Developing a Performance Data Suite to Facilitate Lean Improvement in a Chemotherapy Day Unit

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Abstract

Purpose: A multidisciplinary team from the Peter MacCallum Cancer Centre in Melbourne, Australia, developed a performance data suite to support a service improvement project based on lean manufacturing principles in its 19-chair chemotherapy day unit (CDU) and cytosuite chemotherapy production facility. The aims of the project were to reduce patient wait time and improve equity of access to the CDU.

Methods: A project team consisting of a pharmacist and CDU nurse supported the management team for 10 months in engaging staff and customers to identify waste in processes, analyze root causes, eliminate non-value-adding steps, reduce variation, and level workloads to improve quality and flow. Process mapping, staff and patient tracking and opinion surveys, medical record audits, and interrogation of electronic treatment records were undertaken.

Results: This project delivered a 38% reduction in median wait time on the day (from 32 to 20 minutes; $P < .01$), 7-day reduction in time to commencement of treatment for patients receiving combined chemoradiotherapy regimens (from 25 to 18 days; $P < .01$), and 22% reduction in wastage associated with expired drug and pharmacy rework (from 29% to 7%; $P < .01$). Improvements in efficiency enabled the cytosuite to increase the percentage of product manufactured within 10 minutes of appointment times by 29% (from 47% to 76%; $P < .01$).

Conclusion: A lean improvement methodology provided a robust framework for improved understanding and management of complex system constraints within a CDU, resulting in improved access to treatment and reduced waiting times on the day.

Introduction

With burgeoning demand for complex systemic anticancer regimens, health care systems of many advanced economies face upward pressures on time to delivery of treatment. Accordingly, there is increasing evidence in the literature that excessive appointment delays within oncology treatment centers are a primary source of overall dissatisfaction among patients and health care staff.¹⁻⁵ The Peter MacCallum Cancer Centre (Peter Mac) is a public, tertiary referral, specialist cancer center located in metropolitan Melbourne and is currently the only hospital solely dedicated to cancer care in Australia. One of the busiest clinical units within Peter Mac is the chemotherapy day unit (CDU). This 19-chair unit, dedicated to delivering systemic anticancer treatments to day-admitted patients, currently provides upward of 1,000 treatment episodes per month. Since 2008, the CDU has experienced a 10% growth in demand per annum, far in excess of the 5% national growth predicted by the Australian Institute of Health and Welfare in 2008.⁶

In 2008, the chemotherapy treatment protocols of the hospital were integrated into the CHARM Oncology Information Management Solution (Charmhealth, Bardonia, New York, USA), which was implemented hospital wide to provide decision support and assist with patient booking schedules. Although this system captured a considerable amount of clinical and administrative information, extraction of meaningful data was complex, and fully automated management reports were nonexistent. In early 2010, staff concerns about managing the increasing demand were mirrored by a steady increase in the

number of complaints from patients and carers about waiting times in the CDU. However, the absence of meaningful performance data and appropriate partners for benchmarking rendered the CDU management team unable to articulate its performance and identify constraints to inform an improvement agenda.

In August 2010, a lean business improvement project (supported by a half-time pharmacist and half-time CDU nurse for 10 months) was commenced with the following four aims:

- Develop a suite of performance measures.
- Improve access to the CDU.
- Reduce waiting times on the day.
- Develop a mechanism for prioritizing patient appointments based on clinical urgency.

Methods

This project employed lean redesign principles,⁷⁻⁹ which focus on:

- Viewing the process and specifying value through the eyes of the customer
- Identifying waste in processes and eliminating non-value-adding steps
- Reducing variation and leveling workload to improve quality and flow
- Engaging the staff who do the work and customers who experience the work to redesign the work

A multidisciplinary project steering team comprising staff who routinely manage the service met monthly with the project

facilitators to govern the progress of the project. Three separate work groups (clerical, nursing, and pharmacy) with multidisciplinary representation were established and met fortnightly to support a series of largely discipline-specific interventions. Because of the lack of existing performance data, an extensive diagnostic phase of approximately 4 months preceded commencement of intervention in January 2011, using a series of PDSA (plan-do-study-act) cycles to refine strategies according to performance objectives.

Diagnostic Phase

A number of techniques commonly employed in lean improvement projects were used to identify constraints in the system and prioritize themes for improvement, including: multidisciplinary process mapping sessions of the patient journey on the day and production and delivery of chemotherapy; staff tracking of CDU nurses involved in direct patient care using spaghetti diagrams to identify waste in workflow¹⁰; an audit of daily run sheets to identify the percentage of missing orders and cancellations on the day; semi-structured staff interviews of seven medical consultants, five senior registrars, 18 nurses, three clerical staff members, six pharmacists, and five pharmacy technicians; and a patient opinion and satisfaction survey employing both structured and open-ended questions, which was returned by the first 100 unique patients in the CDU. Additionally, CHARM was interrogated for 2 years' worth of patient activity and treatment data to establish demand and performance trends.

