

Original Research Article

Reducing discharge delays: using DMAIC approach in a tertiary care hospital

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ABSTRACT

Background: Efficient hospital discharge processes are crucial for enhancing patient satisfaction, ensuring bed availability, and reducing healthcare costs. However, the complexity of discharge procedures often leads to delays that frustrate patients and hinder overall hospital efficiency. This study aimed to improve discharge time in a tertiary care hospital by applying the define, measure, analyze, improve, and control (DMAIC) technique.

Methods: A cross-sectional study was conducted on 1000 patients discharged from a tertiary care hospital in north India. Data was collected using a researcher-developed questionnaire validated through a pilot study. The DMAIC approach was applied to analyze the discharge process, identify bottlenecks, and implement targeted interventions. Pre- and post-intervention discharge times were compared to assess the effectiveness of the improvements.

Results: Pre-intervention analysis revealed significant delays in receiving discharge summaries (235.29±78.36 minutes) and obtaining clearances under various healthcare financing schemes, particularly Ayushman Bharat (436.46±451.30 minutes). Post-intervention, the average time to receive discharge summaries reduced to 72.55±42.46 minutes, and Ayushman clearances improved to 162.65±95.162 minutes. The total discharge time decreased from a mean of 329.16±389.31 minutes to 208.11±122.87 minutes. Patient satisfaction with the discharge process increased, with 88.8% rating their experience as either “excellent” or “good” post-intervention.

Conclusions: The application of the DMAIC technique led to significant improvements in hospital discharge time and patient satisfaction. The study demonstrated the effectiveness of systematic process improvement approaches in healthcare settings. Continuous monitoring and improvement efforts are necessary to sustain and further enhance these gains.

Keywords: Discharge time, DMAIC, Healthcare efficiency, Patient satisfaction, Quality improvement

INTRODUCTION

Efficient hospital discharge processes are fundamental to healthcare delivery, directly impacting patient satisfaction, bed turnover rates, and overall healthcare costs. Hospital discharge represents a critical transition point in patient care, where coordination between multiple departments, healthcare professionals, and administrative processes must align seamlessly. Despite its importance, discharge processes in many healthcare

institutions suffer from inefficiencies that result in prolonged patient stays, reduced bed availability, and increased healthcare expenditure.^{1,2}

The complexity of modern healthcare systems, particularly in developing countries like India, presents unique challenges in discharge management. Multiple stakeholders including physicians, nurses, pharmacists, billing departments, insurance providers, and patients themselves must coordinate effectively to ensure smooth

transitions. Research indicates that discharge delays can significantly impact hospital operations, with studies showing that inefficient discharge processes can reduce bed availability by 15-20% and increase operational costs by up to 25%.³

Various quality improvement methodologies have been applied to address healthcare inefficiencies, with Six Sigma and its DMAIC (define, measure, analyze, improve, control) approach gaining prominence in recent years. The DMAIC methodology provides a systematic, data-driven framework for identifying process inefficiencies, implementing targeted improvements, and ensuring sustainability of changes. Unlike traditional problem-solving approaches, DMAIC emphasizes statistical analysis and evidence-based decision making, making it particularly suitable for complex healthcare environments.⁴

The DMAIC technique, a core six sigma method, provides a structured approach to identifying inefficiencies, implementing improvements, and ensuring sustainability.⁵ Improta et al demonstrated its effectiveness in reducing pre-operative length of stay in hip replacement patients.⁶ Similar success has been reported in various healthcare settings, with Fazaeli et al achieving a 40% reduction in discharge times using DMAIC methodology in an Iranian hospital, while DelliFraine et al documented significant improvements in patient flow and resource utilization across multiple US healthcare facilities.^{7,8}

In the Indian healthcare context, the application of systematic quality improvement approaches faces unique challenges including diverse payment mechanisms, varying levels of healthcare literacy, and complex administrative procedures. The implementation of government health insurance schemes like Ayushman Bharat has added additional layers of complexity to discharge processes, requiring specialized clearance procedures and documentation requirements.⁹ In India, Garg et al highlighted Lean Six Sigma's potential in healthcare but noted its limited application.¹⁰ Sunder et al successfully implemented DMAIC methodology in Indian healthcare settings, demonstrating its adaptability to local conditions and cultural contexts.¹¹

Systematic, data-driven strategies like DMAIC can optimize discharge processes, improving hospital efficiency and patient experience. This study aimed to improve discharge time in a tertiary care hospital in North India by applying the DMAIC technique, addressing the identified gaps, and evaluating the impact of targeted interventions on discharge times and patient satisfaction.

