Article

Cancer clinic redesign: Opportunities for Resource Optimization

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Abstract: Ambulatory cancer centers face fluctuating patient demand and deploy specialized personnel who have variable availability. This undermines operational stability through misalignment of resources to patient needs, resulting in overscheduled clinics, high rebooking rates, budget deficits, and wait times exceeding provincial targets. We describe how deploying a Learning Health System framework led to operational improvements within the entire ambulatory center. Known methods of value stream mapping, operations research and statistical process control were applied to achieve organizational high performance that is data-informed, agile and adaptive. Caseload management by disease site emerged as an essential construct that incorporates disease site teams into adaptive, reliable care units, clinically and operationally. This supported clustering interdisciplinary teams around groups of patients with similar attributes, while allowing for quarterly recalibration. Systematic efforts were made in the negotiation required to implement changes that impacted physicians, nurses, clerks, and administrators. Feedback mechanisms were created with learnings curated and disseminated by a core team. The change aligned financial expenditures to the regional demand for specialized services and smoothed clinical operations across 5 weekdays and 2 centers. The impact was predictable, optimized expenditures, increased efficiencies across human and physical resource deployment and improved disease site collaboration in patient care.

Keywords: learning health system; ambulatory clinic, block schedule, disease site teams, interdisciplinary care, cancer operations, oncology value stream

1. Introduction

Ambulatory cancer centers face fluctuating patient demand and deploy specialized personnel that have variable availability. This paper describes an operational redesign of a cancer clinic outpatient facility, serving a regional population, to address efficiency, sustainability and stakeholder requirements in an ever-evolving landscape of clinical demand.

The Champlain regional cancer program is anchored by The Ottawa Hospital (TOH), an academic health science center that serves a population of 1.5 million people. The program provides specialized services by cancer disease sites including medical, radiation and surgical oncology clinics, in addition to palliative care and survivorship clinics. Some disease sites provide clinics that are multidisciplinary in scope and patients see different types of oncologists with similar focus in the same physical location. Overall, the ambulatory cancer centre provides more than 100,000 clinical encounters annually including more than 12,000 initial consults.

The challenges of providing cancer care for a population are intensified by struggles with resource utilization and demand/capacity balance at major nodes along care pathways such as ambulatory cancer clinics. The goal of optimizing services within these pathways is universal in order to improve patient outcomes and experiences within the allocated physical, human and financial resources [1] [2]. Our previous work identified that a unifying approach to this challenge could be achieved using a system level strategy anchored in an iterative learning and design process. In that paper, we focused on integration of lung cancer services from diagnosis to initiation of treatment resulting in an award-winning diagnostic program [3]. Other practitioners have documented these systems-based approaches together with a learning health system vision as successful in meeting similar challenges [4], [5]. The attributes of such a global vision have been documented by Institute of Medicine and several other bodies [6] [7].

Defining the problem

Prior to the intervention, our clinic performance was similar to other Ontario academic health science centers [8] [9]. Symptoms of a system under stress included budget deficits, overscheduled clinics, high rebooking rates, inconsistency in nursing allocation to patient acuity, and wait times for service that exceeded provincial targets. Delays in cancer care can have a substantial negative impact on patient outcome [10] so careful attention to optimizing access to constrained oncology resources is very important. Our system lacked operational flexibility to manage shifting demand for service due to multiple demographic and therapeutic factors, as well as fluctuating availability within provider teams. The complexity of ambulatory clinic environments is an acknowledged challenge to creating efficient operational models [11]. Operations research has focused on the unrealized opportunities in ambulatory scheduling, including block schedules, as well as methods for potential improvements throughout cancer care pathways [12] [13] [14].

The demand/capacity mismatch has a number of fundamental constraints that represent substantial quality dimensions. Physician providers maintain an individual practice for continuity of care while working across multiple disease sites to provide specialized oncology services within a finite system. Preserving this requires a management approach that maximizes resource utilization, teamwork and alignment between the collective agreements and professional expectations of nursing, physicians and clerks. The previous clinic model was problematic and wasteful. It was based on a historical model centered around physician availability and preferences. The oncology nursing team is profoundly impacted by clinic design and the previous model challenged their delivery of specialized care utilizing disease-specific expertise. It did not effectively and equitably align resources to evolving, specialized demands and did not efficiently repurpose resources from clinics scheduled for unavailable providers. Professional responsibilities beyond the ambulatory clinic, scheduled personal time and unexpected HR issues, generated by 50 physicians, are expected to total 600 provider-weeks annually.

