Research Journal of Applied Sciences, Engineering and Technology 8(3): 410-422, 2014
DOI:10.19026/rjaset.8.987
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: April 01, 2014 Accepted: April 28, 2014 Published: July 15, 2014

Research Article

Framework for Patient Flow Improvement

[1]S.V. Medina-León, [2]A. Medina-Palomera, [1]A. González-Ángeles, [3]P. Rogers, [1]M. Gil-Samaniego-Ramos, [1]J. Ceballos-Corral and [1]V. Nuño-Moreno
[1]Facultad de Ingeniería, Universidad Autónoma de Baja California, Blvd. Bénito Juárez s/n, Mexicali, B.C. 21900, México
[2]Instituto Tecnológico de Mexicali, Av. Tecnológico s/n, Mexicali, B.C. 21396, México
[3]Schulich School of Engineering, University of Calgary, 2500 University NW, Calgary, Alberta, T2N 1 N4, Canada

Abstract: There has been much research where the flow of patients was improved, but most of this study is case-specific and only a few papers offer guidelines for patient flow analysis and improvement. In this study a general framework for the analysis and improvement of patient flow is presented, based on a literature review and on experience from a case study in a hospital in Mexico dealing with identifying improvement opportunities that reduced waiting times in the obstetrics/gynecology area of the emergency department. The framework involves an initial analysis using basic tools followed by the selection of a strategy based on system complexity; financial investment required and team participation. The alternative strategies considered were use of advanced analysis tools; use of kaizen events; or direct recommendations. The aim of the framework is to serve as guideline in patient flow improvement projects by helping select the most appropriate improvement path, resulting in project success.

Keywords: Emergency department, healthcare, hospitals, kaizen, patient flow

INTRODUCTION

This study began when it was faced the question of how to improve patient flow in a public hospital located in the city of Mexicali, Baja California, Mexico. By patient flow we mean the movement of patients between and within different service stations, ideally without waiting for a service due to the lack of availability of personnel, equipment or information. Mexicali is an industrial city where industrial engineers are usually used to analyze and improve manufacturing systems. However, we were faced with a healthcare institution wanting us to evaluate its system and receive the resulting recommendations and it was uncertain how to proceed in this different context. Is it the same as in manufacturing/industry? What were the right tools to use? What aspects should it consider?

In the literature there are many articles related to improving patient flow using different analysis tools. For example, Maull *et al*. (2006) used Discrete-Event Simulation (DES) to evaluate the fast track strategy in a hospital emergency department gaining a significant reduction in patient waiting time; Santibáñez *et al*. (2009) used discrete-event simulation to reduce patient waiting time and improve resource utilization in the British Columbia Cancer Agency's ambulatory care unit; Koizumi *et al*. (2005) modeled patient flows using a queuing network to analyze congestion processes in state mental health institutions in Philadelphia; Rohleder *et al*. (2005) used goal programming to improve patient flow by improved surgical service block scheduling; Coffey *et al*. (2005) used critical paths to reduce patient delays, increasing healthcare quality; and Konrad *et al*. (2013) used DES to evaluate the split flow concept for Saint Vincent Hospital Emergency Department (ED) in Worcester, USA, resulting in a reduction in waiting time measures and patient Length of Stay (LOS); the split flow concept consists in splitting patient flow according to patient acuity and enabling parallel processing. However, few articles have focused on presenting a structured methodology to follow in general terms for performing a patient flow analysis. Some of the most interesting work found in the literature is described next.

Hall *et al*. (2006) stated that solutions to delay problems in healthcare come in three forms:

- Alter the service process, for example through scheduling, process changes, automation, etc., in order to increase the capacity for serving customers.

Corresponding Author: S.V. Medina-León, Facultad de Ingeniería, Universidad Autónoma de Baja California, Blvd. Bénito Juárez s/n, Mexicali, B.C. 21900, México, Tel.: +52 (686) 566-4270; Fax: +52 (686) 566-4270 Ext. 1305

- Alter the arrival process, for example through appointments, pricing, information, etc., in order to improve the alignment between capacity and demand.
- Alter the queuing process, for instance through triage, changes in prioritization, moving waiting from the health care facility to the home, etc. in order to reduce the adverse consequences of waiting.

For these three types of patient flow solution they presented an approach to improve patient flow focused on process planning and performance measurement. Under process planning they referred to describing and redesigning the process for improved efficiency, for performance measurement they entailed identifying the system goals and the measures to check if the goals are attained. They also stated that performance measurement is used as an approach for obtaining a picture of patient flow and helping identify improvements. Hall *et al*. (2006) applied their approach for patient flow analysis in Los Angeles County/University of Southern California Hospital using several tools.

Chand *et al*. (2009) presented a structured process analysis and improvement approach. Their approach consisted of:

- Process, team and metrics selection
- Process mapping, validation and identification of sources of variability and possible improvement factors
- Data collection and simulation model development and validation
- Design of Experiments (DOE), statistical models and determination of optimal factor values
- Study of effectiveness of improvement factors

This approach was applied in the Grassy Creek Clinic in Indianapolis where the objective was to reduce patient wait time and improve Physician finish time.