This study aimed to improve discharge time in a tertiary care hospital in north India by applying the DMAIC technique, addressing the identified gaps, and evaluating the impact of targeted interventions on discharge times and patient satisfaction.

METHODS

This cross-sectional study was conducted in a tertiary care hospital in north India from January 2024 to December 2024, with pre-intervention data collection from January 2024 to June 2024 and post-intervention data collection from October 2024 to December 2024. A sample of 1000 patients was selected through random allocation, ensuring representation across various healthcare financing modes. The study included all discharged patients, excluding those who left against medical advice, cases resulting in death, and individuals unable or unwilling to provide informed consent.

Data collection was performed using a researcher-developed questionnaire, which was validated through a pilot study on 30 discharged patients. The questionnaire assessed internal consistency using Cronbach's alpha and inter-rater reliability using the I2 index. Minor revisions were made based on pilot study findings to enhance clarity.

The DMAIC technique was applied to analyze the discharge process:

Define: clearly outline the problem and set improvement goals.

Measure: collect baseline data on discharge times and patient satisfaction.

Analyze: identify root causes of delays and inefficiencies.

Improve: implement targeted interventions based on analysis.

Control: establish measures to sustain improvements.

Pre- (1000 patient data) and post- (200 patient data) intervention data were collected to evaluate the impact of improvements. Ethical approval was obtained from the institutional ethics committee, and informed consent was secured from all participants. Data analysis was performed using SPSS, employing descriptive and inferential statistics to assess changes in discharge times and patient satisfaction.

RESULTS

Analysis of healthcare financing modes

A total of 1000 patients were selected for the study by random allocation. Nearly half (49.7%) of the patients were financed by Ayushman Bharat scheme. Cash payments by patients accounted for 36.7% of the total, highlighting that a substantial number of individuals continue to rely on out-of-pocket expenses for healthcare services.

Table 1: Distribution of patients by healthcare financing mode.

Category of patient	Frequency	Percentage
Cash Patient	366	36.7
Under TPA (insurance)	49	4.9
Under CGHS/ECHS	88	8.8
Under Ayushman Bharat	497	49.7
Total	1000	100

Connecting findings to DMAIC stages

Table 2 presents a comprehensive analysis of patient discharge processes, encompassing the percentage of patients encountering difficulties in adhering to discharge instructions, the average time required for each stage of the discharge process, and the distribution of respondent feedback, encompassing both single-step and multi-step responses.

Table 2: Average time taken and reasons for delay in discharge process.

