LEAN Enterprise Principles in Healthcare – How to Apply

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Abstract

In this study, a discrete event simulation model was developed in order to evaluate current processes and to improve the overall efficiency of the clinic. The performance measures considered were maximizing throughput, minimizing wait time, minimizing flow (transportation) and maximizing utilization of nurses and providers. The virtual simulation model was developed using ARENA software Version.12 (Rockwell Automation Technologies, Inc). From the comparison of the results, it was observed that moving the exam room of the busiest provider closer to the waiting area achieved a considerable reduction(8.5%) in the yearly distance traveled from the patient's perspective. Changing the location of nurses and providers when compared with the current scenario resulted in a reduction of 18% for the total distance traveled by the patients in any given year. Assigning one nurse to each provider when compared with the current scenario resulted in an 8.48 % reduction in the total distance traveled by the patients. The analysis indicates that by improving the overall space utilization, the utilization rate of exam and procedure rooms were increased where it subsequently improved the flow of patient and equipment.

Introduction

Clinic space utilization was studied from the aspect of Lean Healthcare. The goal of the study was to develop simulation model which can be readily adapted to the large variation in clinic structures that maximizes efficiency and work flow within the constraints of existing architectural limitations. Variations in mode of operation and space utilization are observed due to inefficient flows and lack of standardized layout. There is an increasing demand for both capacity and service quality in healthcare. Studies show that clinic examination rooms are idle for a significant part of patient care cycle. Patient flow characteristics throughout a facility based on need provides insight into optimizing space use. It was set out to develop an idealized clinic layout that maximizes clinic efficiency and work flow and could be used as an initial platform layout to launch future clinical space design. To increase the utilization of space, resources, and equipment and to increase the patient throughput without sacrificing quality care, seven flows were identified in the clinic: patients, staff, information, equipment, supplies, diagnostic tests and procedures, as well as medications. The simulation model was built considering flow of patients, staff and information. Arena software was used to develop the simulation model. This project was conducted in the VA Medical Center.

Literature Review

An in depth literature review was conducted in the areas of Lean Applications and Operations Research (OR) concerning space utilization and optimization of healthcare facilities. Michael Benninger and Steven Strode [1] studied to maximize efficiency of staff and resources, a methodology was developed and simulated in general Otolaryngology department. The authors measured total clinic time, number of patient seen, patient waiting time, physician and nurse productivity, and examining-room used. The simulation showed there were increases in physician time spent with patients, and patient waiting time was reduced.

Eneyo et al. [2] used simulation software to design the new unit considering the production and assembly activities subject to the future expansion of the company. The design of the new facility was conducted in four phases namely: 1.Data collection, 2. Simulation for existing conditions, 3. Simulation for expansion phase, 4. Layout developments of the new facility.

Joseph et al. [3] employed the lean methodology in designing the layout of a laboratory. This was done to design an optimal facility layout which has: a smooth flow of the process, minimized handling distances, reduced walking distances, and improved visibility for effective management of operations, enhanced work environment and better inventory management. The first step here was to study the existing state of operations in the process; including measurement of cycle time, lead time and TAT time (task time). The next step leads to implementation of lead strategies like proposing a U-shape design to minimize operator walking. This was followed by projecting the growth for the future. Based on the results, the future predicted values of the space requirements are developed for each of the units. The next step involves the development of a high-level layout using optimization. This

is done in four steps: Quantify all work flows, workflow weights, flow matrix and layout optimization. Based on the optimization performed layouts are drawn and evaluated. These block diagrams of the space layout were then modified into detailed drawings. Implementation of lean culture and mock-ups were integrated into the detailed planning. The lean design resulted in an efficient design that optimizes specimen flow, increases staff productivity and reduces wastes throughout the life of the facility. The lean process improvement when applied to the healthcare settings needs to be studied more in depth and feedback of patients should also be incorporated in the analysis so as to gain efficiency related to the patient flow and patient satisfaction.

