Implementation of Six Sigma Method To Improve Hospital Discharge Process: A Before-And- After Study With The Control Group In A Large Hospital

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Research Article

Keywords: Six Sigma, Hospital, Patient discharge, Quality improvement

Posted Date: July 28th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-731820/v1>

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Abstract

Background: Delayed hospital discharge is a complex process that can impact hospital and service delivery capacity. The improvement of this process requires structural reforms and coordination with different wards, individuals, and the hospital. The present study aimed to use the Six Sigma method to reduce hospital discharge time.

Methods: This pre-post study was conducted based on an experimental design from 2016 to 2020. A series of Six Sigma-driven interventions based on the Define-Measure-Analyze-Improve-Control (DMAIC) cycle was employed in a 1,000 bed tertiary care hospital to decrease discharge waiting time. Two wards in the hospital were allocated to the intervention and control groups. Three months of pre-intervention data were compared with 16 months of post-intervention in each group. The data were analyzed in Stata software (version 14.1). The level of statistical significance was set at 0.000.

Results: There was a significant difference ($P < 0.000$) between pre and post-intervention, as well as experimental and control groups. The discharge time points in the intervention and control groups before the intervention were reported as 438 and 411 min, respectively. After the intervention, the discharge time reached 246 min (3.20 h decrease) in the intervention group ($P < 0.000$) and 475 min in the control group ($P < 0.574$). The waiting time in stations 2, 3, and 4 reached zero after the intervention ($P < 0.000$). The trend of discharge time after the intervention from October 2017 to March 2020 demonstrated that the changes were stable (184 ± 25.56 min).

Conclusions: As evidenced by the obtained results, the Six Sigma methodology can be an effective change management tool for the improvement of discharge time. The findings suggested that the use of electronic discharge and focusing on physician readiness for writing a discharge order would have the greatest impact.

Introduction

The waiting time or the time patient spend to receive medical services is recognized as a factor that reduces patients' satisfaction with the quality of health services, which in turn, plays an essentially role in quality management(1). Patient discharge is the final interaction of patients and their companions with the hospital system. Prolongation of this process causes financial, psychological, and health damages(2). Based on the conducted studies, early discharge of patients can reduce the length of stay (LOS), which in turn, increases the admission capacity for new patients and the satisfaction of discharged patients (3,4). Furthermore, pressures to decrease cost have led hospitals to adopt strategies for the reduction of LOS and improvement of hospital throughput over the past decade(3, 4).

One strategy implemented by hospitals to combat overcrowding is investments in new construction and additional staffing. Process improvement is another strategy which offers the potential for greater return on investment (6). It seems that tackling this issue requires proper management based on science and evolution, rather than financial resources(7). As a result, various approaches have been used to improve the quality and management of health organizations, among which lean management system is a comprehensive management approach.

Lean management, originally termed the Toyota Production System (TPS), was developed in other industries, such as the health care system(5). Six-sigma is a business improvement strategy employed to improve business profitability to drive out waste, reduce costs of poor quality, and improve the effectiveness and efficiency of all operations so as to meet or even exceed customer's needs and expectations (6). It is a set of tools and a way of thinking about how to more effectively assess and study clinical flow and operations to achieve better results for patients, providers, and healthcare delivery systems (7).

Six-sigma projects use a Define-Measure-Analyze-Improve-Control (DMAIC) structure which is considered by many practitioners to be the primary reason for 6 σ 's success [12]. There are several studies in the literature which have reported that six sigma tackles numerous problems in health care(8-10); moreover, it reduces LOS (11) and turnaround times in the laboratory(12). Furthermore, similar trends have been observed in decreased LOS of inpatients and waiting time in other countries (13, 14). In light of the aforementioned issues, the present study aimed to use the Six Sigma method for the reduction of hospital discharge time in a large Iranian hospital.

Materials And Methods

Study Design and Setting

The present study was performed in the central laboratory of Çukurova University Teaching Hospital, Adana, Turkey. This hospital has approximately 1000 beds. The laboratory has been accredited by the Joint Commission International since 2006, making it the first accredited clinical laboratory in a university hospital in Turkey. This research project was conducted in Imam Reza Hospital complex (IRHC) that is a tertiary care teaching hospital with 1000 beds located in Mashhad, Iran. The IRHC provides care to around 6,000 inpatients and 19,000 emergency patients monthly. The study used a quasi-experimental two-group pretest-posttest design and was designed to reduce patient discharge time.