This paper applies our systems-based approach to optimization of the oncology ambulatory clinic and supports optimization of disease site based services. This challenge of optimizing central resources (HR, space & finances) to support multiple individual providers, multiple disease site groups, and varying temporal and disease specific demands is a critical step in the redesign of cancer care.

2. Materials and Methods

Description of the initiative:

To simplify our scheduling operations and recognize the dynamics of both demand and capacity, we adapted and implemented a block schedule approach to clinic scheduling. Block schedule models are widely used to manage allocation of surgical capacity to different surgical specialty teams [15], [16], [17]. These models have the advantage of allocating resources within an overall budget to specific groups of providers serving a specialized pool of patients. Management of capacity within these specialized service domains can be achieved by creating the capacity for repurposing unused resources between providers and teams. This paper demonstrates the adaptation of these concepts to a version applicable to an ambulatory oncology clinic.

The new model sets data-informed targets by disease site that predict service demand six months in advance to allow for capacity planning. Five key elements in block schedule design included:

1. Converted service delivery (high acuity and low acuity) and provider capacity into common units (service delivery minutes) to support comparison, assessment.
2. Reviewed current allocation and identified disparities in resource alignment.
3. Created a quarterly predictive model, including capacity for unexpected demand, to coordinate provider availability within disease sites
4. Active visibility of future gaps in service or constraints in resources supports dynamic allocation of unused capacity.
5. Development of disease site home-bases that aggregate individual practices with nursing and clerical resources, reinforcing the disease site team approach.

Demand / Capacity Analysis

We categorized clinic demand-capacity concerns at the macro and micro level using established methods of operational analysis [18]. Clinic services delivered (demand) and clinics actually assigned (capacity) were retrospectively reviewed for a one year period. Demand: Each service delivered was assigned to a disease site group based on the most recent cancer diagnosis of the patient and was described in scheduled hours. The delivered services were designated "subacute" if they were provided to a patient that had no history of any palliative intent treatment and had not received any curative treatment within the preceding six months. Capacity: Each provider was assigned to disease site teams based on the percentage of their annual services delivered to patients within that disease site group. The capacity of service hours assigned to each provider in the "template" model was tallied, excluding statutory holidays when the clinic is closed.

Block Schedule

The intent of the block schedule was to offer a quarterly map of service delivery (capacity) to meet the service demand calculated in the demand analysis. Past delivered services are estimated to represent current demand. The cancer clinic activity was sorted into disease site groups within each oncology division (medical and radiation). The disease site groups were breast, gastrointestinal, genitourinary, lung, dermatological, gynecological and head & neck. All other services were designated within a miscellaneous disease site category "Small" or were pooled into the larger groups based on the affiliations of the providers. Total half day clinic sessions to be planned for the quarter were designated as the estimated service demand plus a logistics overhead margin. Types of clinics include consult, follow-up, subacute and interdisciplinary based on anticipated demand for each of these types of service. Seasonal smoothing is given using a rolling 9-12 month analysis period to calculate expected service demand for an upcoming quarter.

Logistics Overhead

Overhead margin recognizes that multiple factors impact conversion of capacity to delivered services (i.e there are realistic contingencies in running a clinic such as physician sick days, weather events, etc.) We adopted an initial operational margin of 70% as a standard of manufacturing and project management, however the logistics overhead is ultimately an arbitrary value [19]. The available capacity in the block schedule provides flexibility within defined budget for adjustments required due to unplanned personnel issues or weekly or seasonal spikes in service demand. In essence, we ensured that there was 30% more capacity (more clinics available) than what demand would have predicted.

Block Schedule Quarterly Workflow

Our block schedule contains a regular week and a “short week” template. Analytical tools provide real time reporting on allocation of clinics to providers within each division and expected nursing staff required for the quarter. Changes after construction of the block in the EMR are managed through a controlled change process to swap available sessions in the block schedule and update the EMR reliably.