Naseer *et al*. (2010) developed a tool called "Research into Global Healthcare Tools" (RIGHT) to help healthcare practitioners select the appropriate modeling and simulation technique based on seven questions describing the problem. Through these questions the tool obtains information about:

- The application area (budgetary, service oriented, facilities, risk, etc.)
- The level of insight required from modeling (policy, strategic, managerial and operational)
- The time available to solve the problem
- The money availability
- The accessibility and availability of data
- The level of detail for the solution (e.g., just some insight, trend analysis, system interactions, detailed answer or exact)

Based on the answers the tool assesses the alternative techniques against five issues: time; money; knowledge; data; and level of detail. The top five techniques are selected and displayed in form of a Radar Chart. The techniques considered in the RIGHT tools are classified into categories including:

- Problem Structuring (drama theory and confrontation analysis, robustness analysis, soft system methodology, strategic choice approach and strategic options development and analysis)
- Conceptual Modeling (influence diagrams, process mapping methods and, unified modeling language)
- Mathematical Modeling (decision trees, Markov modeling, multivariate analysis, Petri nets, queuing theory, survival analysis and, analytical optimization techniques)
- Simulation (agent-based simulation, discrete-event simulation, gaming simulation, hybrid simulation, inverse simulation, real time simulation, system dynamics and, stochastic combat simulation)

Eitel *et al*. (2010) presented a discussion of specific methods to improve the ED quality and flow. The authors stated that solutions to improve ED throughput and quality of care can include the implementation of the following methods: demand flow management, critical pathways, process mapping and workflow diagramming, emergency severity index, lean and six sigma business methods, statistical forecasting, queuing systems, DES, balanced scorecard, bedside registration, bioterrorism and disaster planning, the one-bed ahead strategy, improving bed flow by allowing admitted patients with bed assignments to board on hospital floors and changing elective surgery scheduling to accommodate the resource demands for ED patients.

Venkatadri *et al*. (2011) used a two phase methodology to implement process improvement at its cardiac catheterization lab department where one of the key objectives was to reduce patient turnaround time. The first phase consists of using the five stages of the six sigma method as follows: DEFINE by studying and understanding the existing process; MEASURE using process maps and time studies; ANALYZE historical data using statistical tests; IMPROVE by identifying potential causes for delay and recommendations for improvements; and CONTROL by discussing with subject matter experts to ensure recommendations are implemented as expected. The second phase uses DES to quantify the recommendations suggested during the first phase.

Paul and Lin (2012) recently presented the development of a generic methodology to investigate the causes of overcrowding and to identify strategies to resolve them and applied it in the ED. The methodology consists of five phases. Phase 1 is composed of three steps: step 1 refers to understanding the detailed operational logic and procedures in the ED using a process flow diagram; in step 2 all activities listed in step 1 are classified into one of two categories-waiting (for personnel, laboratory-radiology results, beds) or care delivery; and in step 3 activities are categorized as either internal or external (to the ED) in order to identify the factors that are within the team´s control. Phase 2 consists of the development of a DES model. Phase 3 refers to the validation of the DES model. In Phase 4 the model is used to study the effect of resource availability and process improvement on patient throughput and waiting time. After an evaluation of the impact of improvement activities suggested by the project team, recommendations are made. Finally, Phase 5 consists of the implementation of the recommendations. The authors stated that this methodology is a detailed analysis which could reveal the true bottlenecks and present the application in an ED of a hospital.

On the other hand, several case studies in the literature improved patient flow through applying Lean philosophy. Lean has been applied in different hospitals, principally in the United States, UK and Australia (De Souza, 2009). Some of the cases where Lean has been applied to improve patient flow are:

- Bolton Hospitals NHS Trust in the UK (Fillingham, 2007), uses an improvement program based on Lean called Bolton Improving Care System (BICS) and they used a model from their consulting partners “Simpler” to improve patient flow consisting on five steps, which are:
  - Get the process flowing without interruptions.
  - Establish the changed process into staff habits through visual standard work that show the current best way of performing the flow and correct staffing for given demand scenarios.
  - Apply 6S, referring to clear to See, Straighten and Sweep and clean, Safety, Standardize and Sustain.
  - Pull patients from upstream steps when they are ready.
  - Design visual management aids so that leaders can simply go and see what is happening and what the next problem to solve.
- Hôtel-Dieu Grace hospital in Canada (Ng *et al*., 2010), formed a multidisciplinary group to reduce waiting times in the emergency department through a value stream mapping kaizen workshop over three days: on day 1 a current-state map was created and three key bottlenecks were identified and at the end of the day results were presented to a decision panel formed of senior administrators and physicians; on day 2 a future-state value stream map was created; on day 3 projects were planned, including project leaders assignment, timelines, objectives and outcome measures for each project. At the end the projects, implementation plans were presented to the decision panel for approval.

In the literature was found many articles on improving healthcare systems but few of them were presented in generic terms. An analysis of patient flow was done and recommendations were given, but as a result of our experience and literature review a generic framework was subsequently developed to serve as a reference for other professionals embracing projects about patient flow improvement and facing the same questions we initially had.

PROPOSED METHODOLOGY

The various stages of the proposed framework along with literature that supports the different approaches are presented in this section. The proposed framework, shown in Fig. 1, was developed based on the review of the literature and on experience from the case study. This framework aims to: consider evaluation of different problem solving techniques; provide guidance in the decision making process; and indicate how to start-up a patient flow analysis.

The framework starts with an initial analysis phase and then branches into a choice amongst three different strategies (solution approaches), which are:

- Advanced analysis
- Kaizen events
- Direct

A description of each of the sections of the framework is presented in the following paragraphs.

