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Decreasing Patient Wait Time by Process Level Interventions in an Oncology Daycare Unit: A Quasi-Experimental Study

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ABSTRACT

Introduction: The DMAIC approach is a five-phase improvement cycle which enables the advancement of pre-existing processes and was implemented as part of the "lean" process improvement initiative. The present study aims to improve the work efficiency of chemotherapy daycare unit (CDU) at a cancer hospital. The objectives include studying the process flow of the CDU, estimating the patient wait time (PWT) before infusion at the CDU, and implementing new measures to improve its functioning.

Methods: In this quasi-experimental study, PWT of the CDU process was assessed and its work efficiency was analyzed using other parameters of functioning. The research team implemented a planning system using "lean" methods for reducing the patient contact points in the hospital, streamlining the workflow of patient services at CDU and reducing the laboratory waiting time. The patient satisfaction survey enabled measuring the quality of care at CDU.

Results: The study methodology was "lean-DMAIC," which enabled an improvement in the activities performed by the CDU staff. The mean difference in PWT between the two groups (pre- and postintervention) was 13.93 min, which is a significant ($p < 0.001$) reduction (19%) in the mean PWT values. Although the patient satisfaction survey did not show significant results for the general questionnaire conducted on study subjects (95 patients each in the pre- and postintervention groups), the intervention-specific questionnaire on the cohort of 20 patients showed a significant mean difference ($\mu = 4.2 \pm 0.3$ and 4.8 ± 0.2, $p < 0.001$) between the pre- and postintervention groups.

Conclusion: The results of the study implicate the potential of revising the process flow for a subset of oncology patients, and its impact on the efficiency of CDU. Adopting a lean technique in the study resulted in an improvised work approach and an anticipative growth in revenue generation.

1 | Introduction

The present study enables working through the systems of chemotherapy daycare unit (CDU) and enabling a change for better outcomes. The CDU provides infusion treatment services on an ambulatory basis, and avoids in-patient admission. The patient journey for CDU-related services involves various touch points with healthcare professionals, which is further compounded by the diverse group of patients receiving care. The multidisciplinary team managing CDU services include an

Oncologist, Physician, head nurse and junior staff nurses, pharmacist, an administrative staff member and the infusion coordinator. Evidence suggests the negative association between prolonged patient wait time (PWT) and patient satisfaction [1]. PWT incorporates the laboratory turn-around time (TAT) which is defined as the time elapsed between drawing of blood and availability of results in the electronic medical record (EMR). The common investigations done for the CDU activity include complete blood count and complete metabolic panel.

Table 1 depicts the evidence regarding PWT and relevant outcomes from various quality improvement projects including their study methodologies and patient-centered initiatives. These ingenuities have improved the utilization and quality of health care, efficiency of diagnostic methods, reduction of costs and time needed for treatment.

The study aims to improve the work efficiency of CDU at a cancer hospital. The objectives comprise studying the process flow of CDU, estimating the PWT before infusion treatment at CDU, and implementing new measures to improve the functioning of CDU. The rationale includes the work load and time delays at the CDU, due to the increasing demands on the infusion center, laboratory, pharmacy, and other clinical areas. PWT is the "critical to quality" (CTQ) metric computed in the present study, which includes the time elapsed (in minutes) between patient registration and initiation of treatment infusion at CDU. The critical to customer (CTC) metric is in line with the needs of patients, which measures their purchase decisions and evaluation of healthcare services. The tool used to assess CTC in the study was patient satisfaction surveys (both independent and dependent cohort). This study provides evidence on a quality improvement project, in the context of an Indian cancer hospital.

Lean management system encourages service efficiency by identifying and rectifying nonvalue added (NVA) activities, as well as revising the value added ones. Another strategy called "Six sigma" enables the efficiency of business processes and follows a well-established method known as DMAIC. The acronym stands for five phases: "define, measure, analyze, improve and control," and is a data driven quality strategy used for improving the healthcare processes [2]. Although an integral component of the "Six sigma" initiative, DMAIC can also be implemented as a standalone quality improvement procedure or as part of the "lean" process improvement initiatives [6]. The synergy of both lean and six sigma methodologies is known as "lean six sigma," which is an innovative and effective approach in operational excellence [2]. The research team comprising the listed authors in the study participated in the implementation process, and their perspectives contribute to the action research approach of lean-DMAIC in the hospital.

2 | Methods

Figure 1 depicts the five lean principles as defined by Womack and Jones [7]. These principles provide a framework for increasing the efficiency of the CDU, by creating a better flow of work process and developing a culture of continuous improvement. The planning system implemented at CDU was based on this ideology, with intent to optimize the services at CDU. The DMAIC process was used for identifying the root cause of the problem and improving quality. It entitles measuring the impact of the improvement through data analytics. The research team executed the DMAIC activities by initiating with the Define phase.

2.1 | Define Phase (Problem, Opportunity for Improvement, Improvement Activity)

At the Sammprada cancer hospital located in Bangalore, India, the CDU provides chemotherapy to 10–12 out-patients/day. It is maintained by two senior staff nurses, who provide infusion services and quality healthcare. The daycare unit provides services from 8 a.m. to 8 p.m. on weekdays, and from 8 a.m. to 4 p.m. on weekends. The CDU is supervised by a physician, and comprises of other team members such as junior nurses and coordinators. The two senior staff nurses work in shifts from 8 a.m. to 4 p.m. and 12 p.m. to 8 p.m. The junior staff nurses are posted each for the morning and evening sessions, with an additional nurse providing supplementary services. The Pharmacy is managed by the pharmacist and is assisted by another coordinator. The medicines are indented from the intranet portal, and the loading room has an infusion coordinator for the medication-related services.

