyota Motor Company has consistently improved, achieving this success by implementing better processes that had superior design, better efficiency, and increased sales (Schwagerman & Ulmer, 2013).

Lean thinking was first introduced in the 1940s by the Toyota Motor Company (Womack & Jones, 1996). Mass production philosophies, developed by Henry Ford and used in the Western world, were based on high volume production of products with minimal changes in order to obtain high profits in the long run. On the other hand, the Toyota production system (TPS) was based on continuous flow production, which was quite different from the previous method, as their rate of production changed according to demand and they produced customized products as per the requirements of the customer. TPS had the principle of creating a product that was valuable to the end consumer (Melton, 2005). During the period from 1940 to 1980, Toyota evolved on the basis of lean thinking, which helped the company enhance its supply and distribution chain so as to improve customer satisfaction.

Currently, lean principles are implemented not only in a variety of manufacturing or production practices but also in the service industry such as in healthcare. Implemented lean principles vary considerably from production to production and service to service, but lean thinking emphasizes a reduction of waste, human efforts, investment, and production time, producing products with fewer defects and increasing the satisfaction level of its employees. Lean thinking is a process that requires a continuous learning culture, which companies and their employees who implement lean tend to forget. Without the continuous learning culture, lean tools are just standard works and the power of these tools become significantly limited (Rother, 2010; Schwagerman III & Ulmer, 2013).

According to Womack and Jones (1996), there are five principles involved in lean thinking implementation: (i) identify the value from the point of view of the customer, (ii) map the flow of the process, (iii) create a modified process that helps to reduce waste, (iv) establish a process that meets the customers demand, and (v) redesign the process to attain perfection and reduce waste. There are few articles that explain the successful implementation of these five principles in various industries. However, the level of yield achieved in some of these industries is nowhere near that of the Toyota Motor Company. This is because lean implementation

means not only application of its tools, such as 5S, value stream mapping, Kaizen, Kanban, etc., but also that the effectiveness of the implementation depends on the company's culture, its people, and how its principles are taught and learned (Schwagerman & Ulmer, 2013). This culture of thinking and innovating has to be developed in teaching hospitals.

Lean principles have created a revolution in both manufacturing and service industries worldwide for many years by creating a balance between quality and cost while providing value to customers using the most efficient and effective methods. Lean has enabled Toyota to become a quality leader. Similarly, lean can be applied to the service industry, such as healthcare management. Real-life application of lean thinking in teaching hospitals will improve efficiency, reduce the number of mishaps, increase patient satisfaction, reduce / residents' anxiety reduce residents' work hours and improve residents' confidence in their new environment through the use of various lean thinking tools such as Kanban cards, Heijunka, plan-do-study-act (PDSA), poka-yoke, visual controls, standard work, versatility charts, etc.

Lean in Healthcare

Lean thinking has been implemented in many hospitals throughout the United States. In the 1990s, hospitals started to experiment with lean thinking, and it has had the same impact and outstanding results as in other industries. There are many successful lean thinking applications in healthcare areas, such as in diagnostic units, hospital departments, hospital in-patient care units, parallel applications in multiple hospital-based units, multiple hospital-based units in collaboration, hospital-based pharmacies, parallel applications in multiple units within a hospital, and non-hospital clinics, that improved time savings and the timeliness of service, reduced costs or enhanced productivity, and upgraded several quality aspects that helped to reduce errors or mistakes, improved staff and patient satisfaction, and reduced mortality. There are many other intermediate outputs, which include reduced steps in a process and walking distance, increased process understanding, better staff engagement, increased willingness to collaborate, calmer and more focused working environments, reduced time to resolve error alerts, increased number of signaled errors, and improved teamwork (Mazzocato, Savage, Brommels, Aronsson, & Thor, 2010).

Similarly, the challenges that teaching hospitals face due to the July effect can be reduced by improving their processes using lean thinking. Because the yearly cohort turnover in teaching hospitals is a known, unavoidable, and recurring challenge, measures can be taken upfront to reduce the after effects. This can be done by addressing the various challenges separately.