Advanced Access Scheduling

Appointments in the cancer clinic address urgent, semi-urgent and non-urgent clinical concerns ranging from oncological medical crises to routine checkups after a history of prostate or breast cancer. Advanced access scheduling is a best practice strategy to address these challenges and improve clinic performance [20]. It involves designating portions of the clinic template for short term (urgent) and long-term (planned) activity so that the planned activity does not overwhelm capacity for urgent activity.

3. Results

3.1. Demand Capacity Assessment

We compared the total clinic services delivered in a one-year period to the total clinic hours nominally assigned to each disease site team (Figure 1). The total delivered services would have required 12,078 half day clinic shifts for delivery without over-scheduled or over-time clinic. The actual clinics planned in the template for the year were 9937, suggesting that the center had been at 122% of capacity in overscheduled and/or overtime clinics. Since some clinics are cancelled without scheduling another clinic in that time slot to replace it, the actual rate of overscheduled or overtime clinic service was higher than the calculation. Individual disease site teams had variable degrees of balance between demand and capacity. Services delivered to patients that had no history of palliative treatment and had completed their most recent curative treatment more than 6 months previously were characterized as subacute, although clinical needs in this population vary substantially between disease site groups.

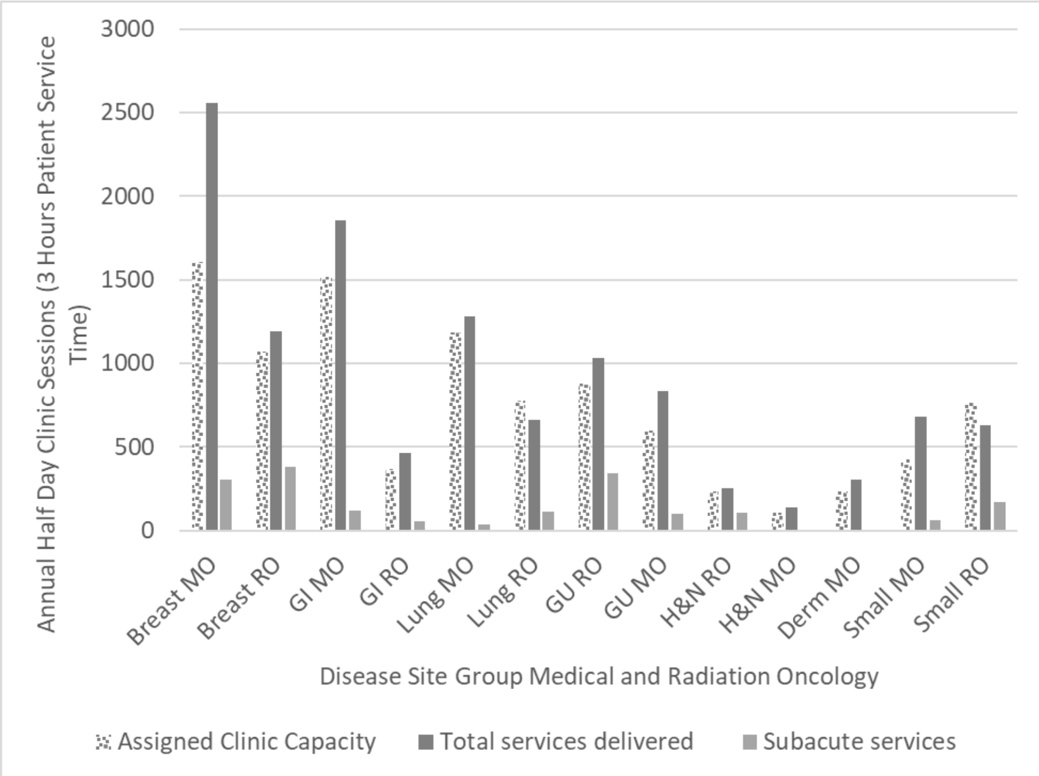

Figure 1. Annual service delivery was compared to scheduled capacity by disease site. Assigned capacity and delivered services did not match because there was no mechanism to align. Subacute services are >6 mo post curative treatment and are nominally least urgent services in center. (Jul 17-Jun 18)

3.2. *Advanced Access Scheduling*

Our old workflow generated high rates of appointment rebooking and clinic overscheduling because the clinical appointment calendar was open for 24 months in the future. The advanced access scheduling workflow discontinued booking any patient appointment more than 90 days in the future. These changes reduced monthly center-initiated cancellation and rebooking of patient appointments from more than 1512 in 2016 to less than 847 in 2019 (Figure 2). Regaining control of the future calendar was an important prerequisite for transition to a dynamic model with quarterly updates.

