DOI: 10.15415/jmrh.2015.21004

Application of Lean Six Sigma in Reduction of Medication Errors

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Received: June 15, 2015| Revised: July 21, 2015| Accepted: July 29, 2015

Published online: October 05, 2015 The Author(s) 2015. This article is published with open access at www.chitkara.edu.in/publications

ABSTRACT This study focuses on reduction of medication errors by application of Lean Six Sigma approach in Medication Administration by nurses in a corporate chain hospital of India. It helped the hospital to understand the impact of dedicated Medication Nurse on the Medication administration error rate. The purpose of the research is to redesign the policy on medication administration i.e. introducing the concept of Medication nurse for the management of medication administration errors and depletion of interruptions faced in medication delivery in order to improve the efficiency, effectiveness and safety of care delivered to patients. As per the study done on medication administration, the medication error rate found was very high in a ward (mostly contributing were 31% of missed dose, 21% of wrong dose and 17% at wrong time) due to many interruptions and challenges faced by nurses during drug administration which in turn affecting the safety of care delivered to the patients and total medication delivery time taken by a general nurse was 9 minutes. By using the Lean Six sigma methodology, it was observed rate of medication errors was decreased, the complexity of the work flow became simple and systematic, the work load on all nurses was decreased, and the average time for drug administering was decreased by 55% i.e. to 4 minutes in three months. Thus, it helped in reducing mess up and complexity in the ward with better utilization of other nurses to perform other activities which are needed to be done at the same time and delivering best quality of patient care with high efficiency.

KEYWORDS: Lean Six Sigma; Medication Administration; Medication Errors

Journal of Multidisciplinary Research in Healthcare
Vol-2, No-1
October 2015
pp. 55–72

I. INTRODUCTION

In the hospitals, —Medication Administration is a very common term used. Medication administration is defined as preparing, giving and evaluating the effectiveness of prescription and non- prescription drugs by the nurses to patients in the hospital.

Medication administration need to be safe and effective, but as it involves human, errors may arise in administering the medication. The medication errors include wrong drug, missed dose, wrong route, wrong time, no documentation and wrong documentation. The Lean management applies the concept of reducing the waste to increase the value of product and service and Six Sigma DMAIC methodology helps in reducing variability and therefore waste, fewer errors, better processes, improved patient care, greater patient satisfaction rates and more productive employees that translate to bottom-line improvement.

These two methodologies are utilized in medication administration to bring out streamlined process without interruptions, thus, to reduce rate of medication errors.

II. REVIEW OF LITERATURE

Originally, lean was developed as a production philosophy and quality system, with elements of both craft production and mass production. Lean thinking, with its emphasis on standardization, tries to eliminate inventory and improve processes. Time between a customer requesting a service and then receiving it is minimized. Various tools that together came to be known as lean production were first pioneered at the Toyota Corporation and were later used in the automotive, manufacturing and service industry and eventually health care [8]. The key concept in lean thinking is “value”. Value is defined as the capability to deliver exactly the (customized) product or service a customer wants with minimal time between the moment the customer asks for that product or service and the actual delivery at an appropriate price [22]. The application of lean management in health care can also be holistic such as the transformation of an overall business strategy [17, 19]

Six Sigma, like Lean, is a business management strategy used to improve the quality and efficiency of operational processes. While Lean focuses on identifying ways to streamline processes and reduce waste, Six Sigma aims predominantly to make processes more uniform and precise through the application of statistical methods [2]. Six Sigma was originally developed by Bill Smith of Motorola in 1986 as a way of eliminating defects in manufacturing, where a defect is a product or process that doesn’t meet

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customers' expectations and requirements. The name *Six Sigma* refers to a quality level defined as the near-perfect defect rate of 3.4 defects per million opportunities [16].

A variety of systematic methodologies for identifying, assessing and improving processes have been developed as part of the Six Sigma approach. The Six Sigma improvement model, *Define, Measure, Analyze, Improve, and Control* (DMAIC) specifies the following sequence of steps for understanding and improving a process: 1) defining the project goals and customer (internal and external) requirements; 2) measuring the process to determine current performance; 3) analyzing and determining the root cause(s) of relevant defects; 4) improving the process by eliminating defect root causes, and 5) controlling future process performance. Another Six Sigma methodology, *Design for Six Sigma* (DFSS), is used to systematically design new products and services that meet customer expectations and can be produced at Six Sigma quality levels [7].