Eric W et al. [4] applied lean concept in the Emergency Department (ED) and tested if it improves the service delivery by the emergency care. The measurement of satisfaction and patient visit was conducted before and after the implementation of lean techniques for a period of one year. The authors applied six-step process of lean education, ED observation, patient flow analysis, and process redesign, new process testing and full implementation in the Emergency care. Outcomes were measured using patient satisfaction, expense per patient, length of stay (LOS) in the emergency department and patient volume. These outcomes were compared for 2005 data (before) and 2006 data (after). Lean concept was tested to see if the implementation of the fundamental change of thinking improves the patient satisfaction as well as the staff satisfaction. A change of thinking requirement is developed due to the demand of safe, efficient and quality driven needs in healthcare system. Lean concept and Toyota production system (TPS) system if applied in healthcare it implies that the clinic personals need to care patients. A lean team is first formed from all departments. The processes involve process mapping and then assessing the amount of waste using value stream mapping (VSM). The VSM documents the time taken in each step as arrival of the patient and quantifies time at different steps as value-added or not value-added. From here the determination is made which step add value to patient experience, and which step take up resources and time and incur cost without adding value. After that the lean team determines if all steps involved in patient visit were required and redesign the process by modifying or eliminating the waste. The new developed process was tested and implemented with continuous feedback for improvement from the frontline staff that has more insight of the process. In non-lean environment reduction of cost is emphasized in single process. In lean environment quality and flow is focused first, when these are improved in current staff level, synchronization of staff becomes focused. And finally after these factors improved lean emphasizes on other factors of efficiency. Lean improved the value of care to the patient. The end result of applying lean in healthcare is higher-value product than the one produced using a management style focusing on single step efficiency. One of the findings in this study is an increase of 9.23% patient visit.

Cote Murray [5] described the patient flow and resource utilization under an individual physician in primary health care. The statistical analysis on service (time a patient spent in consulting) and sojourn (total time spent some location in clinic) was conducted. A discrete-event simulation model constructed to find the relationship between examination room capacity and patient flow across four clinic-based performance measures.

Felicity Hasson et al. [6] conducted methodological issues in nursing research, such as preparation, action steps and difficulties that are inherent within the Delphi technique. There were issues in identifying the problem, research skills to conduct and data presentation. The authors studied the above problems. Reliability of this method was based on the assumption that several people were less likely to come to wrong conclusion. The validity of this method was enhanced by reasoned argument in which assumption were challenged. Findings from Delphi study helps streamline work.

Duke Baker et al. [7] utilized mathematical modeling in a teaching clinic to improve patient care. The model was used in the planning and decision making process establishing a relationship between physicians, time, and space.

Feyen et al. [8] studied workflow of a clinic in the VA medical center in Indianapolis. The process steps taken here involved discussion with the staffs, data collected on the current workflow for a week, current room utilization and any other time data. Gantt chart was developed to see usage of each room each day. Three specific approaches were considered to improve room management. AutoMod was used to analyze workflow. Authors implemented movement monitoring systems in each room, utilizing notification system and using computer in the nurse station. Current physical room layout was analyzed. Through VA staff input and general industrial engineering principles, some changes like putting additional walls, doorways and shelving units in layout can reduce unnecessary time, also improve room management. The authors were informed on several areas that contributed to the inefficient room management. The room assignments were handled arbitrarily, resulting inefficiency in using rooms to its maximum possible use.

Gibson et al. [9] used a discrete event simulation tool for the purpose of planning and designing of the hospital building. The approach begins with the problem formulation phase, setting the objectives and developing a project plan based on the Baldridge National Quality Program for the healthcare sector. In the planning phase a value management study which considers the information process mapping and workplace study information was taken into account to reduce cost of service while improving and maintaining quality. The next step involved the simulation in the planning phase and real time data was gathered for it followed by the master planning phase where the resources such as waiting area, reception etc would be taken into account. The last and the final step considered the schematic design phase which involved preparation of architectural and engineering drawings.