The July Effect Phenomenon

An exhaustive literature review was conducted using the key words "July effect," "July phenomenon," "teaching hospitals," "handoff in healthcare," "residents," "interns," and "health IT," utilizing online databases such as Google Scholar. Information about various clinical skills that affect a particular group of patients in the month of July in teaching hospitals is provided in Tables 1 and 2. Furthermore, these tables provide a list of procedures followed to alleviate challenges that have been raised and to identify the presence or absence of the July effect.

TABLE (1): LITERATURE REVIEW OF THE ARTICLES THAT CLAIM THAT THE JULY EFFECT DOESN'T EXIST

Paper cited	Sample studied	Implementation or research details	Comments
Riguzzi, Hern, Vahidnia, Herring, & Alter, 2014	A retrospective analysis of a sample 283,621 from 2001 to 2008	Length of stay (LOS) was compared between teaching and nonteaching hospitals during the month of July with respect to the rest of the year	LOS is longer in teaching hospitals with residents than in nonteaching hospitals irrespective of the time of the year
Schroeppel, Fischer, Magnotti, Croce, & Fabian, 2009	12,525 patients in a month and 14,798 patients in a quarter were analyzed	Patients admitted after blunt force injuries from July 2001 to June 2006 are evaluated and compared with the outcomes of the quarterly and monthly analysis	The July effect didn't exist at the Level 1 trauma center
DiBiase, Weber, Sickbert-Bennett, Denniston, & Rutala, 2014	Hospital-wide surveillance with 781 residents and 67 subspecialty residents	Data were collected from 2010 to 2012 and healthcare- associated infections(HAI) from April–June were compared with those from July–September	There was no evidence of existence of July effect in HAI
Cohen et al., 2013	47 interns were trained in boot camp and 109 interns who didn't participate in the camp at the Northwestern University	Interns were trained in various clinical skills at boot camp before the internship began	The skills of interns showed significant improvement after the boot camp irrespective of gender, age, prior experience, or self-confidence

DiBiase et al., 2014	A systematic review done by the authors on 39 studies out of 18,919 articles and abstracts reviewed that were published between 1989 and July 2010	Different studies have supported various issues resulting from the July effect	The paper states that the studies provided anecdotal evidence of the July effect, but little hard data to confirm it.
Gopaldas, Overbey, Dao, & Markley, 2013	A retrospective analysis of data collected from hospitals nationwide from 1998–2007	The teaching hospitals surgeries were compared with nonteaching hospitals to understand their success rate	This paper states that success in surgeries is better at teaching schools than at nonteaching schools
Ehlert et al., 2011	Data were gathered on the 10 most common inpatient operative procedures from 2005–2007, which included a total of 89,473 patients	Analysis of the 10 most common inpatient operations and the time of the surgery	This paper states the stage of the disease affects the result not the time
McDonald, Clarke, Helm, & Kallmes, 2013	968,086 cases of spinal surgery were studied from 57,663,486 hospitalized patients nationwide from 2001–2008	Data were compared between teaching and nonteaching hospitals	The paper states that there is negligible effect of the July effect on spinal surgeries

TABLE (2): LITERATURE REVIEW OF ARTICLES THAT CLAIM THAT THE JULY EFFECT DOES EXIST

Papers Cited	Sample studied	Implementation or research details	Comments
Ratnapalan et al., 2012	129 patient records by 12 trainees in June 2006 and 122 patient records by 11 trainees in July 2006	Medical records were reviewed and compared between June and July 2006 in five areas; the same audit was repeated in July 2007 with sample charts displayed	There was a significant increase in errors by the new trainees in July 2006, which was significantly reduced when sample charts were displayed in July 2007
Inaba et al., 2010	A 5-year study of 24,302 injured patients admitted to Los Angeles County and University of Southern California hospitals	Clinical and demographic characteristics were compared; the number of preventable and potentially preventable deaths were found	At the beginning of the academic year, number of errors increased, making preventable deaths complicated, but there was no impact on mortality
Jen, Bottle, Majeed, Bell, & Aylin, 2009	Administrative hospital admissions data from 2000–2008	A retrospective study comparing the errors on the first Wednesday after the start of academic year to the previous week's Wednesday	Evidence was found that the possibility of death increases in English hospitals at the start of the academic year