To select the wards of intervention and control groups, a team was formed consisting of ward secretaries (n=2), head nurses with at least 10 years of work experience(n=2), hospital quality improvement officer, hospital admission and medical records officer, as well as hospital billing officer and faculty members of health system management and health information management (n=3). The participants were contacted via phone calls and were asked to attend the meeting after explaining the study objectives and introducing the researchers. Moreover, the faculty members of health system management were invited to ensure more widespread coverage of the issue.

Four wards were selected during a meeting based on the following criteria: 1) the same discharge time or a maximum of 15% standard deviation with the total discharge time of the hospital, 2) the same LOS with a maximum of one-day difference. Accordingly, wards of general surgery, orthopedics, heart-1, and heart-2 were selected. Thereafter, general surgery and heart-1 were selected as the intervention group and orthopedics and heart-2 as the control group. The study was approved by the IRHC administration in accordance with the quality assurance policy.

Intervention

The hospital throughput project was conducted at IRHC from July-October 2017 with ongoing key performance metrics monitoring, following a process improvement framework developed using Six Sigma principles. Six Sigma relies on a structured approach to uncover the root cause of a problem using the Define, Measure, Analyze, Improve and Control (DMAIC) method by defining the problem, measuring the defect, analyzing the causes, improving the process by removing major causes, and controlling the process to ensure that defects do not recur(18).

A multidisciplinary team (value team) was formed at the outset, including a physician, chief medical resident, director of bed management, manager of billing, patient care unit manager, head nurses of wards, unit clerk representative, assistant director of health information management, and manager of the transport services. The hospital administrator was the assigned Six Sigma expert responsible for team building and project management. Following the DMAIC approach, the team set out to define the scope of the project and decided to focus on the improvement of the administrative processes that contributed to delayed discharge. To identify the hospital discharge process and define the problem, the discharge process was broken down into seven logical sub-processes called seven stations.

A time study (stopwatch) was used to measure each step in the process to determine the time consumed by each of the seven sub-processes to prepare the discharge summary, and the discharge process of 140 patients was measured. In the next step, to discuss the solutions and approve the new discharge process, the method of expert discussion and focused group discussion was used. The team, through extensive discussions, completed a root cause analysis for delayed discharge. Moreover, they outlined barriers and wastes and proposed changes from the perspective of each stakeholder, and interventions were implemented according to Table 1.

Data gathering and Measurements

Dataset for hospital inpatients' analyses included 140 patients in the pre-intervention phase (November 2016-February 2016) and 140 patients post-intervention (July 2017-March2020). The stratified random sampling was employed in this study. patients were

randomly selected from each ward in the intervention and control groups in different months. Data related to patient discharge time (time from discharge order to patient leaving the hospital) was examined.

The inclusion criteria for patients were the medical records of patients who were discharged from the selected wards during the study period. On the other hand, the exclusion criteria entailed: patients who died and those who were discharged from the hospital without settlement. For all patients, the start and end time points of each station in the discharge process were checked and recorded in a data table. The main sources of data for the extraction of the start and end times of each station were the hospital information management system and the patient's physical medical record. In addition, to check data accuracy, the original data was matched with other medical record documents, such as the date and time in the physician order, nursing report sheet, and summary sheets. verbal consent was obtained from participamts that was approved by the ethics committee. In addition to the ethical approval, all methods were performed in accordance declaration of Helsinki.

Statistical Analysis

Categorical variables were summarized by number and percent, while continuous variables were described as mean and standard deviation. The comparability of the intervention and control groups was assessed by comparing some characteristics of their patients using the Chi-Square test for categorical variables and independent t-tests for continuous variables. Outcome variables (waiting times) before and after the intervention in each group were compared using an independent t-test since the patients were different before and after the intervention. In each group, the mean difference and its 95% confidence interval were calculated for all stations. Intervention and control groups were considered statistically significantly different in any station if their confidence intervals exclude each other. All statistical analyses were carried out using Stata software (version 14.1), and the level of statistical significance was set at 0.05.

