Iran Red Crescent Med J. 2021 December; 23(12):e1505 doi: 10.32592/ircmj.2021.23.12.1505

Published online 2021 December 20

Original Article

Implementation of Electronic Patient Discharge: A Successful Strategy to Increase Hospital Bed Capacity during the COVID-19 Pandemic

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Received 2021 September 15; **Revised** 2021 November 06; **Accepted** 2021 November 06.

Abstract

Background: The ongoing coronavirus disease 2019 (COVID-19) pandemic increased the need for inpatient beds, indicating the need for hospitals to increase the efficiency of beds.
Objectives: This study aimed to increase hospital bed capacity using the implementation of Electronic Patient Discharge (EPD).
Methods: This qualitative-quantitative study was conducted in a tertiary care hospital using the pre-and post-intervention designs, and the main outcome was patient discharge time. By applying the Six Sigma model, including definition, measurement, analysis, improvement, and control, the patient discharge process was assessed and improved by some interventions such as EPD. All hospitalized patients with COVID-19 from 21 March 2020 to 22 July 2021 were examined for the post-intervention. In addition, data were collected from the hospital information system.
Results: By the use of EPD, patient discharge time decreased to 47.70% (from 10.19 h to 5.33 h) ($P<0.000$). According to the Sigma level, the yield and defects per million opportunities of the discharge process also increased to 55%.
Conclusion: Six Sigma methodology can be an effective change management tool to improve discharge time to cover the demand created during pandemics. According to the results of the present study and the obtained saved time, one bed is added to the hospital capacity for every five discharges.

Keywords: Bed, COVID-19, Hospital, Patient discharge, Six Sigma

1. Introduction

Healthcare is a significant sector as our lives depend on it, especially during the recent coronavirus pandemic (1). Global coronavirus disease 2019 (COVID-19) mortality rates are likely to be affected by multiple factors, including hospital resources, personnel, and bed capacity. As the COVID-19 pandemic continues, the question is whether hospitals have adequate resources to manage patients. However, the shortage of beds, equipment, and human resources in hospitals has been one of the most important challenges in providing hospital services to COVID-19 patients (2,3). Consequently, hospital overcrowding has become a widespread problem (4,5), as well as limited bed capacity and admission bottlenecks have led to extensive negative impacts on quality and safety (6). The focus on the timing of discharge may be the least disruptive and most effective way to address limited bed capacity for the hospitals during pandemics. From a holistic point of view, a proper patient discharge process ensures a coherent care chain (7).

According to previous studies, the use of management solutions and technology can assist in modifying this process (8-11)

Lean Six Sigma (LSS) is a program that can help healthcare providers to achieve conflicting objectives (12). Moreover, LSS is both a quality management philosophy and a methodology, which in the case of being implemented in an organization, assists in increasing the process capability and efficiency by reducing the defects and wastes (13).

The LSS projects have been successfully applied in the healthcare field to improve processes and remedy inefficiencies (14). For instance, they have been used to reduce medical errors (15), improve pharmacist dispensing errors (16), enhance efficiency in outpatient ophthalmology clinics (16, 17), as well as during the COVID-19 pandemic (18).

On the other hand, the use of some technologies, such as automation of hospital processes (e.g., patient discharge), has been emphasized as a successful solution in previous studies (20).

2. Objectives

The present study aimed to evaluate and improve the patient discharge process by implementing electronic patient discharge (EPD) interventions via the Six Sigma model.

3. Methods

3.1. Study Design and Setting

By applying the pre- and post-intervention designs, this qualitative-quantitative study was conducted in a tertiary care hospital with 1000 beds in Mashhad, Iran.

3.2. Data Collection

The statistical population of the study included COVID-19 patients for post-intervention and non-COVID-19 patients in wards assigned to COVID-19 patients. Accordingly, six-month pre-intervention data (from 23 August 2019 to 20 December 2019) were compared with 16-month post-intervention data (from 21 March 2020 to 22 July 2021). The number of samples studied in the pre- and post-intervention was equal to 15,552 and 10,814, respectively. The main outcome of this study was the decrease in the average time from writing the discharge order by the physician until the patients receive the exit card.

Data were collected from the hospital information system (HIS), and post-intervention data were checked for approximately 30 patients by the stop-watch tool and through direct observation as well as face-to-face interviews with the relevant personnel.

3.3. Interventions

In the first step, a preliminary review of the data and identification of discharge steps was performed through a team with ten experts, including the ward secretary experts, head nurses, billing staff, and nurses. Secondly, the factors that delayed the discharge process were identified after specifying the most important factors .

