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Abstract

The Lean methodology was used to reduce examination cycle and lead times for the radiology clinic Bayamon Radiology Center. They clinic had a conventional X-ray system that uses x-ray films. Voice of the Customer and Value Stream Maps were used to determine areas of improvement and ameliorate bottlenecks to improve customer satisfaction. The investigation was implemented to upgrade the X-ray equipment to a digital system that improves clinic flexibility. The project was implemented in October 2019.

Introduction

The Lean methodology has been widely implemented in medium to large-scale businesses for many years, but micro and small businesses have often failed to take advantage of the potential growth seen with the adoption of this methodology. Lean looks to maximize resources and process speed by providing the tools with which to analyze process flows and delays at each process activity. Micro and small businesses have very tight profit margins; it is therefore crucial to maintain competitiveness and lean methodology can reduce costs, increase productivity, and increase overall profits in the long run as it has for many medium to large companies. [3]

Background

Micro businesses classified by the European Union are classified as that have less than 10 employees. Micro, small, and medium sized businesses have flat hierarchy. [2] Given the flat structure these types of businesses rely on the leadership skills and expertise of the owners and lack the resources (labor, financial, time, etc.), organizational structure, and knowledge to implement operational improvement activities that large sized companies enjoy. Lean manufacturing methodology was first implemented by O. Taiichi with the main goal of reducing waste. The lean Methodology focuses on increasing process speed by providing tools that are used to analyze process flow and delay for each process step encountered. [4] Activities are divided into 2 main groups: value adding activities and non-value adding activities. According to Bonaccorsi et al. non-value adding activities are divided into 10 categories [1]:

- Duplication: performing tasks more than once like data re-entering.
- Incorrect Inventory: not keeping in stock necessary items to complete a task.
- Lack of customer focus: Employee unfriendliness or poor attention to the customer.
- Overproduction: processing paperwork prior to completing a task.
- Unclear Communication: lack of a standard work flow or incorrect information.
- Motion/Transportation: poor workspace layout and ineffective filing.
- Underutilized Employees: in adequate tools and limited authority.
- Variation: lack of standard operating procedures.
- Waiting/Delay: waiting for supplies or equipment downtime during the work day.

The Voice of the Customer (VoC) is important in identifying value added and non-value added activities, by obtaining feedback from customers on products or service. The 3G kaizen principles, Gemba, Gembutsu, and Genjitsu, in the kaizen methodology are used by decision makers to observe where and how the services are provided. [4] The information obtained from executing the 3G lead to better decisions. The first principle discussed is gemba or "the actual place", which refers to where the process occurs, more commonly known as the shop floor. The second principle is Gembutsu, or "the thing" which refers to the product or service which is the main focus of the improvement effort. The last principle is the Genjitsu or "the facts" which refers to the area of the kaizen.

Problem

The design project will complete an evaluation to a radiology clinic, Bayamon Radiology Center (BRC), a micro business serving to over 2000 patients annually. The clinic has a conventional x-ray equipment that uses x-ray films and digital sonography equipment and does not have a digital storage of all patient x-rays and sonograms with their respective diagnoses. Radiologist must come in to the clinic to complete patient examinations reports. For this reason, the lead time given to customers by the clinic is three (3) to four (4) business days to obtain exam results for any study. The long lead times makes it hard to compete with larger clinics that send results on the same day and causes loss of clients, delay in patient treatment and diagnosis.

Methodology

Lean methodology focus tools include Value Stream Map (VSM) and the Voice of the Customer (VoC). A VoC written survey was used to determine what patient wants the investigation to focus on. The survey focused on ranking three choices in order of preference. The following choices were provided: Cycle Time, Lead Time, and Queue Time.

Gemba, Gembutsu, and Genjitsu, or the 3Gs of kaizen or continual improvement, are used in the study to obtain information at the clinic for ten (10) studies. Gemba refers to where value is created for the patient. Each step of the process flow and operating procedure was gathered for analysis. Measurements like cycle time, lead time, transportation time, and handling time were gathered to obtain a baseline. The data in CVSM was based on the flow of information and x-ray films. Based on the data gathered the bottleneck was identified. A kaizen was completed to determine the improvement opportunities. Additionally, the variable costs (cost dependent on output) for the x-ray process was determined by observing historical data of three (3) months on clinic output and required x-ray equipment supply. From the data gathered the variable costs for the conventional equipment was determined. The Future Value Stream Map (FSVM) was designed to improve flow, and reduce waste, ultimately leading to a reduction in lead time for the patient exam results. Finally, a performance analysis was conducted to ensure process robustness and effectiveness of the FSVM.

Results and Discussion

The Voice of the Customer (VoC) analysis was completed through a short survey completed at the end of each visit where patient ranked in order of preference the following entries: reduction in examination time (cycle time), reduction in examination results time (lead time) and customer Service (customer focus). Each rank was given a scaled value where Rank 1 is 5 points, rank 2 is 3 points, and rank 3 is 1 point.

