

Application of Six Sigma DMAIC in Bangladesh Health Industry

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Abstract

Bangladesh has made remarkable achievements over the past decades in developing the healthcare sector despite many hurdles and financial constraints. However, the healthcare sector is gradually falling behind in terms of better service due to inefficiency and medical errors. This study presents how Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) can be systematically used to eradicate inefficiencies and medical errors. The study begins with a brief introduction about the health industry of the Bangladesh and how far it has progressed with the current timeline. Bangladesh has been striving to develop their health industry but high expenditure, medical errors and inequality in service are some of the key obstacles that is hindering the growth of health industry. To overcome the obstacles, Lean Six Sigma DMAIC, a data driven optimization tool, is used. Hospital inefficiency, medical errors, lack of better service, outdated medical instruments and medicine quality require sufficient improvement. The study is done qualitatively as well as quantitatively and the data are collected through questionnaires from 60 patients in Ruma, Chokoria, Chittagong. Lack of better doctors, outdated surgical instruments, medical errors and unsatisfactory health services are focused. The suggested optimization tool tackles these issues through a structured approach in five phases namely, Define, Measure, Analyze, Improve and Control. This allows the health industry to locate the pain points effectively and reduce variation in products or services. Collaboration between the hospital management, doctors, medical equipment manufacturing companies and health service providers is essential in ensuring sustainable growth and continuous improvement.

Keywords

Lean Six Sigma, DMAIC, Optimization, Healthcare management

1. Introduction

Over the last 42 years since independence Bangladesh has made lot of strides in the health sector (R Hossain 2015). The establishment of hospitals, clinics, diagnostic centers, clinical trials, outsourcing, telemedicine and also modern medical devices and equipment contributed to this huge growth. Committed to providing better healthcare, the Government of Bangladesh increased the budget in its healthcare sector. However recent data presents a growing expenditure in health and inequality in service. The lack of skilled health workers combined with poor distribution of the doctors throughout the whole country is a major issue. Diseases such as diarrhea, tuberculosis, respiratory infections, heart diseases, unplanned urbanization, dengue and many more are prevalent in many parts of Bangladesh. In short, Bangladesh healthcare needs improvement in various areas. Although many awareness programs are being arranged by the NGOs regarding health issues, it needs to spread out into rural communities as well. Cost of medicines needs to be reviewed as many patients are unable to purchase medicine due to poverty. Better doctors are required in minor cities and towns to reduce the hassle of going to big cities for better medication for minor issues. Regulatory compliance in pharmaceutical processes is critical to ensure the safety, efficacy, and quality of pharmaceutical products (Wei and Nurhaliza, 2024).

This research paper presents a systematic review of how Six Sigma DMAIC framework can be used to improve Bangladesh's Healthcare Sector through a five-step approach. DMAIC means **Defining** the problem, **Measuring** the

problem performance, **Analyzing** the causes behind the problem, **Improving** by providing new solutions and **Control** the stated solutions. Applying this methodology will result in a significant reduction in patient waiting time as well as medical errors. The DMAIC methodology is a continuous improvement process which not only improves the process performance but also output quality systematically. Overall it brings a positive impact for the hospitals as more patients are satisfied with their care and opens more opportunity for further development.

2.Literature review

Six sigma is a statistical method which judges how far a certain process drifts from perfection. A process that follows the six sigma methodology has a failure rate of only 0.00034% which concludes that the process has virtually no defects (Kumar 2024). Six Sigma aims to deliver products with a quality of near perfection by reducing defects and errors, cutting down variations and boosting quality as well as efficiency. The term six sigma is derived from the bell curve in statistics, in which sigma represents the standard deviation from the center (CFI Team, n.d.). The reason behind using six sigma is for achieving extremely low defects and to obtain such results, a structured approach is followed which is known as DMAIC. Data-driven processes are at the core of Six Sigma methodologies, a powerful approach for eliminating defects and improving overall business performance (Amrepinspect 2024). In DMAIC, the problem, customers, process and the output to improve is, at first, identified in the Define phase. Relevant data is then collected to set up a baseline for improvement in the Measure phase. The available data is analyzed to find the root cause of the defects in the Analyze phase after which practical solutions are developed and tested to improve the performance of the process in the Improve phase. Finally, to sustain the improvements, various process controls are implemented in the Control phase. The whole process is repeated frequently to identify the best practices and reach close to perfection.