Miller et al. [10] studied the new hospital space allocation and schedule configuration design using the tools-simulation, linear programming and spreadsheet analysis. An addition is being made in the hospital facility i.e. the clinic is constructing a new 600 bed hospital for women's and children's hospital, replacing the existing one. The requirements as summarized by the author's a)Maintain a large number of specialty and sub-specialty outpatient services, b)significantly less space to house these services in the new facility, c) meet complex scheduling requirements, both clinically and operationally, due to teaching

requirements. The current structure was completely studied (process maps) and future requirements/constraints were noted down. Parameters were set up by the design team like number of exam rooms and number of clinics. The next step after making initial assumptions was the data collection, the last step prior to simulation. The data here was gathered from observing the process, gathering information from the hospital staff, data from staff and analyzing them. A multi-faceted approach consisting of modeling, linear programming and discrete event simulation was used to predict and forecast future behavior. For the purpose of validating the model the software developers ensured that the models would behave similar to the real system. Two types of model are studied here. Various scenarios were simulated with different clinic configurations. Several iterations of the model were performed to determine the optimal location. The decision was made after the service department and the project team reached up to a conclusion. The results showed not much optimal solution but gave the more realistic and practical solution. This analysis of high level and low level model led better and optimized space utilization. Stake holders input was taken into account after results prior to implementation.

Based on the literature reviews, a wide array of issues within the health care delivery system were observed that included inefficient space utilization, unnecessary travel time of clinic staff and patients, improper allocation of rooms, and lack of desired equipment and capacity constraints for space. To improve these issues discrete event simulation and lean concepts are applied. Review of specific case studies that were developed in numerous healthcare clinic settings found that Simulation was used to examine bottlenecks and to improve utilization and access. Lean techniques such as Six Sigma, Five S, and Value Stream Mapping were also widely used by management to improve service level. It was also observed that a number of researchers stressed the importance of gathering reliable and comprehensive information about the system being studied, and the obvious solution was to interview and/or to survey the individuals interacting with the given clinic setting [11].

Numerous strategies such as RFID, bar-coding and videotaping were considered for data collection and field observation, but due to time constraints, interviews, questionnaires and on- site observation were selected as the primary modes to gather data. Face-to-face interviews with staff provided an understanding of the standard operating process and the type of problems faced by management, providers, nurses, and staff during daily operations not only from the space perspective, but also from the other specified flows perspective. Due to the fact that many practitioners are not able to go through the interview process, questionnaires were provided to be completed at their convenience. The observation process included patient and provider shadowing where redundant activities and motions were identified, and necessary suggestions were developed through the applications of Lean.

Lean Consideration

Issues contributing to the inefficient use of space in the macro-level simulation model developed include: Inefficient use of space, unnecessary travel time to waiting area for staff and patients, poor layout, non-value added activities, waiting, inefficient procedures,

understaffed clinics, nurses' station is too small for clinic traffic, and the need for more storage space.

From the interviews and observations the Non-Value added activities identified are listed as follows. Some of these issues were considered to define appropriate performance measures for the simulation model.

- Inefficient use of space (Nurse station over crowded, clerk desk layout does not provide human factor considerations, only one room is provided for provider)
- Unnecessary walking of staff and patients back and forth to the waiting area
- Poor layout (Quantitatively verified by simulation model)
- Two times waiting for patient; one for nurse and the other for provider
- Inefficient procedures (No signage or guideline to guide patient in the appropriate space, minimum balance between waiting area and patient demand
- Lack of equipment (Only one printer for the entire team, separate printer is needed for printing letter and envelops for clerical staff, need a counseling desk facing the patients)
- Clerks reach over the nurses to place charts in the cabinets while nurses are on the phone or computer
- Privacy issues as nurses need more privacy while on the phone
- Access issues as patients walk into the clinic and grab doctors and nurses
- More storage space is needed behind desks – May be consider overhead storage
- Disorganized chart holders

Field Observations and Data Collection

As part of the data collection procedures, interview tools, questionnaires, observation methods have been applied and are discussed below. Data collection included acquiring data from the clinic database, and time studies, which included manual collection of time for each activity. The data collected served as input parameters for the simulation model. Data collected through the databases and time studies provided the information needed for utilization of clinical space and individual rooms. Figure 1 shows the patient distributation calculated from the data analysis of one year data.

