Using Six Sigma to Reduce Patients' Waiting Time and Length of Stay in an Emergency Department

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Abstract

Emergency Departments (ED) has been characterized by complex systems of medical resources and large volumes of patients worldwide. In an effort to deal with such a complex system and streamline processes in ED, many quality improvement techniques have been implemented in this regard. The purpose of this paper is to use Six Sigma DMAIC methodology to reduce the patients' waiting time (WT) and length of stay (LOS) in the ED at Benghazi Medical Center (BMC). Tools within each phase of the DMAIC framework were defined and implemented starting by defining and outlining the problem in the define phase and ending by the improve phase where a set of recommendations were suggested based the observations noted in the measure phase and the root cause analysis in the analyze phase. The findings reported in this research may benefit the medical staff in the ED and the policy makers at the hospital to improve quality of the services provided at the ED and ultimately increase patients' satisfaction.

Keywords: Six Sigma, DMAIC, waiting time, length of stay, emergency department

الملخص

تتكون أقسام الطوارئ بأنظمة معقدة من الموارد الطبية وأعداد كبيرة من المرضى في جميع أنحاء العالم. في محاولة للتعامل مع مثل هذه الأنظمة المعقدة ولتبسيط العمليات في غرف الطوارئ، تم تطبيق العديد من تقنيات تحسين الجودة في هذا الإطار. الغرض من هذا البحث هو استخدام منهجية Six Sigma DMAIC لتقليل وقت انتظار المرضى (WT) ومدة الإقامة (LOS) في قسم الطوارئ في مركز بنغازي الطبي (BMC). تم تحديد واستخدام الأدوات في كل مرحلة من مراحل إطار DMAIC بداء من تعرف المشكلة في مرحلة التعريف وانتهاءا باقتراح توصيات في مرحلة التحسين وذلك بناءا على الملاحظات التي تم اكتشافها في مرحلتي القياس والتحليل. النتائج الواردة في هذا البحث قد تفيد الطاقم الطبي في قسم الطوارئ وصانعي السياسيات في المستشفى لتحسين جودة الخدمات في قسم الطوارئ وزيادة رضا المرضى في نهاية المطاف.

1. Introduction

There have been a considerable worldwide increase in Emergency Departments (EDs) visits during the last few years coupled with reduction in system capacity (Eitel et al. 2010; 70). In the United States, the annual ED visits were increased from 90 million to 114 million from 1992 to 2003 (Burt et al., 2001; 150). Although there are many definitions for ED crowding, there is still no clear consensus on a generalizable definition of it. According to The American College of Emergency Physicians Crowding Resources Task Force, ED crowding may refer to the situation where the need for ED services surpasses the available resources (Hussein et al., 2017; 2). When this case occurs, patients admitted to the ED are often forced to wait for many hours before they receive treatment or being seen by a physician. This will also lead to increase patients' length of stay (LOS) and hence reduce their satisfaction.

In Libya, no studies have been conducted to measure the volume of ED patients to local hospitals. Nonetheless, it is expected that the epidemic of ED crowding in Libya doesn't differ from that of the United States given the current situation in the country. This project aims to reduce patients' waiting time (WT) and length of stay (LOS) in an Emergency Department (ED) at Benghazi Medical Center (BMC) using Six Sigma DMAIC approach (stand for Define, Measure, Analyze, Improve, and Control). In section 2 of this research, a literature review of the application of Six Sigma in healthcare focusing on ED crowding are discussed. The methodology including the application of DMAIC framework is reported in section 3.

2. Literature Review

Since its development by Motorola in the mid-1980s, Six Sigma has been widely implemented and investigated in industry as well as in research. This including the application of Six Sigma in healthcare industry. In this regard, Habidin et al. (2015; 152) used Six Sigma DMAIC methodology to reduce waiting time in an emergency department in a district hospital of Pahang in Malaysia. In the define phase, the scope of the problem was defined using SIPOC (Suppliers – Inputs – Process – Outputs –Customers). In the measure phase, a process flow chart was designed to understand the current flow of the process. In the analyze phase, the root causes of the problem were identified and categorized using a Fishbone diagram. In the improvement phase, the Failure

Modes and Effects Analysis (FMEA) was conducted to identify potential defects in the process. To maintain improvement, a Gantt chart was created in the control phase.