Organizations that implement Six Sigma invest in quality improvement, cost reduction and efficiency improvement (Van Den Heuvel, J., Does, R. J., & Verver, J. P. 2005). A three sigma process, for example, has a defect rate of 6.7%, while a Six Sigma process has only 3.4 defects per million opportunities (Sharma, Bhanot, Gupta, & Trehan, 2022). The introduction of Six Sigma in a hospital stimulates a culture of awareness to find opportunities to improve healthcare delivery and to take responsibility for eliminating shortcomings (Van Den Heuvel, J., Does, R. J., & Verver, J. P. 2005). A case study was conducted in a general hospital in Baja California, Mexico (Rosas-Hernandez et al. 2021) where the DMAIC approach was implemented and the results communicate that the combination of lean and DMAIC appears to be an effective approach to implement in healthcare processes in order to identify, evaluate, and reduce wastes, as well as increasing efficiency (Rosas-Hernandez et al. 2021). A non-profit teaching hospital with 944 beds and 6000 employees, 400,000 OutPatient (OP) and Emergency Room (ER) visits and 40, 000 InPatient (IP) discharges reduced infection rates by 75% with savings of \$1.2M/Yr (Ganti and Ganti n.d).

Since achieving independence in 1971, Bangladesh has had notable health advances, becoming a prime example of “good health at low cost” (Bhuiyan, H. K. H., & Ferdous, J. 2023). The success in expanding immunization, improving maternal and child health, and in reducing malnutrition must be commended (Islam, A., & Biswas, T. 2014). Despite numerous successes there still remain many different problems to solve such as reforms of healthcare in rural areas, accessibility to better medication in public hospitals, availability of drugs and many more. (Islam, A., & Biswas, T. 2014) stated that in many public hospitals the available ambulances are either inoperative or being used by the physicians and other staff. Shortage of logistics in most public health care centres, especially at the Upazila Health Complexes and district hospitals is a common phenomenon (Islam, A., & Biswas, T. 2014).

2. Research methodology

Six sigma DMAIC has a significant importance in healthcare sectors in terms of problem solving and delivering effective and efficient health services. To further analyze this research, both qualitative and quantitative methods are used. As for quantitative methods, the relevant data are collected from research paper reviews, newspapers, online journals, books and through various relevant databases. Qualitative data are collected through questionnaires and short interviews of individuals who are in the health sector and through observations. The DMAIC framework is then used in the following way:

Define: Describe the problems that need to be solved and establish project goals and opportunities for improvement. This step focuses on finding out different possibilities, impact of the problem and how frequent it is happening.

Measure: Measure the process performance, examine the data and find out defects. After problem definition, the system performance is measured using necessary data to evaluate the current state of the process performance.

Analyze: Identify the root cause of the problem along with associated parameters. With the current performance data in hand, this step involves thoroughly reviewing and analyzing the data to find the root cause and identify which parameters affect the performance.

Improve: Develop solutions and implement them to resolve the issue. From the analysis phase, the root causes are identified and necessary solutions are developed and implemented to eliminate the problem.

Control: Monitor the implemented solution and track the progress. It is crucial to ensure that the implemented solution is stable and working as planned. Also an action plan is prepared to sort out any new problems while the solution is being executed.

3. Implementation case study

Surgical error is one of the common and major problems in the medical sector in Bangladesh. It is very critical to a patient's life and this problem can be seen massively in Upazila area and many Government hospitals. By applying Root Cause Analysis (RCA) combined with the DMAIC framework, we can identify the specific causes of these errors and develop solutions. The DMAIC framework for this problem, is going to be used in the following way: -

Define: Define the problem and the goal that needs to be achieved.

Measure: Inspect the present status of the problem.

Analyze: Analyze the present situation and look for solutions.

Improve: Implement the solutions to achieve the goal.