Rosenthal & Vaughan-Sarrazin, 2013	Patient level data from 700 hospitals in period 1993 to 2001	Monthly trends of length of stay and mortality were compared during the start of the academic year and the rest of the year	Increased resource utilization was seen at both major and minor teaching hospitals and decrease in quality was observed at major teaching hospitals
Shulkin, 1995	28,541 medical records prepared during a 12-month period	Quality of care was assessed by screening the data using 47 quality indicators	The surgical department showed some adverse effects during July, and poor documentation was observed during the start of the academic year
Haller et al., 2009	Administrative and 19,560 patients record data from 1995–2000 in Melbourne, Australia	A retrospective cohort study that compared the rate of undesirable events at the beginning of the academic year to the rest of the year	The number of undesirable events increased among trainees irrespective of the level of their clinical experience

Statement of Problem

A detailed literature review on research suggested both an increase and no increase in fatalities due to the July effect. Articles that claimed no evidence of the July effect also addressed the challenges faced by hospitals due to cohort turnover resulting in decreased patient care, increased length of stay, etc. One thing that was clear from the literature review was that cohort turnover poses challenges for teaching hospitals and needs to be addressed. The implementation of lean principles remains one of the quality tools used by researchers, practitioners, and industry professionals to improve a process by reducing waste, streamlining the process by developing standardized procedures, and providing error-proof mechanisms. However, the authors found a dearth of research on utilizing lean as a quality tool in teaching hospitals to achieve process improvement, and this paper addresses this gap in the literature. This paper discusses the utilization of lean principles and other quality tools for mitigating the July effect by providing recommendations for ensuring patient safety and reducing waste in healthcare operations.

Discussion and Recommendations

This section focuses on the various factors that cause the July effect in order to find the root cause. Once the root cause of each challenge is identified, various subcategories addressing those root causes were evaluated. Furthermore, suggestions for improving the identified issues are discussed.

Fishbone Diagram

In order to conduct the root-cause analysis using a structured approach, a fish-bone diagram was created, as shown in Figure 1. A fishbone diagram typically is used to assist with problem solving and brainstorming. The six categories of the fish bone diagram were deduced from the extensive literature review of various articles that mentioned the July effect. The literature used to understand the cause and effect relationship of the July effect are cited and shown in Table 3. The categories and subtopics were identified as the top processes that affect or increase errors during the month of July. In the latter parts of the discussion, we provide recommendations for diminishing these challenges.