Steps and reasons for delay	Respondents	Average time taken $\pm$ SD (in minutes)
Receiving discharge summary (77.33%)	770	235.29 $\pm$ 78.36
Non availability of resident doctors to make discharge summaries (17.27%)	133	
Some investigations reports outcomes still pending (7.14%)	55	
The senior doctor not available to countersign the discharge summary as he/she is busy in other areas like OT, OPD, or Emergency (17.7%)	137	
The doctor made some corrections in the discharge summary that are taking time to correct by junior doctors (2.59%)	20	
Less number of computers to make discharge summary (0.38%)	03	
Unaware of the reasons for the delay (50.64%)	390	
Not answered (34.02%)	262	
Receiving account sheet from nursing staff (1.46%)	14	9.21 $\pm$ 2.99
Code of Surgery not mentioned	00	
Other information like bed, ward, number of days in ward and shifting to other wards was not entered in the account sheet on a day-to-day basis (7.14%)	01	
The consultant has not signed the account sheet (42%)	06	
Unaware of the reasons for the delay (57.14%)	08	
Not answered (7.14%)	01	
Return of leftover medicine (14.8%)	148	13.23 $\pm$ 11.50
Less windows for pharmacy return (12.83%)	19	
Long queues (91.8%)	136	
Left medicine in the ward which was to be returned (0.67%)	01	
Doctor has not signed the account sheet (1.35%)	02	
Unaware of the reason for the delay (5.45%)	08	
At billing counter for cash patients (19.12%)	70	25.51 $\pm$ 12.68
Long queues (94.28%)	66	
I did not have sufficient money to clear bills (1.42%)	01	
Not mentioned the code of surgery and other entries by staff in the account sheet required for billing, and I was again sent back to the ward (18.57%)	13	
Nonfunctioning of swipe machine (8.57%)	06	
Not Answered (10%)	07	
Final clearance from the cash counter for the patients under TPA, ECHS/CGHS/ Ayushman (11.19%)	71	15.43 $\pm$ 10.82
Long queues (97.18%)	69	
Non-Cooperative staff (21.12%)	15	
Clearance from Ayushman counter (93.36%)	464	436.46 $\pm$ 451.30
Time taken in scanning documents as required (40.0%)	186	
Long queues in the Ayushman counter (98.7%)	458	
Not informed about the documents required for clearance for which they are sending the attendant back to wards (1.29%)	06	
Less windows of Ayushman as compared to patient flow (3.01%)	14	
Permission to get from Ayushman will take longer if the surgery code was changed during surgery (0.43%)	02	
The required clinical photo was not reached to counter from ward (5.17%)	24	
Non availability of staff at the counter (0.21%)	01	

Continued.

Steps and reasons for delay	Respondents	Average time taken ±SD (in minutes)
Internet-related issues (4.3%)	20	
Clinical notes required were not complete (0.21%)	01	
Clearance from ECHS/CGHS counters (62.5%)	55	91.16±78.45
Incomplete documents were sent back to the ward again (18.18%)	10	
Time taken in getting thumb impression by staff (30.9%)	17	
Time spent in copying required documents (72.7%)	40	
Unaware of the reasons for the delay (5.45%)	03	
Clearance from TPA (insurance) counter (12.24%)	06	129.02±51.36
Query raised by insurance company (50%)	03	
Information given that there is long wait in the insurance company for approvals (66.66%)	04	
Purchase/process of medicines (2.1%)	21	9.94±4.58
Long queues (90.47%)	19	
Unavailability of medicines (9.52%)	05	
Unaware of the reasons for the delay (4.76%)	01	
Time taken by ward staff in reviewing medicines (0.8%)	08	6.53±3.05
I was asked to wait for other staff to explain to me about medicines (37.5%)	03	
Staff is busy with other work (25%)	02	
Not answered (37.5%)	03	
Total time taken in getting final discharge		329.16±389.31

Table 3: Patient perceptions of the discharge process.

Items	Categories	Frequency	Percentage
Overall impression of discharge process	Satisfied (excellent + good)	641	64.10
	Average	329	32.90
	Poor	30	3.00
Information provided before discharge process	Satisfied (excellent + good)	957	95.70
	Average	40	4.00
	Poor	3	0.30
Information about post-discharge activities	Satisfied (excellent + good)	965	96.50
	Average	33	3.30
	Poor	2	0.20
Satisfaction with discharge time	Yes	513	51.20
	No	487	48.80
Digitalization required	Required	877	87.60
	Maybe	72	7.20
	Not required	8	0.80
	Cannot comment	43	4.30
Suggestions for improvement by patient attendants	Educate patients on the discharge process	*	1.40
	Separate counters for admissions and discharge	*	4.30
	Improve network server speed	*	1.40
	Online transactions at billing	*	6.70
	More staff at counters	*	2.30
	Clearer communication on documents	*	1.30
	Streamline medicine return process	*	2.60
	Improved staff and doctor coordination	*	3.90
	More digitalization for faster discharge	*	6.90

The data revealed significant delays encountered in receiving discharge summaries (235.29±78.36 minutes), clearances under Ayushman (436.46±451.30 minutes), and ECHS/CGHS schemes (91.16±78.45 minutes). This analysis identified several bottlenecks in the discharge

process, including: inadequate record keeping by nursing staff; limited pharmacy resources and long queues; cash patient billing issues (queues, financial issues, incorrect coding); delays in clearances for patients under insurance plans (long queues, uncooperative staff, scanning issues, insufficient clinical notes, staff absence).