Medications need to be safe and effective. Doctors, nurses, nurse practitioners and a few other professionals are trained in how to safely give you medication. Administration of medications requires understanding how the medication is entering your body. It also requires knowledge of when the medication needs to be administered, possible side effects, and toxicity [4].

Medication error due to the wrong drug, the wrong dose, the wrong timing of administration, or the wrong route of administration accounts for 1.3 million injuries each year in the United States, according to the Food and Drug Administration [1].

Nurses receive disproportionate blame for medication errors; the nursing literature often highlights medication error rates found in research studies and reports, and attributes these to nursing administration of drugs [3, 9]. Assumptions have also been made about limited drug calculation and numeracy skills among nurses resulting in medication administration errors [6, 12, 13] Nurses may also attach feelings of guilt and blame to medication errors in which they are involved, and often continue to experience these emotions long after the event [15, 18]. Placing blame for medication errors on an individual or a group of professionals should be avoided as it does not allow the root cause of errors to be addressed [20].

Medication Error Research

Medication errors can occur during prescribing, transcribing (transferring prescriptions to different documentation), dispensing or administering drugs [21]. Actual drug errors are more likely to be reported by staff than potential errors or near misses [11]. Also, the psychological mindset of the nurses on

medication errors having fear of being blamed for errors, thus, many nurses only report errors that have actually caused patient harm. Therefore, errors related to drug administration are more likely to be reported even though they may have arisen from one of the other stages in medicine management, such as prescribing [11]. Because of the different methods used to study error, it is difficult to ascertain the actual medication error rate and at which stage these errors are most likely to occur. In case to avoid these situation there is need of redesigning the policies so as to minimize the medication error rate such that all patient's medication is taken care of and given in timely manner in the way that all 6 rights are followed. When the nurse is administrating the medicine mainly the six rights must be followed in order to reduce medication errors which are right individual, right medication, right dose, right time, right route and right documentation.

As errors during administration are one of the most common types of medication errors, with one study showing that they occur in nearly 25% of doses in hospitalized patients. Lean methodology, derived from the Toyota Production System, is increasingly being used in health care as a way to design safer and more efficient systems of care. The application of Lean approaches to improve medication administration safety. A redesigned medication administration system that incorporated human factors engineering techniques to minimize interruptions, implement medication administration nurse, and standardize nursing workflows results in a significant reduction in administration error rates [5].

Continuous change in complex healthcare environments is a challenge for nurse leaders, but it can also be an advantage. Change can leverage the introduction of innovations that improve the quality of care delivery. It all depends on how change is managed. Six Sigma and Lean are two performance improvement methodologies that could be utilized to improve the quality of healthcare.

From the emergency room to the board room, Lean Six Sigma (LSS) can reduce variability and therefore waste, fewer errors, better processes, improved patient care, greater patient satisfaction rates and more productive employees that translate to bottom-line improvement. LSS builds on the knowledge, methods and tools derived from decades of operational improvement research and implementation. In this project study the workload of Nurses has been analyzed during medication administration. Nurses are the one of the responsible factor for the administrative direction of the healthcare facility including serving as a clinical resource person, interpreting and enforcing policies and procedures, intervening in difficult situations and medical crises, having overall responsibility for appropriate utilization of hospital resources

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and for patient care, and serving as a liaison to facilitate communication and problem solving within the healthcare facility [14].

III. PURPOSE OF THE STUDY

The purpose of the study is to redesign the policy on medication administration i.e. introducing the concept of Medication nurse for the management of medication administration errors in order to improve the efficiency, effectiveness and safety of care delivered to patients.

IV. OBJECTIVE OF THE STUDY

- To understand interruptions faced by general nurses during medication administration
- To study time taken by general nurses to deliver medication to assigned patients
- To study the process of medication administration by nurses and identifying the non value added touch points during the process
- To study the impact of dedicated Medication Nurse on the Medication administration error rate
- To have comparative Time motion study on Medication Administration by General Nurse and Medication Nurse to know the time taken by both nurses for the purpose.