Third, appropriate solutions were suggested by the Six Sigma team to optimize the discharge process based on the various stations in the form of instructions for EPD. According to Table 1, the Six

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

Barriers, Waste, and Modifications	Patients	Billing officer	Health Information Management (HIM)	Nurse/Head nurse	Physician
Barriers	Lack of awareness and accountability to patients in the field of care providers Inconsistent communication between care providers Lack of attention to patient-centered discharge planning	Billing staff unavailable Unclear about the discharge load for the day Multiple calls to service staff to post charges Multiple calls to admission staffs to obtain financial coverage Numerous shortages and defects of medical records and frequent contact of accounting personnel with the department to eliminate defects	Lack of clear and specialized job descriptions Lack of access to specialized officials in connection with the elimination of file defects in a professional manner	Lack of familiarity with the discharge process Written discharge order pending the approval of attending physician	Unavailability of test results, as well as diagnostic and therapeutic measures Lack of access to physicians to approve some forms related to medical records
Wastes and overuse	Waiting for the physician to be present for discharge Waiting to write the discharge order Waiting to receive documents from other wards of the hospital (para clinical wards, etc.) Waiting for the physician to sign the main reports Waiting for other care providers to sign Waiting for the cashier to issue an invoice.	Waiting for physicians Waiting for insurance carriers to financially clear patients Waiting for medical records to be completed (in the inpatient ward) Waiting to be present with the patient	Waiting for the physician to record the discharge order Waiting to receive action reports Waiting for insurance, expert approval, and patient identity Waiting for the presence of an escort to settle the account	Waiting for the Physician to be present at ward Waiting for the drug list to be approved by the pharmacy Waiting to receive the medication needed by the patient to be prescribed before discharge	Waiting for the results of tests and diagnostic tests that provide unnecessary care Patient rounding before the available medical results leading to fragmented care and rework

Table 1. Continued

Modifications and interventions	Separation of patient movement, from physics of medical record movement, in the discharge process Removal of some stations in the discharge process for patients Creating electronic performance of the discharge process Coordination with an insurance expert to receive approval for insurance at the wards	Changing the ward secretary to HIM experts (multi-threaded tasks) Providing discharge process for patients In partnership with HIM staff The HIM can control, code the medical record, and provide the billing at the ward Starting the preparation of the documents required for discharge before the patient's discharge time (even days before) Using HIS to update and prepare action reports Changing the patient discharge process and transferring the coding station, and preparing reports after the patient leaves	Training in all stages of electronic clearance and evaluation and completion of medical records to HIM experts [Through Job Training (OJT)] Replacement of ward secretaries with HIM experts Introduction of E-form to manage all transfers	Communicating the electronic discharge process to the head nurses to familiarize the staff and physician to correct the visit time Introducing the scanning of medication requests to reduce hand delivery by the clerk and improve availability at the nursing station Emphasis on pharmacy personnel and set hours to specify for drug delivery	Requesting a discharge order Until 9 A.M. every day Determining the criteria for discharge at different times Notifying physicians to prioritize the registration of discharge records

Sigma team included award secretary [changed to health information management (HIM) expert after the implementation of EPD], a nurse with at least ten years of relevant work experience, a head nurse, a medical records officer, billing staff, and two faculty members with a relevant research background. Moreover, the discharge process was modified based on the Six Sigma model using the Define, Measure, Analyze, Improve, and Control (DMAIC) method. In order to identify the hospital discharge process and define the problem, the discharge process was defined in the seven stations.

In particular, HIM experts work on the classification of diseases and procedures to ensure that they are standardized for clinical, financial, and legal uses; hence, they are responsible for the quality, integrity, and protection of patients' health information. HIM experts in Iran typically have a bachelor's or Master of Science degree in health information technology (12). Then, the on-the-job training method was used in the implementation of the EPD.

3.4. Statistical Analysis

Six Sigma steps were performed after determining the discharge stations. Six Sigma scores, yield [percentage of discharges meeting the Sigma team's objective (439 min)], and defects per million opportunities (number of defects in a process per one million opportunities), were also measured to further assess the deviates of the process from total accuracy or perfection. Moreover, the total average time of discharge before the EPD was used as the Sigma team's objective. The cases with a long time were considered as defects in the discharge process. Afterward, the following equation was used to calculate the defects per million opportunities:

$$\frac{\text{Number of defects}}{\text{Number of units} \times \text{Number of opportunities}} \times 1000000$$

The process yield is calculated by subtracting the "total number of defects" from the "total number of opportunities," dividing by the "total number of opportunities," and finally multiplying the result by 100. In order to compare the time noted by the stations before and after the intervention in the ward, the mean and standard deviation of each station were first compared using the Mann-Whitney test. In order to investigate the effect of the intervention, the difference between the two averages (before and after the intervention) and a 95% confidence interval were first calculated and compared. In addition, Excel (version 2016) and SPSS (version 22) software were applied to summarize and analyze the data.