Also, El-Eid et al. (2015; 1) implemented Six Sigma to improve patient discharge process in an ED at The American University of Beirut Medical Center (AUBMC) in Beirut, Lebanon. The aim of the study was to reduce the patient discharge time and length of stay (LOS) for patients admitted to ED. The study followed a pre, post intervention design to measure the effectiveness of using Six Sigma in enhancing patient discharge process. The results indicated that the discharge time was reduced from 2.2 hours to 1.7 hours while the LOS for ED patients was significantly decreased from 6.9 hours to 5.9 hours.

In addition, Molla et al. (2018; 405) used Lean Six Sigma to increase patient throughput by reducing patient discharge time in ED at the University of California, Davis Medical Center. The authors used a quasi-experimental design to evaluate patient discharge time, LOS, and readmission rate. The results revealed that a 21.3% increase in the number of discharge orders issued by 10:00 am. Besides, the results showed a 7.5% increase in the number of patients discharged by noon. Moreover, no significant change in readmission rate or LOS were observed.

Furterer (2018; 389) used Lean Six Sigma to reduce patient LOS in ED at a community-based acute care hospital. The study used the DMAIC methodology to reduce LOS, reduce the number of patients left without being seen, and increase patient satisfaction. After applying Six Sigma, the LOS was decreased from 6.4 hours to 4.5 hours, which represents a 30% improvement. Also, the study reported that the percentage of patients left without being seen was decreased from 6.5% to 3%. Finally, the study reported that the patient satisfaction was increased from 65.9% before implementation to 73.5% after implementation.

3. Methodology

Emergency departments (ED) play an important role in a patient's treatment journey. A patient is admitted to the hospital, transferred to another hospital, or discharged based on an emergency physician plan. This study was carried out in Benghazi Medical Center (BMC), one of the main local hospitals in Benghazi, Libya. The hospital is currently working with clinical capacity of 400 beds. The ED staff works in two shifts with 4 physicians and 6 nurses in each shift. The Six Sigma DMAIC, which stands for Define, Measure, Analyze, Improve, and Control, was used to reduce patients' WT and LOS in ED.

4. Results and Discussion

This section describes application of the DMAIC framework in ED at BMC. Due to the time constraint in addition to lack of top management commitment at BMC in applying proposed changes, only the define, measure, analyze, and improve phases of the DMAIC framework were implemented.

Define Phase

The define phase is the first phase of the Six Sigma DEMAIC approach. In this phase, the project outlines, metrics, and objectives are clearly identified. The main tools of the define phase are discussed in the following sections.

1. Project Charter

The project charter is a helpful tool that describes the project scope, goals, and anticipated benefits. The project charter is used in the initiation phase of the project. The project charter for this project is illustrated in Appendix A.

2. High-level process map

The inclusion of a high-level process map in the define phase assist in focusing on the main processes involved in the scope of the project.