Initial analysis: In this phase of the framework, the objective is to understand the process being improved, including determination of:

- The steps with the longest waiting times
- The causes of waiting
- The opportunities for improvement
- The possible improvement actions
- The problem solution strategy to follow

In this phase, a key aspect is the participation of personnel from all levels involved in the project; therefore the authors do not recommend the use of complex methods which might not be understood by all personnel.

The inclusion of this phase in the framework is due to two reasons:

- Firstly the system should initially be analyzed without the use of complex methods. In the literature there are very interesting articles presenting the use of advanced analysis methods such as discrete-event simulation, Markov chains or queuing theory. However, many cases can be solved using simple analysis tools such as flowcharts, cause and effect diagram, Pareto

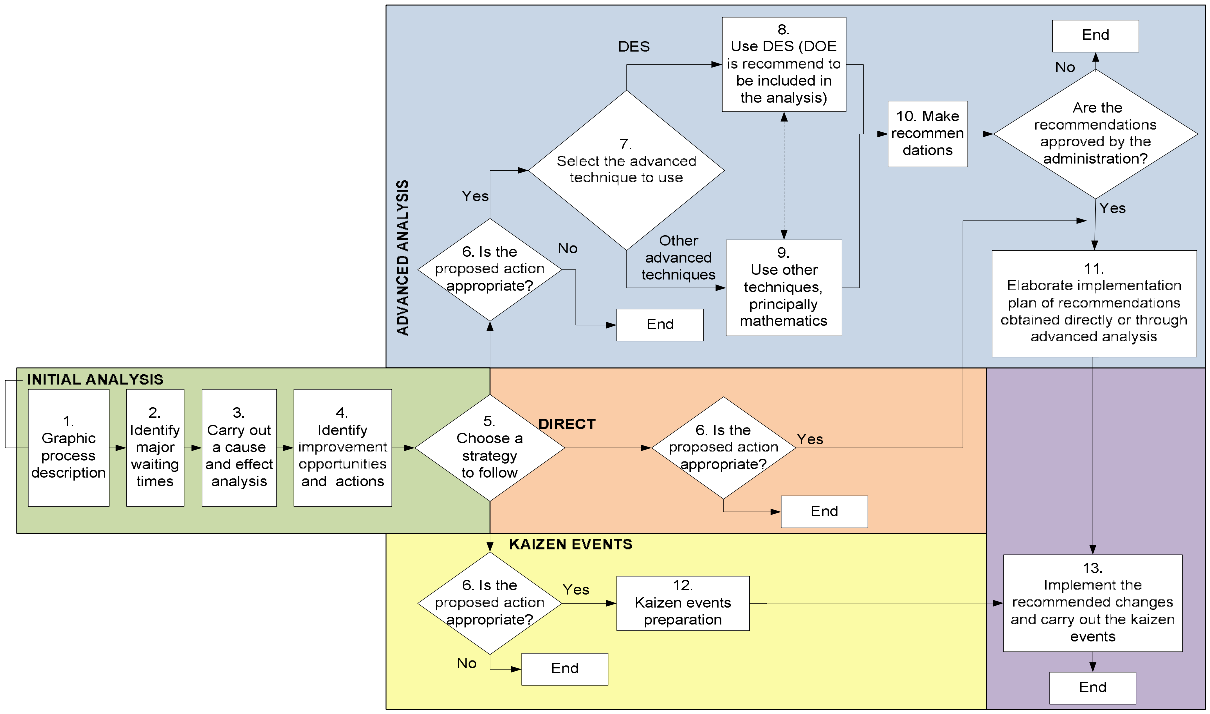

Fig. 1: Framework for patient flow improvement

diagram or brainstorming. An example of using basic analysis tools in healthcare was presented by Fernandes *et al*. (1997) who used a flowchart and a cause-and-effect diagram to analyze root causes of laboratory delays for an emergency department. In addition to this perspective, Brailsford (2005), in her article about barriers to implementation of simulation models, mentions "academics and end-users have different agendas because while academics need to publish in peer-reviewed journals and must thus demonstrate theoretical or methodological advances, the end-user wants a simple, easy to use model". It is important to make clear that the authors are not against the use of advanced analysis tools, nevertheless the authors consider that the analysis must be started using simple tools before adding additional complexity if and when needed.

- It is extremely important that process owners and participants (administrators, consultants, internal or external analysts) be involved in any patient flow improvement project from the very first step. The project must include the participation of multidisciplinary personnel, which may include physicians, nurses, laboratory technicians, administrators and cleaning and maintenance personnel because they are the ones with deep knowledge of the system. The participation of process owners/participants in the project increases the probability of a successful implementation because they have been involved in the development of the resulting action plan rather than this being imposed by an external analyst. The literature supports this as reported in the study by Brailsford *et al*. (2009) who found that only 18 articles about simulation projects published out of 342 were implemented successfully. Brailsford (2005) argues that one key point for a successful implementation is that at least one of the authors worked in the institution. Similarly, Tunnicliffe (1981) recommends the participation of the decision maker in the project for a successful implementation. In addition, Hanna and Sethuraman (2005) argue that the most significant results in healthcare projects have been achieved when efforts are led by a team of individuals representing all of the stakeholders. All of these studies highlight the importance of the participation of personnel in the projects in order to achieve a successful implementation.