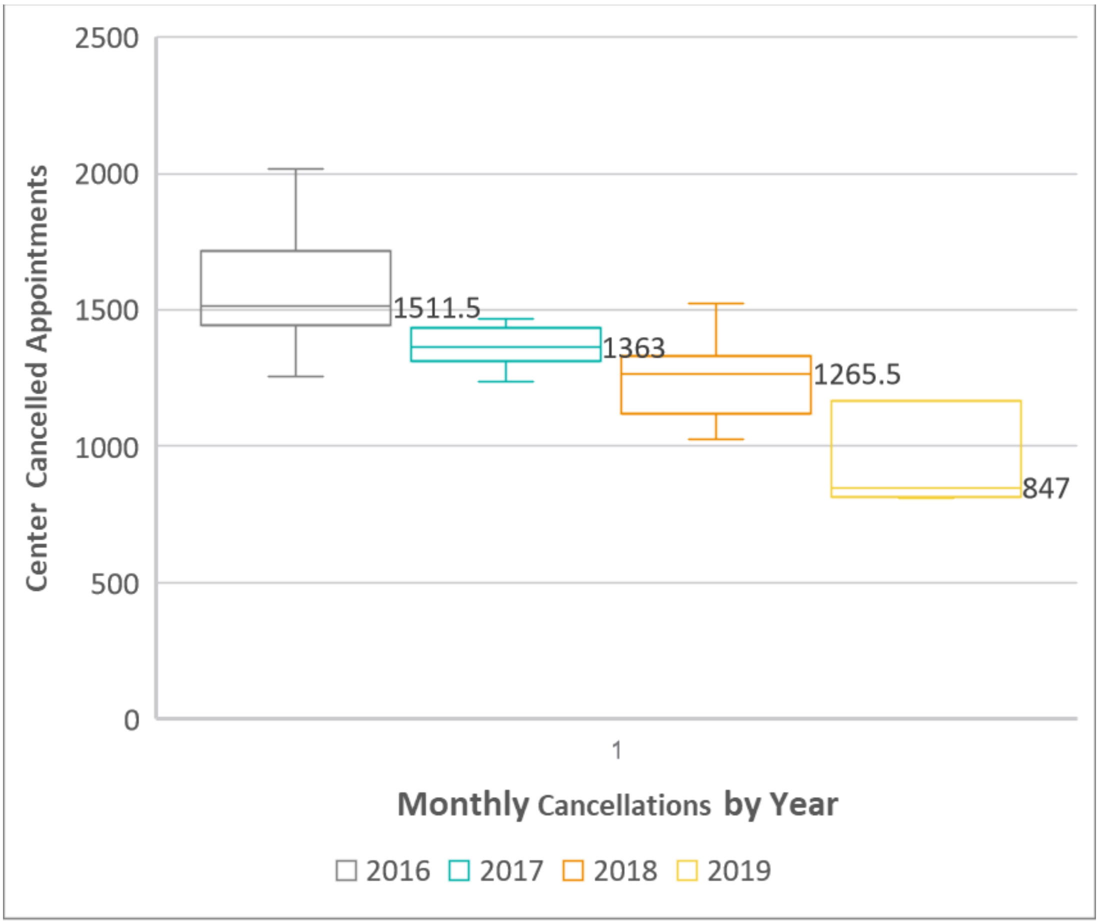

Figure 2. Advanced access scheduling was an operational prerequisite for a dynamic scheduling model. Appointment cancelations decreased and calendar was available for quarterly update.