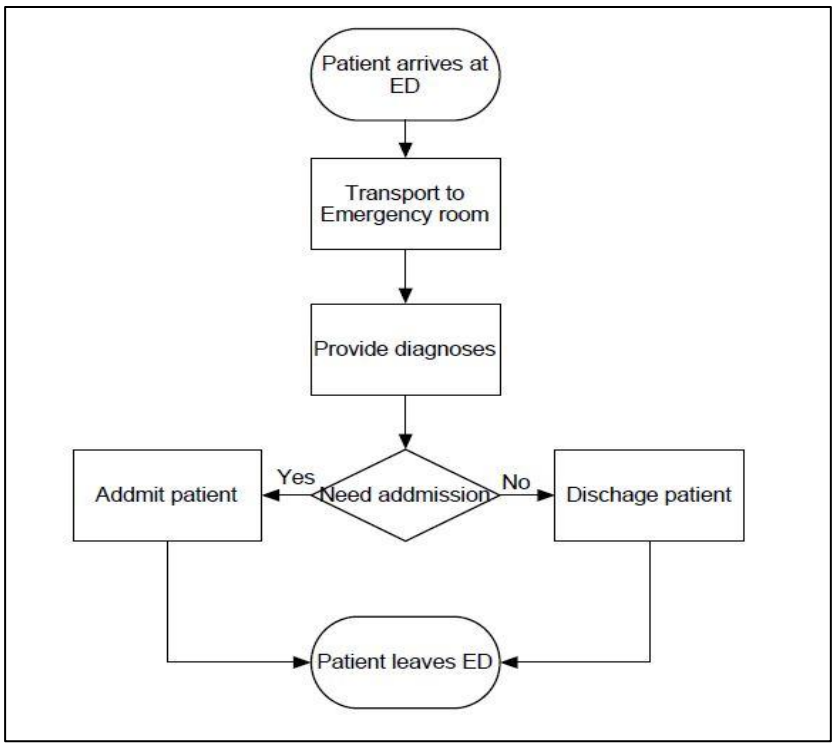

Figure 1 High-level process map of ED

3. SIPOC

The SIPOC, which stands for (Suppliers, Inputs, Process, Outputs, and Customers), is a Six Sigma tool used to explain what and who is involved in this project. Defining customers, sources of information, and suppliers of information and materials are demonstrated using SIPOC. The start and the end points for each process are also described in this section.

Table 1 SIPOC for ED processes

Suppliers	In puts	Process	Out puts	Customers
- patient - nurse - physician - pharmacy - catering unit - external providers - cleaning and sterilizing unit - Security personnel	- disease/ sickness - initial diagnosis - comprehensive diagnosis and treatment - medications - food supplies - medical devices - cleaning materials - Secured environment - assessment sheet.	See Fig. 2	-patient receives treatment. -patient dismissed from ED	- patient

Measure phase

In this phase, internal processes that have an impact on quality characteristics and the most important needs of the customer are measured. After defining the boundaries and goals of the project in the previous phase, gathering data to establish an understanding of the current state of the problem can be performed. However, in some circumstances, there is a difficulty to gather or collect reliable data. Generally, different kinds of questions should be asked before collecting data include where the important data may be found, who can provide reliable data, and how the data can be collected with minimal effort. Brainstorming techniques can be used at this stage to encourage creativity and provide insights to the problem at hand. In addition, process-mapping tools are important to document and verify how processes work within specific conditions.

1. Detailed process map

The most important processes that were highlighted in the Define phase will be discussed in detail in this phase. Therefore, each of these processes is under the focus of the project team to understand the current state and system of the ED. The following is the detailed process map for this project. It illustrates the process from the moment the patient arrives at the ED going through providing diagnoses and treatment to the discharge from ED or admission to the hospital.