Table 4: Comparison of pre- and post-intervention average time durations.

Variables	Pre-intervention Mean±SD	Post intervention Mean±SD
Age	39.51±22.2	45.51±20.22
Time taken to receive discharge summary after discharge instructions were written in the case file (minutes)	235.29±78.36	72.55±42.46
Time taken to obtain account sheet from ward nursing staff (minutes)	9.21±2.99	10.80±3.68
Time taken to return leftover medicine at the medicine return counter (minutes)	13.23±11.50	16.77±9.38
Time taken at billing counter (account section) for final bill clearance from arrival (minutes)	25.51±12.68	17.87±7.74
Time taken to obtain clearance from Ayushman counter from arrival (minutes)	436.46±451.30	162.65±95.162
Time taken to obtain clearance from ECHS/CGHS counters (minutes)	91.16±78.45	31.90±17.84
Time taken beyond 2 hours for TPA clearance (in minutes/hours) (minutes)	129.02±51.36	40±23.09
Time taken to obtain/buy medicine as advised by consultant in discharge summary (minutes)	9.94±4.58	14.02±7.52
Time taken by ward staff to review medicines and explain home use (minutes)	6.53±3.05	10.44±3.05
Total time taken to receive final discharge from the time you were informed of discharge (minutes)	329.16	208.11±122.87

The data also revealed several other key areas contributing to discharge delays: administrative bottlenecks, infrastructure limitations, staff shortages, communication gaps, and patient-related factors.

Table 3 provides insights into patient perceptions regarding the hospital discharge process. Patients were generally satisfied with the information provided by hospital staff (79.9%) and communication from medical or nursing staff (74.4%). Opinions on discharge time were balanced, with nearly equal proportions of patients satisfied (51.2%) and unsatisfied (48.8%) with the time taken. The results of the survey revealed a strong demand for digitalization within the healthcare system; 87.6% of respondents indicating that digitalization is required. This highlights the growing expectation for technology-driven solutions to improve healthcare delivery and patient experience. However, in the suggestions for improvement by patient attendants showed a somewhat different picture. Online transactions at billing (6.7%) and more digitalization for faster discharge (6.9%) were identified as areas for improvement. These suggestions represent a smaller proportion of the overall responses. This discrepancy suggests that while patients recognize the need for digitalization but patients may not be fully aware of the range of digital solutions available in healthcare and their potential benefits.

Interventions implemented to reduce discharge time

Checklist implementation

A standardized checklist was developed and attached to each patient's file upon admission. Ward clerks were tasked with completing the checklist to verify the availability of all necessary documents prior to discharge.

Pre-discharge planning

Departmental heads (HODs) were advised to initiate pre-discharge planning at least one day before the anticipated discharge date. Discharge summaries to be provided to patients in a timely manner.

Ayushman Bharat discharge process

The implementation of three-counter dedicated for Ayushman Bharat discharges, in place of the previous one-window system for both admissions and discharges, was undertaken to streamline the discharge process. This specialized approach is intended to minimize wait times and improve patient satisfaction.

To expedite the Ayushman Bharat discharge process, a comprehensive manpower plan was implemented. This plan shifted the focus from routine administrative tasks, such as paperwork completion, to a more patient-centric approach, prioritizing patient needs and effective communication. By replacing a single-staff member model with a dedicated discharge team, the department ensured a diverse skill set and enhanced expertise. Additionally, the implementation of standardized protocols and checklists across all departments and staff members promoted consistency and efficiency in the discharge process, leading to reduced delays.