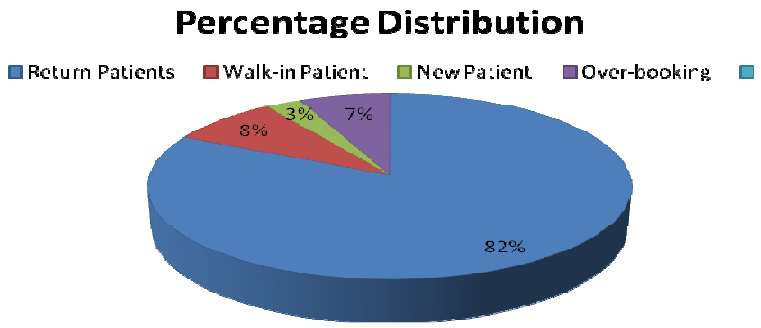

Figure 1: Percentage Distribution of Patients

A series of face-to-face interviews were conducted with various staff in the clinic led to some key findings about the operation of the system. Interviews provided valuable insight about individual staff processing the patients, and problems they face in a given day. The interview process took an average of 25 minutes per session. In some cases, follow-up interviews were necessary in order to validate the information. The Interviews focused on daily job functions and the system's inefficiencies. Data collected was verified with the interview results to measure the reliability of each other.

Questionnaires were sent to staff who were unavailable for direct interviews and to collect data that could not be captured from the data bases. Questionnaires included checking whether all the staff classifications are following the same operating procedures, whetherthere are differences between them which are difficult to capture from face- to-face interviews due to time constraints.

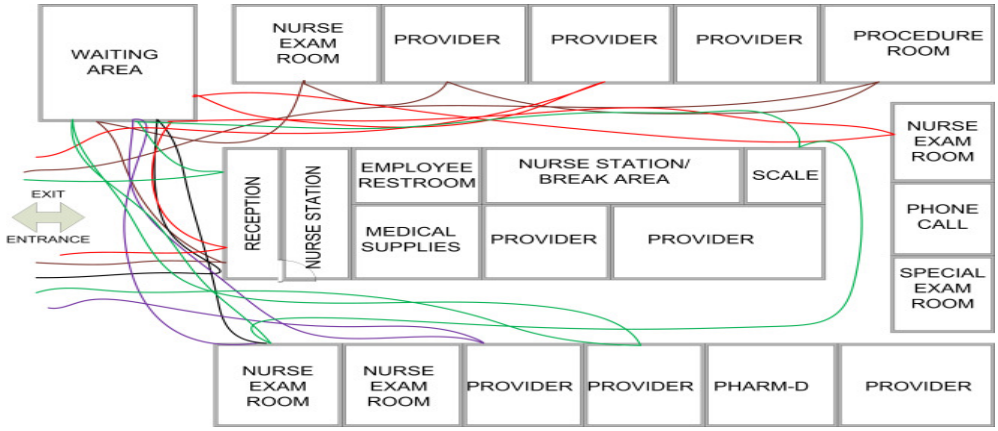

Figure 2: Spagetti diagram for patient flow

The observation process consisted of tracking patient flow from the moment they check-in at the clinic until they leave the system. This observation process enabled us to get an insight of

the standard operating procedure and to draw process maps, based on the spaghetti diagram shown in Figure 2. Figure 3 indicates the partial process map for the studied clinic.