FIGURE (1): FISHBONE DIAGRAM FOR JULY EFFECT

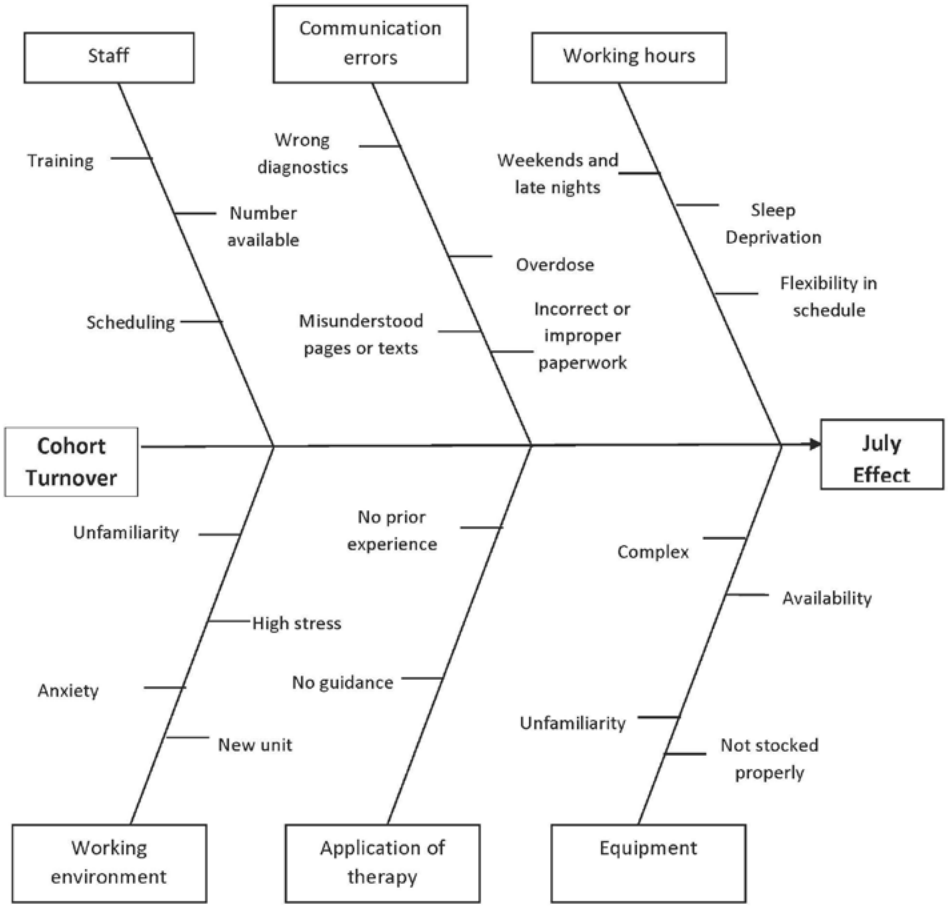


TABLE (3): THE SIX CATEGORIES OF FISHBONE DIAGRAM AND LITERATURE CITED

Reasons	Causes	Citation from literature
Staff	Training	Ehlert et al., 2011; Myers & Bellini, 2012; Riesenberg et al., 2009; Riguzzi, Hern, Vahidnia, Herring, & Alter, 2014
	Working hours	Riesenberg, Leisch, & Cunningham, 2010
	Scheduling	McDonald, Clarke, Helm, & Kallmes, 2013; Myers & Bellini, 2012
Communication error	Wrong diagnostic	Riesenberg et al., 2009; Shulkin, 1995
	Overdose	McDonald et al., 2013
	Incorrect or improper paperwork	Myers & Bellini, 2012; Peets & Ayas, 2012; Ratnapalan et al., 2012; Shulkin, 1995
	Misunderstood pages or text	Riesenberg et al., 2010; Shulkin, 1995
Working hours	Weekend and late nights	Ehlert et al., 2011; Peets & Ayas, 2012
	Sleep deprivation	Peets & Ayas, 2012; Steyrer, Schiffinger, Huber, Valentin, & Strunk, 2013
	Lack of flexibility in schedule	Ehlert et al., 2011; Peets & Ayas, 2012; Riesenberg et al., 2010
Working environment	Unfamiliarity	Cohen et al., 2013; Riesenberg et al., 2009
	High stress	Riesenberg et al., 2010; Steyrer et al., 2013
	Anxiety	Cohen et al., 2013
	New unit	Riesenberg et al., 2010; Riguzzi et al., 2014
Application of therapy	No guidance	Young et al., 2011
	Prior experience	Cohen et al., 2013; DiBiase, Weber, Sickbert-Bennett, Denniston, & Rutala, 2014; Riesenberg et al., 2009
Equipment	Complex	Cohen et al., 2013
	Availability	McDonald et al., 2013
	Unfamiliarity	Cohen et al., 2013; McDonald et al., 2013; Riguzzi et al., 2014
	Improper stocking	Riguzzi et al., 2014

Poka-yoke/Error-proof Mechanism

The percentage of human and system errors significantly increase when a system is not fool proof. In order to reduce these errors, training and education of the workforce and mistake proofing the system is essential (Deming, 1982). Similarly, in teaching hospitals, when new residents start their residency, various external factors and system issues increase the challenges for these new residents, which in turn hamper their performance and put patients' lives at risk. Smooth transition of new residents at teaching hospitals is necessary, and in order to accomplish this, a fool-proof mechanism needs to be provided that will help residents be more comfortable in their new role and effectively manage their duties.

Lean principles are very effective tools that have been utilized by various manufacturing and service industries for decades to systematically analyze and address problems. Knowing what errors occur and when they occur is not sufficient. It is important to address each error and provide a mistake-free environment. Error-proofing is a technique used to create a foolproof system to prevent people from making mistakes. This is achieved by designing equipment, processes, and tools in a such a way that there is no room for mistakes to take place or processes to be performed incorrectly. These error-proofing techniques can be utilized by teaching hospitals to eliminate mistakes and provide an environment for residents to thrive. Some examples of error-proofing are bar coding, which provides a bar-coded bracelet that can electronically identify the patient and ensure that each patient receives the correct treatment. Each sample specimen is labeled with a barcode rather than with a handwritten note, which can reduce ambiguity.