In summary, the strength of this phase is the observations and participation of the personnel. At the end of this phase each of the resulting improvement actions is evaluated to determine if it requires advanced analysis methods, or if it is more convenient to pursue it through a kaizen event or if it is so simple that the solution can be obtained following just the initial analysis. It is recommended to use advanced analysis methods only when the improvement actions require a significant financial investment or the problem is complex to solve. For example a problem

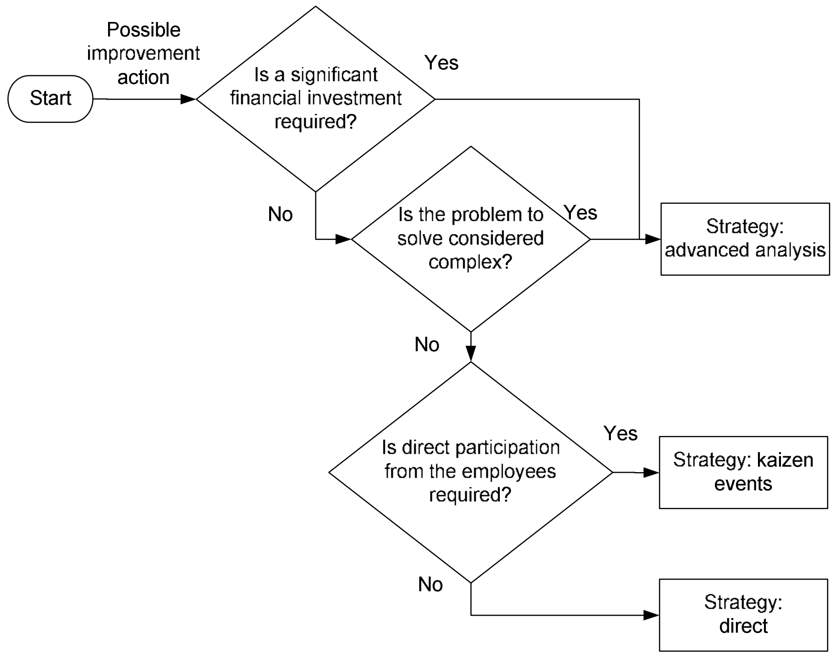

Fig. 2: Flowchart for selecting the preferred strategy

is considered complex when any of the following apply:

- There is significant uncertainty about the expected results.
- There are multiple interacting factors to consider.
- Additional experimentation and optimization is required to find the best solution.

When the improvement actions do not require advanced analysis methods but do require team work and personnel involvement, a kaizen event is the recommended strategy. Finally, if the improvement action does not require advanced analysis methods or team work and the solution is so simple that can be determined during the initial analysis phase the preferred strategy is direct. Figure 2 shows the flowchart for selecting the most appropriate strategy to follow.

Solution strategies: The strategies to follow for the identified problems were categorized above and in Fig. 1 as:

- Advanced analysis
- Direct
- Kaizen events

This section describes each of these strategies in more detail.

The advanced analysis methods strategy:
DES: Discrete-Event Simulation (DES) is the preferred advanced analysis tool for the problem of improving patient flow; therefore it is highlighted as a single block in the framework. In the literature, several authors have used DES to improve patient flow, for example Mahachek and Knabe (1984), Ruohonen *et al*. (2006), Balci *et al*. (2007), Duguay and Chetouane (2007), Pérez *et al*. (2008), Brenner *et al*. (2010) and Zeng *et al*. (2012).

The importance of this technique for improving and analyzing patient flow is:

- DES allows modeling complex systems such as a hospital. A hospital is complex because:
  - It is a stochastic system involving random events such as: patient arrivals, LOS and type of surgical procedure to perform.
  - It embodies significant time-dependent behavior, for example the patient arrival rate changes depending of the time of day, day, week or month.
  - It includes many resources for the provision of care, each of which might prevent smooth patient flow, e.g., nurses, physicians, cleaning personnel, beds, surgical wards and equipment.
  - It involves complex patient flow paths, with patients typically passing through several departments, in each of which several processes might be performed.
  - There are floating or shared resources that are not assigned to a unique process, for example a physician divides his day in external consultation, emergency department, surgical rooms, inpatient wards and administrative work.

  Davies (1994) and Stafford (1978) compared DES to several mathematic techniques such as Markov chains, semi-Markov Chains, input-output analysis and queuing analysis. They found that DES adjusts to modeling healthcare systems due to its complexity while many optimization techniques such as linear programming, have a limited capacity to characterize the complexities of healthcare systems. An optimization technique may require many unreal process assumptions, resulting in invalid and unrealistic solutions. Also Karnon and Brown (1998) compared decision trees, Markov chains and DES. They mentioned that the main advantages of DES are that it allows the modeling of more complex and dynamic systems, permits experimentation and better captures more uncertain details about the modeled system. Paul and Lin (2012) described the ED as a highly complex system where a valid mathematical model would be in itself very complex and based on using DES in their methodology for improving patient flow.

- DES allows detailed modeling of parts of the system, as required. Unlike mathematical or system dynamics models, DES allows the system to be modeled to an arbitrary level of detail, for example the physician consultation process can be divided into sub-processes for a more detailed analysis. Related to this, Brailsford and Hilton (2001) commented that system dynamics models are not appropriate for detailed modeling and perform poorly with stochastic variation. Likewise, Davies (1994) noted that optimization models cannot be used to study daily operations details of a healthcare clinic such as appointment scheduling, routes and service priorities, which can be easily captured by a DES model.
- DES allows experimentation without interfering with the real system. Healthcare systems are peculiar because:
  - In many situations observers or process analysts are not allowed due to patient privacy.
  - Experimentation is not allowed when patient health is at risk.