The key baseline measures were defined as follows:

- Patient and staff satisfaction with the service.
- Patient demand and activity by day of the week.
- Patient access (time from referral to first CDU treatment).
- Patient waiting times on the day (time from appointment to treatment commencement).
- Predicted length of stay (LOS) versus actual LOS as a potential measure of waste (idle chair time).
- Chair utilization rates, cancellations on the day, and did not attends.
- Percentage of chemotherapy manufactured and released by the cytosome within 10 minutes of the scheduled appointment time.

Issues for improvement were themed and prioritized for intervention. An analysis of root causes using a fishbone diagram and the "five whys" approach¹¹ was completed for key prioritized issues.

Intervention Phase

Interventions were piloted in a stepwise approach over a 5-month period with project staff providing assistance with refinement of the strategies, including ongoing performance audit and feedback. The project team communicated regularly with the unit managers of the CDU and cytosome and assisted with communication of proposed work changes to frontline

staff. Nursing and pharmacy staff met fortnightly to discuss objectives and review interventions in light of any measured changes in performance. Standard work procedures were created for key flow management roles, such as the cytosome and CDU coordinator roles, which were considered to be pivotal in facilitating early authorization, preparation, and release of chemotherapy orders and which the diagnostic phase had revealed were person-dependent roles.

Evaluation Phase

Performance measures designed during the diagnostic phase were collated monthly. Two months after implementation of the full set of interventions, performance measures were compared with those at baseline and from an equivalent period the year before. Quantitative outcome measures were wait time (in days) to access first treatment, patient waiting times (in minutes) on the day of treatment, availability of chemotherapy in the CDU relative to patient appointments, and treatment chair utilization, all relative to changes in activity, namely number of treatment episodes and LOS. Quantitative parameters were presented as medians and interquartile ranges. Categorical variables were compared using a χ^2 or Fisher's exact test where appropriate. Continuous variables were compared using the Mann-Whitney U test. Statistical significance was demonstrated if $P < .05$.

Results

The CDU patient journey is illustrated in Figure 1, and a summary of key interventions and results is provided in Table 1.

Issues Prioritized for Intervention

The following issues were prioritized for intervention:

1. Inequity of treatment access for patients receiving combined chemotherapy and radiotherapy regimens, who are already disadvantaged by long-standing access block to radiotherapy (baseline: median delay to commence treatment for chemotherapy only, 7 days; for combined chemotherapy and radiotherapy, 25 days) and are further delayed by poor coordination between radiotherapy and CDU booking staff.
2. Waiting times on the day exceeding many patients' expectations because of a combination of suboptimal preparation and poor collective understanding of the chemotherapy manufacturing constraints, resulting in inadequate lead time for the cytosome to manage demand (baseline: percentage of chemotherapy manufactured within 10 minutes of patients' appointment times, 47%; proportion authorized for release to the CDU within 10 minutes of patients' appointment times, 15%).
3. Managing increasing demand with fixed capacity when chair utilization for a day unit was already 80%, and non-value-added time in the chair was $< 5\%$.
4. No clinically meaningful system to assist scheduling staff in prioritizing patient appointment slots based on clinical need.

Figure 1. Peter MacCallum Cancer Centre (Peter Mac) chemotherapy day unit (CDU) patient journey. With the current model of care, approximately 40% of patients report directly to the CDU on treatment day because required pathology is performed beforehand externally and medical review attended at Peter Mac 1 to 2 days beforehand; 30% of patients have medical review and required pathology on the same day as treatment at Peter Mac. Chemotherapy is released from the cytotoxic production unit of the pharmacy (ie, cytosuite) after nurse coordinator and clinical pharmacist review of the order and blood test results to confirm that these are consistent with the intentions of the treating team and safety of the patient.

Solution Design Phase

A range of solutions was proposed drawing on lean techniques, such as use of visual management aids, development of standard work procedures, just-in-time manufacturing, 5-minute team meetings to aid daily problem solving, performance measurement and feedback, and leveling out demand to improve flow. Possible interventions were critiqued by frontline staff in the three working groups for feasibility of the intervention in practice and its acceptability for both staff and patients. Feedback from the patient preference surveys was central to this process. Because of the complexity of issues surrounding waiting times on the day, a total of 10 separate interventions, some simple and some complex, were proposed (Table 1).