Visual Control and Standardized Work

When residents start their residency, they lack prior experience working independently with patients (Young et al., 2011); yet they are expected to diagnosis and treat patients in unfamiliar environments, which increases the chance of error (Barach & Philibert, 2011; Young et al., 2011). New residents are unfamiliar with their new working environment, equipment, hospital layout, and culture, which can cause anxiety. Various studies have demonstrated that a substantial percentage of residents experience significant anxiety during residency (Bellini, Baime, & Shea, 2002; Peterlini, Tibério, Saadeh, Pereira, & Martins, 2002). Anxiety negatively affects the performance of residents, which impacts their ability to perform effectively (Mitchell et al., 2005). It has been observed that the severity of a patient's condition increases the level of anxiety and stress among the residents (Peterlini et al., 2002). Furthermore, as residents shift from one unit to another unit during their residency rotations, the location of instruments, procedures followed, and culture within the new unit is different, among other uncertainties. Such uncertainty also increases anxiety and reduces residents' confidence (Bellini et al., 2002).

Research hospitals can reduce certain sources of anxiety among residents by providing a familiar environment among different units, for example, by specifying similar locations for commonly used instruments and arranging stock rooms in a similar manner (see Figure 2). Such efforts can reduce the learning curve for residents by reducing the time it takes to become familiar with each new unit. Furthermore, residents need to spend less time locating specific instruments or specific information. Using the same kind of basic equipment, such as sphygmomanometer, ventilator, or endoscope, etc., to perform similar tasks in all the units also can be helpful. Lean thinking emphasizes the use of less complex instruments, because that lowers the learning curve, makes maintenance and configuration easier, and addresses one piece instead of batch production. If hospitals use dedicated machines in the performance of tasks, it helps residents learn more quickly how to use each machine. Using similar machines in different units during the residents' rotations reduces the amount of time needed to learn new machines.

Furthermore, Kanban cards should be used to replenish and manage the inventory. Kanban cards provide a mechanism to provide a place for everything and everything in its place to ensure that materials are accessible with no wasted motion or searching; they also reduce running out of supplies and overstocking by providing enough inventory based on customer usage. A Kanban card is placed before the buffer stock so that there is enough time for replenishment. Whenever residents see the Kanban card, they can bring it to a specified location so the supplies can be replenished and they do not have to worry about running out of supplies.

FIGURE (2): REORGANIZED STOCK ROOM WITH EFFECTIVE VISUAL CONTROL

Pull System

Residents can get distracted by frequent paging, and that can hinder the information gathering and diagnosis or treatment of patients (Volpp & Grande, 2003). Such interruptions can further lead to active errors (Mueller, Lipsitz, & Hicks, 2013). Because residents cannot gauge the urgency of a notification, they tend to respond as soon as the notification is received, which causes disruption (Volpp & Grande, 2003). In teaching hospitals, if each pager message were to include its status as an emergency or nonemergency, it would help residents to stay calm. Furthermore, hospitals can send nonemergency messages or e-mails at a particular time of the day so that the residents can know to look at them later. The pull system of lean principles should be used for information management. A pull system focuses on providing "what [the] customer wants and when [the] customer wants [it]" (Womack & Jones, 1996). Information should be provided to residents only if and when it is useful. This reduces ambiguity and continuous paging. Furthermore, a continuous improvement system should be established by reviewing the feedback from the residents on managing information sharing.

Automation

Pen and paper is commonly used for information collection and transfer in hospitals. Medical errors increase when there is no uniform mode of information recording and transfer. Medication errors are one of the most common medical errors reported (Gogan, Baxter, Boss, & Chircu, 2013). Such errors can occur due to illegible handwriting, a noncomputerized system, and not investigating patient medical history properly. Illegible handwriting makes it difficult to discern the correct information, lack of a computer system causes nonuniform flow of information, and lack of patient history can put a patient at risk of allergic reaction to medication or negative medication interactions (Gogan et al., 2013; Rosenthal, 2013).

These medical errors can be reduced by using an electronic medical record (EMR) system. EMR systems have each patient's case history and treatment information (Qureshi et al., 2015). This helps to promote the effective handoff of a patient between residents and other hospital staff. These EMR systems not only help in patient handoffs but also can be utilized in emergency situations to provide information about the patient's medical history including drug allergies, prior tests, surgeries, in-patient dates, etc. and also to provide correct treatment without errors. Using an EMR system can reduce duplicate testing or over-processing of patient information, which is expensive and both time and resource consuming, increasing the efficiency of residents and patient treatments (Qureshi et al., 2015).