Control: Ensure the improvement is consistent to avoid such problem

3.1 Define phase

The define phase includes three important steps such as problem identification, defining objectives and understanding customer requirements which are described below.

Problem definition: It is often seen that in rural areas, the minor operation cannot be operated properly due to shortage of equipment and qualified surgeons although the government has a massive budget for making a new medical or clinic. Also, existing equipment becomes useless because of the lack of maintenance.

Objectives: The objective is to increase the availability of surgical equipment and ensure more safe operation in Upazila area and Government hospitals.

Customer requirements: Due to the increasing surgical error in rural areas and Government hospitals, many are trying to access the city hospitals for better surgery but at a higher cost, leading to customer dissatisfaction. Hence, in order to improve the customer satisfaction level, the customer requirements were noted based on the voice of customers as shown in Table 1.

Table 1. Customer requirements

Pain points	Customer complaints	Customer requirements
Reduction of surgical errors in rural Government hospitals	<ol style="list-style-type: none"> 1. Improper distribution of qualified surgeons. 2. Lack of surgical equipment. 3. Long waiting time for getting surgery. 	<ol style="list-style-type: none"> 1. Provide fully functioning Operating Theater(OT). 2. Ensure up to date surgical equipment with regular maintenance. 3. Optimal distribution of qualified surgeons.

3.2 Measure phase

The measure phase involves monitoring the extent of the surgical errors taking place through a case study.

Case study - 1:

Aklima khatun lives in Chokoria, Chittagong. On 21th April 2021 at around 11.30AM, she felt unbearable pain in her appendix so she got admitted into a local clinic. The doctor identified her appendix blast and advised to remove it but

the operation theater is not in working condition due to degraded surgical equipment. As a result, the duty doctor referred her to the Chittagong Ma o Shishu hospital; however, she had to travel a long distance of 32 kilometers(km) to reach the referred hospital. Unfortunately, Aklima could not reach the destination on time and sadly passed away.

Case study - 2:

In Chittagong, several hospitals are frequently receiving infection cases, resulting in extra cost for medical care, delays in providing treatment and mortality in some cases. There are many reasons behind this problem but of them, a prominent reason is using low grade surgical equipment like blades, scissors, gauges etc. in removing tumor from tumor patients. The following table 2 summarizes the data, taken from 60 patients, regarding the types of surgical errors, root cause of the errors and survival rate of hospitals located in Ruma, Chokoria, Chittagong.

Table 2. Surgical errors, outcomes, root cause and percentage

Serial No.	Surgical errors	Outcome	Root Cause	Number of patients affected	Percentage (%)
1	Retained faulty equipment	Serious injury while surgery	Lack of proper inspection	15	25
2	Communication failure	Wrong site surgery	Poor marking	10	16.67
3	Technical error	Nerve damage	Lack of training	20	33.33
4	Unsterile surgical tools	Infection	Insufficient sterilization before a surgery	10	16.67
5	Procedural	Medication error	Wrong dose	5	8.33

From this data it can be seen that surgical errors for example faulty equipment, lack of proper communication and inability to follow the procedure can reduce the survival rate by as low as 30% which can lead to severe consequences and in some cases, mortality.

3.3 Analyze phase:

In this phase, the summarized data is analyzed using the Pareto Analysis Chart and Fishbone diagram to sort out the major defects and address them to improve the process. To visualize the surgical errors quantifiably combined with their cumulative percentage, Pareto charts are plotted in Figure.2.