The charter for the project (Appendix A) was created by the research team, including the study objectives for decreasing the laboratory TAT and PWT. The CTQ metric is an attribute which has a significant impact on the perceived quality of the process. The CTQ metric in the study is decreasing the PWT, which includes its subcomponent laboratory TAT. The CTC metric implies the measurable quality of services at the CDU, and is derived by the patient satisfaction surveys' which assess the expectations and needs of the patients.

Figure 2 documents the process flow at CDU, which enables the identification of opportunities for improvement.

The process flow diagram as depicted in Figure 1 provides an overview of the activities in the infusion process, and cancer patients receive diverse health services in a single day. The flow of services are seemingly complex for a patient to navigate, and involves interaction with various health professionals. All patients receive the services in the mentioned order, and infusion services will be postponed for patients with health complications which mandate an oncologist's opinion. The Pharmacy and loading room are located in close proximity to the CDU.

2.2 | Measure Phase

The metrics include PWT, which encompass the laboratory TAT as well. The research team identified the key variables after brainstorming with the multidisciplinary team. Inclusion criteria are adult cancer patients with same-day laboratory and CDU services, who comprise approximately two-thirds in proportion. Exclusion criteria are patients who had an appointment with the Oncologist on the same day as well, apart from the CDU services.

TABLE 1 | Literature review of quality improvement studies.

Sl. no.	Author name, title of study, and country	Study objective	Methodology	Salient findings
1	Alzahrani et al. [1] "Improving utilization of the chemotherapy unit through implementing the medication early release project," Saudi Arabia.	A quality improvement project for reducing the PWT before initiating treatment, improving patients' experience, and enabling the effective functioning of unit through better resource utilization.	Multiple plan-do-study-act (PDSA) cycles were implemented toward achieving a PWT of < 60 min. The charge nurse enabled the medication early release program	Multiple PDSA enabled a reduction on average PWT from 2 h 27 min to 30 min on average. Patient education measures ensured zero drug wastage. Patient satisfaction survey showed enhancement following the changes.
2	Hernandez et al. [2] "Lean healthcare and DMAIC to improve the OR supply process in a public hospital," Mexico.	Reduce waste in public hospitals by improving the medical supply process for the operating room	Lean healthcare implementation following the DMAIC approach was carried out	Reduction in over-processing requests by 15.3%, defective identification numbers by 46.5%, unnecessary inventory by 2.8%, transportation waste by 16.7%, and improvement in redundant processing by 94.8%
3	Aggarwal et al. [3] "A study of lean in oncology: reducing waste and increasing value," Netherlands.	Effectiveness of lean methodologies in cancer drug delivery, diagnostics, and waste in the system	DMAIC approach was used to study the effectiveness in terms of improvement, revenue generation, and customer satisfaction	Lean increases patient and physician satisfaction by decreasing the reporting TAT, creating an improvised work approach and better understanding of generating revenues
4	Gjolaj et al [4] "Decreasing laboratory turnaround time and patient wait time by implementing process improvement methodologies in an outpatient oncology infusion unit," United States of America.	To streamline phlebotomy processes at CDU, and tracking the lab TAT and PWT	Using DMAIC method, the study enabled streamlining phlebotomy processes at CDU. The lab TAT and wait time for CDU patients was tracked for 9 weeks	17% decrease in wait time for all patients and 53% decrease in laboratory TAT for patients requiring same day lab and CTU services
5	Seshachalam et al. [5] "Predictors of dissatisfaction with daycare chemotherapy services among patients with cancer: A single center retrospective study," India.	To analyze the factors predicting the overall patient dissatisfaction with the daycare chemotherapy services	Two prospective audits were conducted to record the time and duration of all patient-related activities using structured questionnaires and a patient satisfaction survey	The mean oncologist waiting time was 30 min (SD 17.4) and the bed allotment time was 1 h (SD 1.04). The mean satisfaction score was 4.6 (SD 0.3) out of 5.

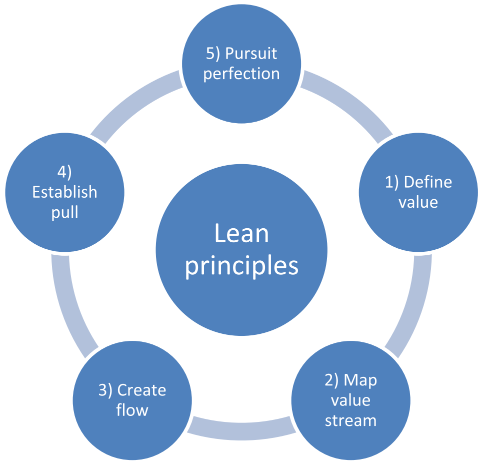

FIGURE 1 | Five lean principles.