Individual control chart was used to analyze trends in average daily discharge time, special cause variations (non-routine events), and common cause variations (routine events), and assess the process for stability (statistical control). To further assess variation in the process, the following were also measured: six sigma scores (number of short-term standard deviations between the center of a process and the closest specification limit), yield (percentage of discharge times meeting team goal of 212 min), defects per million (number of times that discharge time exceeded the target per million discharge opportunities).

Table 1. Barrier, Waste, and Change from the Perspective of Different Stakeholders

	Patient feedbacks	Accounting and medical records staff	HIM(health information management)	Nurse/head nurse	Physician
Barriers	Lack of response and information about the discharge process and the necessary documents	<p>Shortage of personnel in the accounting and medical record units</p> <p>Lack of staff knowledge about the volume of discharged patients per day</p> <p>Lack of coordination and organization of medical records sent by the wards to the medical records and accounting unit</p> <p>Numerous shortages and defects of medical records and frequent contact of accounting personnel with the department to eliminate defects</p>	<p>Lack of clear and specialized job descriptions</p> <p>Lack of access to specialized officials in connection with the elimination of file defects in a professional manner</p>	<p>Lack of familiarity with the discharge process</p> <p>Need to have a specialist confirm the patient's discharge</p>	<p>Unavailability of test results, as well as diagnostic and therapeutic measures</p> <p>Lack of access to physicians to approve some medical records shifts</p>
Wastes (misuse and overuse)	<p>Waiting for a physician to be present regarding discharge</p> <p>Waiting for discharge order to be written</p> <p>Waiting to receive care service reports</p> <p>Waiting time for discharge (At different stations from ward to department of medical records and accounting)</p>	<p>Waiting for insurance carriers to financially clear patient (in the inpatient ward)</p> <p>Waiting for medical records to be completed (in the inpatient ward)</p> <p>Waiting to be present with the patient</p> <p>Waiting for the medical records to be completed (in the department of medical records)</p>	<p>Waiting for the doctor to record the discharge order and fill out the nursing report</p> <p>Waiting to receive action reports .</p> <p>Waiting for insurance, expert approval, and patient identity</p> <p>Waiting for the presence of an escort to settle the account</p>	<p>Waiting for the doctor to be present at ward</p> <p>Waiting for the drug list to be approved by the pharmacy</p> <p>Waiting to receive the medication needed by the patient to be prescribed before discharge</p>	<p>Waiting for the results of tests and diagnostic tests that provide unnecessary care</p> <p>Patient rounding before the available medical results leads to fragmented care and rework.</p>
Corrections and Interventions	Separation of patient movement ,from physics of medical record movement, in the discharge process and removal of some stations in	Changing the ward secretary to HIM experts (The multi-threaded tasks)	Replacement of inpatient ward secretaries whose fields were not health information technology.	Communicating the electronic discharge process to the head nurses to familiarize the staff and doctors to	Requesting a discharge order Until 9 A.M. every day

the discharge process for patients	Providing discharge process for patients by HIM staff	Training of HIM experts in all units related to the discharge process (Through on job training-OJT).	correct the visit time	Determining the criteria for discharge at different times
Creating electronic pending charge report to facilitate charging	The HIM can control, code the medical record, and provide the Billing at the ward	The performance score of the HIM expert is determined by the head nurse (40%), the head of the health information management department (30%), and the head of the accounting unit(30%).	Emphasis on pharmacy personnel and setting hours to specify for drug delivery	Notifying physicians to prioritize the registration of discharge records
Electronic performance of the discharge process	Starting the preparation of the documents required for discharge before the patient's discharge time (even days before)			
Coordination with an insurance expert to receive approval for insurance in the wards	Accurate use of hospital information system to update and prepare action reports			
	Changing the patient discharge process and transferring the coding station and preparing reports after the patient leaves			

Results

The discharge process was broken down into seven logical sub-processes called seven stations (Fig. 1).

The hospital data from 280 patients admitted to selected wards during the pre and post-intervention were analyzed. In the modified discharge process, four steps were eliminated. The most important change in the patient discharge process was changing the ward secretary to HIM experts. In the electronic patient discharge, all discharge processes are performed without the presence of the patient and the medical record at the inpatient ward. In this process, the patient is discharged using the POS system, which is available to the HIM expert, and all these processes are performed in the relevant inpatient ward. The HIM expert of each department should correct the defects of the medical records and deliver them to the medical records department within 48 h after the discharge. There were no significant differences between patients' variables before and after the intervention in intervention and control groups (Table 2).