V. METHODOLOGY

The focus of the research is on the application and implementation of lean six sigma in order to reduce medication errors. A pilot study was done in a particular ward of a corporate chain of hospital with a sample size of 100 to find out the feasibility of the study. This made the investigator to get clear idea about the research problem and feasibility of the study. This involved time motion study on the medication administration process by nurses with close observation on works being done. To support this evaluation, a checklist was made enlisting all the steps which are performed as the basis of evaluation of application design and its implementation.

SIX SIGMA DMAIC METHODOLOGY

Define

During the Define phase, the team and its sponsors decides consensus agreement on what the project is and what it should accomplish. Then it was decided to study the percentage of errors occurring in Ward A6 during medication

administration in the time duration of January 2014 to August 2014 first. A project charter is developed that defines the business case, problem statement and goal statement. The decision was made to limit the scope of this project only to the workload of Nurses.

After this, the problem identified by the team was that the medication error rate reported was very high in the wards due to many interruptions and challenges faced by nurses during drug administration resulting into work overload which in turn affecting the safety of care delivered to the patients. The project was run in a particular ward to minimize the error rate to see the feasibility of the solution undertaken. The goal was ultimately to make the efficient and effective system of delivering medication by nurses to patients with least chances of medication errors.

Measure

During the Measure phase, the measures were taken through time motion study analysis and Fish bone analysis and Process Flow Analysis. The tool time motion study was helpful in data gathering and recording the time needed to perform drug administration activity by nurses including the check points on patient identification, placing medicine bedside, accessing MAR, cross checking labeled medicine with written ordered drugs, checking expiry of the drugs and documentation.

The tool used Fish Bone analysis or Root Cause Analysis determined the various interruptions and challenges faced during medication administration which is as follows:

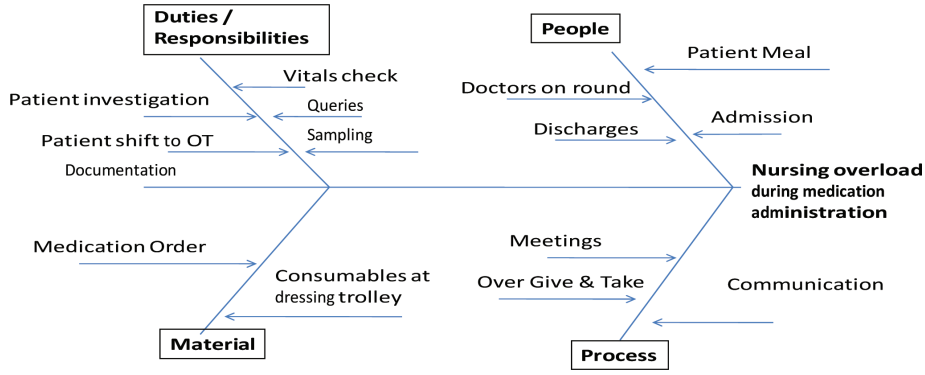

Figure 1. Fish Bone Analysis to analyze various challenges faced during medication administration

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Analyze

In the analyze phase, a thorough data analysis carried out to narrow down the Percentage of errors occurred in Ward A6 during medication administration by nurses in time duration from January 2014 to August 2014, from the study. Summary of the analysis of data of medication errors gathered is as shown in the graph below.

As shown in the graph above, the medication error rate, it was high in the months January 2014 to August 2014, before the concept of medication nurse came into existence. After the introduction of the concept, the errors were reduced i.e. from September, 2014 and kept on reducing as the nurse was getting trained in medication administration.

According to the data, Out of all medication errors, the maximum error found was in case of missed dose, secondly the wrong dose and third is the wrong time.