Heijunka/Leveling the Workload

Long work hours by residents are a common practice with some shifts lasting for 36 hours. Studies have shown that extended work hours impair neurobehavioral performance. Sleep deprivation reduces cognitive psychomotor function and increases the chances for error (Pilcher & Huffcutt, 1996). When residents work for 36 hours with little rest, it causes a severe decrease in the performance of the residents (Grantcharov, Bardram, Peter, & Rosenberg, 2001).

A study was conducted to compare the working hours of interns in traditional settings with those using an intervention method that was designed to reduce sleep deprivation (Landrigan et al., 2004). The traditional setting was one in which residents worked long hours, whereas in the intervention setting, the residents' schedules reflected shorter work shifts. The study found that eliminating the extended work shifts and reducing the number of hours a resident worked during a particular shift helped in reducing medical errors by almost 36% (Landrigan et al., 2004). Reducing the length of work shifts doesn't ensure elimination of the sleep deprivation challenge among residents. It also is important to critically plan residents' schedule so they can get an ample amount of sleep before they return to duty. Heijunka addresses the problem of imbalance in the production process by providing load leveling. Heijunka provides levelling by eliminating waste and inefficiencies in the production and interpersonal process. Similarly, Heijunka can be utilized by a teaching hospital to balance the schedule of residents so they do not have to work extremely long hours and be sleep deprived, which is a recipe for disaster.

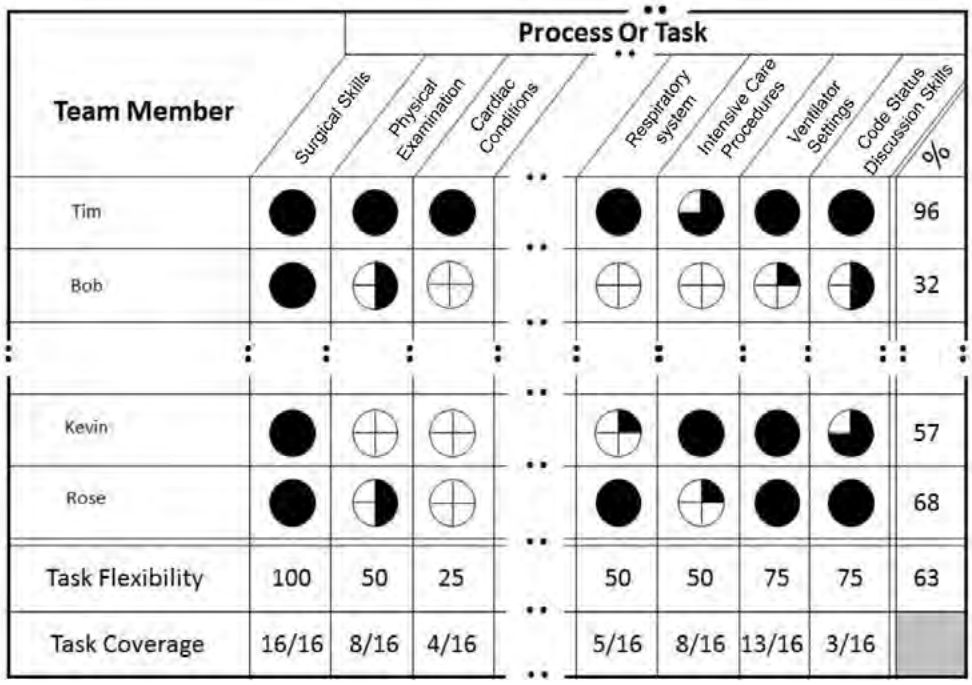
On the other hand, short work shifts for residents increase the number of patient handoffs. This can again increase the number of errors due to improper communication at the time of patient handoff. Having an EMR system can be very useful when residents have shorter shifts. Electronic patient records free up residents' time so they can relay patient information at the time of handoffs. This can save a significant amount of time and reduce the number errors in the long run. Later, the residents' schedule can be gradually extended if needed, as they become more aware of and comfortable with the work environment and tight schedules (Landrigan et al., 2004).