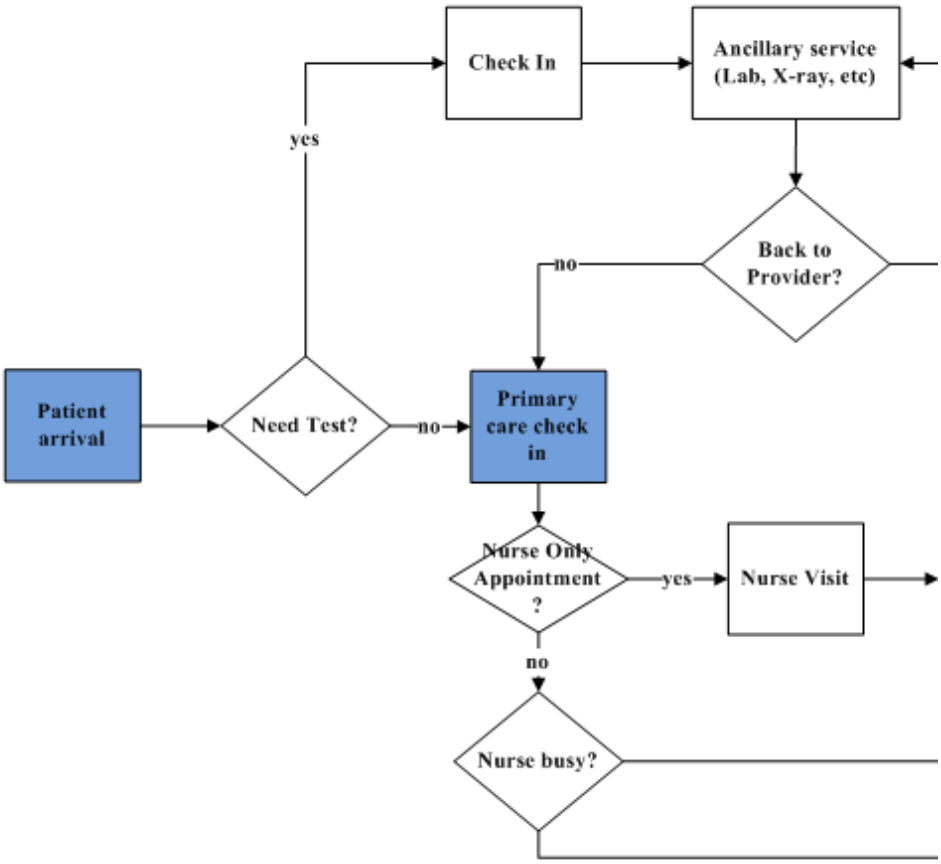

Figure 3: Snapshot of patient flow in a typical Clinic setup

The data collection process starts at the early stages of the simulation. Based on observations and completed interviews/questionnaires with staff, a comprehensive understanding of the operations and functions within the clinic was obtained.

Based on knowledge of the current operating procedures and feedback from the Delphi study with clinic management and staff, a conceptual model was developed which eventually was used to develop a conceptual model required for building the simulation model as shown in Figure 4.