Based on evidence from Gjolaj et al.'s [4] study, standard deviation (SD) of the TAT was derived as 31.75 min. For the present quasi-experimental study, sample size was calculated assuming 6.5% margin of error of SD, 5% level of significance, 95% confidence interval, and SD of 31.75, which results in 95 subjects for both pre- and postintervention groups [8]. The baseline data on the duration of patient care was gathered during the period August to September 2022, and the endline data following the "lean" intervention was collected from October 2022 to November 2022. Since patient satisfaction survey is a measure of the quality of care, the research team conducted the same using a questionnaire [5] which was validated in-house. Following informed consent, this survey was done on all patients (independent sample) both in the pre- and postintervention groups (95 each). The eight questions focus on all aspects of services at the CDU.

Also, a cohort of 20 consecutive patients (dependent sample) was surveyed with another questionnaire (five questions) which was specifically designed focusing on the interventions. Although these 20 patients are a sub-set of the 95 study subjects, they were the adjoining group whose treatment fell on either side of the lean intervention initiative. The low-dose chemotherapy is administered once in 7–10 days in our hospital. This questionnaire was also validated in-house, and was administered just before and after the intervention during September to October 2022. Seshachalam A et al.'s study [5] showed a 58% agreement of nursing care services, and hence the sample size in the study was calculated as "20" with an absolute precision of 22% and 95% confidence level [9]. For both questionnaires, patients were scored on a scale of 1 (very poor) to 5 (very good) and stratified as satisfied (score = 5) and not satisfied (score ≤ 4).

The three-sigma control limits for PWT is computed as mean ± 3 × SD, which is different from the confidence interval (CI). The formula for calculating CI includes "$Z_{\alpha/2}$" which is the standard normal deviate and "se" which is the standard error of mean. Hence, in-place of an interval plot, i-control chart has been plotted in the present study. The team assessed the PWT of 95 observations (preintervention) and an average for the metric was calculated as 75.74 ± 3.95 min. This voice of process measurement enabled the benchmark of 75 min for PWT, which became the yardstick for grading 40 subjects as "delay in care."

The research team held deliberations with the multidisciplinary team and enlisted the causes for patient care delays. The Pareto chart as depicted in Figure 3, portrays the frequency of these causes or problems among the 40 subjects. Further assessment of the causes revealed that missing/confounding treatment orders were the greatest reason for delay followed by laboratory delays. The fallacies in treatment orders are a result of cognitive biases such as "confirmatory bias" and "anchoring." The former bias reflects the inappropriate belief in evidence that confirms pre-existing beliefs while ignoring contradictory corroboration, the latter bias implies proclivity toward favoring one's initial impression [10]. Given the enterprise-coupled solutions for such fallacies, the research team addressed laboratory delays as an important metric. As shown in Figure 3, the Pareto chart depicts that 80% of the causes for delay in patient care are due to the initial six reasons.

2.3 | Analyze the Process for Determining the Root Causes of Variation, Defects

This phase determines the value (critical factors) and nonvalue added services which cause a delay in the PWT associated with oncology care. The research team in consonance with the CDU staff completed the "root cause analyses" via a fish bone diagram (Figure 4). The possible causes of inefficiency were identified in each "area," which was previously recognized by the process flow diagram (Figure 2). The research team evaluated the process failures as depicted in Figure 4, and pin down the important reasons for the long PWT. This includes prolonged laboratory TAT, and disjointed processes such as lack of organized workflow of CDU staff and delay in preparation of chemotherapy infusion.

2.4 | Improve by Addressing and Eliminating the Root Causes

The focus in "improve" phase is to generate solutions for the identified process failures in the root cause analyses. The research team implemented a planning system using "lean" methods for reducing the patient contact points in the hospital, streamlining the workflow for patient services at CDU and reducing the laboratory TAT. The face validity of these interventions was assessed by interviewing external reviewers ($n = 4$). They were randomly chosen from the specialities of oncology, internal medicine and hospital administration. The experts reflected on whether the planned interventions were gleaned from the identified problems represented in the fish-bone diagram. Their opinions were recorded on the following domains: appropriateness, acceptability, harmonious, interpretation, and relevance to the experience of cancer patients at CDU. The experts reported "good" face validity for the planned lean interventions, which were in-tune with the process change failures.

Lean healthcare enables continuous improvement through employee participation in reducing the nonvalue added activities, revising a few value added activities and synthesis of solutions aligning with the patient needs. The implemented planning system includes the following "lean" measures which are discerning for improving the quality of CDU services:

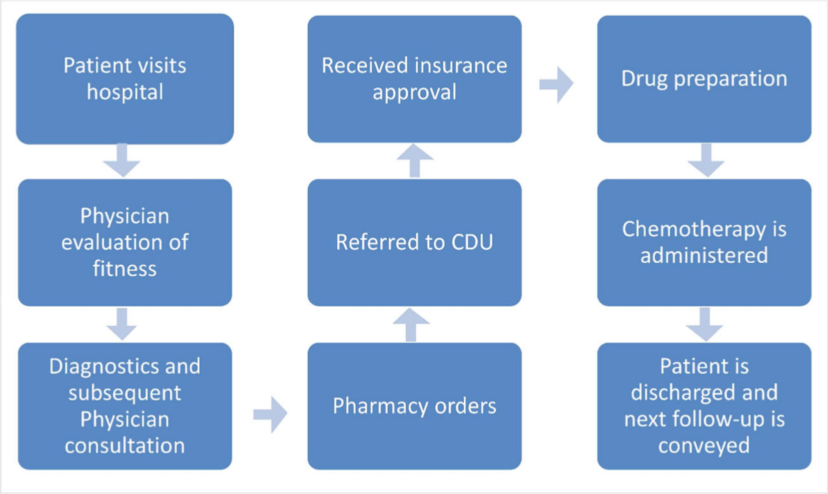

FIGURE 2 | Process flow diagram at the CDU.