At the micro level, our clinic experienced a constant churn of absent providers and requests for additional clinics. The median monthly clinic cancellations were 211 with a range from 121 to 290 cancelled half day clinics. Providers offered limited, urgent coverage to each other's patients during their absences. This model generated constant, high volumes of requests for clinics outside the provider's usual template, with high operational energy and cost of operations.

3.3. *Implementation of Quarterly Block Schedule*

The block schedule provides a flexible, modular, planned model for clinic operations. Visibility and control of the operation are improved, while key medical and nursing professional needs are supported (Table 1).

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Table 1. Comparison of Standing Template to Block Schedule Operational Model for Ambulatory Oncology Clinics

Aspect	Standing Template Model	Block Schedule Model
Physician Attendance	Oncologists in clinic ~ 40 wks/yr, variable mix of planned and unplanned absences	Oncologists in clinic ~ 40 wks/yr, variable mix of planned and unplanned absences
Physician Planning	Each physician has standing template of weekly clinic schedule and cancels unwanted shifts	Each physician defines expected quarterly schedule in advance including planned absences within total division footprints
Workload around vacation	Constant churn of physicians requesting makeup clinics before and after absences	Total clinics for quarter planned and staffed then swapped around as necessary aligned to annual workload expectations
Access to Consult	Variable capacity to see new patient consults depending on occupancy of standard templates	Consult clinics separate from other work can be reassigned to available providers to maintain acceptable patient access
Workload and Cost of Staffing	Constant churn of nursing and clerical staffing between scheduled, cancelled and makeup clinics combined with vacation/sick calls, variable and unstructured office time	Staffing needs and vacation planned quarterly in advance and resource team is only needed for sick calls. Patient navigation workload time planned and assigned with duties.
Physician Oversight	Annual physician reappointment meetings to discuss career goals, disease site professional focus areas	Quarterly opportunity to adjust match between demand and capacity, monitor alignment to annual workload goals
Budget Control Weekday Clinic Allocation	Budget and space concerns if new physician joins team and needs dedicated clinic template assigned Competition for Tuesday; nobody wants Fridays	No change to budget or space when new members join team within total workload based on budget and regional demand. More providers can use Tuesdays and participate on Fridays
Alignment Demand / Capacity by Patient Groups	Unclear match, rarely updated, between regional demand for disease site services with allocation/assignment of medical and interprofessional resources	Total amount of clinical services to deliver per disease site defined by regional demand and resources allocated as total quarterly clinical hours – disease site footprint
Interdisciplinary Clinics	Difficult to plan consistent interdisciplinary clinics	Interdisciplinary clinics allocated sessions of resources and staffed by process within team

The following features were implemented within the block schedule model and are changes from the template model:

- By creating specific capacity to meet regional service demand, the clinic budget became tied directly to patient demand for specific services.
- The clinic budget is not impacted if providers enter or depart. Total services planned remain stable and the provider team can determine staffing strategies.
- Interdisciplinary clinics are planned in advance to desired volume and staffed within a defined envelope.
- Scheduling into the block schedule quarterly provides a structured method to adjust to current conditions in demand and capacity including personnel issues
- Creating the capacity to repurpose available clinic shifts supports the expected behavior of providers and enables swapping of clinic capacity within a defined overall budget.
- The model increased consistency of operations promoting larger percentage of full-time staff that are well-utilized during all shifts.
- The schedule clusters interdisciplinary teams around groups of patients and promotes timely, responsive, patient-centered care as well as provider work-life balance.

*3.4. **Outcomes***

The cancer clinics operate out of 6 physical modules containing 8 – 16 exam rooms, located within two sites. Prior to the scheduling change, the activity level varied between modules of similar size and within each module from week to week. The average weekly encounters ranged from 42 in Mod C to 312 in Mod A (Figure 3). The average weekly encounters now range from 205 in Mod F to 400 in Mod A. These data indicate services are being distributed more evenly through the available clinic capacity and underutilized weeks have been decreased. The underutilized weeks are a significant root cause of unnecessary expenditures as full-time staff cannot be reduced dynamically in response to reduced activity.

The block schedule was implemented simultaneously with the launch of an electronic medical record (EMR). The post-launch period was one of reduced service volume as the center adapted to these large changes. By the following year, activity rebounded above pre-change levels in spite of adaptations to pandemic operations including increased virtual and telemedicine care.