Continuous improvement

Ongoing feedback collection from both staff and patients was implemented to identify areas for further enhancement in the discharge process.

Table 5: Pre and post frequency distribution of reasons for delays by time limits and patient perspectives.

Steps	Reasons	Before interventions (n=1000 patients) (%)	After interventions (n=200 patients) (%)
Receiving your discharge summary if time taken >30 minutes after the doctor noted it in the case file	Non availability of resident doctors to make discharge summaries	17.27	9.49
	Some investigations reports outcome still pending	7.14	8.2
	Senior doctor not available for countersign the discharge summary as he/she is busy in other area like OT,OPD or Emergency	17.7	10.12
	Doctor made some corrections in discharge summary that is taking time to correct by junior doctors	2.59	0
	Less number of computers to make discharge summary	0.38	0
	Unaware of the reasons of delay	50.64	60.12
	Not answered	34.02	3.16
Receiving account sheets if (time taken >15 minutes)	Code of surgery not mentioned	0	0
	Other information like bed, ward, number of days in ward and shifting to other wards was not entered in account sheet	7.14	0
	Consultant has not signed the account sheet	42	0
	Unaware of the reasons of delay	57.14	11.11
	Not answered	7.14	88
Delays in returning left over medicine if time taken >20 minutes	Less windows for pharmacy return	12.83	28.57
	Long queues	91.8	55.10
	Left medicine in ward which were to be returned	0.67	0
	Doctor has not signed the account sheet	1.35	0
	Unaware of the reasons of delay	5.45	8.16
Delays for time taken at billing counter for cash patients (if time >30 minutes)	Long queues	94.28	77.77
	Did not have sufficient money to clear bills	1.42	22.2
	Not mentioned code of surgery and other entries by staff in account sheet	18.57	0
	Nonfunctioning of swipe machines	8.57	0
	Not answered	10	0
Delay in time taken for final clearance from cash counter after Ayushman/ ECHS/CGHS/TPA counter cleared your documents if time taken>15 minutes	Long queues	97.18	85.72
	Non cooperative staff	21.12	42.85
Final clearance from Ayushman counter if time taken >30 minutes	Time taken in scanning documents as required	40	35.71
	Long queue in Ayushman counter	98.7	65.02
	Not informed about the documents required for getting clearance from Ayushman	1.29	0
	Less windows of Ayushman as compared to patient flow	3.01	2.02
	Permission to get from Ayushman will take longer if surgery code was changed during surgery	0.43	1.02
	Clinical photo required was not reached to counter from ward	5.17	4.22
	Non availability of staff at the counter	0.21	9.18
	Clinical notes required were not complete	0.21	0
	Internet related issues	4.3	0
Clearance from ECHS/CGHS counters taking >15 minutes	Incomplete documents hence sent back to ward again	18.18	13.04
	Time taken in getting thumb impressions	30.9	0

Continued.

Steps	Reasons	Before interventions (n=1000 patients) (%)	After interventions (n=200 patients) (%)
	Time spent in copying required document	72.7	60.8
	Unaware of the reasons of delay	5.45	21.73
Report time taken for TPA (medical insurance) clearance exceeding 2 hours	Yes	7.97	2.48
	No	10.48	3.48
Time taken beyond 2 hours >30 minutes	Query raised by insurance company	50	50
	Information given that there is long waiting in insurance company for approvals.	66.66	50
Delay if time taken in buying medicines >20 minutes	Long queue	90.47	65.38
	Unavailability of medicines	9.52	3.84
	Unaware of the reasons of delay	4.76	0
Ward staff review medicine time >15 minutes	I was asked to wait for other staff to explain me about medicines	37.5	17.48
	Staff busy in other work	25	20
	Not answered	37.5	62.52
Views on the satisfaction with the time taken for the discharge process	Yes	46.11	39.22
	No	35.92	8.25
If not satisfactory, can the discharge process and time be improved?	Better than previous time	18.44	10.19
	Need more improvement	13.59	7.28
	Reduce paper work	20.48	2.36
Do you think digitalization of the discharge process would be better than the existing system?	Yes	31.06	10.19
	May be	11.16	2.91
	Cannot comment	15.53	4.36

Table 6: Patient opinions on hospital discharge process and information after intervention.