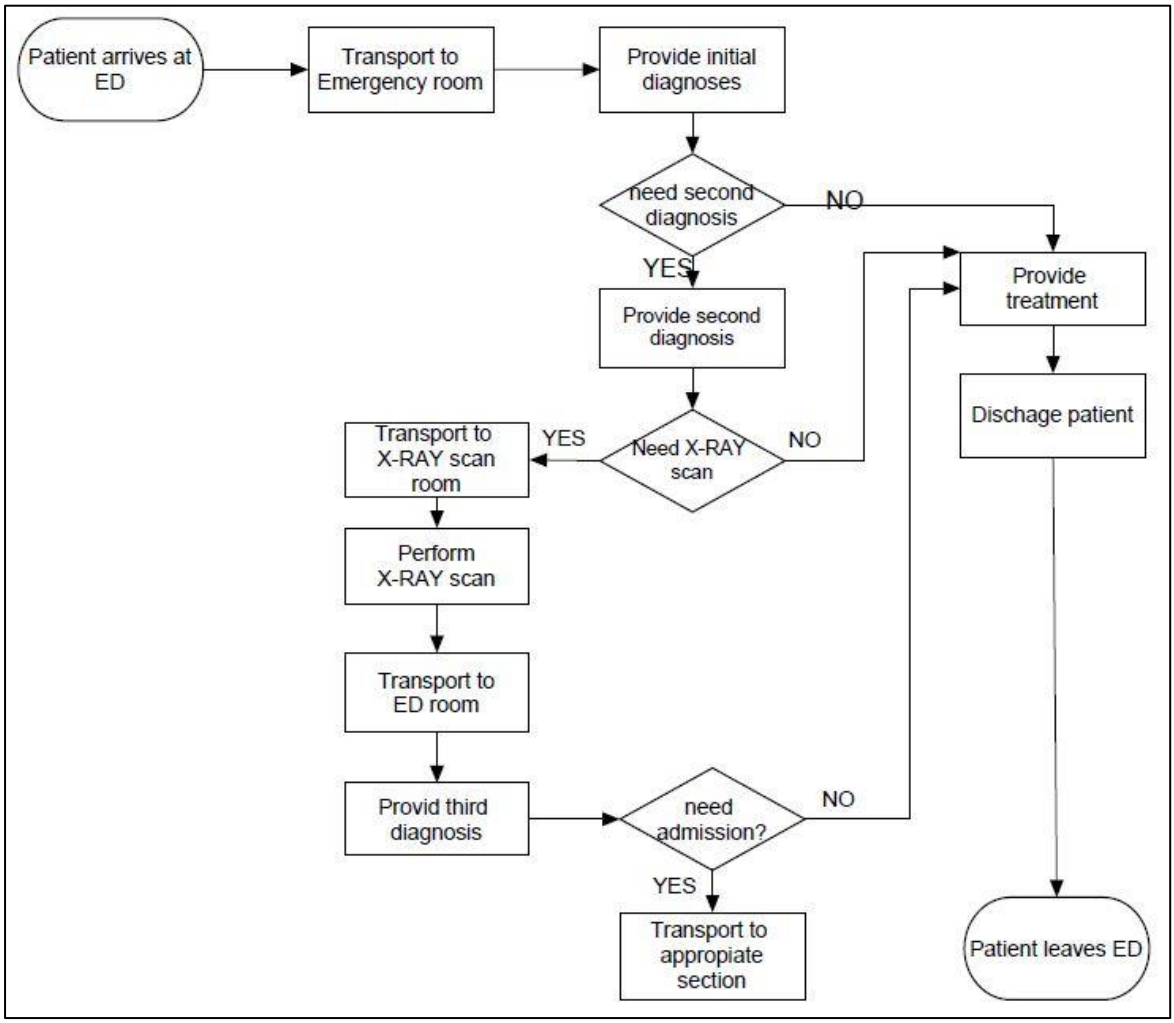

Figure 2 Detailed process map

2. Data Collection plan

To accurately identify the root causes of the problem, a sound data collection plan should be outlined as a part of the measure phase deliveries. As many factors contribute to the extended WT and LOS, there is no way to identify these factors but to numerically measure them. Therefore, the goal of collecting data is to reduce both WT and LOS through analyzing the given data using statistical methods.

1. Methodology

   Process owners will deliver data, if available, to the team as part of the data collection process. However, if the required data are not available and need to be collected, the team will collect the data collection, and the process owners will supervise the process.

2. Data to be collected
    a. Number of patients in each shift
    b. Patient's arrival time
    c. Diagnosis time
    d. Time of treatment
    e. Patient's discharge time

Analyze phase

In the analyze phase, the data that were collected in the measure phase will be used to identify the root causes of the problem using statistical methods such as control charts and fishbone diagram.

1. Control charts

A total of 20 samples of size 10 were randomly collected to construct the control limits of WT and LOS. Using Minitab 16 statistical software, the *X*-bar and *R*-control charts were constructed and shown in Fig. 4 and Fig. 5. For both WT and LOS, the process is found to be out of control and an investigation is needed to identify the root causes of the problem and hence eliminate them.