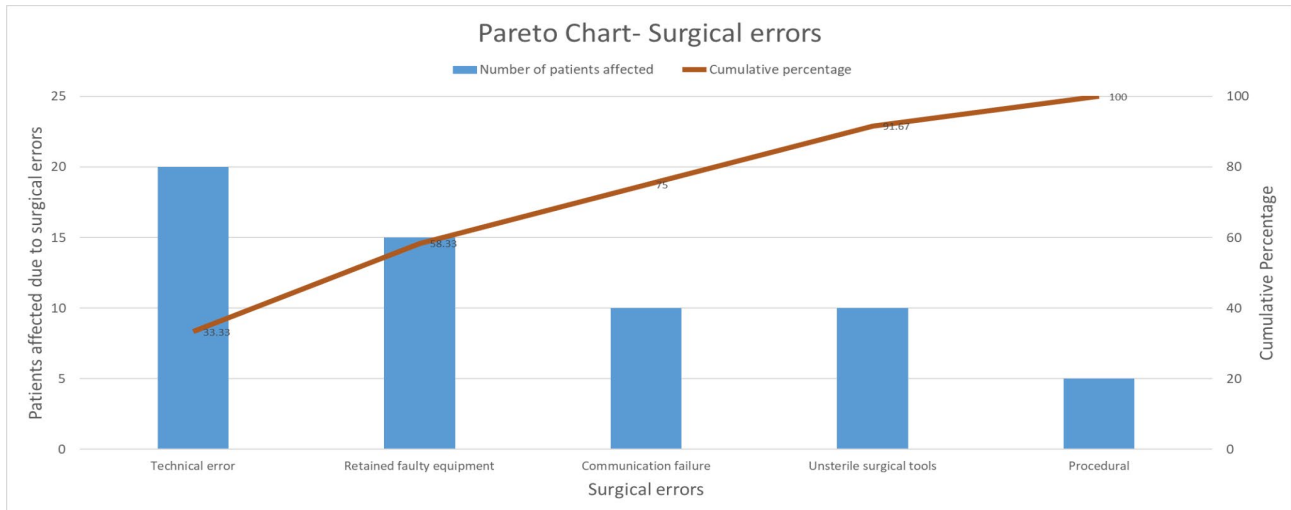


Figure 1. Pareto chart on the basis of data from Table 2

From the Pareto charts, it can be assessed that Technical error and Retained faulty equipment contribute largely to surgical errors which can be as high as 58% of all the surgical errors. So, priorities are set in order of solving the highly contributing problems in the first place.

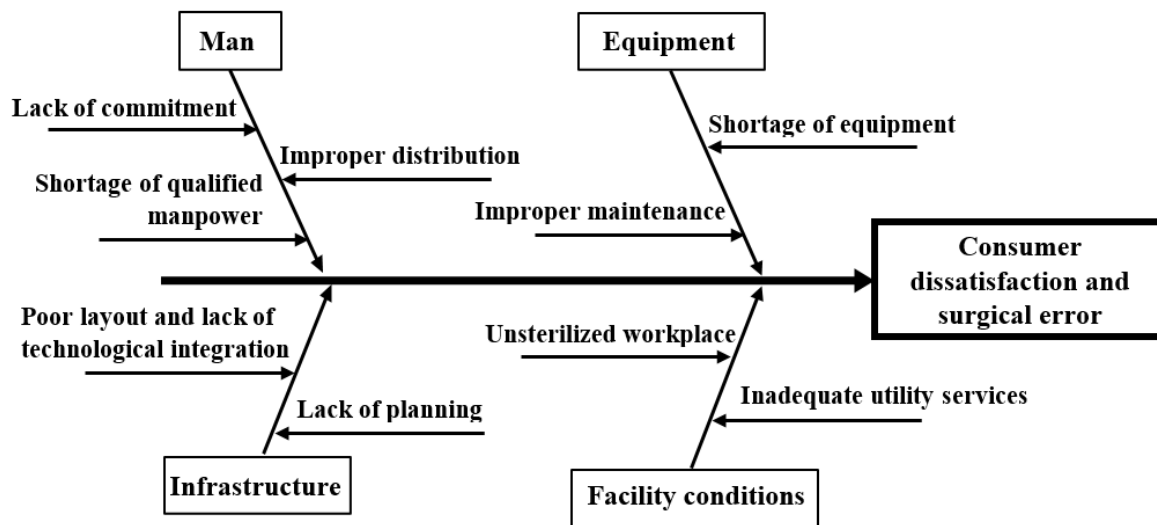


Figure 2. Fishbone diagram.