Patient Satisfaction Survey

A total of 100 patient survey responses were returned, accounting for a response rate of 67%. Ninety-eight percent of respondents were not first-time patients to the CDU; 44% had made between two to 10 prior visits, whereas 54% had visited the CDU on > 10 prior occasions to receive their treatments. Seventy-four percent of respondents preferred to receive their chemotherapy on the same day as their medical appointment to avoid making two trips, even though they were informed that this choice would result in substantially longer overall waiting times and LOS. Seventy percent of respondents preferred morning appointments, before 11 AM, and an additional 20%

preferred appointments between 11 AM and midday. No patients opted for appointment times after 5 PM[SCAP]. Forty percent of patients indicated preference for having their pretreatment blood pathology performed externally, close to home, to assist with a shorter length of stay on the day, with only 25% indicating they would prefer to attend the hospital on the day before treatment to ensure no delays in waiting for blood results on treatment day. The proportions of patients reporting they would be dissatisfied if they had to wait for their chemotherapy > 60, 30, 20, and 10 minutes were 78%, 57%, 30%, and 8%, respectively.

Despite service difficulties, overall patient satisfaction was high, with 78% of patients rating the likelihood that they would recommend the Peter Mac CDU as a place for cancer care to a friend or relative as 10 of 10 and an additional 20% scoring the likelihood between 7 and 9. Hence, despite issues with prolonged waiting time on the day, the CDU enjoyed a favorable net promoter score of 82%.

Access

A CDU access key performance indicator was developed to enable reporting to the board of directors, with the target of 95% for all time-critical patients commencing treatment within 14 days of referral to a pathway. However, this target was not met, with 79% of single-modality patients and only 38% of combined-modality patients commencing treatment within 14

Table 1. Summary of Key Interventions and Results

Improvement Goal	Intervention	Measure	Early Baseline (June to July 2010)	Project Baseline (September to October 2010)	Postintervention (June to July 2011)	P
Improve access for patients receiving combined chemotherapy and radiotherapy pathways	Established day-of-week demand pattern using historical data on combined-modality patients, and quarantined slots in CDU schedule for combined-modality patients only	Median wait (days) between referral to combined-modality pathway and commencement of treatment	26 days	25 days	18 days	< .01
	Quarantined slots were managed by weekly telephone conference between radiotherapy bookings clerks and CDU bookings clerks to ensure there was adequate space for patients nearing top of radiotherapy waitlist with urgent start dates	Check: median wait (days) between referral to chemotherapy-only pathway and treatment commencement	7 days	7 days	7 days	NA
Reduce waiting times on the day	Development of drug-specific scheduling business rules (based on manufacturing constraints pertaining to cost and shelf life)	Waiting time on day of treatment (appointment time to treatment commencement)				
	Increased advance medical record preparation and pathology request work (5 v 1 day in advance) by clerical, nursing, and pharmacy staff role redesign	Median 75th percentile	29 minutes 59 minutes	32 minutes 62 minutes	20 minutes 47 minutes	< .01 < .01
	Provided individual physician audit and feedback of performance around medical record availability and pathology requests	Check: median (interquartile range) No. of patients treated per day	40 (37-43)	39 (35-43)	43 (37-45)	.08
	Improved the visual management of priority orders through the Cytosuite by writing the appointment time and date on the outside of each tub in production line					
	Moved to just-in-time (24 to 48 hours in advance manufacture) instead of up to 7 days in advance manufacture to reduce drug waste and pharmacist time spent recycling chemotherapy products	Percentage of chemotherapy recycled or disposed*	N/A	29%	7%	< .01
	Used daily team huddle between cytosuite, CDU pharmacist, and CDU nurse coordinator to improve daily flow	Percentage of chemotherapy manufactured within 10 minutes of appointment	N/A	47%	76%	< .01
	Prereleased interventions to reduce traffic/interruptions on day checking to see if chemotherapy has arrived	Percentage of chemotherapy released to CDU (full authorization to proceed with administration) within 10 minutes of appointment	N/A	15%	31%	< .01
Improve capacity to manage demand	Developed agreed suite of clinically meaningful performance measures to enable demand management	No. of measures	1	1	7	
Improve consistency of access based on clinical need	Developed agreed categories for determining priority for access based on three clinical urgency categories; however, delays to inclusion of categories in treatment planning questionnaire within e-prescribing platform prevented timely pilot and hence evaluation	Percentage commencing within category target	No agreed category system	No agreed category system	Three categories by clinical urgency†	Not able to pilot test during project

Abbreviations: CDU, chemotherapy day unit.