The scaled results are summarized in Figure 1. Results show that patients value exam results time (lead time). For this reason, the focus of the investigation was to reduce the lead time for patients obtaining their examination results. Behind the lead time, customer service and cycle time were viewed with approximately the same importance.

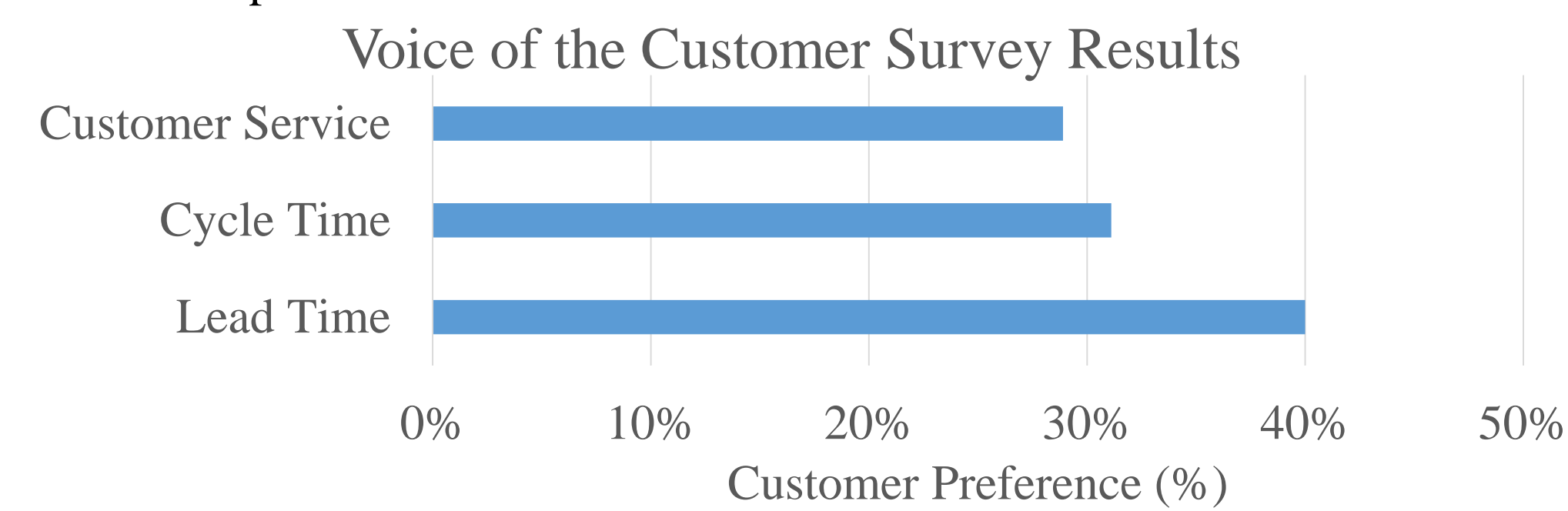


Figure 1
Voice of the Customer Survey Results

Having focused the investigation using the VoC results, the 3G principles discussed in the methodology section were completed. The Gemba walk was completed for ten (10) x-rays examinations were each step of the process was observed from customer's arrival to exam report retrieval. Value added activities and waste (muda) were determined, accordingly. Data collected was used to determine cycle time, queue time, and lead time. A current value stream map was generated based on the results obtained from the Gemba walk (Figure 2). From the data obtained the x-ray examination and film development completed by the technician has the highest cycle time at twenty five (25) minutes from the total sixty four (64) minute cycle time. Nonetheless, after completing a bottleneck analysis it was determined that the main bottle neck is the queue time from when the exam is completed to when to the study is read and transcribed. The clinic has one (1) radiologist that comes on average every fifteen (15) hours to complete all the studies placed in the kanban. In order to reduce the lead time and cycle time the CVSM was evaluated in a kaizen with all the employees.

The kaizen used the root cause analysis technique of 5 Whys to determine the root cause of the problem. The problem evaluated was as follows: the lead time of the patient exam report wants to be reduced.