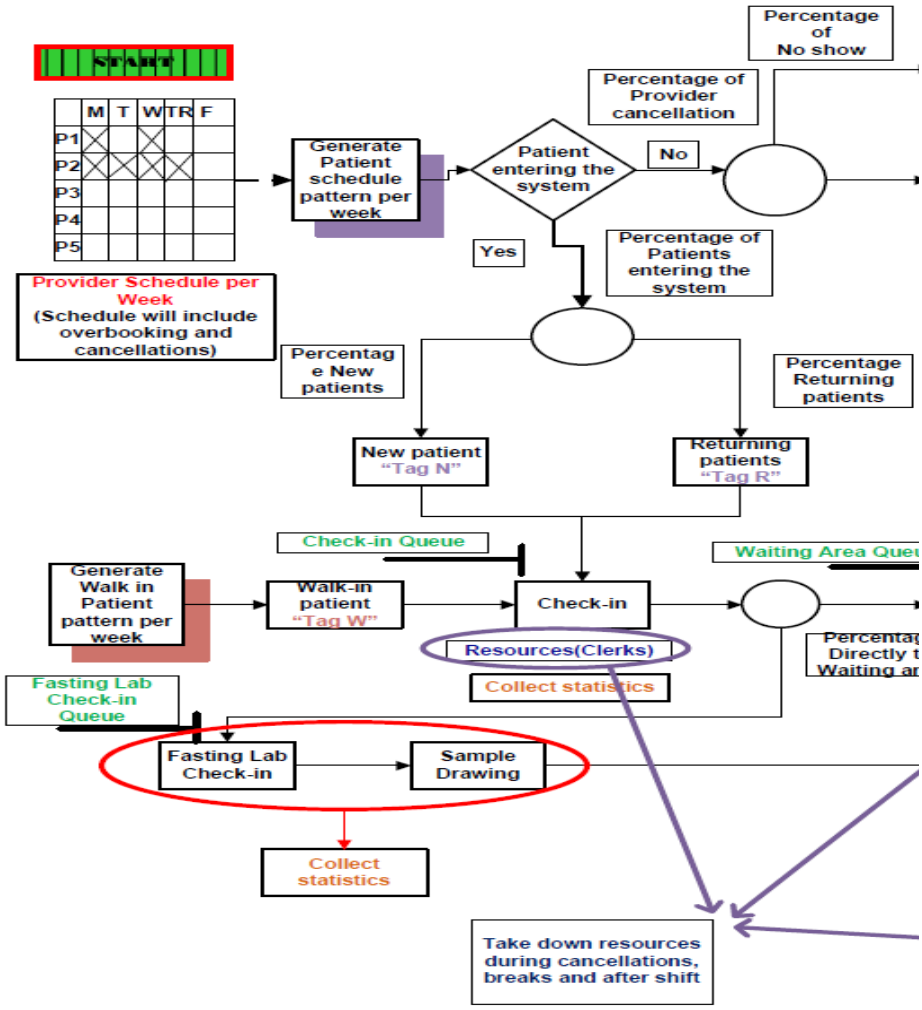

Figure 4: Snapshot of the Conceptual model for the Clinic

Simulation Model

The simulation model considers utilization of providers, nurses, and clerks. Providers are considered the primary resource utilizing the space in the simulation model. The utilization of nurses as a secondary resource is considered to be another important feature of the model. Nurses provide triage and assessment services to patients, which include taking vitals, doing clinical reminder tests, reviewing medications, etc. After the nurse assessment is complete, the patient is seen by the provider. Nurses typically work eight hours per day. Table 1 shows the input parameters and assumtions for one of the scenarios. The utilization of clerks is also considered as an integral part of service provided to the patients. The clerks are mainly involved in patient check-in, verification, and scheduling activities. Clerks typically work an eight-hour shift. A simulation model is built to examine impacts of various activities within the clinic settings and to provide an efficient environment within the clinical space for both patients and staffs. this model will also help to maximize the utilization of space and other resources, a simulation model is build to examine the impacts of various activities within the

clinic setting. The performance measures considered for the model development are maximize throughput, minimize wait time, minimize flow (transportation), and maximize utilization of nurses and providers. Figure 5 shows the partial simulation model developed in Arena.

Table 1: Input parameters and assumptions

Input	Type of input
Simulation run period	One month
Number of Replications	10
Patient arrival	Schedule based
Nurse only patient arrival	0
Walk-in patient arrival	0
Walk-in patient type (nurse only vs. provider visit)	50%
No Show rate	0
New vs. Return patient	0
Clerk service time	N(1,0.05)
Nurse service time	N(18,3)
Provider service time	N(25,5)
Distance between any two areas in the clinic	Distance in feet