*Chemotherapy wastage results were based on two 5-week audits at baseline and postintervention.

†Category one, urgent: treatment to commence within 2 days. Definition: patient at imminent risk of significant complication or deterioration if chemotherapy not started within 2 days (eg, imminent airway obstruction, superior vena cava obstruction). Category two, semi-urgent: treatment to commence within 7 days. Definition: patient at significant risk of complication or deterioration if chemotherapy not started within 7 days (eg, rapidly progressive disease or advanced disease with risk of critical organ and/or structure compromise). Category three, next available appointment: treatment to commence within 14 working days. Definition: all other groups of patients not meeting above category criteria (key performance indicator, 95% commencing within 14 days).

days of referral. Although inequity of access for the combined-modality patients was not an unexpected finding, the availability of linear accelerators for radiotherapy treatment and not CDU chair availability was identified as the major rate-limiting step for chemoradiotherapy access. However, a simple scheduling intervention (Table 1) successfully produced a 7-day reduction in wait time (from 25 to 18 days; $P < .01$), with no

consequence on median access for single-modality patients (constant at 7 days).

Capacity, Demand, and Chair Utilization

Utilization was initially calculated at 85%; however, this dropped to approximately 80% after a review of nurse-to-patient allocations and teamwork models, which enabled an in-

crease in capacity of 30 minutes per chair per day without additional nursing hours. To assist with this analysis, aimed at providing greater flexibility to accommodate longer treatments and improved patient flow, nursing hours per patient hour (total number of paid direct care nursing hours rostered per hour of direct patient treatment time) were calculated and found to be 0.48, which equated to a nurse-to-patient ratio of closer to 1:3 than 1:4. A comparison of predicted pathway length (incorporated in the e-prescribing platform) with actual LOS (which includes both value-added and non-valued-added time) revealed consistently < 5% difference with minimal variation, indicating little idle time in the treatment chair. In view of this finding, no interventions were targeted toward reducing waste during treatment. Average LOS in the chair was 130 minutes.

Waiting Times

An analysis of root causes revealed a multitude of contributing factors causing patient delays on the day, with the vast majority related to process issues. The main themes highlighted were:

- Inadequate prework (delays in authorization of chemotherapy orders, patient reviews on the day of treatment, and waiting for late blood pathology results)
- Combination of high-cost drugs, short expiry, and rigid trial stipulations limiting the proportion of chemotherapy that could be manufactured before confirmed patient arrival
- Cytosuite staff have limited visual management of the priority orders in the production line and cannot easily confirm patient attendance before commencing the manufacture of high-cost drugs

Patients' wait from appointment to treatment commencement was calculated from electronic data. The median and 75th percentile waits improved from 32 to 20 minutes (38% reduction; $P < .01$) and 62 to 47 minutes ($P < .01$), respectively. Although baseline waiting times did not seem unacceptable to staff, results from the patient survey showed 57% of patients indicated they would be dissatisfied if they had to wait > 30 minutes. These delays were often not communicated to patients ahead of time because chemotherapy production constraints (often quite predictable to pharmacists) were not widely understood by nursing staff. This gap between patients' expectation of service and the service that they actually receive is perceived as a sign of poor quality and has been reported on previously.¹² Key interventions aimed at reducing wait times and current performance data are summarized in Table 1. Other data for benchmarking are summarized in Table 2.

Discussion

This project has delivered significant gains for the CDU team and its patients, including a 38% reduction in median patient waiting time. Improved efficiency has allowed a two-fold increase in timely availability of fully authorized chemotherapy and a 22% reduction in wastage associated with expired drug and pharmacy rework.

Although most of the recommendations of the project reference group were adopted, certain recommendations, such as acquisition of a portable pathology machine, could not be accommodated because of high cost. Furthermore, the suggested change to conduct more medical reviews of patients at least a day before treatment, although likely to reduce patient wait time by providing the cytosuite with greater lead time for chemotherapy production, would require patients to attend the hospital on two separate occasions, which was against majority patient preference (74%). Although patients were able to articulate their preferences for treatment choices, they seemed less able to respond to open-ended questions in the survey, which sought description of thoughts and feelings. There may be some element of bias in the responses received from these patients stemming from an eagerness to please. Most respondents felt the need to compliment the quality of service received during their care within the CDU. As such, the project team saw little value in repeating the survey to evaluate patient satisfaction with the interventions, given that ongoing staff and patient feedback guided implementation.