When the process flow of medication administration was analyzed, the steps followed during medication administration are checking the patient identification by name and identification number, placing the medicine bedside of the patient, checking expiry of the medicine, Accessing the Medical administration record, Cross checking the prescribed medicine with medicines placed bedside and documentation of the medicines administered. The steps which were missed and contributing to medication errors were as shown in

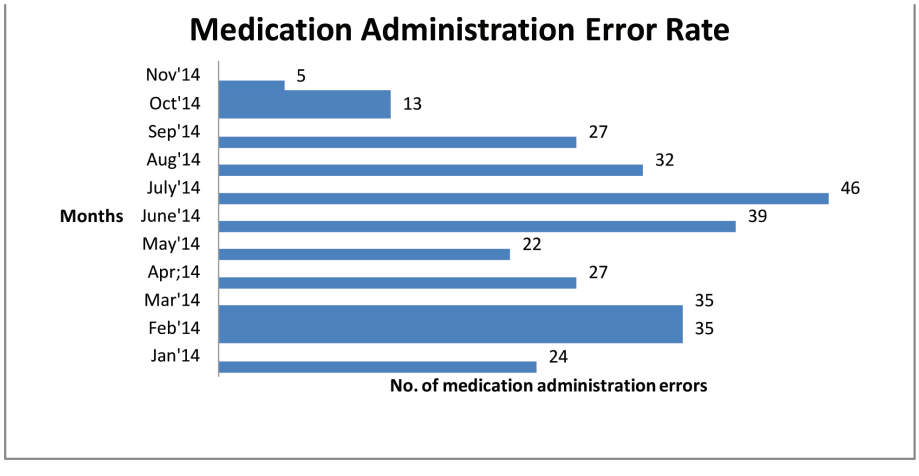

Figure 2.

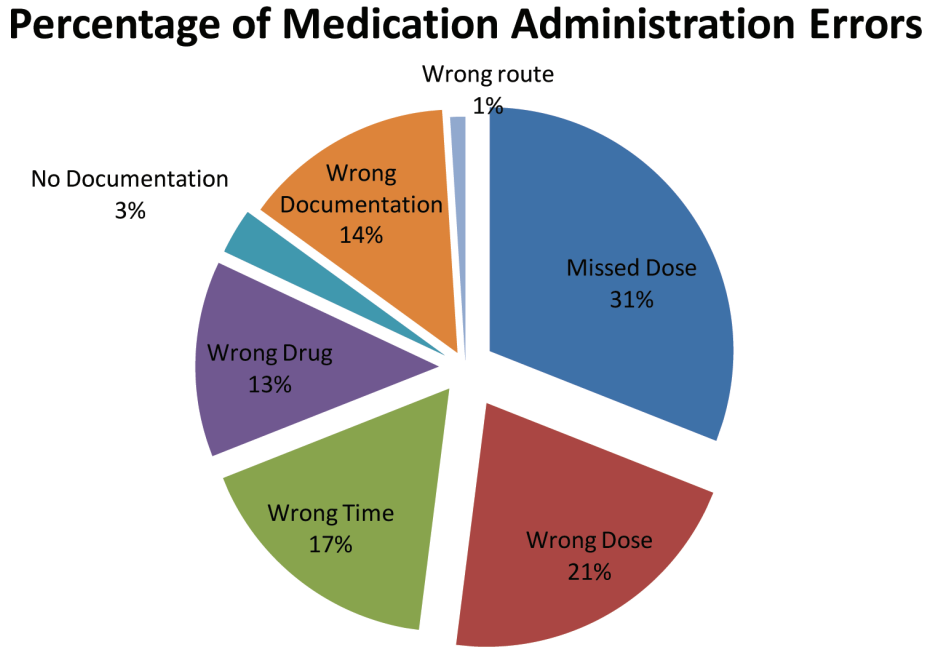

Figure 3.