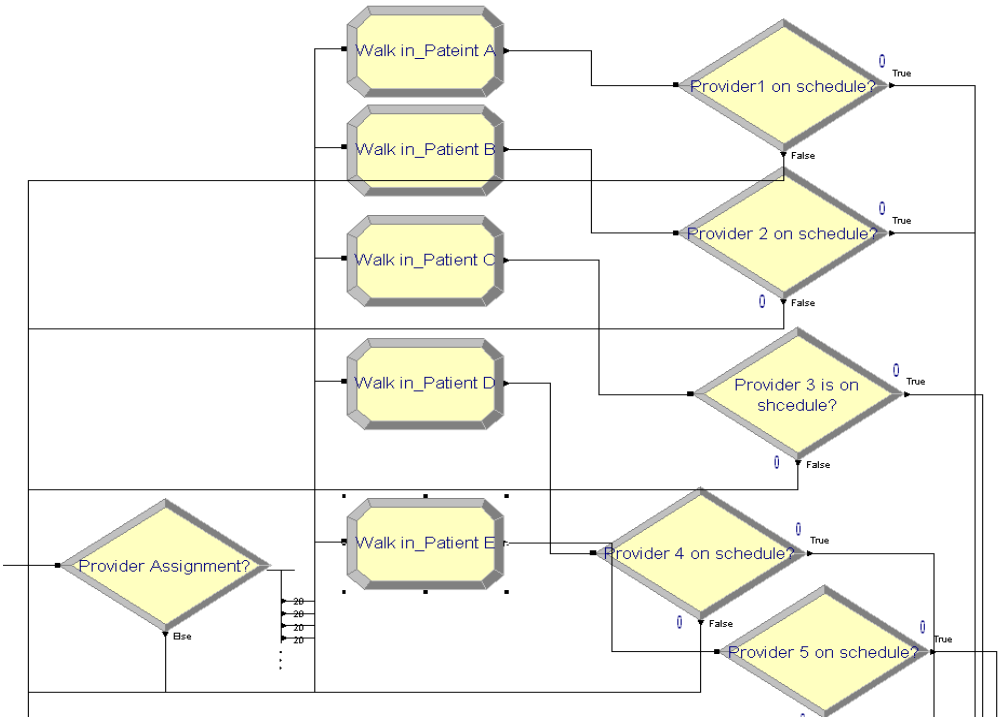

Figure 5: Snapshot of the Model in ARENA Version 12

Simulation Results

The simulation was analyzed considering the following resources; resource utilization, scheduling and distance traveled within the clinic. Four different scenarios were run to study these above resources.

Resource utilization

Utilization of resources focuses on the servers, receptionist, nurse, and providers. One scenario is to add and remove assistants (nurse and/or receptionist) during busy and empty schedules. Another scenario is to change the providers' working time; in general, all providers start their work at the same time (8:30 am and 1:30 pm). This causes a heavy load on the nurses. By staggering the slots of the providers and nurses, this variation is expected to be controllable. This can be applied for all working days or only busy days.

Structured scheduling

The scenario for this measure is to improve the system through patient type. What happens if patients are scheduled based on their type? For example, *regular* patients are visited in the morning while patients requiring long visits are scheduled in the afternoon or defining a scheduling pattern such as two regular patient following one long-visit patient and repeating the pattern.

Traveling in the system

It is important to determine the distances between any two areas in the system and approximate the daily traveling distance /time/cost in the clinic. It is also possible to figure out heavy traffic areas in the clinic. Based on that, a number of scenarios are tested and the best is selected. Scenarios include movement of resources and equipment and/or adding new resources and equipment. A summary of scenarios are illustrated as follows:

Scenario 1 - Changing provider's workstation
From the results, when the scenario is compared to the current situation it can be concluded that by moving the exam room of the busiest provider, (i.e. having their exam room closer to the waiting area) one can achieve a considerable reduction (8.5%) in the yearly distance (feet) traveled from the patient's perspective.