With the availability of performance measures, CDU initiatives are now directed at reducing LOS by optimizing use of antiemetics, switching from intravenous to oral where appropriate, and using longer-acting 5HT₃ antagonists for fractionated daily treatments. However, efficiencies gained during our project could not be readily translated into funded increased patient throughput because of the existence of activity-capped funding arrangements. In Victoria, public hospitals are funded according to a case-mix, activity-based funding system, with day chemotherapy facilities generally earning a standard case-mix payment, expressed as WIES (ie, weighted inlier equivalent separation) for every treatment episode. Hospitals receive full funding up to an activity target; thereafter, funding is at a marginal rate up to a second target. Consequently, in some operating environments, like that of Peter Mac, where demand has exceeded the funded activity targets, there exists a perverse disincentive to increase throughput when there will be no corresponding increase in activity-based reimbursement. Despite this disincentive, public demand for cancer treatment is high, and there is considerable pressure on health services to increase efficiency and reduce waste to enable more patients to be treated at the same or reduced cost.

It is in this health care environment that lean improvement methods have achieved increasing popularity, with many different health services in a variety of settings publishing positive results from adoption of lean techniques.^{8,9,13-15} The success of lean business improvement methods has been previously reported at a day oncology center in the Netherlands, where authors showed 12% increase in staff member productivity after lean process improvement⁵ and in a cytosuite to reduce waste associated with process variation and error.¹⁶ On reflection, one of the greatest benefits of this project was the development of multidisciplinary teamwork after the process mapping events, which led to a new appreciation for the constraints of each craft group and how they affected patient experience. Indeed, lean methodology continues to support a multidisciplinary prob-

Table 2. Presentation of Other Demand, Capacity, and Workforce Data for Benchmarking

Factor	Netherlands Cancer Institute 2007	Peter MacCallum Cancer Centre Q3 2011
No. of chairs/beds	30	19
Median No. of patients per day	—	48
No. of colocated specialist consultation rooms	—	4
No. of patient visits per annum	15,662	12,000
Average No. of visits per chair per annum	522	632
Average nursing FTEs	12.21	12.5
Average all-staff FTEs	21.75	20.1*
Average treatment time, minutes	132	130
Average No. of nursing hours per patient hour of treatment	—	0.48†
Median wait on the day from appointment to treatment commencement, minutes	—	20
Median delay from referral to treatment to treatment commencement (chemotherapy only), days	—	7
Median delay from referral to treatment to treatment commencement (combined chemotherapy and radiotherapy [approximately 25% of workload]), days	—	18
Percentage of patients who have medical review on same day as treatment	—	~ 30
Chair utilization, %	—	80
No. of patients who experience cancellation on day, % of total	—	10
No. of unique chemotherapy pathways prescribed	—	570
No. of products manufactured by cytosuite per annum	—	30,000
Cytosuite FTEs (two pharmacists, four technicians, one robot)	—	6

Abbreviations: CDU, chemotherapy day unit; FTE, full-time equivalent; Q3, third quarter.

* Total Peter MacCallum CDU FTEs: 12.5 nursing, 1.5 pharmacist, 1.6 patient services assistant, four clerical.

† Nursing hours based on direct care nurses (excludes supernumerary CDU nurse coordinator and manager).

lem-solving approach within the CDU leadership team, as evidenced by joint ownership of the new performance measures monitored monthly at a combined CDU management team meeting. Undeniably, the demand for cancer treatment in most advanced economies is on the rise, resulting in a flurry of public strategy, planning, and investment to prepare for the future needs of our community. Although recent innovations in surgical oncology are leading to shorter LOSs with more-targeted and often less-invasive interventions, the same is not always true for trends in the delivery of chemotherapy. Indeed, evidence suggests emergence of more-complex multiagent and fractionated regimens has resulted in increased LOS. With the push to accommodate more chemotherapy regimens within the ambulatory setting, there is not only increased demand on CDU treatment spaces but also further scheduling complexity associated with maneuvering lengthy treatment schedules into an ambulatory facility within limited operational hours. Unlike the well-accepted targets for waiting times for elective surgery, there are currently no nationally agreed targets for waiting times or guidelines for prioritizing which patients receive the next available chemotherapy or radiotherapy treatment slot.

We agree with van Lent et al⁵ that there is a need to benchmark performance around capacity, demand, efficiency, and service to ensure a high standard of care and meet the increasing number of new chemotherapy referrals. Indeed, understanding the capacity and demand equation is of paramount importance to system-wide service planning and underpins the need for long-range infrastructure and workforce planning, which will be critical if we are to meet the needs of future patients with cancer.

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