Production Stability:

There is lack of available data to understand the number of times residents have to perform the same task over and over again to become competent (Jansma, Wagner, & Bijnen, 2011). Most of the time residents learn by doing. Residents first perform tasks under the guidance of senior personnel and then repeat those tasks on their own (Jansma et al., 2011). Sometimes they might need to perform a procedure based only on their theoretical (instead of practical) knowledge, which can increase the chance of an error. As in a manufacturing operation, it can be helpful if a skill versatility visual display is be used to track residents' competency in a particular procedure or machine operation (an example of a versatility chart is shown in Figure

3). A versatility chart provides visual information of the skill level of each worker and helps in cross-training, skill management, and motivating other employees to enhance their skills. This provides residents with information about who else they can ask for help when performing an unknown procedure by themselves, thereby subjecting patients to risk. A versatility chart can create production stability by promoting the development of multiple skills among residents and by eliminating inabilities in the process. Lean thinking emphasizes cross-training of employees and motivating employees to be cross-trained so that they can address the needs in other areas during emergencies. Similarly, it is important to train residents for different procedures and emergency situations so that they can be well prepared and handle them with confidence. Teaching hospitals also should provide training and workshops to improve the competence of the resident (Nadel et al., 2000). Such trainings will help standardize practices in hospitals.

FIGURE (3): VERSATILITY CHART



Toyota production systems were remarkably successful with manufacturing cars using lean principles. Lean thinking in the healthcare sector wouldn't be a simple translation, but methods of improvement and better quality can be learned from techniques used in the automotive sector. These learned methods can be adapted and developed with an aim of improvement in providing healthcare. Applying lean principles in healthcare would encourage, motivate, and inspire everyone to work in even the most stressful and difficult environment of hospitals.

Kaizen

Kaizen means continuous improvement; it requires a team to work together and make incremental changes. There are many quality control tools, specifically lean tools, which can be used to improve the quality of healthcare and increase patient safety by eliminating the July effect. The PDSA model method provides a system for a continuous improvement cycle with small, frequent improvements. PDSA helps in systematically identifying the nature and scope of a problem, which in this case, would focus on addressing the July effect. PDSA can help identify the key people who need to be involved in this process analysis and improvement, what needs to be measured, what strategy needs to be implemented, and at the end, how to keep the process as a closed loop with room for future improvement. This includes training the staff, patient follow up, and regular meetings to assess the development of the model for improvement. To make lean efforts sustainable in a teaching hospital, it is important to have continuous improvement through Kaizen events that can ensure small incremental positive changes in the process by involving residents in the process.

Limitations

This paper is based on existing literature with respect to lean thinking in healthcare, the July effect, cohort turnover, and quality management systems. Although recommendations are provided based on prior research conducted in various teaching and nonteaching hospitals, the effects of these implementations need to be systematically measured to identify the degree to which benefits accrue. The other limitation is that lean implementation requires a thorough study of the individual processes. Furthermore, because processes might differ from hospital to hospital, when implemented, the chance of obtaining the expected level of output from these processes may be reduced. Thus, the generalization of recommendations is limited and needs to be adapted based on each teaching hospital's requirements.

Future Research

Within the discussion and recommendations, the authors have identified various areas where lean and other qualities tools can be implemented in teaching hospitals. In future research, these recommendations have to be implemented in a teaching hospital in order to evaluate the long-term effects of implementing lean principles and to observe the level of improvement in each process. The errors in the implemented processes must be detected and better and improved processes must be implemented. The observed results can then be reported from the time of implementation.

Conclusion

Quality of care is imperative in the healthcare industry; after all, the lives of patients are at risk. When a phenomenon such as the July effect can be easily observed in an industry, there is need for improvement of the existing processes. The processes can be improved by addressing the various effects of cohort turnover at different levels. Lean principles have been previously adopted in the medical field with significant positive outcomes; however, the implementation of lean principles has not been measured in teaching hospitals. The adoption of simple tools, such as the versatility map, visual displays, and EMRs, will result in a better overall quality of outcomes for patients. By implementing the suggested routes of improvement—better training and follow up as well as staggering resident entrance dates—the industry can take steps toward improved processes and ultimately higher quality work.

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