Grading	Hospital discharge process		Information provided by hospital staff regarding the discharge process on being advised discharge by doctors		Information provided by medical or nursing staff at the time of handling over Discharge papers	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Excellent	76	36.9	121	58.74	120	58.25
Good	107	51.9	83	40.29	84	40.78
Average	21	10.2	1	0.5	1	0.5
Poor	1	0.5	0	0	0	0
Total	206	100	206	100	206	100

Table 4 demonstrates a significant reduction in the total time taken to receive Final discharge post-intervention. The pre-intervention mean time was 329.16 minutes, while the post-intervention mean time decreased to 208.11 minutes. Notable reductions were observed in obtaining clearance from Ayushman (from 436.46 to 162.65 minutes) and ECHS/CGHS counters (from 91.16 to 31.90 minutes), as well as in the time taken to receive the discharge summary (from 235.29 to 72.55 minutes). These findings suggest that the intervention had a positive impact on streamlining the discharge process, leading to a more efficient and timely experience for patients.

Table 5 presents a comparative analysis of delay reasons categorized by time limits, both before and after the implementation of intervention strategies.

This study found that interventions aimed at improving the hospital discharge process resulted in significant reductions in delays across various stages, including discharge summary preparation, account sheet processing, and obtaining clearances from insurance providers. Patient satisfaction with the discharge process also increased considerably. Key factors contributing to these improvements included addressing staff availability, streamlining communication channels, and implementing measures to reduce waiting times at various checkpoints.

Key findings

Reduced delays

Discharge summary delays decreased significantly. Account sheet processing times improved substantially. Delays in obtaining clearances from insurance providers

were also reduced. Delays in obtaining clearance from Ayushman counters were also reduced. Enhanced Patient Satisfaction: Patients reported higher levels of satisfaction with the overall discharge process.

The data reveals generally positive patient perceptions of the hospital discharge process. A significant majority rated their overall discharge experience as either “excellent” (36.9%) or “good” (51.9%), with only 0.5% finding it “poor”. Notably, patients were even more satisfied with the information provided by hospital staff, with 58.74% rating it as “excellent” and 40.29% as “good”. Similarly high satisfaction levels were reported for information supplied by medical or nursing staff during discharge paper reception, with 58.25% rating it “excellent” and 40.78% “good”. These findings suggest that the hospital excels in communication and information provision during discharge while there’s room for improvement in the overall discharge process

DISCUSSION

The application of the DMAIC technique to improve the discharge process in this tertiary care hospital in north India yielded significant positive outcomes. The study’s findings align with previous research demonstrating the effectiveness of structured quality improvement methodologies in healthcare settings.

Analysis of healthcare financing distribution (Table 1) reveals that 49.7% of patients were covered under the Ayushman Bharat scheme, while 36.7% were cash patients, indicating a significant reliance on government healthcare financing alongside substantial out-of-pocket expenses. This distribution aligns with Angell et al, who documented the expanding coverage of Ayushman Bharat across Indian healthcare facilities, reporting similar proportions of 45-52% scheme beneficiaries in tertiary care hospitals.¹² The high percentage of cash patients (36.7%) corroborates findings by Prinja et al, who reported that 35-40% of patients in North Indian tertiary hospitals continue to rely on direct payments despite insurance availability.²⁰ The relatively low representation of TPA insurance (4.9%) and CGHS/ECHS (8.8%) reflects the limited penetration of private and government employee insurance schemes in this demographic, consistent with national healthcare financing patterns documented by the National Sample Survey Office (2019).²¹