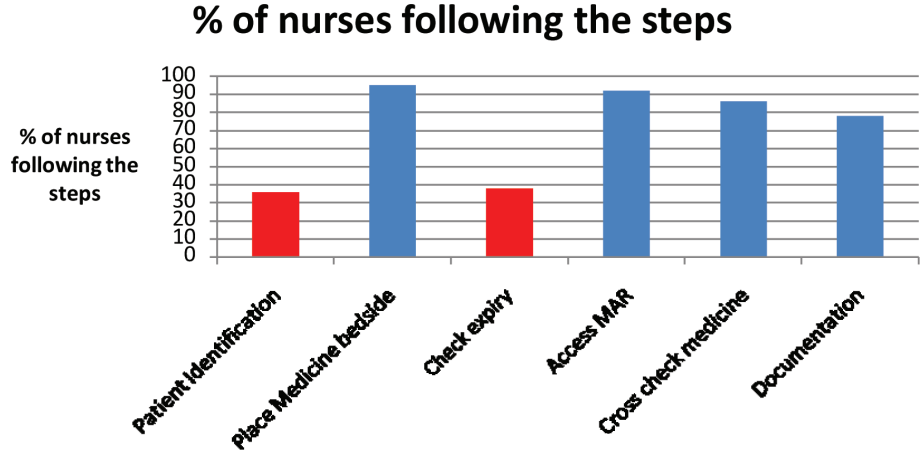

Figure 4.

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As per the graph shown above, the maximum percentage of steps which are not followed by nurses are checking patient identification and checking expiry of the medicine (less than 50%; marked in red bar) which are essential steps to be followed while medication administration. These steps are mainly forgotten in a hurry as nurses have so many interruptions in between medication administration i.e. like vitals check, attending doctors while visits, helping out patients in having food, patients investigations, shifting of patients to OT, admissions, discharges, bringing consumables from dressing trolley and clearing out queries from nursing station.

The Fig. 4 illustrates in step 1 i.e. Checking patient identification by checking patient's name and UHID depicts that 36% of nurses are checking patient identification by checking patient's name / UHID and 64% of nurses don't check patient identification. Thus, it was observed nurses used to remember patient bed no. rather patient's identification.

In step 2 i.e. Nurses placing medicine bedside, It is depicted that 95% of nurses are placing medicines bedside while medication delivery and 5% of nurses don't place medicine bedside. Thus, it was observed most of the nurses follow the steps correctly and the nurses who aren't following just have to give small dose through oral route.

In Step 3 i.e. Medication administration record sheet assessments by nurses, it is depicted that 78% of Nurses' check MAR during medication delivery and 22% of nurses don't check MAR. It was observed those 22% of nurses were giving second dose, thus, it was remembered whether to give tablets or IV in that particular dose to the patient.

In Step 4 i.e. Checking expiry of the medicine, it is depicted that that 32% of nurses were checking expiry of the medicines before medication administration and 62% of nurses were not checking expiry of the medicines before medication delivery. Thus, it was observed that nurses take it as a pharmacist responsibility that they have sent the medicines with expiry check already, so, take this step casually.

In step 5: Cross check labeled medicine with written medicine, it is illustrated that 92% of nurses cross check the label of medicine with written order and 8% of nurses don't. Thus, it was observed the step is followed correctly by majority of nurses and other nurses told that they have already cross checked the medicines during the time the receiving.

In Step 6: Documentation done correctly, it is depicted that 86% of nurse document correctly the patients record the 14% case found for wrong documentation. It was observed that documentation is done at right times after the medication to the patients but still 14 % cases are down the line.

In the hospital, during the patient care, medication administration is done by nurses as prescribed by the doctors for patients. Medication administration needs to be safe and effective, when the nurse is administrating the medicine mainly the six rights must be followed in order to reduce medication errors which are right individual, right medication, right dose, right time, right route and right documentation.

But as nurses face many challenges and interruptions during medication administrations, the medication errors occurs. As per the previous study to find out the medication errors occurred in A6 Ward, there were 31% of missed dose, 21% of wrong dose and 17% at wrong time.

In the present study, attempts were made to understand the process followed during medication administration by nurses. The problems found in steps to be followed during medication delivery by nurses too. During this, the major problems found were during the patient identification and checking the expiry of the drugs. These steps are not followed in majority of the cases, so further give rise to medication errors of wrong dose. The interruptions faced by nurses during drug delivery are like vitals check, attending doctors while visits, helping out patients in having food, patients investigations, shifting of patients to OT, admissions, discharges, bringing consumables from dressing trolley and clearing out queries from nursing station The missed dose error is mainly occurred due to the interruptions faced during the process of medication administration. The interruptions faced further delays the medication to the patient, thus the medication error of wrong time arises.