Table (2): Comparability of the intervention and control groups based on characteristics of their patients							
Variables		Intervention group		p value	Control group		p value
		Pre. N (%)	Post. N (%)		Pre. N (%)	Post. N (%)	
Sex	Male	35 (50%)	34(48.5%)	0.866	45(64.2%)	45(64.3%)	1
	Female	35 (50%)	36(51.4%)		25(35.7%)	25(35.7%)	
Refer to social worker	Not Referred	42(60%)	38(54.3%)	0.495	51(72.8%)	41(58.6%)	0.075
	Referred	28(40%)	32(45.7%)		19 (27.2%)	29(41.4%)	
Insurance organization	Iran Health Insurance	47(67%)	43(61.5%)	0.59	37(53%)	31(44%)	0.136
	Social Security	16(23%)	17(24.3%)		21(30%)	28(40%)	
	others	7(10%)	10(14.2%)		11(17%)	11(16%)	
Age ± SD (y)		48.59(± 16.5)	43(± 13.5)	0.063	61.9(± 14.9)	59.7(± 13)	0.608
Length of stay ± SD (days)		6.31(± 7.9)	3.37 (± 2.2)	0.117	7.58(± 6.7)	5.51(± 3.3)	0.394
Previous admission times ± SD		1.60((± 1)	1.54(± 0.85)	0.417	1.8(± 1.4)	2.17(± 2.1)	0.153

After the interventions, it was found that the discharge time (totally) decreased by 3.20 h in the post-intervention, as compared to the pre-intervention phase ($P < 0.000$) in the intervention group (Table 3).

Table 3. Waiting time in the seven stations defined in the patient discharge process, pre and post-intervention in the intervention and control wards

Stations	Intervention Group				Control Group			
	Pre Intervention	Post Intervention	P Value	Difference (Confidence Interval)	Pre Intervention	Post Intervention	P Value	Difference (Confidence Interval)
	Mean(±SD)	Mean(±SD)			Mean(SD)	Mean(SD)		
Station1	267.3(±64.5)	193.4(±9.5)	0.0000	73.8(49, 98)	230.4(±9.6)	218.6(±6.3)	0.741	11.74(-11, 34)
Station2	37.3(±27.1)	0	0.0000	37.31(31, 42)	45.58(±34.2)	116.3(±85.7)	0.000	-70.72(-89, -51)
Station3	16.3(±7.9)	0	0.0000	16.33(14, 18)	33.3(±28.3)	25.8(±13.3)	0.472	8.22(0.54, 15)
Station4	38.6(±37.2)	0	0.0000	38.57(29, 47)	26.44(±16.4)	25.5(±14.2)	0.363	0.9(-1, 5)
Station5	52.5(±47.7)	30.9(±36.2)	0.0040	21.47(7, 35)	54.8(±48.9)	39(±32.2)	0.149	15.82(2, 29)
Station6	17.2(±19.2)	14.8(±25.4)	0.0030	2.31(-5, 9)	16(±30.8)	50.6(±75.9)	0.000	-34.54(-54, -15)
Station7	9.6(±14.4)	7.5(±16.4)	0.0040	2.19(-3, 7)	5.2(±10.3)	3.7(±7.2)	0.000	1.44(-0.94, 3)
Total	438.8(±8.5)	246.7(±20.8)	0.0000	192(41, 130)	412(±11.7)	475(±7.1)	0.574	-63.6(-87, -10)

As illustrated in Table 3, there was a statistically significant reduction in the average waiting time for patient discharge in the intervention group in all seven stations ($P < 0.05$). The implementation of electronic discharge eliminated the stations of 2, 3, and 4 in the intervention group (Fig. 1). In the control group, the average waiting time for patient discharge was reduced in five stations (1, 3, 4, 5, and 7); nonetheless, this reduction was statistically significant only in station 7. However, in stations 2 and 6, the average waiting time was statistically significantly increased ($P < 0.05$).