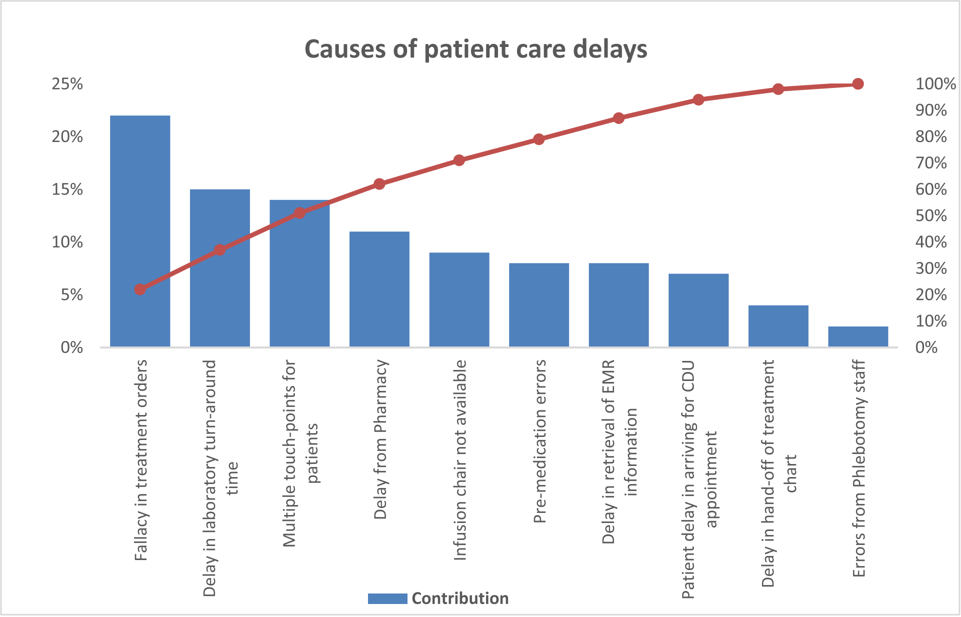

FIGURE 3 | Pareto chart of the causes for delay in patient care.

i. Patients are provided a specific reporting time, with registration and laboratory services rendered consecutively. This was possible by linking the activities of CDU, registration department and the laboratory through an information management system.

ii. In this regard, a phlebotomy station was established inside the CDU.

iii. A change was effected in the laboratory for processing of phlebotomy samples, from batch to continuous flow as and when the samples are delivered.

iv. The nurses followed a procedural checklist which resulted in optimization of the workload.

v. Pharmacy inventory was stock-piled based on services provided during the previous month, which enabled in catering the needs of the anticipated number of patients during the current month.

vi. The pharmacy and infusion coordinator were familiarized with the new workflow, which also contributes to the streamlining of supply chain systems.

vii. CDU nurses were allotted specific beds, despite being a daycare unit. This enabled an effective management of workload as well as efficient utilization of time. They were re-trained regarding the documentation of patient care plan.

viii. A newly appointed patient navigator enabled patient movement through the touch points in the hospital, and bridged the communication gaps in a courteous manner. This ad-lib prevented the criss-cross movement of patient attenders through the system.

ix. The training of personnel in these “lean” methodologies has enabled an inclusive growth and overall process improvement in the CDU.

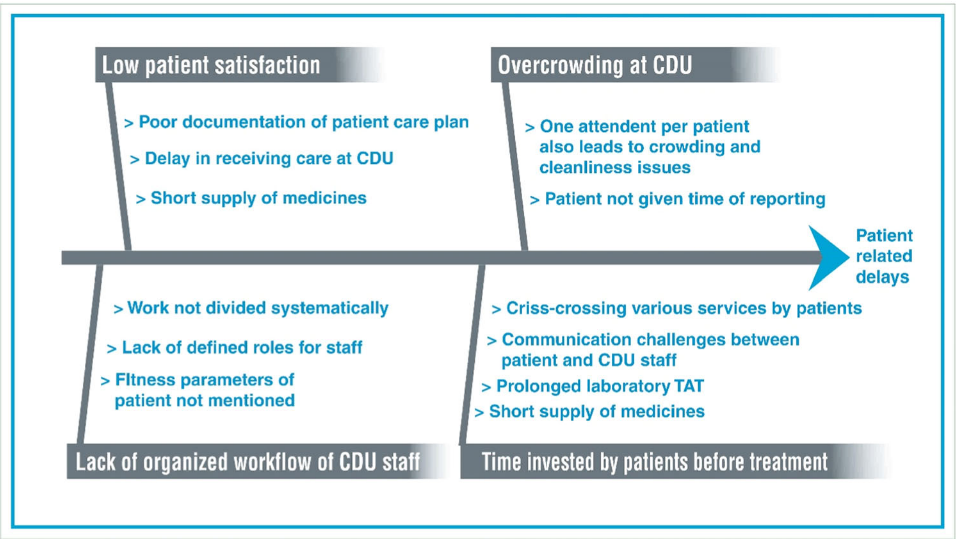

FIGURE 4 | Fish bone diagram of the root cause analyses.