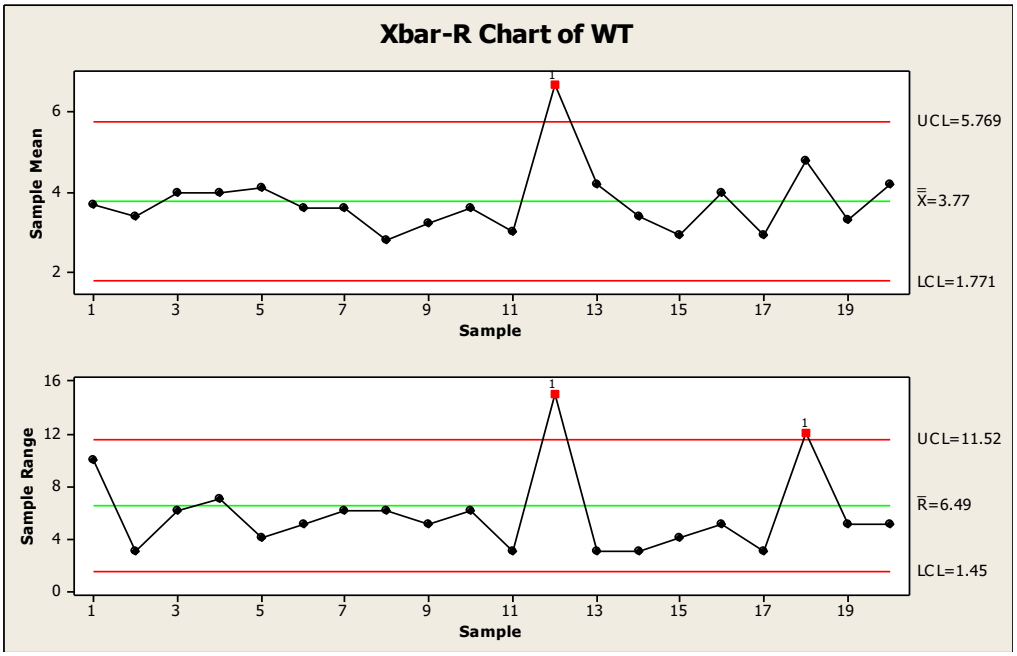

Fig. 4 *X*-bar and *R*-control charts of WT

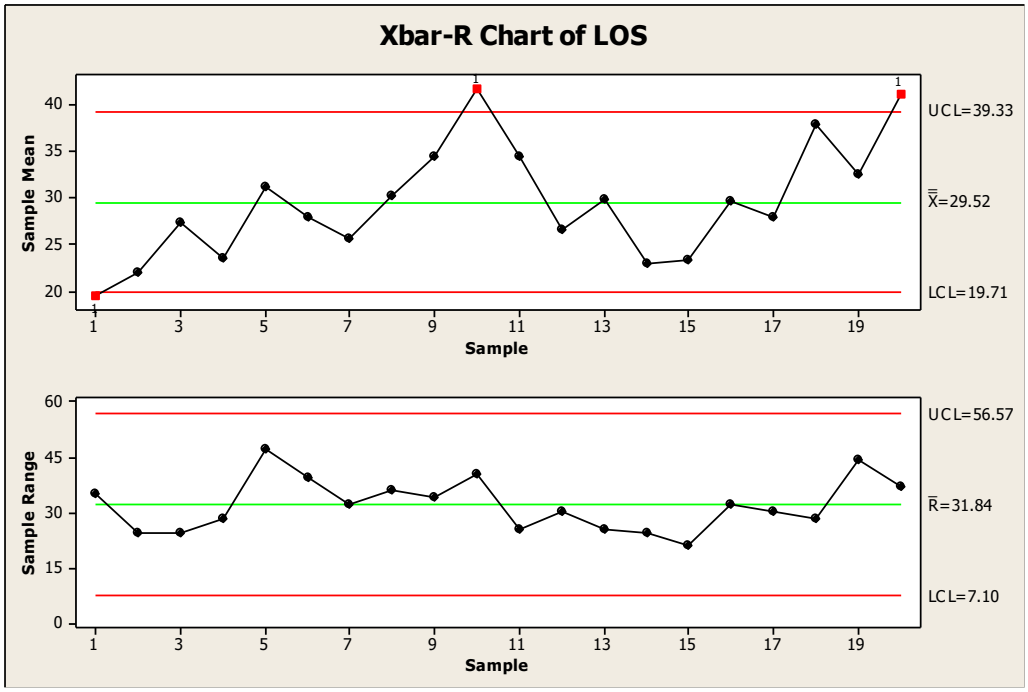

Fig. 5 *X*-bar and *R*-control charts of LOS

2. Cause-and-effect analysis

In addition to control charts, the Fishbone diagram was constructed to identify the causes of the excessive waiting time and length of stay as illustrated in Fig. 6.