4. Results

The findings revealed that four out of the seven previous steps were eliminated in the modified discharge process of patients with COVID-19.

The most important change in the EPD process was to define a new position for HIM experts in the departments. Moreover, most discharge tasks were performed without the need for patient presence and

Table 2. The samples' characteristics in the pre- and post-intervention

Variable	Sub-variable	Pre-intervention		Post-intervention		P-value
		N	%	N	%	
Gender	Male	8795	56.6	5872	54.30	0.07
	Female	6757	43.4	4942	45.70	
Age (years)	0-10	1724	11.1	1	0.01	<0.001
	10-20	1045	6.72	65	0.60	
	20-30	1634	10.51	454	4.20	
	30-40	2294	14.75	1211	11.20	
	40-50	1801	11.58	1394	12.89	
	50-60	2082	13.39	1863	17.23	
	60-70	2304	14.81	2475	22.89	
	>70	2668	17.16	3351	30.99	
LOS (days)	0-3	9512	61.16	2543	23.52	<0.001
	3-6	2517	16.18	3279	30.32	
	6-9	1444	9.28	1995	18.45	
	9-12	744	4.78	1051	9.72	
	12-15	480	3.09	651	6.02	
	>15	855	5.50	1295	11.98	
Payment Methods	Insured	14074	90.50	9894	91.49	0.551
	Uninsured	1478	9.50	920	8.51	
Request a discount by referring to a hospital social worker	Requested	4698	30.21	3310	30.61	0.882
	Not requested	10854	69.79	7504	69.39	

systematically. Furthermore, the patient's payment in the same ward was made by the point-of-sale (POS) system. 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.

Table 2 presents some of the studied samples' characteristics according to the research period (pre- and post-intervention). There was a significant difference between age and length of stay (LOS) variables in the two periods.

Table 3 presents the characteristics of the stations and the waiting time in each.

Regarding the waiting time for discharge, all stations demonstrated a significantly shorter waiting time (P<0.000) in the post-intervention compared to that in the pre-intervention (Table 3).

According to the results before the interventions, the average discharge time before EPD was 611.57±477.64 min (10.19 h), which reduced to 291.74±272,323 min (5.33 h) after EPD. Moreover, a 47.70% decrease was shown in the average discharge time. The higher decrease in time was related to Station-1 by 176 minutes reduction, and the lower change was indicated in Station-2.

Six Sigma scores were in the range of 1.37-1.55, with a yield of approximately 44.82% in the pre-intervention phase. After the interventions, the number of errors reached zero, the Sigma score was less than 3.4, and the yield and defects per million opportunities of the discharge process also increased by 55%.

Table 3. Waiting time for discharge based on the requirements for the patient's discharge order

Station Number	Station Description	Pre-intervention Mean Time from Discharge (±standard deviation)	Post-intervention Mean Time from Discharge (±standard deviation)	Difference (Confidence Interval)	P-value
Station-1	Discharge order until discharge announcement in HIS	374.14(101.83)	197.68(13.74)	176.46(125,22)	<0.001
Station-2	Announce clearance in HIS until received in the accounting dashboard	97.56(248.2)	37.03(170.86)	60.54 (53,62)	<0.001
Station-3	Received in the accounting dashboard until the completion of the medical record calculation	19.08(130.35)	12.81(88.79)	6.26(4,8)	<0.001
Station-4	From the time of completing the calculation of the medical record until the time of issuing the exit card	120.79(375.73)	72.31(229.96)	48.48(42,54)	<0.001
Whole discharge process	A time between discharge order and issuance of the exit card	611.57(477.64)	319.84(288.59)	291.74(272,32)	<0.001

Discussion

This study aimed to decrease discharge time; the findings indicated that the implementation of EPD led to a decrease in total discharge time to 319.84 min. According to the results, if the discharge time is reduced by 5.33 h per patient, it means that for every five patients discharged with the mentioned corrections, one bed will be completely added to the hospital capacity (5×4.86h≈24h).

The yield and defects per million opportunities of the discharge process also raised by 55% in the post-intervention period and increased up to 100%. Many studies have used the Six Sigma model to decrease the average discharge time (19-23).

A study conducted at Imam Reza Hospital in 2013 showed a 26% reduction in discharge time (24). In this regard, there is some evidence for the lack of demonstrable sustainability following the application of the Six Sigma model in healthcare settings (25).

The yield and defects per million opportunities for assessing the improvement of the discharge process have been used in some studies. Vijay et al. (2014) attempted to reduce discharge time from 611 min to 319 min post-intervention; this study calculated the discharge sigma as the Six Sigma level of 95% (27).