The technique used to implement lean in the study is value stream mapping (VSM), which is a vital component of lean transformation [11]. It enables optimization of the processes supporting the patient journey, through initially mapping the activities and proposing an improved scenario for the future. The VSM tool as shown in Figure 5 was used for diagnosing the processes, communicating with the hospital staff and improving the PWT.

Kaizen event, a quality improvement initiative was conducted for enabling the buy-in of healthcare staff. Given its "learning by doing" approach, the multidisciplinary team visualized the process flow diagram (Figure 2) and was trained on the desired change in the process using the VSM (Figure 5). They were informed of the new metrics (PWT) for measuring the success of the intervention, and were encouraged to implement the revised workflow protocols. After the initial turbulent period of 3–5 days, the implementation of the new workflow was streamlined with the existing processes at CDU.

2.5 | Control the Future Performance

Following the validation of interventions, the workflow process was explained to the key stakeholders. The construct validity of the intervention was assessed by the patient satisfaction survey (Table 4: dependent cohort), which showed a significant difference in mean scores ($p < 0.001$). During this period of process change, the CDU staff was supportively supervised and the revisions were duly operationalized. To ascertain the sustainability of the interventions, the staff was periodically evaluated for conformity and the results of new metrics were shared with the Oncologist.

3 | Results

In this quasi-experimental study, the PWT of CDU process was assessed and its work efficiency was analyzed using other parameters of functioning. Table 2 shows the socio-demographic profile of patients, stratified as pre- and postintervention groups ($n = 95$ in each group). The primary outcome was PWT, which was measured by the observation of research team. Hence, the socio-demographic data were only described and no further analysis was done on this profile.

Table 3 depicts the three sigma control limits For PWT: upper control limit (UCL), lower control limit (LCL), and central limit (CL) (which is similar to the mean value). The mean PWT value is 75.7 min for the baseline (preintervention) cohort and 61.8 min for the post-intervention group.

Figure 6 depicts an I-control chart which was plotted considering the 95 samples. The mean ± SD of PWT values are 75.74 ± 3.95 and 61.8 ± 5.76 min for preintervention (baseline) and postintervention groups respectively. The mean difference in PWT between the two groups was 13.93 min, which was significant ($p < 0.001$) when assessed by the independent "t" test. This time series graph shows a 19% reduction in the mean PWT values, post the intervention. The Shapiro-Wilk test of normality for the PWT of patients in the pre- and post-intervention groups, provides the following statistics: 0.99 with p-value "0.668" and 0.979 with p-value "0.123" respectively. This indicates "normality" of data for the two-sample groups. The assumption is that "95" patients in each group represent an independent random sample of independent subjects, and the unknown variances of the groups are equal.

An important outcome of the lean technique includes assessing the impact of process change on the levels of patient satisfaction. The following two surveys (independent and dependent) represent the "voice of customer" analyses in the study. Table 4 depicts the results of patient satisfaction survey (95 patients each in the pre- and postintervention groups), where-in the independent "t" test did not show significance for the difference in mean scores ($\mu = 4.2 \pm 0.4$ and 4.3 ± 0.3, $p = 0.063$). The Shapiro–Wilk test of normality for the change in satisfaction scores of patients in the pre- and postintervention groups, provides the following statistics: 0.937 with p-value "0.345" and 0.898 with p-value "0.161" respectively. This indicates "normality" of data for the two-sample groups. The assumption is

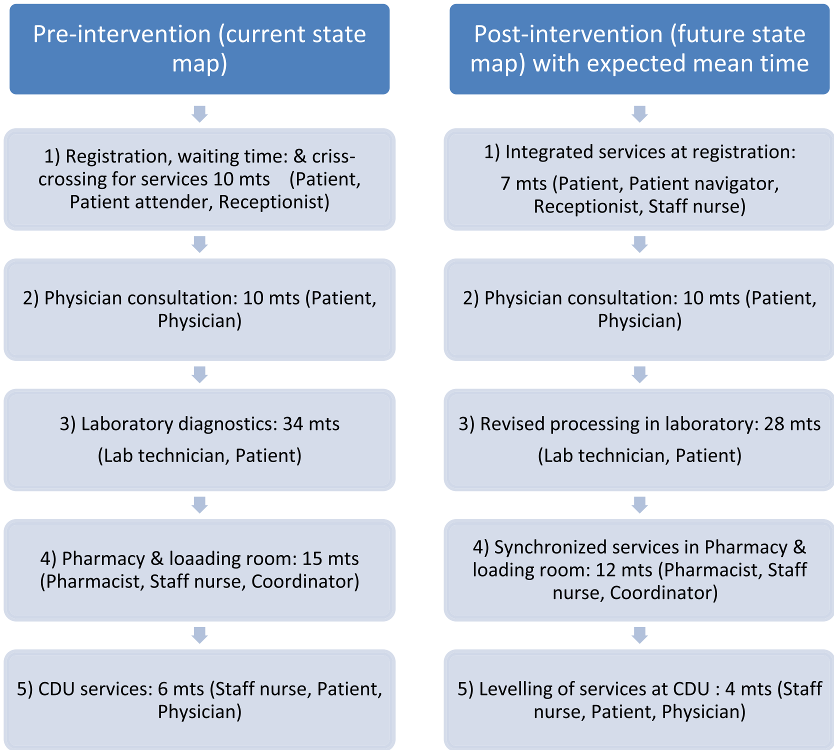

FIGURE 5 | VSM of services before infusion at CDU, mean time (minutes) and staff involved.