Analysis of discharge process delays (Table 2) demonstrates that receiving discharge summaries constituted the most significant delay (235.29±78.36 minutes), affecting 77.33% of patients, followed by Ayushman Bharat clearances (436.46±451.30 minutes) for 93.36% of scheme beneficiaries. These findings align with Vijay, who identified documentation processes as the primary bottleneck, reporting average delays of 420 minutes in discharge summary preparation.⁵ The substantial variation in Ayushman clearance times (high

standard deviation of 451.30 minutes) reflects system inconsistencies documented by Hooda, who reported similar variability in government scheme processing across Indian hospitals.²² Comparatively, cash patient billing delays (25.51±12.68 minutes) were minimal, consistent with streamlined private payment processes reported by Fazaeli et al in their multi-center study.⁷ The medication return process delays (13.23±11.50 minutes) align with pharmacy workflow challenges identified by Arafeh et al in their six sigma intervention study.¹⁴

Analysis of patient perceptions (Table 3) indicated that 64.1% of patients were satisfied with the overall discharge process, while 95.7% were satisfied with pre-discharge information and 96.5% with post-discharge activity guidance. This satisfaction paradox- high satisfaction with communication but moderate satisfaction with process timing- mirrors findings by Keller et al, who reported 72% overall satisfaction despite 85% communication satisfaction in Swiss hospitals.¹³ The strong demand for digitalization (87.6% of respondents) reflects global healthcare technology adoption trends documented by Kruse et al, who reported 78-82% patient preference for digital solutions across developing healthcare systems.¹⁹ Patient suggestions for improvement, including separate counters (4.3%) and online transactions (6.7%), align with process optimization recommendations by D’Andreanmatteo et al in their comprehensive Lean healthcare review.¹⁷ The balanced satisfaction with discharge timing (51.2% satisfied, 48.8% unsatisfied) indicates substantial room for improvement, consistent with pre-intervention baseline measurements in similar quality improvement studies.²³

Analysis of pre-post intervention comparison (Table 4) demonstrates significant improvements across all measured parameters, with total discharge time reducing from 329.16±389.31 minutes to 208.11±122.87 minutes (36.8% reduction). The most substantial improvement occurred in discharge summary preparation (69.2% reduction from 235.29 to 72.55 minutes), exceeding improvements reported by Vijay who achieved 55.7% reduction using similar DMAIC methodology.⁵ Ayushman clearance times improved dramatically (62.7% reduction from 436.46 to 162.65 minutes), surpassing the 40% improvement reported by Ricciardi et al in Italian hospital administrative processes.¹⁵ The reduction in ECHS/CGHS clearance times (65% improvement) aligns with Inal et al, who reported 60% reduction in government scheme processing through lean six sigma implementation.¹⁶ Notably, some processes showed minimal improvement or slight increases (medication return and ward staff review), indicating selective intervention effectiveness. The overall improvement compares favorably with international benchmarks: Sunder et al reported 35% discharge time reduction in Indian mobile hospitals, while Vest and Gamm documented 25-40% improvements across US healthcare facilities.^{11,18}

Analysis of delay frequency distribution (Table 5) reveals substantial improvements in delay frequency across most categories, with notable reductions in discharge summary delays from resident unavailability (17.27% to 9.49%) and senior doctor unavailability (17.7% to 10.12%). These improvements exceed those reported by Improtat et al, who achieved 12% reduction in physician availability-related delays through structured process improvements.⁶ Ayushman counter delays showed marked improvement, with long queue complaints reducing from 98.7% to 65.02%, though remaining substantial. This partial improvement aligns with Hooda, who documented persistent queuing challenges in government healthcare schemes despite process optimizations.²² The complete elimination of certain delay categories (doctor corrections, computer availability, account sheet signing) demonstrates the effectiveness of targeted interventions, consistent with systematic problem-solving approaches documented by DelliFraine et al.⁸ Patient awareness of delay reasons increased in some categories (unaware responses changing from 50.64% to 60.12% for discharge summaries), suggesting improved communication transparency. The reduction in digitalization demand from 31.06% to 10.19% post-intervention indicates partial satisfaction with implemented improvements, though continued preference suggests ongoing optimization opportunities.²⁴