Through a simulation model, the system can be observed and experimentation can be performed without interfering with patient health. Through the use of simulation we make sure that the proposed improvements have a positive impact before implementing the changes in the real system.

As a final point on the use of DES, it should be highlighted that design of experiments techniques should be used during model analysis due to the importance of performing a more efficient experimentation (Sanchez, 2007).

Other advanced techniques: DES is not the only advanced analysis technique, therefore the framework includes the option of using other techniques, typically mathematical modeling of some sort, on an individual basis or in conjunction with DES.

If only analytical/mathematical techniques are used, unlike DES, the results can typically be obtained in less time, with less data and usually with less financial investment. DES requires considerable time, mainly due to the great quantity of data required and that many healthcare institutions do not have the required information in electronic format or in any format, therefore it has to be collected. Davies (1994) commented that optimization models require only one experimental run to generate optimal or near-optimal solutions while simulation models require a great effort in time, cost and data collection.

Mathematical techniques can also be considered as a complement to DES, for example it is common to use optimization techniques with DES, indeed optimization techniques are already incorporated in some simulation software packages (e.g., optimum-seeking simulation, Rogers (2002)). Some examples of mathematical techniques are: queuing theory, differential equations, Markov chain analysis, semi-Markov chain analysis, input-output analysis, linear programming and integer programming and decision trees.

Some examples of improvement actions that may require advanced analysis are:

- Facility layout
- Balancing of resources such as beds, equipment and personnel
- Determining the incorporation of new resources such as surgical rooms, equipment and personnel
- Evaluating changes in processes and policies

After using advanced analysis techniques, the resulting recommendations are presented to the administration that makes the final decision regarding implementing the proposed changes. If the recommendations are approved, then follows the preparation of an implementation plan.

The kaizen events strategy: Kaizen is derived from the Japanese language meaning Continuous Improvement. It is part of the Lean Philosophy and means that people in the organization keep gradually, incrementally and continuously improving processes.

A kaizen event is a structured and planned way for implementing kaizen. Burton and Boeder (2003) describe it as “a planned and structured event that enables a group of associates to improve some aspect of their business. Prior to the actual event, an area is chosen and prepared, a problem is selected, leaders and teams are chosen, the problem is baselined, an improvement target is set, measurements are selected and a time frame is set for the event”.

The authors recommend using kaizen events when the improvement action does not require advanced analysis techniques but does require direct participation of system personnel and teamwork. In addition, it is recommended to carry out kaizen events after implementing changes resulting from advanced techniques analysis (if performed), because usually those changes have more impact and are interrelated; for example a recommendation after using advanced analysis might be changing the layout of an emergency department but also a kaizen event might be using 5S, which is a tool for keeping work areas systematically clean, organized and safe (Tapping *et al*., 2009). Both activities are interrelated and it is recommended to change firstly the layout distribution of the department and then work to organize the area with 5S.

In the literature, there are several cases where hospitals used kaizen events at implementing Lean obtaining improvements in patient flow. For example Dickson *et al*. (2009) reported the implementation of a 5-day kaizen event to institute Lean in an emergency department where average patient LOS was reduced and Ng *et al*. (2010) used a three day kaizen event to reduce waiting times in an emergency department where mean registration to physician time and LOS for discharged patients decreased.

Other healthcare improvement approaches found in the literature besides Lean were Six Sigma, Theory of Constraints, Reengineering and StuderGroup´s Hardwiring Excellence (De Souza, 2009; Vest and Gamm, 2009; Langabeer *et al*., 2009). De Souza (2009) commented that in the United States, Lean is becoming a successful approach in the healthcare private sector. Vest and Gamm (2009) considered that the most relevant transformation strategies in healthcare are Lean, Six Sigma and Studer Group´s Hardwiring Excellence. Langabeer *et al*. (2009) commented that Lean and Six Sigma are the leading improvement initiatives. After a review of these improvement strategies, Lean was determined to be the proper approach to incorporate in the framework for patient flow improvement because of its simplicity, its involvement of employees from all levels and that it is not just a problem-solving methodology but a work philosophy which promotes respect, team work and continuous improvement thinking.

Lean is made part of the framework (through kaizen events) on account of the following:

- There are simple low cost improvements that can be realized, without making complex analysis, because they do not require a significant investment and can be done in a short period of time.
- It is important to include in the framework the direct participation of personnel, since by doing this resistance to change is reduced and the probability of a successful implementation and follow up is increased.
- Employees know the most about the process to be improved and this knowledge must be taken advantage of to help in identification of causes of problems and of solutions.
- It helps to keep personnel interested, compared with the use of advanced techniques such as DES that require much time to use and involve low participation of personnel, leading to a potential lack of interest from the personnel in the study.
- When a study ends, the institution will be able to continue using kaizen events to maintain the improvement system. A Kaizen event is a simple Lean tool that can be adopted by the personnel as a cyclical activity in the institution with low training.

Some examples of improvements that may be realized with kaizen events are:

- Implementing a 5S program to improve the organization of the work place (Tapping *et al*., 2009)
- Use of the SMED technique (Single Minute Exchange of Dies) to reduce preparation times of surgical rooms or beds (Wedgwood, 2006)
- Implementing Kanban to control level of inventories (Tapping *et al*., 2009)
- Implementing Points of Use Inventory consisting of storing material where it is used
- Standardization of operations (Tapping *et al*., 2009)
- Use of visual boards to show patient status, workers and processes
- Increase efficiency through the elimination of unnecessary processes

The direct strategy: This option is included in the framework because in the case study many improvement actions identified in the initial analysis phase did not require further analysis nor did they require teamwork or employee participation for implementation. Basically the only requirement for implementing such recommendations is the approval of administration. For example for the case study many maintenance orders for the building were generated in this phase.