TABLE 2 | Socio-demographic profile of patients.

Sl. no.	Profile	Preintervention group *n* (%)	Postintervention group *n* (%)
1	Age (years)		
	18–49	55 (58.1)	51 (53.7)
	50–69	24 (24.7)	25 (26.3)
	≥ 70	16 (17.2)	19 (20)
2	Sex		
	Male	22 (23.6)	31 (32.6)
	Female	73 (76.4)	64 (67.4)
3	Residence		
	< 10 kms from hospital	43 (45.6)	39 (41.1)
	≥ 10 kms from hospital	52 (54.4)	56 (58.9)
4	Primary diagnosis		
	Breast	26 (27.6)	21 (22.1)
	Lung	7 (7.9)	12 (12.6)
	Gastro-intestinal	11 (12.2)	13 (13.7)
	Gynecological	13 (13.9)	7 (0.074)
	Head and neck	14 (14.6)	17 (17.9)
	Genito-urinary	6 (6.5)	11 (11.6)
	Others[a]	16 (17.3)	14 (14.7)
5	Payment method		
	Out-of-pocket expenditure	51 (53.3)	48 (50.5)
	Private insurance	44 (46.7)	47 (49.5)

[a]Includes hematological and neuro-endocrinal malignancies.

TABLE 3 | Three sigma control limits for the PWT.

Control limits	Mean (minutes)	SD (minutes)	Three-sigma control limits (mean ± 3 × SD)
Baseline (preintervention)	75.74	3.95	UCL = 75.74 + 3 × 3.95 = 87.59
			LCL = 75.74–3 × 3.95 = 63.89
Postintervention	61.8	5.76	UCL = 61.8 + 3 × 5.76 = 79.08
			LCL = 61.8–3 × 5.76 = 44.52

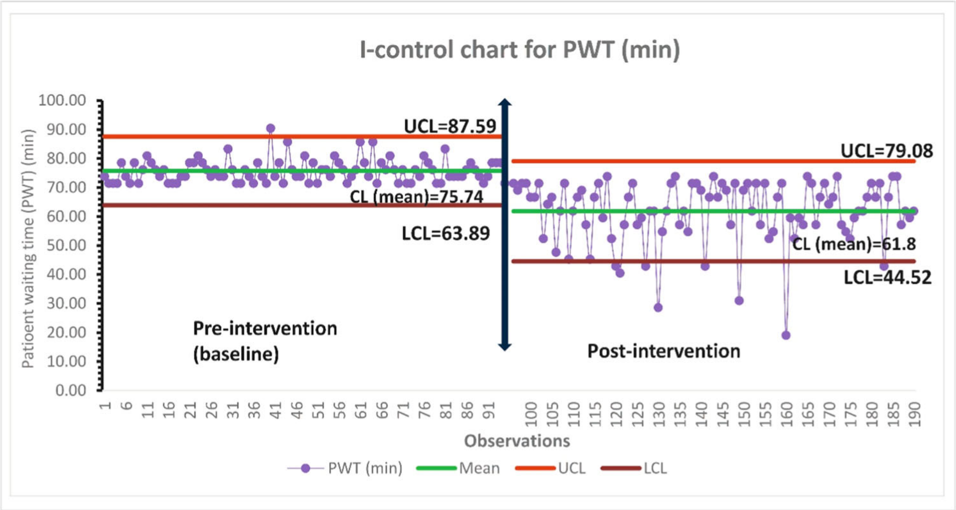

FIGURE 6 | I-control chart for PWT.

TABLE 4 | Independent survey on 95 patients in each group.

		Preintervention (in %)		Postintervention (in %)	
Sl. no.	Questions	Satisfied (Score = 5)	Dissatisfied (Score ≤ 4)	Satisfied (Score = 5)	Dissatisfied (Score ≤ 4)
1	Appointment booking	68.4	31.6	74.7	25.3
2	Doctor's consultation	70.5	29.5	76.8	23.2
3	Nursing care	72.6	27.4	78.9	21.1
4	Pharmacy service	43.2	56.8	54.7	45.3
5	Laboratory service	69.5	30.5	81.1	18.9
6	Housekeeping	43.2	56.8	48.4	51.6
7	Billing service	64.2	35.8	72.6	27.4
8	Overall daycare chemotherapy unit services	73.7	26.3	85.2	14.8

that "95" patients in each group represent an independent random sample of independent subjects, and the unknown variances of the groups are equal.

Table 5 shows the results of survey done on the dependent cohort of 20 patients, and the paired "*t*" test showed significance for the difference in mean scores ($\mu = 4.2 \pm 0.3$ and 4.8 ± 0.2, $p < 0.001$) between the pre- and postintervention groups. The assumptions include "20" patients representing a random sample of independent subjects, and the underlying distribution of change in satisfaction scores being approximately normal.