- Why does the lead time for the exam report take sixteen (16) hours? The main contributor to the sixteen (16) hours lead time is the queue time between the exam completion and the reading and transcription.
- Why does the queue time for exam reading and transcription fifteen (15) hours? The clinic only has one (1) radiologist than comes in every fifteen (15) hours on average. Why does the radiologist come in every fifteen (15) hours? The radiologist has other commitments and clinic financial resource constraints prevent clinic from having the radiologist during the working day.
- Why does the radiologist have to visit the clinic to complete the exam report? Conventional x-ray equipment uses physical films that prevent the digitalization of the study.
- Why does the clinic used conventional x-ray films? The clinic has been operating since 1992 and has not upgraded the equipment

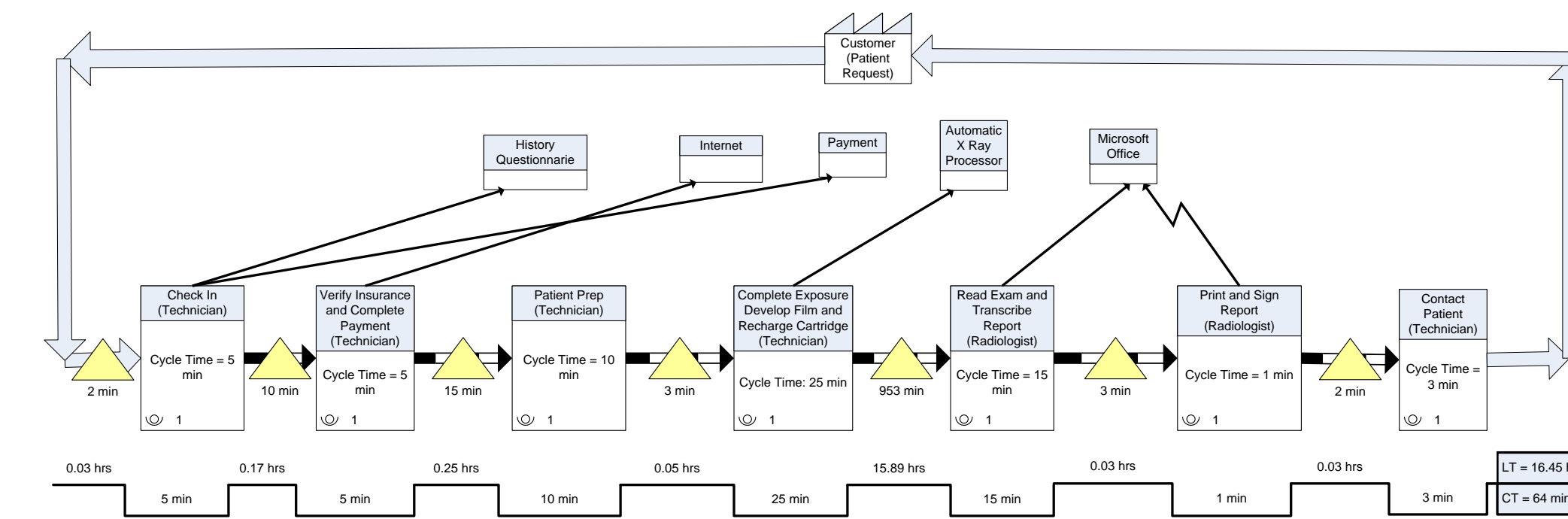


Figure 2
Current Value Stream Map

The most effective counter measure based on the analysis completed was that a digital x-ray and a PACS system would enable radiologist to read and transcribe exam reports without having to come into the office thereby completing examination reports throughout the day remotely

In addition to the time waiting and delay observed in the CVSM, the kaizen identified all the supplies required for BRC to complete the examination process based on three (3) month historical variable costs of x-ray examination supplies. The data obtained showed that ninety three (93) percent of the monthly cost of \$1215 stems from the conventional x-ray system. Based on the 5 Whys analysis and the variable cost analysis completed in the kaizen the Future Value Stream Map was developed with the new digital x-ray system (Figure 3), where through a wired network the server, digital x-ray cassette, x-ray workstation and receiver were connected securely. The total cost of implementation for the system was sixty thousand (60,000) dollars.