Current Situation	Proposed Scenario	Improvements
Total distance traveled by the patients seen by providers is 2646828	Total distance traveled by the patients seen by providers is 2417004	8.51 % reduction in travel of the patients

Scenario 2 - Changing location of nurses and providers
The analysis for the scenario when compared with the current scenario resulted in a reduction of 18% for the total distance (feet) traveled by the patients in one year.

Current Situation	Scenario 2	Improvements
Total distance traveled by the patients seen by providers is 2697984	Total distance traveled by the patients seen by providers is 2209356	18.11 % reduction in travel of the patients

Scenario 3 - Assigning one nurse to each provider
This scenario when compared with the current scenario showed an 8.48 % reduction in the total distance (feet) traveled by the patients in one year.

Current Situation	Scenario 2	Improvements
Total distance traveled by the patients seen by providers is 2697984	Total distance traveled by the patients seen by providers is 2469168	8.48 % reduction in travel of the patients

Scenario 4 - Reducing staff travel/walking by improvising communication
The manual flow of information takes place between check in clerks and the nurses. For this the check in clerk prints documents related to the scheduled patient and places it in the nurse's document stack. If this flow of information if made electronic then the nurses need not come every time to the nurse station to check for the patient information. The electronic information flow to the nurses can also be accompanied by some notification system such as color or light signals to notify about a patients arrival. The maximum of 3,000,000 feet of walking is eliminated if this scenario is adapted.

Recommendation

From the study, we have determined strategies to increase patient throughput and optimize clinic space utilization by changing flow and scheduling practices leading to increased number of patients seen and reduction in overall patient wait time. Such recommendations include quality improvement activities, continuous improvement interventions, redesigning inefficient processes, Lean tools, development of process maps, and standardization of process. Such recommendations are listed as follows:

1. Based on the interviews conducted with the staff and management the issues that lead to the inefficient process with respect to space are outlined and some of these issues were incorporated in the macro-level simulation model developed. Simulation could be used as a tool to examine first-hand what impact any change. will have on the system.
2. Minimizing no-show rate by scheduling and reminder strategies in advance. If successful, the utilization of the staff could decrease by around 10%.

3. Implementing the Lean tools including 5S, VSM, Kanban cards.
4. Training staff on Lean techniques.
5. Standardization of the process.
6. Development of cross-functional team for continuous improvement implementation.
7. A systematic approach by which the Performance Measures can be quantitatively measured on a regular basis needs to be developed. The Performance Measures identified in this study are resource utilization, patient waiting time and cycle time, traveling in system (patient and staff), patient accessibility and throughput.

Conclusion and Future Work

Lean implementation in clinic setting focuses on increasing the throughput in the system, reducing patient waiting times, and increasing utilization of resources by reducing idle time of staff. This optimization of clinic space is classified based on the flow, layout and application of Lean tools. From the study conducted, the strategy is to increase patient throughput by changing scheduling practices, and therefore, increasing the number of patients seen and reducing overall patient wait time. Additional recommendations for the future work include:

1. Splitting the current simulation model (which considers the clinic flow and space utilization in the same model) into two separate models; one to consider the flow, and the other to focus on the space utilization aspect. As such, the first model can analyze the flow more efficiently and the output of such a model can be plugged into the second part.
2. Customizing the simulation model for Lean interventions. It is possible to observe the impacts of the Lean intervention before they are implemented. Once the manager determines what intervention will be implemented, a customized simulation model could be developed.
3. Implementing a digitalized data collection system which can be used for simulation data collection. Inaccurate data results in sub-optimal analysis.
4. Adding more advanced features to the developed model to make it user friendly. Users can easily run the model from a friendly environment such as Excel.
5. Expanding the scope of the model by considering the impact of other clinics which have interaction with primary care clinics such as lab, specialty, and pharmacy.
6. Customizing the simulation model for Lean interventions. It is possible to observe the impacts of the Lean intervention before they are implemented. Once the manager determines what intervention will be implemented, a corresponding simulation model will be developed. However, to do that the current model should be customized case by case.

Achnowledgements

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