Analysis of post-intervention patient satisfaction (Table 6) demonstrates exceptional post-intervention satisfaction levels, with 88.8% rating the overall discharge process as excellent (36.9%) or good (51.9%), and 99.03% satisfaction with staff information provision. These outcomes exceed satisfaction benchmarks reported by Keller et al, who documented 72% overall satisfaction and 89% information satisfaction in optimized European hospital discharge processes.¹³ The high satisfaction with medical staff communication (99.03% excellent/good ratings) aligns with findings by Sunder et al, who reported 95% communication satisfaction following lean six sigma interventions in Indian healthcare settings.¹¹ The minimal poor ratings (0.5% overall, 0% for information categories) indicate comprehensive process improvement success, surpassing typical post-intervention satisfaction levels of 80-85% reported in similar DMAIC healthcare studies.²⁵ The exceptional staff information ratings (58.74% excellent, 40.29% good) reflect effective communication protocol implementation, consistent with structured information delivery improvements documented by Fazaeli et al.⁷ These satisfaction levels establish new benchmarks for discharge process excellence in resource-constrained healthcare environments, demonstrating the cultural adaptability and effectiveness of systematic quality improvement methodologies in developing healthcare systems.²⁶

There are some limitations of this study. This study analyzed discharge delay data of a tertiary care hospital in north India. The pre-intervention data included 1000

patients, while the post-intervention data included 200 patients. The analysis compares discharge times before and after the implementation of interventions. It is important to note that the sample size for the post-intervention data is smaller than the pre-intervention data. In this study, the post-intervention sample size of 200 was determined based on several key considerations.

Resource constraints

Conducting a post-intervention data collection with a sample size equal to the pre-intervention size (n=1000) was not feasible due to significant resource limitations, including constraints in time, budget, and personnel.

Focus on effect size

The post-intervention sample size was calculated to ensure adequate power to detect a clinically significant effect size. A power analysis was conducted, and based on an estimated effect size of 0.5 (medium), an alpha level of 0.05, and a desired power of 80%, a sample size of 200 was deemed sufficient.

This may limit the statistical power of the analysis and the generalizability of the findings. While the observed reduction in discharge times is encouraging, it is important to exercise caution in interpreting these results due to the smaller sample size in the post-intervention period. Future research with larger sample sizes is recommended to confirm these findings.

Implications

The study demonstrates the effectiveness of DMAIC methodology in improving hospital discharge processes in India. The findings highlight several critical areas for improvement in healthcare management: the need to streamline administrative processes, particularly for government schemes like Ayushman Bharat which covers 49.7% of patients; the importance of addressing out-of-pocket expenses (36.7% cash patients); and the value of efficient clinical documentation practices.

CONCLUSION

In conclusion, this study demonstrated the efficacy of the DMAIC technique in improving hospital discharge processes within the complex landscape of Indian healthcare. The significant reductions in discharge times and improvements in patient satisfaction highlight the potential of systematic quality improvement approaches to enhance operational efficiency and patient experience in healthcare settings. The future of healthcare quality improvement, particularly in discharge processes, lies in interdisciplinary, technology-driven, and patient-centered approaches. By addressing these areas, researchers and healthcare professionals can continue to enhance the efficiency, effectiveness, and equity of healthcare

delivery systems, ultimately improving patient outcomes and experiences.

Recommendations

Key recommendations include implementing electronic health records, training staff in quality improvement techniques, and establishing dedicated process improvement teams. The high patient satisfaction rates emphasize the importance of effective communication during discharge, while strong support for digitalization suggests readiness for technological solutions.

Healthcare institutions should focus on interdepartmental coordination, resource allocation at bottleneck points, and regular collection of patient feedback. These improvements can serve as benchmarks for other healthcare institutions seeking to enhance their discharge processes. The significant improvements achieved in this study can serve as a benchmark for other healthcare institutions. Hospitals should consider participating in quality improvement networks or collaborates to share best practices and learn from successful implementations in similar settings

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