IMPROVE

During the improve phase, root-causes were identified and solutions were generated and tested by piloting. Data collected during this phase was to be reviewed against the data after the implementation of following recommendation as a measure of improvement.

The recommendation to improve the process was:

- Introduction of the concept of dedicated medication nurse who was responsible for medication administration of patients.
- Train the nurse for medication administering for a month and after a month, same training should be given to other nurses too.

After evaluation, the solution was implemented in Ward A6 only first. The solution that was implemented was focused on reducing the time taken for medication administration by other nurses, reducing the other work interruptions while medication administration which were vitals check, attending doctors

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while visits, helping out patients in having food, patients investigations, shifting of patients to OT, admissions, discharges, bringing consumables from dressing trolley and clearing out queries from nursing station. Other impact of this concept was:

- The rate of medication errors was decreased to zero.
- The complexity of the work flow became simple and systematic.
- The work load on all nurses was decreased.
- The average time for drug administering was decreased almost by 55%.

CONTROL

In the control phase, the improvements that were identified during the improve phase were documented and thoroughly captured. A roadmap of solving the problem was established. Implementation plans as well as change management procedures were suggested to ensure the successful transition of the solution to the team that was ultimately responsible for the process. In order to maintain the sustainability the gains made from the process improvements it was suggested to redesign the policy on medication administration to introduce the concept of dedicated medication nurse for medication administration and to implement it in other wards too and monitored periodically.

LEAN MANAGEMENT TOOLS:

Lean management is an approach of running an organization that supports the concept of continuous improvement; it is a long-term approach to work that systematically seeks to achieve small, incremental changes in processes in order to improve efficiency and quality. Lean management gives the clear understanding of processing time which includes the value added time and non value adding time. Accordingly, there are mainly seven waste involved in production which are: (TIMWOOD) i.e. transportation, Inventory, Motion, Waiting, Over processing, Over production and Defects. Thus, Lean techniques utilized in the study to reduce wastage during medication administration by nurses and increase better utilization of nurses.

In the study the waste in process was identified by spaghetti diagram; thus all the value adding and non- value adding activities performed by nurses during medication administration came into light. The interruptions thus faced are as shown in the diagram:

As per the research study-

The various non value adding activities performed during medication administration are vitals check, attending doctors while visits, helping out patients in having food, patients investigations, shifting of patients to OT,

admissions, discharges, bringing consumables from dressing trolley and clearing out queries from nursing station.

Thus, the gap points found during medication administration:

- Patient name/ UHID of patients is not checked- remembered by bed no. mainly
- Expiry of the drugs is not checked
- Documentation is not done at the time of medication of the patients- results into the medication errors
- Vitals status is checked after each medication

On application of the concept of medication nurse in Ward A6, the process flow of medication administration followed by the medication nurse was as follows:

As per the research study the comparative time taken by general nurses and medication nurse in administering medicine is as shown in Fig. 7 which is as follows:

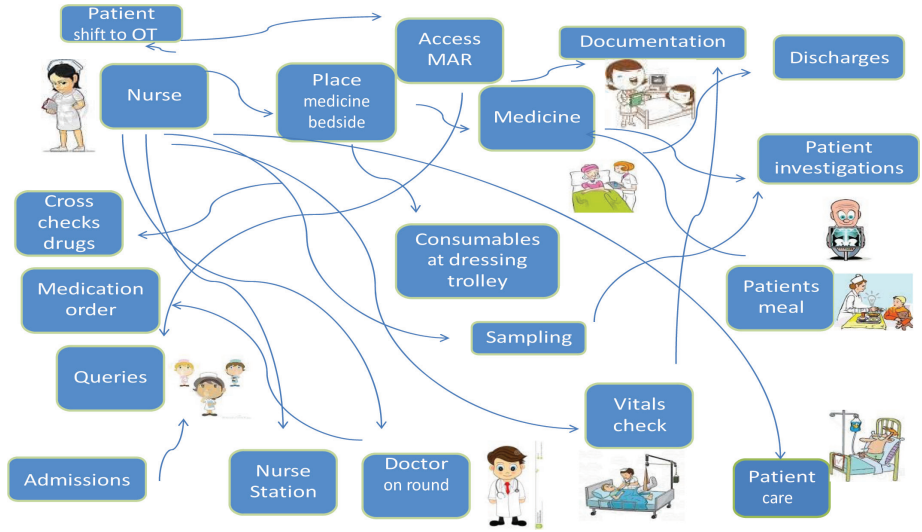

Figure 5. Spaghetti diagram during Medication Administration

Thus, it was depicted from the figure that the average time taken by medication nurse is **55%** less than that of general nurse during medication administration as general nurse was administering medicine in **9 minutes** and the medication nurse took **4 minutes** to deliver the medicine. So, medication nurse delivers medicine without facing interruptions, with more effectiveness and efficiency Thus, Lean

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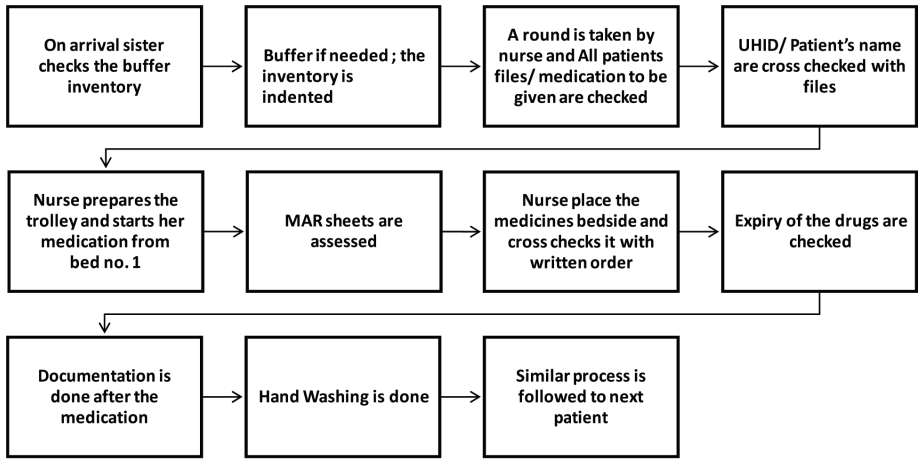

Figure 6. Process followed in drug administration by medication nurse

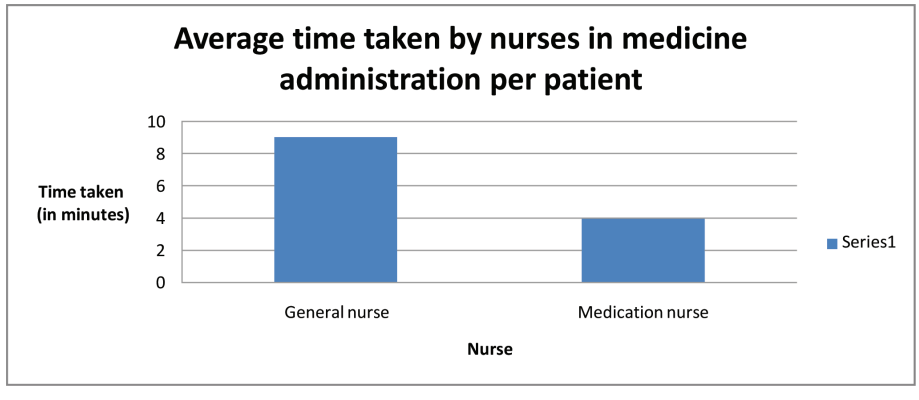

Figure 7.

tool helped in removing all the non value added steps and making te process for drug administration by medication nurse became simple and systematic. This process is designed to decrease the medication errors in the wards. During the process, the best safety of care is provided to patients by nurses; thus the process increased efficiency of nurses and quality of care provided. During medication delivery the works performed by other nurses are as follows:

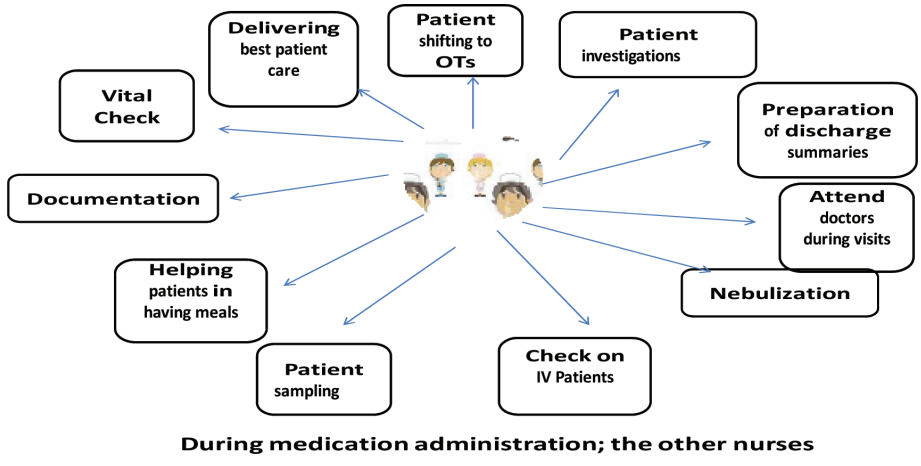

Figure 8.

Thus, the concept of medication nurse leads to-

- Follow all the steps of drug administration
- Minimizing medication errors
- Reduced mess up of the ward
- Lean management as waste is reduced
- Other works are performed by other nurses which are needed to be done at the same time
- Timely medication administration to patients
- Delivering best patient care and high efficiency

VI. RESULTS AND FINDINGS

Thus, Maximum cases in which the following steps are not followed while drug administration:

- Checking patient name/ UHID – not followed in 64 % of nurses
- Checking expiry of the drug– not followed in 62 % of nurses

Case research evidence shows significant and rapid improvement amounting to55% of reduction in the time taken by nurses in administering medicines to patients following implementation of the approach and significantly improved the rate of medication errors in Ward A6 and the complexity due to interruptions while medication administering became simple with follow up of all the steps.

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Table 1

Area	No. of Nurses assigned	No. of patients under study
A1	4	20
A2	4	20
A3	4	20
A4	4	20
A5	4	20
A6	1	20

Table 2

Steps to be taken as defined in Policy	% of nurses following the steps
Check UHID/ Patient Name	36%
Place Medicine bedside	95%
Access MAR sheets	78%
Check expiry of the medicine	38%
Cross check labeled medicine with written medicine	92%
Documentation done correctly	86%

Average time taken by nurses in administering medicines to patients in wards A1 – A5 = **9 min**

Average time taken by medication nurse in administering medicines in ward A6 = **4 min**

If there are 12 patients to give drugs; the average time taken by medication nurse to give medicines is = 1 hr 17 min

VII. CONCLUSION

In nutshell, it is derived from the above discussion that during medication administration, there are key challenges faced by nurses. Hospital administration perceived significant burden after reporting of high medication error rate from the wards.

As per the study, the lean techniques and six sigma DMAIC methodology used to study all the non value added tasks performed during medication administration and to eliminate the interruptions faced during the process to give a practical solution for the problem, thus, the concept of medication nurse came into existence and applied in Ward A6 as a pilot project. Further

a comparative time motion study on medication administration by medication nurse and general nurse gave positive results to the solution, thus, to be implemented in other areas too.

Through the research as well as experience, it is discovered that the concept of medication nurse lead to follow all the steps of drug administration as defined in policy and on time medication delivery which helped in minimizing medication errors. It helped in reducing mess up and complexity in the ward with better utilization of other nurses to perform other activities which are needed to be done at the same time and delivering best quality of patient care with high efficiency.

The scope of the research further needs the policy on medication administration to be redesigned including the concept of medication nurse and application of it to all the Wards in order to induce efficiency and effectiveness. For the purpose, the medication nurse should get medication administering training for at least a month to sustain the achieved benefits and day to day change of medication nurse in an area should be avoided as it can lead to more medication errors due to insufficient training. A periodic cross check on the medication nurse work is required to be done to bring out other small improvements.

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