4 | Discussion

In this quasi-experimental study, PWT of the CDU process was assessed and its work efficiency was analyzed using other parameters of functioning. The study methodology was "lean-DMAIC," which enabled an improvement in the activities performed by the CDU staff. The bottlenecks were studied in detail and suggestions were provided to improve the efficiency. The "root cause analyses" facilitated the uncovering of critical causes for delay in patient care. The VSM enabled the mapping of process flow at CDU and minimize the nonvalue added activities as well as revise the value added ones. The

TABLE 5 | Dependent survey on the cohort of 20 patients.

Sl. no.	Questions	Preintervention (in %)		Post-intervention (in %)	
		Satisfied (Score = 5)	Dissatisfied (Score ≤ 4)	Satisfied (Score = 5)	Dissatisfied (Score ≤ 4)
1	Reduction in patient touchpoints	25	75	40	60
2	Presence of patient navigator	40	60	70	30
3	Organized workflow of nurses	50	50	60	40
4	Advent of drugs at the CDU	40	60	50	50
5	Decreased laboratory TAT	30	70	40	60

intervention includes lean process improvement initiatives toward reducing PWT and improving patient satisfaction. The 19% reduction in mean PWT (75.74 ± 3.95 vs. 61.8 ± 5.76 min) was significant ($p < 0.001$), which suggests an increased throughput in the process.

The effectiveness of lean methodologies in cancer diagnostics, drug delivery, and waste in the system was demonstrated in Aggarwal et al.'s study [3]. The study [3] used DMAIC approach as a platform to study the effectiveness in terms of improvements, revenue generation, and customer satisfaction. The results indicate that lean methodology has created an improvised work approach and a better understanding of generating revenues. Fichera et al. [12] followed the DMAIC approach for service level interventions in an oncology department, for increasing the patient satisfaction. A discrete event simulator was integrated with the value stream map tool, and several management factors were evaluated. The result of "lean-DMAIC" in the present study has the potential for revising process flow of a subset of oncology patients, and its impact on the efficiency of CDU. However, due to lack of randomization in the study design (quasi-experimental), important confounding variables have not been controlled.

Gjolaj et al.'s [4] study shows that streamlining workflows and placing a phlebotomy station inside of the chemotherapy unit, decreased the laboratory TAT by 53% for patients requiring same day lab and CTU (chemotherapy unit) services. During the study pilot, the wait time from patient arrival in CTU to being seated in the treatment area decreased by 17% [8]. The mean laboratory TAT was 24 min during the pilot phase, when compared with the baseline time of 51 min [4]. As depicted in VSM tool (Figure 5), the laboratory TAT in the study was purported to reduce from the current mean value of 34 min to a future state mean value of 28 min postintervention.

The effectiveness of lean healthcare technique and DMAIC approach in reducing waste in public hospitals in Mexico was reported by Hernandez et al.'s [2] study, where-in the outcomes include an improved medical supply process for the operating room. The different causes of inefficiency in the supply process were evaluated and controlled through different tools including a value stream map, Kanban method and the 5S program. The results of the study has direct effects on cost reduction, efficient resource utilization, and shrinking the staff processing time, which eventually leads to a better work climate. Alzahrani et al.'s [1] study implemented three PDSA cycles, which enabled the reduction on average PWT from a baseline of 2 h 27 min to an endline of 30 min. Zero drug wastage was ensured in their study through patient education measures, and patient satisfaction survey also showed enhancement following the changes.

In this study, the association of socio-demographic and clinical predictor variables was not studied in a regression analysis model. Hence, the possibility of controlling for confounding does not arise. These independent variables are collected in the qualitative form, and the outcome "PWT" is a quantitative dependent variable. Hence, the assumptions of linear regression such as linearity, homoscedasticity, normality, and multi-collinearity cannot be checked directly. Given the nonrandom nature of group assignments, regression analysis will provide unreliable results. Since patients are not assigned to the intervention randomly, there is no concept of randomization. Hence, intervention and nonintervention (control) groups do not exist. The systematic differences between pre and postintervention groups might continue to exist, which thus makes it difficult to establish causality.

In the study, the Kaizen participative activity facilitated the acceptance of the initiative by the healthcare staff. Baril et al. [13] report the implementation of a lean project according to DMAIC problem-solving procedure in an oncology clinic. This project includes a simulation model to validate the ideas proposed by the participants of Kaizen event, and provide evidence for achieving consensus. Such a model enables the reduction of barriers when implementing lean, which includes skepticism and lack of ownership of solutions [13]. During the Kaizen event, a business game enabled realizing the solutions and a discrete event simulation tested how the solutions could modify the PWT.

The patient satisfaction survey in the present study does not report any significance ($p = 0.063$) for the independent sample ($n = 95$) analysis, however, the dependent cohort ($n = 20$) showed a significant outcome ($p < 0.001$). The independent survey was conducted through the duration of 4 months (August to November 2022). Given the initial difference between the patients in the independent survey and their nonrandomized assignment for intervention, the alternative interpretation of the nonsignificant results was "maturation" [14]. Maturation is a threat to internal validity, which is interpreted as naturally occurring changes over time which mask the intervention effect [14]. Although patient satisfaction is influenced by various healthcare dimensions, the magnitude of effect in the study was determined by laboratory TAT, nursing care and pharmacy services (Table 5). The streamlining of these processes enabled reducing the healthcare touchpoints for patients, which resulted in significant patient satisfaction (for the dependent cohort).