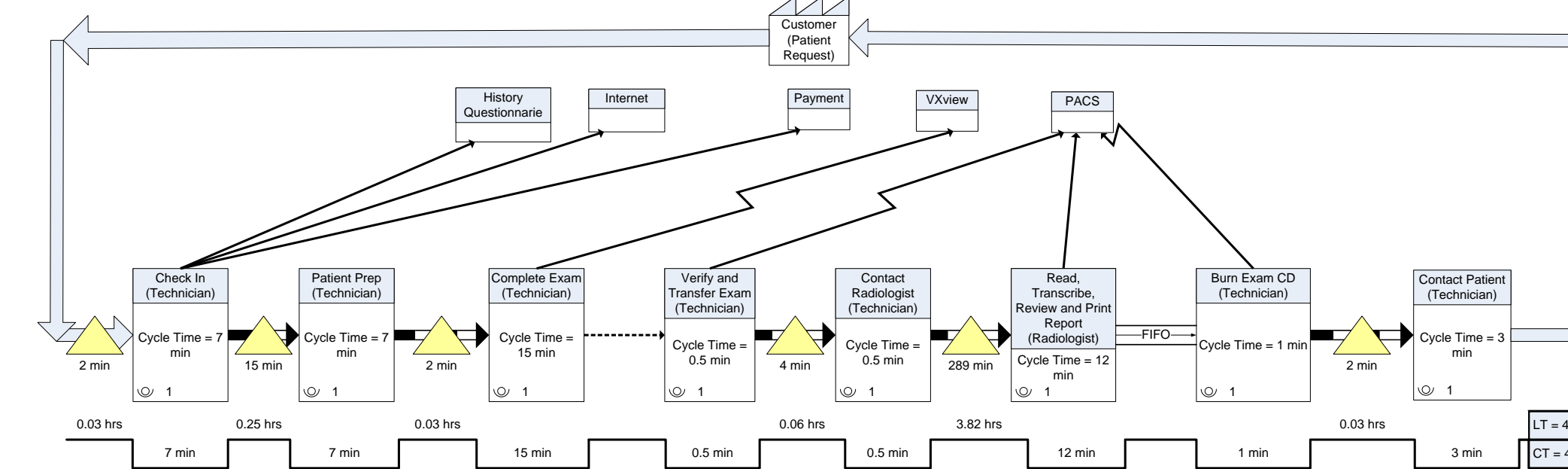


Figure 3
Future Value Stream Map

After the implementation of the digital x-ray and PACS system the queue time was reduced seventy six (76) percent from fifteen (16) working hours to four (4) working hours. Also, the total lead time was reduced by twelve (12) hours. In line with the VoC survey need, the cycle time was also reduced by ten (10) minutes since the development of the exposure was slower than the digital transfer of images. Moreover, the check in, insurance verification and payment were standardized into one process step. Additionally, the PACS system reduced the cycle time of patient examination reading and transcription by two (2) minutes. The PACS system functionality included report templates that eliminate the need of creating and modifying reports. The radiologist places the reading in text and the PACS system automatically generated the report with all the clinic requirements. The average variable cost per month expected after the implementation was one hundred seventy three (173) dollars. The implementation reduced the monthly cost by eighty five (85) percent, since the films and development chemicals were replaced by an inexpensive CD-ROMs and envelopes.

Conclusions

This investigation focus was to reduce the lead and cycle time for patient examination results at Bayamon Radiology Center, a radiology clinic in Bayamon, Puerto Rico. The investigation implemented Lean methodology techniques to ultimately improve the customer/patient experience. VoC surveys helped identify the value added activities and non-value added activities and focused the investigation on what the customer needs.



Figure 4
Vieworks Digital Cassette Implemented

Lean tools were designed to improve processes and reduce waste, using root cause analysis and value stream mapping. Value stream mapping was used to visualize and determine bottlenecks in the process. The hidden waste was identified and quantified. Root cause analysis (5 Whys) was used to determine that the conventional x-ray system was a main contributor to the lead and cycle times. The main contributor to the sixteen (16) hour lead time was the queue time due to radiologist availability.

The digital X-ray and PACS system led to a reduction in lead time of twelve (hours) and a reduction in cycle time of ten (10) minutes. Additionally, the implementation removed the harmful chemical exposure, since chemicals are not used in the digital x-ray system. Variable costs using conventional x-ray were determined using three (3) month historical data. An average monthly cost reduction of eighty five (85) percent was achieved since the digital x-ray equipment removes the need for the x-ray films, envelope, and developing chemicals.

The study shows that using Lean techniques to identify waste is effective in improving small business productivity, and the lean concepts can be successfully applied in the service industry. With this successful implementation the clinic loses less clients, reduces delay in patient treatment and diagnosis, and eliminates employee exposure to harmful developing chemical exposure.

Future Work

The adaption of Lean Methodologies for micro and small service industry businesses still need to be developed and expanded. Further implementation of lean methodologies in the industry will help more small businesses understand and successfully implement lean methodologies. The health services industry in particular would benefit greatly from reductions in cycle and lead times.

Acknowledgements

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References

- [1] A. Bonaccorsi and et al., "Service Value Stream Management (SVSM):," *Journal of Service Science and Management*, vol. 04, no. 4, pp. 428-439, 2011.
- [2] A. Griffin and J. R. Hauser, "The Voice of the Customer," *Marketing Science*, vol. 12, no. 1, pp. 1-27, 1993.
- [3] J. Antony and et al. *Lean Six Sigma for Small and Medium Sized Enterprises: A Practical Guide*, 1st ed., Boca Raton: CRC Press, 2016, pp. 1-10.
- [4] S. Leming-Lee et al., "The Lean Methodology Course: Transformational Learning," *The Journal for Nurse Practitioners*, vol. 13, no. 9, pp. e415-e421, 2017.
- [5] Six Sigma Training Site, "Six Sigma Training," 10 September 2018. [Online]. Available: <http://www.sixsigmatrainingfree.com/six-sigma-blog/gemba-gembutsu-genjitsu>. [Accessed 28 September 2019].