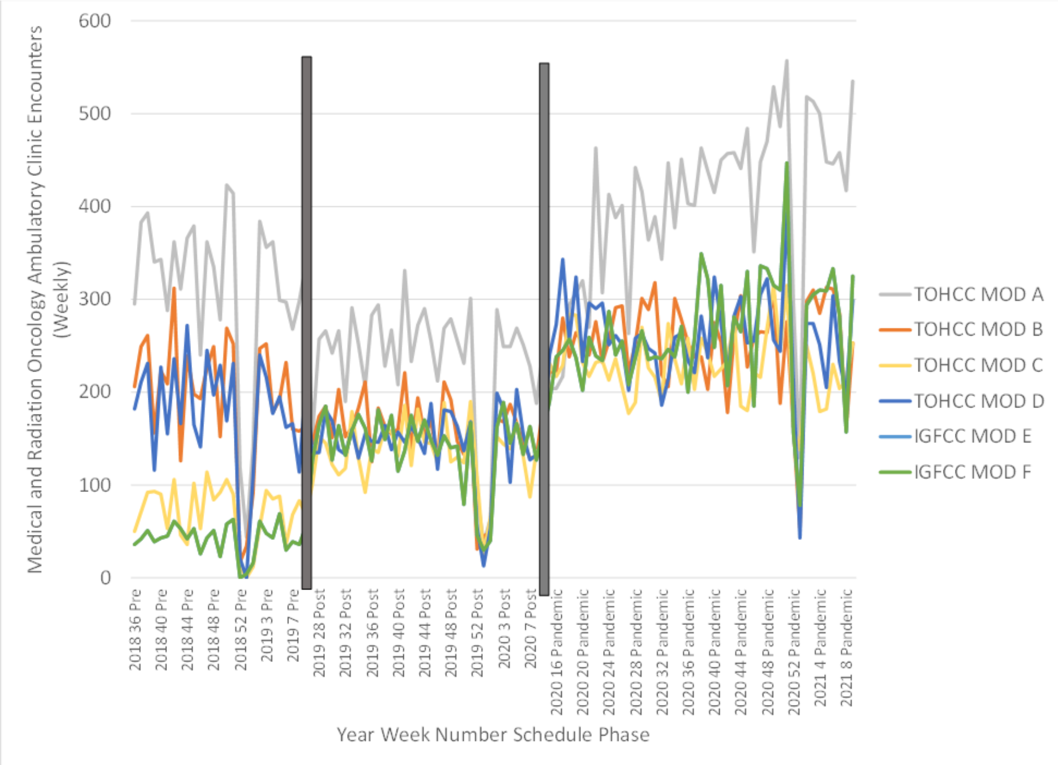

Figure 3. The weekly activity in the six modules became less variable between modules and between weeks. Variable activity results in overstretched or underutilized staff. In the pre-phase Modules C and F were underutilized and variability was higher than in the post and pandemic phases. Module A is larger than the other modules.

At the clinic operational level, staffing must be resolved on a daily basis. Clinical activities, planned absences and last minute sick calls of physicians and nurses are arranged in order to make a viable daily plan for the clinic. Variability in clinical volumes complicates the challenge of arranging for a matching complement of providers. It is preferred to have similar clinical volume and a consistent nursing quota each weekday, e.g. Tuesdays. Routine variability between weekdays, like between busy Tuesdays and slow Fridays, requires more part-time or casual staff to match the variable volume.
Implementation of the block schedule reduced variability within and between each weekday (Figure 4). The range of total encounters on Tuesdays was decreased from 505 to 302. In the Pre state, average Friday activity was 56% of Tuesday activity while in the most recent Pandemic period, Friday activity is 69% of Tuesday activity. These data indicate that utilization of clinic resources is more consistent and even between weekdays, promoting a consistent workforce.