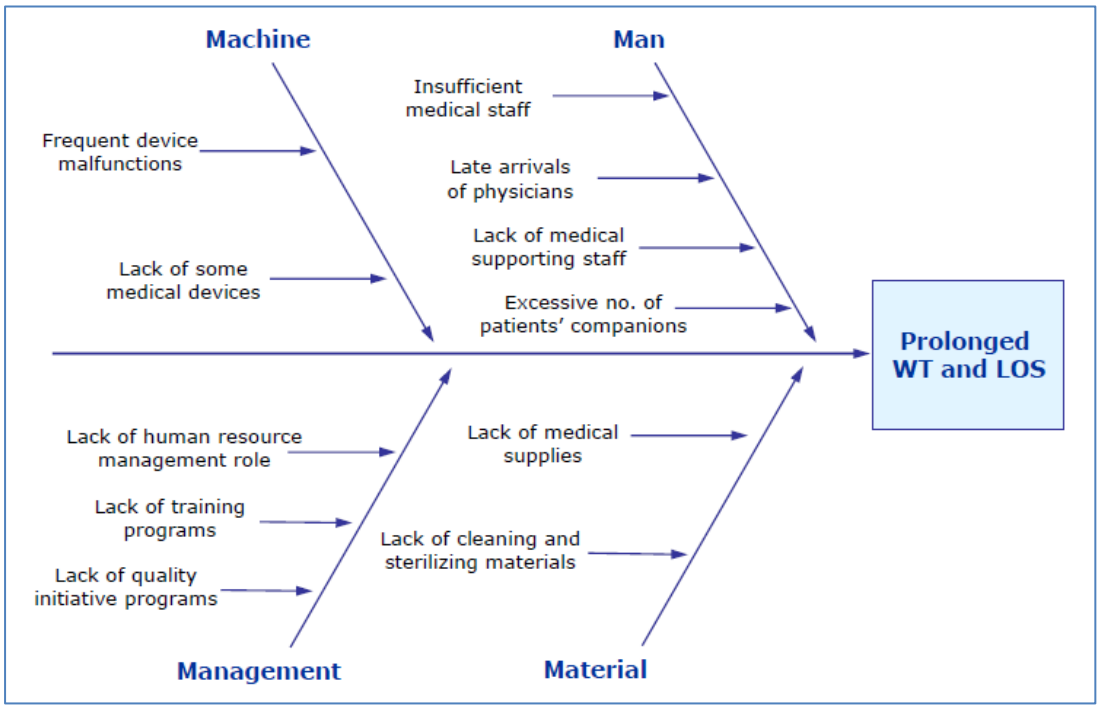

Fig. 6 Fishbone diagram for the main causes of excessive WT and LOS

Improve phase

In the improve phase, solutions to the problem are proposed using a variety of tools such as improved process map. Besides, general recommendations that include some changes in the current processes may be suggested. Based on the analysis, an improved process map was constructed and shown below. Two main processes were included in the improved prosses map which are the reception room to collect basic information from the patient and the filter room contains a triage process to determine the level of severity of the patients conditions and hence direct them to the appropriate section or department.