An important point in teaching hospitals regarding the increase in the waiting time for patients to be discharged is the number of medical assistants at the time of discharge in the ward because the writing of the summary sheet is done by the physician after the discharge order. If the number of physicians in the relevant ward increases, the time of writing the summary sheet will be reduced, which is one of the requirements for the patient's discharge (28).

Allen et al. used the Six Sigma model to improve discharge times by focusing on improving communication between nurses and physicians by implementing a standardized discharge form that led to a drop in discharge time from 3.3 h to 2.8 h (29). However, in the present study, determining the minimum data required for patients' discharge helped reduce their discharge time.

The electronic discharge system was the main process modified in the present study, which has been mentioned in various studies as a tool to ensure complete (30) and reliable discharge summary (31), expedite the discharge time (32), and increase staff satisfaction (33). The availability of a HIS, the possibility of tracking medical records (non-electronic), the presence of IT professionals and proper coordination with the health insurance organizations, as well as the availability of sufficient hardware equipment, such as computers, scanners, and printers in each ward, were considered significant requirements.

The main limitation of this study was the lack of adjusting for all possible confounders during the study, particularly in the post-intervention phase. Assigning the Imam Reza Hospital for the reception and care of patients with COVID-19 was the most important confounder that could have affected the results. However, in the intervention used in the present study, some discharge stations were omitted, which did not associate with the considered type of patients; therefore, from the research team's point of view, this limitation did not significantly affect the effectiveness of the intervention.

In general, this study, similar to some other investigations, confirmed the effectiveness of using Six Sigma methods on improving the patient discharge process (19, 29, 34).

By all means, it should not be forgotten that the electronic clearance process is complex, and its modification requires the cooperation of all people involved in this process (23, 35, 36).

The results of the present study also demonstrated the contribution of the multidisciplinary team members of the hospital to the reduction of discharge time (37). A significant cause of the long discharge process was the poor communication between different stakeholders (e.g., treating physicians, consultants, nurses, pharmacy staff, and the accounting department). 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 for sustaining and controlling the improvements.

Furthermore, the results suggested that focusing on physician readiness for writing a discharge order would have the most significant impact on the reduction of the patients' discharge time. According to the results of an investigation conducted by GR El-'Eid et al., the discharge time decreased by 22.7% from 2.2 h during the pre-intervention period to 1.7 h post-intervention ($P<0.001$) (23).

Many studies have demonstrated that increasing early discharges using a structured framework for quality improvement is achievable and sustainable. For instance, Beck et al. applied the Lean methods to modify workflow and attain early discharges (38). In the same way, Patel et al. used the Plan-Do-Study-Act (PDSA) framework to achieve early discharges (39). 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 (39, 40)

Each hospital is comprised of an extensive range of services and functional units, which indicates large amounts of financial resources and time needed to build a hospital (3,41)

Furthermore, some organizational factors such as lack of time, an urgent need of other patients to be dealt with, shift work forcing medical staff to discharge patients before doing an accurate assessment of their health problems, staff not knowing the patient well enough, and the most important factor, the high percentage of patient turnover in the emergency departments may also be a contributing factor to an inefficient discharge process (7). However, prolonged and combined outbreaks can lead to the progressive spread of disease with rapidly increasing service demands that can potentially overwhelm the capacity of hospitals. In these conditions, increasing hospital capacity by improving hospital processes is a quick action to cover the rapidly increasing service demands in an epidemic or a pandemic situation. The present study indicated that applying the Six Sigma model and applying IT solutions, such as the electronic discharge process, can increase the discharge process in a short time and at a meager cost.

Provision of an active and ready hospital bed is a significantly longer process (42,43), especially in critical situations, such as the prevalence of COVID-19. This process involves building the physical space and providing the equipment and needed personnel, and it may normally take several years for a small hospital in government systems. In the present study, the capacity of hospitalization was increased by modifying the hospital process in a short period and also with the participation of all stakeholders.

Acknowledgments

The authors thank Mr. Mohsen Shokoohizade for his efforts to extract data from the hospital information system.

Footnotes

Authors' Contribution: Study concept and design: MY, MS, SF; acquisition and cleaning of data: MY and MS; analysis and interpretation of data: MY and SF; drafting of the manuscript: MY and MS; critical revision of the manuscript for important intellectual content: MY, SF, MS; statistical analysis: MY, MS; administrative, technical, and material support: MY, SF; study supervision: SF.

Conflict of Interest: The authors declare that they do not have any conflict of interest. This study was performed following the Declaration of Helsinki.

Funding/Support: This research is part of a large project (Grant Code No. 990315). The study protocol was approved by the Research Ethics Committee of Tehran University of Medical Sciences, Tehran, Iran (Ethical code: IR.TUMS.NIHR.REC.1400.012).

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