CASE STUDY

The case study experience involved analyzing patient flow in a public hospital in the city of Mexicali, Baja California, Mexico. The scope of the study was the obstetrics and gynecologist emergency department with the additional restriction to exclude personnel

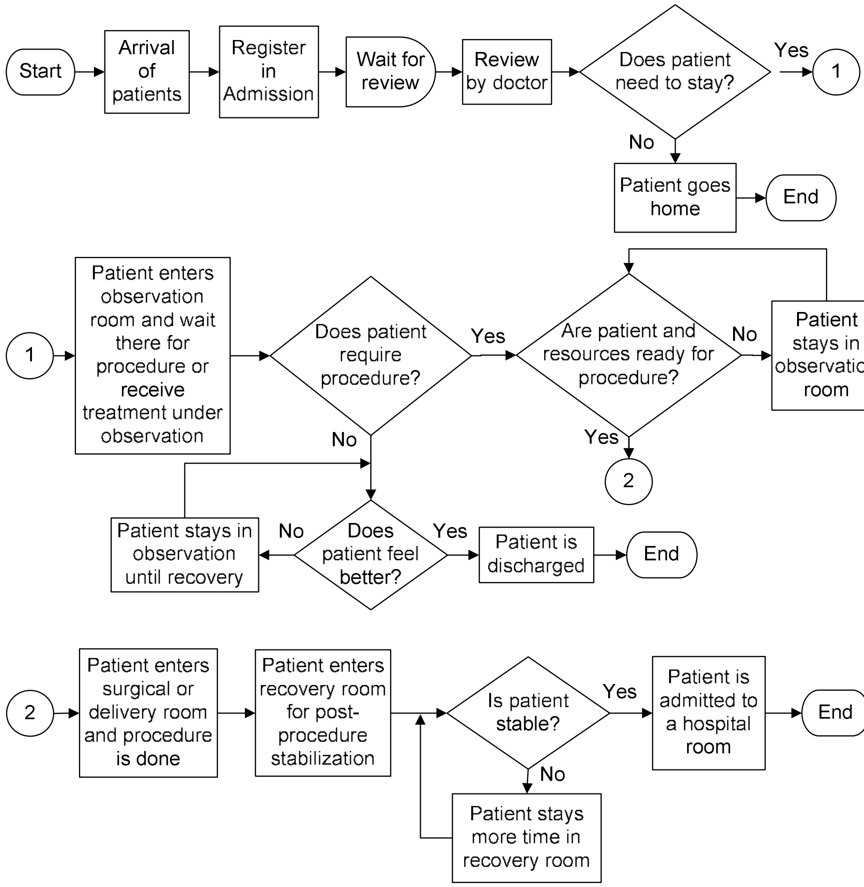

Fig. 3: Flowchart of patients in the obstetrics and gynecologist area of the emergency department

decisions such as hiring or moving personnel to other departments. At the end of the study the recommendations were presented to the hospital administration. Some results from this study have been published previously in different articles addressing initial analysis (Medina *et al*., 2012), the use of DES (Medina *et al*., 2010) and use of Queuing theory (Medina *et al*., 2011).

The principal highlights of the case study are presented as follows.

Initial analysis-case study: The process in general terms can be represented as shown in the flowchart of Fig. 3. Using a Pareto chart, "Wait for review" was identified as the longest waiting time, following which a cause and effect diagram (Tapping *et al*., 2009) was used to explore the causes of the wait to enter review. Each of these causes was analyzed and possible improvement actions were determined. Also in the initial analysis general improvement recommendations from the employees were considered.

Selection of strategies-case study: Base on the possible improvement actions for each cause an evaluation of the strategy to follow was made. As mentioned previously, the criteria for selecting a strategy are shown on the flowchart of Fig. 2. The results of the initial analysis were presented to the administration to approve which actions were pertinent based on the interest of the institution and considering cost factors. Basically they agreed on assigning and balancing beds within rooms using the strategy of advanced analysis. It was interesting that the institution did not consider the implementation of kaizen events to be appropriate due to possible problems with unions and because they did not want to disturb the daily activities of the personnel.

Direct-case study: In the case study there were many recommendations from personnel for improving the system that were simple and in many cases obvious (for example fixing a leaking faucet or installing a sign). Although not all of these recommendations have a direct impact on the flow of patients, it certainly affects it indirectly because personnel get frustrated and these circumstances may take more of their time in daily activities. Also, it did not want to leave out this type of improvement recommendation from the framework´s because this is the voice of the employees. The recommendations were presented to the administration in order to act upon them.

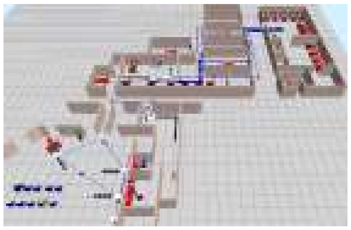

Fig. 4: Animation view of the simulation model for the gynecology/obstetric emergency department

Kaizen events-case study: As mentioned previously, the institution did not consider the implementation of kaizen events to be appropriate; therefore we were not able to work with this strategy in this case study. However, it could support the inclusion of this strategy due to the benefits gained in other case studies when the institution accepts their implementation. The authors have experience on working with the local Red Cross implementing the 5S program obtaining reductions in transportation times, operations times (times devoted to searching for parts was reduced significantly) and space optimization. Also in the literature it was found several successful implementations of kaizen events that support its inclusion in the framework, some of these examples are the work of Dickson *et al*. (2009), Ng *et al*. (2010) and Fillingham (2007).