Using causal analysis tools such as the fishbone diagram, a total of 9 causes are found which are responsible for customer dissatisfaction and surgical error. Using this tool, the four key categories, Man, Equipment, Infrastructure and Facility conditions, are identified along with the respective causes which are further analyzed to come to an optimal solution.

3.4 Improve phase:

In improve phase, in depth discussions are carried out and various solutions are devised. Following are the solutions that are best suited to cater the surgical error problem.

1. Healthcare institutes have increased student intake to provide more qualified manpower than before.
2. Surgical simulation training has been introduced to facilitate surgical procedures and provide safer hands-on training.

3. Local equipment and manufacturing companies for surgical instruments increased their production to eliminate equipment shortage.
4. Location wise dedicated maintenance team has been stationed to oversee preventive, corrective and predictive maintenance.
5. Surgical instruments undergo steam sterilization before being used for surgery.
6. Augmented reality coupled with Artificial Intelligence is being implemented to provide real time analysis and assist in decision making while performing surgery.

3.5 Control phase:

The control phase serves to sustain the creative solutions found after a lot of qualitative and quantitative analysis so that the errors no longer persist. Since surgery is an intricate medical procedure, hence ensuring minimum error is paramount. If not controlled, then the possibility of further surgical error will only add up which can result in far worse conditions than before. Key initiatives to ensure the solutions bring surgical errors to minimum are as follows.

- a. Revising the medical policy to ensure strict adherence to surgical guidelines.
- b. Ensure regular training of medical staff, nurses as well as surgeons.
- c. Establish a culture of safety.
- d. Promoting the use of checklists to ensure appropriate surgical tools are being used.

4. Discussion

The remedial action taken against minimizing surgical errors proved to be valuable in curbing the amount of surgical errors and improved the overall process. The improved result significantly boosted the hospital morale and retained the trust of the patients undergoing surgery. The addition of augmented reality and AI assisted the surgeons in performing surgery without excessive stress thus reducing the number of wrong surgeries. Furthermore, the wide availability of sterilized surgical tools and related equipment made the operation smoother hence, increasing customer satisfaction.

The overall Six Sigma DMAIC process continues to be beneficial in reducing the number of defects and errors related to surgery in a systematic way. Enhanced communication between the employees, increased customer and employee satisfactions, positive attitude in the workplace, uplifted morale of the employees etc. are some of the benefits gained by the hospitals. This systematic approach not only helped the hospitals regain the customer’s trust but also reduce the amount of surgical and other related errors, increase productivity, optimize the overall surgical process and reduce operational cost.

Table 3. Number of patients affected due to faulty equipment and technical error (before and after scenario).

Number of patients affected due to surgical errors (in Percentage)		
Surgical errors	Before	After
Retained faulty equipment	25	6
Technical error	33.33	10

5. Conclusion

In this evolving and challenging era, new issues are constantly on the rise for which new tools and techniques are continually developed. Various improvement tools are frequently used such as PDCA cycle, Kanban system, Value stream mapping, Six Sigma, Process mapping, Pareto chart and many more. In this research paper, the importance and application of Six Sigma DMAIC has been presented along with a case study where the Six Sigma DMAIC framework has been used systematically to reduce the amount and types of surgical errors in hospitals located in Ruma, Chokoria, Chittagong.

Previously, surgical error such as retained faulty equipment and technical error rose to as high as 25% and 33.33% respectively, creating a negative impression for the company as well as the quality of the service. To overcome the problem, the DMAIC framework has been initiated to systematically locate the key problems and resolve them. After implementation, the faulty equipment and technical error reduced to staggering 6% and 10% respectively, achieving a

huge milestone for the medical administration as well as improving customer satisfaction. Considering the overall positive impact of the Six Sigma DMAIC framework on improving the surgical procedures, the hospital management in Ruma came to a conclusion that the DMAIC framework truly helped in reducing medical and surgical errors as well as fostering a positive relationship with the customers. The present study has certain limitations and is mainly designed for a specific industry's specific process. The opportunities are limitless with this improvement tool and can be applied to different manufacturing industries, food and beverage industries and smartphone factories as well. Further research can be conducted on how the DMAIC framework can be implemented in the context of the Kanban system.

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Biographies

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