Control phase

The application of the Six Sigma methodology not only improved the process performance but also process improvement in ensuring the sustainability of results in the long run. The most daunting challenge in any improvement initiative is the sustainability of the archived results(1). Therefore, control charts were used to monitor the ongoing performance of key variables. After the implementation of all of the improvements in the process, a decrease was observed in the mean duration of the discharge process as demonstrated in Fig. 1 which shows the control chart before and after improvement. The mean discharge time decreased by approximately 43% from 438 – 246 min. The lower and upper control limits of the individual values and the moving range also showed a reduction, indicating a more stable process.

The individual control chart upper control limit post-intervention dropped from 1440 – 498 min. During the intervention phase, a mixture pattern is observed denoting an unstable process with one out-of-control point. In the post-intervention phase, no special cause variations are detected, signifying a stable process. The application of the LSS methodology not only improved the process performance but also process improvement in ensuring the sustainability of results in the long run. The most daunting challenge in any improvement initiative is the sustainability of the achieved results.

Six Sigma score ranged within 0.87-1 in the pre-intervention phase. After the intervention, the Sigma reached 2.125. Furthermore, errors in the intervention group decreased from 26 – 10 (Table 4).

Table 4
Summary of Sigma Process Results (In Intervention group)

Date	Mean Time from Discharge Order Logged Until Patient Leaves, min	Errors In Intervention Group, number	Sigma Calculation	Yield	Six Sigma Score
November 2016	333	26	742857	25.72	0.875
December 2016	317	25	714285	27.975	0.937
February 2017	301	24	685714	30.23	1
July 2017	241	22	628571	34.95	1.125
August 2017	175	18	514285	49.87	1.5
September 2017	221	20	571428	44.82	1.137
October 2017	194	15	428571	54.88	1.625
November 2017	165	11	314285	69.12	2
December 2017	158	9	257142	69.12	2
February 2018	175	10	285714	69.12	2
July 2018	164	9	257142	69.12	2
December 2018	196	17	485714	54.88	1.625
May 2019	183	16	457142	54.88	1.625
October 2019	184	17	485714	54.88	1.625
March 2020	157	10	285714	73.39	2.125

Discussion

Hospital overcrowding poses a daunting challenge to the healthcare system since limited bed capacity and admission congestion exert enormous negative impacts on quality and safety(15). The constrained bed capacity can be effectively addressed by the management of discharge timing; nonetheless, significant institution-specific barriers exist in its implementation (16). For instance, different staff and wards are involved in this process, including physicians, nurses, ancillary service staff, patients, their families, and the billing department. Therefore, it requires great coordination between them. The present study validated the application of Six Sigma DMAIC methods to reduce and optimize the discharge process with a specific focus on orthopedic and surgical wards.

Although some pieces of evidence on the effectiveness of Six Sigma in the healthcare setting have been criticized for weak methodological design(17), the present study included a large pre and post-intervention analysis of a total of 280 patient records. Although the average discharge time reduced from 438.78-246.74 min, demonstrating a 43.76% decrease (3.20h), it is higher than the upper specification limit (212 Min) as fixed by the process owners. This improvement is comparable with the findings of a study conducted by Arun Vijay(6) who demonstrated a decrease of 61% in the discharge timing after the implementation of the Six Sigma Methods. In the same vein, in their study, Dayai K et al. (2012) reduced discharge time from 247 – 195 min post-

intervention (78% decrease) by the identification and implementation of administrative interventions based on a 2-month experience with no mention of total records included(18).

These findings are in agreement with those reported by Allen et al. who showed a significant reduction in the average discharge time from 3.3–2.8 h (19). Findings suggested that focusing on physician readiness for writing a discharge order would have the greatest impact. According to the results of the study by GR El-Eid et al., discharge time decreased by 22.7% from 2.2 h during the pre-intervention period to 1.7 h post-intervention ($P < 0.001$)(3).

Others have demonstrated that increasing early discharges using a structured framework for quality improvement is achievable and sustainable. For example, Beck et al. used the Lean methods to modify workflow and attain early discharges(20). Along the same lines, Patel et al. used an Institute for Healthcare Improvement PDSA (Plan-Do-Study-Act) framework to achieve early discharges(21). A feature common to all these successful interventions is a standardized forum for communication, such as a multidisciplinary huddle. Other elements central to the success of these interventions include accurate measurement with data analysis, use of checklists, feedback, and identification of patients the day before discharge (21, 22). One of the key points of interest in this study was the increase in discharge time in control wards, compared to that in the intervention group. This finding can be attributed to changes in the number of patients or ward staff.