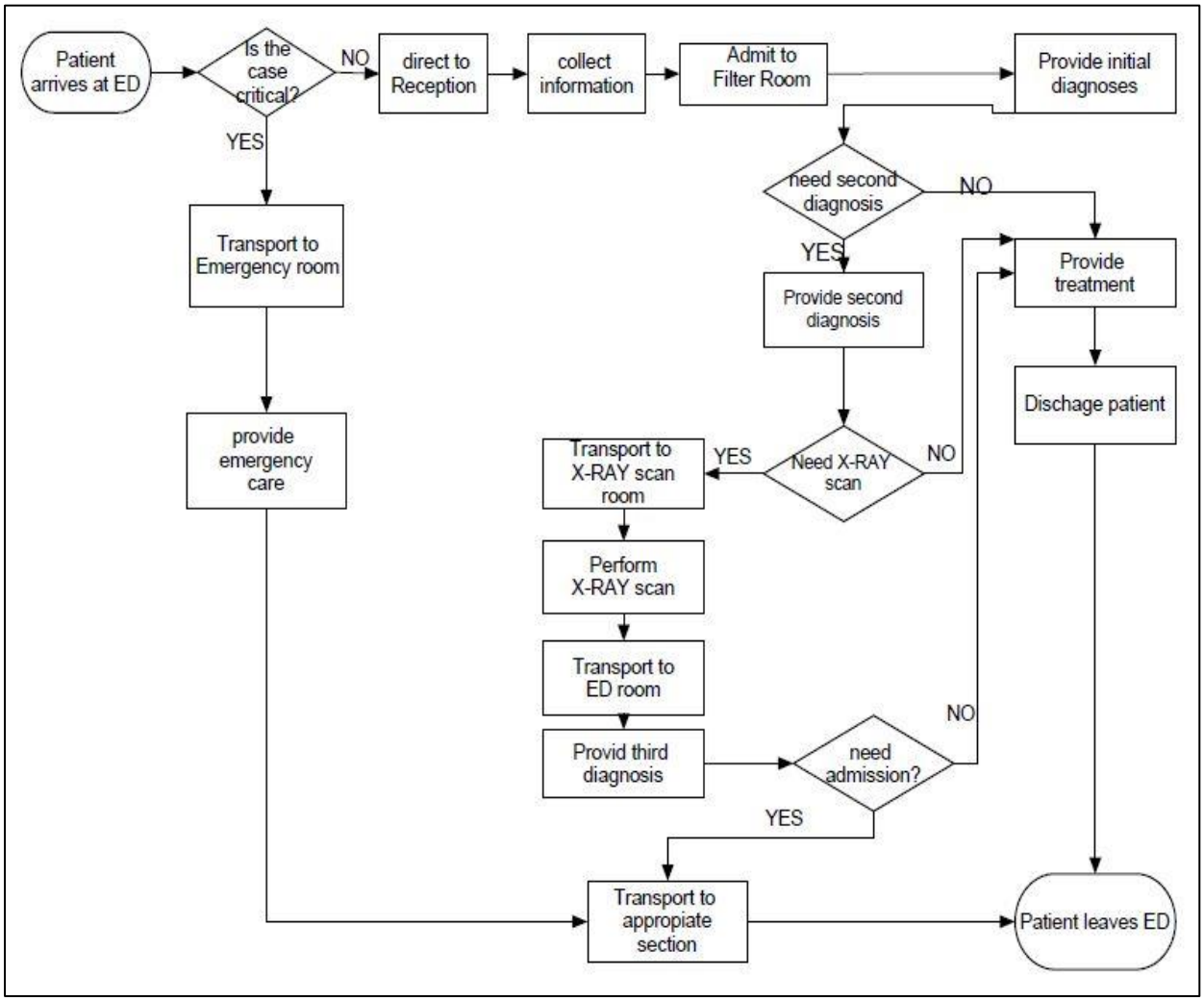

Fig.7 Improved process map of ED

In addition, based on the analysis that were conducted in the analyze phase, a set of recommendations that may lead to reduce both WT and LOS can be outlined as following:

- Activation of the reception room to help direct patients and collect relevant information.

- Addition of signs and directions inside the hospital facilities so that patients can easily identify their requested destination.
- Increasing the capacity of the ED by assigning more medical staff in each shift.
- Inclusion of a triage process to facilitate streamline the process of patients care and treatment.
- Enhancing the coordination between the ambulance and the emergency department in case of emergencies

4. Conclusions

The Six Sigma DMAIC approach was implemented at ED of BMC to reduce WT and LOS. In the define phase, the project charter, a high-level process map, SIPOC were constructed. In the measure phase, a detailed process map and data collection plan were constructed. In the analyze phase, statistical tools including control charts to measure the capability of the WT and LOS processes. The results showed that processes concerning WT and LOS were out of control. Subsequently, a cause-and-effect analysis were used to identify the root causes of the problem. In the improve phase, an improved process map as well as a set of recommendations were proposed to improve the quality of the services provided at the ED and ensure that the improvements obtained remain at the same level. The application of Six Sigma in ED has been shown to provide many benefits to the ED and to the hospital at large, especially if the suggested recommendations were implemented. Thus, policy makers and medical professionals working in hospitals should seriously consider the application of Six Sigma in their facilities to benefit from its promising outcomes.

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Appendix A

Project Charter

Project Title: Using Six Sigma to Reduce Patient's WT and LOS at an Emergency Department
Problem Statement: Delivering on time treatment at the ED is a crucial in saving factor patients' lives. The current ED processes work with excessive variability with unsatisfactory levels of WT and LOS.
Project Scope: The scope of this project will be bounded by the ED of BMC. All processes outside the ED will be considered beyond the scope of this work.
Project Goals: The team working on the project aim to achieve the following: - Streamline current ED processes - Reduce patient's WT and LOS, which will lead to increase in customer (patient satisfaction) - Increase process efficiency by eliminating non-value-added tasks
Assumptions: All physicians, nurses, and other medical staff are available during their entire shifts.
Constraints: Some of the challenges that the team might face during their work on the project include: - Lack of top management commitment - Lack of historical data