Seshachalam et al.'s [5] study outlines a mean satisfaction score of 4.6 (SD, 0.3) out of 5, and the lowest score was for pharmacy services (mean: 3.96, SD: 0.67). All the patients were fully satisfied (score = 5) with doctor's consultation and appointment booking, whereas the proportion was 58% for nursing care and 25% for pharmacy services. The patients' complaints were associated with factors such as place of residence, payment method, waiting time for the oncologist, and flow of patients. The authors report that doctor's consultation and bed availability are key constraints, which lead to an uneven distribution of active nursing care in the daycare chemotherapy unit.

The present study suggests that establishing an efficient workflow for patients can emphatically impact the PWT. This includes organizational re-engineering measures such as reinstituting the phlebotomy services in the CDU, and effective processing of samples in the laboratory from batch to continuous flow as and when delivered. Such emendation of the course can categorically decrease the laboratory TAT. The operational efficiency was further improved by scheduling the chemotherapy appointments, in accordance with the availability of beds.

Adopting a lean technique in the study resulted in an improvised work approach, and an anticipative growth in revenue generation. The findings of the patient satisfaction survey are limited to the instrument used however variations of this tool have been used in other ambulatory oncology settings.

4.1 | Limitations

The research was implemented in one hospital center, and further multicentric longitudinal studies are required to understand the change process. Linear regression analysis was not conducted, which otherwise will enable the controlling of confounding factors and establishing causality. The subcomponents of PWT as listed in Figure 5, were not analyzed separately for statistical significance. The questionnaires of the patient satisfaction survey did not address the social and psychological causes of patient distress.

5 | Conclusion

The purpose of the study was to revise the workflow and decrease the laboratory TAT, which in-turn reduces the PWT. The activity was planned toward streamlining the CDU process by utilizing the existing resources. While implementing the lean technique using the DMAIC steps sanctioned the delimitation of problem, it also assisted in guiding toward a solution. The combination of these two approaches conduced an increase in efficiency of the infusion center. The benefits include reduction of PWT, hastening of process by the staff and efficient utilization of resources. Although lean is an advanced tool for enhancing revenue generation, by decreasing the PWT it also carries potential for increasing the satisfaction of both patients and healthcare staff. This approach will set a benchmark in patient management for other centers, and promote the benefits of using lean methods.

Author Contributions

Avani Radheshyam: investigation, writing–original draft, data curation. **Vinod K. Ramani:** conceptualization, project administration, writing–original draft, methodology, visualization. **Manohar Mhaske:** data curation, software, formal analysis. **Radhehsyam Naik:** funding acquisition, supervision, resources, writing–review and editing, project administration, validation.

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Ethics Statement

The study was approved by the Institutional Ethics Committee. Written informed consent was taken before conducting the patient satisfaction survey.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy/ethical restrictions. It contains information which could compromise the privacy of research participants.

Transparency Statement

The lead author Vinod K. Ramani affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Appendix

Project charter:

Sl. No.	Contents	Scope	
1	Aim	To improve the work efficiency of chemotherapy daycare unit (CDU) at a cancer hospital.	
2	Objectives	(i) To study the process flow of CDU and estimate the patient wait time (PWT) before infusion, (ii) To implement new measures for improving the functioning of CDU.	
3	Problem	The work load and time delays at the CDU are due to the increasing demands on the infusion center, laboratory, Pharmacy, and other clinical areas.	
4	Importance	The resulting patient-related delays reflect on the quality of system at the CDU. Identifying and streamlining the value added services and reducing the nonvalue added ones, critically enables a reduction of PWT and increased patient satisfaction,	
5	Expected outcomes	To revise the workflow at CDU and decrease the laboratory TAT, which in-turn reduces the PWT. The CTQ metric computed in the study is PWT, with a baseline of 75 mts and a target of 65 mts. The CTC metric as derived by the patient satisfaction survey is 'overall CDU services' with a baseline mean score of 4.2 and a target of 4.5	
6	Measures	The combination of lean-DMAIC conduced an increase in efficiency of the CDU, measured by a reduction of PWT, hastening of process by the staff, and efficient utilization of resources.	
7	Risks/Barriers	Resistance of staff members to accommodate process change initiatives in their routine activities, which was addressed through supportive supervision measures.	
8	Stakeholders	Cancer patients undergoing infusion services at CDU, multidisciplinary team involved with CDU activities, oncologist, hospital management, research team	
9	Scope		
	In scope	The planning system includes critical measures to improve the quality of services at CDU, including an information management system, process change tasks and a patient navigator.	
	Out of scope	Value stream mapping of the timelines of each activity associated with CDU, and improvement postintervention.	
10	Project team	*Team member*	*Project role*
		Dr. Radheshyam Naik	Lead and Principal investigator
		Dr. Vinod K. Ramani	Research coordinator
		Manohar Mhaske	Statistical analysis
		Avani Radheshyam	Investigator in research team