One of the notable strengths of this study was the corrections made to reduce the duration of discharge, and it was indicated that these corrections had good stability. The majority of similar studies lacked a control group and long-term follow-up(3, 21, 23). Nevertheless, the results pointed to a positive impact on the reduction of patient discharge time due to the application of suggested recommendations for 16 months. As a result of this breakthrough improvement, more patients will be managed in the particular department. This, in turn, increases the number of admissions, room turnover, hospital profitability, and patient satisfaction.

The results of the current study also demonstrated the contribution of the multidisciplinary team members of the hospital to the reduction of discharge time. The findings of this study would be of great help to hospital administrators and policy planners in expediting decisions about the implementation of six sigma method to improve the quality of care in hospitals. All organizations experience resistance to change. Physicians as one of the most important and highly constrained resources in hospitals are mostly autonomous in the management structure and immune to incentives typically available in other organizations. Owing to the autonomous nature of their profession, it is difficult for physicians to accept standardization, especially when it goes against their own interests. Physicians do not feel comfortable adopting a standardization initiative unless there is transparent evidence regarding its impact on patient outcomes(7)

Furthermore, a major cause of the long discharge process was poor communication between different stakeholders (e.g., treating physicians, consultants, nurses, pharmacy staff, and the accounting department). Since the discharge process is a highly people-dependent process, it was imperative to observe the complexity of communication in this process(24). It is recommended to involve physicians in the analysis and development of solutions through participation in the improvement team or holding workshops to discuss quality improvement issues with other stakeholders to encourage collaboration in the proposed methods to sustain and control the improvements.

In addition, one of the main processes modified in this study was the use of an electronic discharge system which has been mentioned in various studies as a tool to ensure complete (25) and reliable discharge summary (26), expedite the discharge time (27), and increase staff satisfaction(28).

Limitations

The coverage of this study and obtained improvements were limited to two wards of the research setting. Therefore, an appropriate precaution needs to be taken while generalizing the results. Moreover, another limitation of the study is related to the pre-post intervention observational design that limits the ability to control for all possible confounders. Patient acuity and staffing levels of different stakeholders are possible confounders that were not taken into account. Furthermore, the outcomes were retrieved from a database that included timestamps that were manually entered by clerks and prone to error.

Conclusion

The results of the present study confirmed the effectiveness of the Six Sigma DMAIC method in the reduction of discharge time. The discharge time was reduced in the intervention wards after the intervention with the implementation of the Six Sigma DMAIC problem-solving process and interventions. In addition, after the intervention, discharge waiting time was reduced in the intervention wards, compared to that in control wards. Furthermore, the obtained results pointed to other positive consequences, such as increased number of hospitalized patients, shortened waiting time for elective and emergency hospitalization, empty hospital beds, especially emergency beds, as well as increased bed turnover, hospital profitability, and satisfaction of patients and their companions as the most valuable achievement of this method.

Abbreviations

IRHC: Imam Reza Hospital Complex

MUMS: Mashhad University of Medical Sciences

CI: Confidence Interval

DMAIC: Define, Measure, Analyze, Improve and Control

LOS: Length of Stay

SPSS: Statistical Software for Social Sciences

Declarations

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper. This study was performed in accordance with Declaration of Helsinki.

Acknowledgments

We would like to thank all the staff of Imam Reza Hospital who helped us in this research.

Funding :This study was supported by a grant (No. 922303) from Mashhad University of Medical Sciences.

Ethical consideration: Ethic cod: IR.MUMS.REC.1399.109 (the Ethics Committee of Mashhad University of Medical Sciences).

Authors' contributions:

Study concept and design: MY, SF, MS; acquisition of data: MY,MS; analysis and interpretation of data: MY, SF,MS,HH; drafting of the manuscript: MY, SF; critical revision of the manuscript for important intellectual content: MY, SF,HH; statistical analysis: MY,MS, H.H; administrative, technical, and material support: MY, SF; study supervision: MY, SF. all authors have read and approved the manuscript.

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Figures

Figure 1

Discharge process flow map (after implementation of intervention)

Figure 2

Individual control chart of average discharge time calculated in min. LCL=lower control limit, UCL=upper control limit