Advanced analysis-case study: For assigning and balancing beds within rooms, Discrete-Event Simulation (DES) was used as the analysis tool. Figure 4 shows an animation view of the simulation model for the gynecology/obstetrics emergency department. The methodology for applying DES in the case study is shown in detail in the article by Medina *et al*. (2010). After applying DES, the recommendations were to increase the number of beds in the observation room from 7 to 11 beds, considering that further increases beyond 11 beds resulted in negligible reductions in total waiting time. With the incorporation of the additional beds the total wait time is reduced from 40.13 to 11.47 min which represents a reduction of 71% in waiting time.

The incorporation of the additional beds in the observation area required changes in layout which involved:

- Relocating the waste room
- Relocating the resting room
- Changing the size and orientation of the desk used in the observation room to gain more space
- Removing division walls in the observation area

The modifications to the layout can be appreciated in Fig. 5. After making these changes, it is possible to incorporate the additional beds without making a major investment in facility layout.

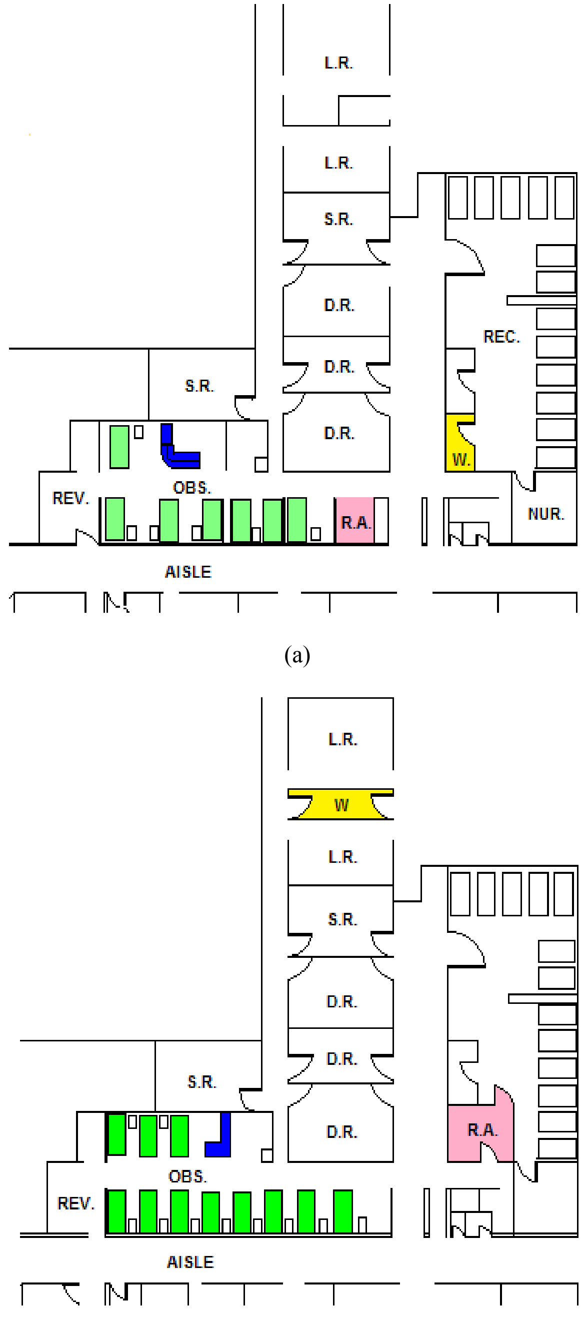

Fig. 5: Layout of the obstetric/gynecology emergency department, (a) actual layout, (b) proposed layout D.R.: Delivery room; L.R.: Locker room; NUR.: Nursery room; OBS.: Observation room; R.A.: Resting area; REC.: Recovery room; REV.: Review room; S.R.: Surgical room; W: Waste room

DISCUSSION

In comparing the proposed framework against related works found in the literature, the following aspects are highlighted:

- The proposed framework considers an initial analysis using basic tools facilitating the participation of healthcare personnel. Lean based projects (Fillingham, 2007; Ng *et al*., 2010) use Value Stream Mapping (VSM) as the initial analysis tool which is very useful in identifying waste. The Lean approach was one option for the framework initial phase but some health institutions, such in the case study, are not willing to adopt an improvement program (such as Lean Thinking) as a first step. However, they do have an interest in their systems being evaluated, therefore it was decided to use simple analysis tools at this initial phase that were more familiar to the employees and did not required extensive training such as the flowchart diagram, cause and effect diagram and Pareto diagram. Some other approaches in the literature have the same perspective. For example Paul and Lin (2012) used a flowchart and then activities were classified as waiting or care delivery; Chand *et al*. (2009) included in their approach process mapping, sources of variability identification and possible improvement factors; Hall *et al*. (2006) presented a phase where the service processes are documented and the processes are redesigned with an improved efficiency but they did not present a list of specific tools to use. Venkatadri *et al*. (2011) increased the complexity of the initial analysis through the use of the problem solving six sigma methodology and statistical analysis.
- With respect to analysis tools, the proposed framework is not limited to include only modeling and simulation techniques as in the approach of Naseer *et al*. (2010) or only DES as in the approach of Chand *et al*. (2009), Venkatadri *et al*. (2011) and Paul and Lin (2012). The proposed framework, does consider DES as one of the favorite tools for patient flow advanced analysis, coinciding with Davies (1994), Stafford (1978) and Karnon and Brown (1998), but includes the option of using other techniques either alone or in conjunction with DES. For example Cochran and Bharti (2006) used DES with queuing theory. On the other hand Hall *et al*. (2006) recommends only three improvement guidelines without defining any types of technique. Eitel *et al*. (2010) and Naseer *et al*. (2010) presented a list of possible methods to use to improve quality and patient flow showing that there is more than one technique to improve patient flow.
- The proposed framework considers the Lean philosophy through the use of kaizen events, however not all approaches consider it, despite this being a proven approach in both the industrial sector and the healthcare sector. Examples include the cases of the Virginia Mason Medical Center (Nelson-Peterson and Leppa, 2007) and the University of Pittsburgh Medical Center (Thompson *et al*., 2003) in the US, Bolton Hospitals NHS Trust in the UK (Fillingham, 2007), the Flinders Medical Center in Australia (King *et al*., 2006) and the Hôtel-Dieu Grace hospital in Canada (Ng *et al*., 2010).
- The involvement of personnel and the participation of a multidisciplinary team is emphasized in the proposed framework, which considers this fundamental due to the great knowledge of the employees about the process. Also with employee participation the resistance to change decreases and the probability of a success implementation is increased.

RESULTS AND CONCLUSION

A framework for patient flow improvement is proposed. The process starts with an initial analysis and then classifies the action improvement options under three strategies: advanced analysis; kaizen events; and direct implementation. The proposed approach helps to identify and select strategies to follow for improving patient flow.

Certainly the proposed framework has gaps and one of them is that the decision criteria to select other advanced tools is open, leaving the analyst to make the decision based on his/her knowledge (less experienced analysts may make poorer decisions here than more experienced ones). In comparison, Naseer *et al*. (2010) recommend one or several techniques based on the problem characteristics, however the disadvantage is that this approach includes only modeling and simulation techniques.

During the realization of the case study, difficulties arose and these are presented in the following paragraphs since they are likely of general relevance (and will need to be dealt with by others in other studies).

Limited access to historical records: There was limited access to historical records because the physicians in charge of files and statistics did not authorize the access to information or related statistics; they argued that it was confidential information even though it was not asking for patient names.

Incomplete records: The records available were incomplete. For example the registry book for arrivals was missing the arrival time for some patients.

Physicians' attitude: It is difficult for physicians to accept that their work area can be analyzed as a system; therefore they showed poor disposition and credibility to the study. Indeed some of the physicians perceived this study as a spying project. One of the physicians expressed openly "we do not need external analysts to improve patient services because we already know the solutions to the problems". In this case study the nurses were the ones who participated more actively.

Based on the previous obstacles it is clear that careful attention must be paid to the system personnel, especially in healthcare institutions where the employees are not used to these types of project. To improve the relations with the personnel, it is recommended to consider these three points.

Involve the employees: Personnel must be involved in all the phases of the project in more or less degree but active participation in the generation and application of improvement ideas must be assured.

External analysts or consultants are facilitators: External analysts or consultants to the work area must function as facilitating the changes to improve the work area, otherwise there may be problems during the implementation because the personnel do not take the improvement ideas as their own.

Communication: Personnel must know about the purpose, scope, activities and benefits of the project. In particular if the area is visited for collecting information, the analyst must inform the personnel what type of information will be collected.

The difficulties faced in the case study are not unique. In previous healthcare projects, Brailsford (2005) referred to attitude problems for hospital personnel in improvement projects, Langabeer *et al*. (2009) showed the results of a survey where 37% of the sample reported that physicians represented the greatest organizational obstacle to the greater penetration of quality initiatives and Carter and Blake (2005) listed different difficulties in the collection of information in their healthcare projects.

The proposed framework for patient flow improvement starts with simple analysis and may stay at the same level with kaizen events or go even simpler with direct actions. Only if it is required will the process move to include the use of advanced analysis techniques. It is important to make this distinction between strategies because problems have different complexity levels, investment needs and requirements for the participation of system personnel. The framework outlines as first instance evaluating the problems with simple tools before selecting a strategy.

When comparing the proposed framework for patient flow improvement with works found in the literature, the added value is the inclusion of an initial analysis with simple tools, the evaluation and selection of strategies, considering lean thinking through kaizen events as a strategy as well as advanced analysis techniques where DES is the most popular technique for analyzing patient flow problems and finally highlighting the importance of multidisciplinary participation of all the employees involved.

Nevertheless the real value of this framework for patient flow improvement is to serve as guideline in future healthcare projects aimed to reduce waiting patient times.

RECOMMENDATIONS

The proposed framework would be enriched by specifying decision criteria for selecting advanced techniques. Naseer *et al*. (2010) have the most extensive list of techniques, but these are limited to modeling and simulation, therefore more research is needed.

Healthcare is relatively new at implementing Lean initiatives and while pioneering healthcare institutions have experimented practically with adapting Lean to their system, many lessons have been learned; however, there is still work to do on establishing implementation guidelines and preparedness for adopting the Lean philosophy in healthcare.

As Langabeer *et al*. (2009) states physician's resistance is a topic of interest that requires the proper attention in order to facilitate improvement actions, therefore research should be done to identify issues that may increase the active and positive involvement of physicians in improvement projects.

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