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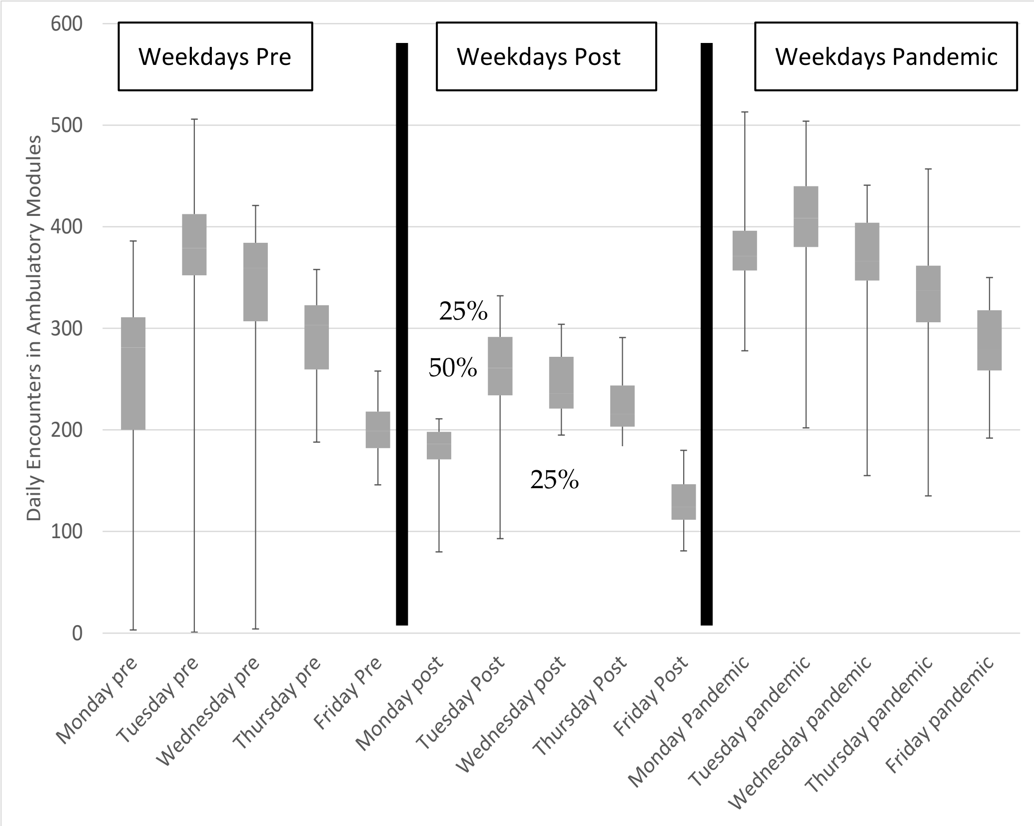

Figure 4. Daily encounters on each weekday are less variable. Box plot contains 50% of period totals for the weekday in the box and 25% of the weekdays in the period are in each whisker. Low volume days have been reduced; each weekday is less variable week to week and the difference between Tuesdays and Fridays is reduced. Phases: Pre 9/18-2/19, Post 7/19-2/20, Pandemic 8/20-2/21

The purpose of the block schedule was to reduce the variability in the volume of service delivery by providing better visibility, planning and control to clinic operations. When services are distributed more evenly and underutilized weeks are decreased, operations are more predictable. Predictability makes it easier to staff the clinic with the right number of professionals to deliver the scheduled amount of care. This matching between activity and staffing takes place on a daily basis with a nominally similar weekly plan for each weekday.

The variability of total clinical encounters from one Tuesday to the next and between Tuesdays and Fridays is the overall variability the block schedule was intended to reduce. This is the variability that deviates the center from the same staffing targets at the clinic each day. The coefficient of variation (standard deviation/mean) measures the distribution of data away from the mean. To assess the overall variability of the weekdays during the three time periods, the coefficient of variation for the 5 weekdays in the period was averaged together. This overall variability of the 5 weekdays clinical volume was reduced following implementation of the block schedule (Figure 5). Implementation of the block scheduled reduced variability of service volumes across all weekdays and clinic locations. The median weekday coefficient of variation was reduced from 0.26 to 0.15. These data indicate that the variability on each weekday is now within 15% of the median during 66% of the time. The implications of this significant reduction in variability is to be responsive to demand while maintaining quality and resource utilization (both human and physical resources).

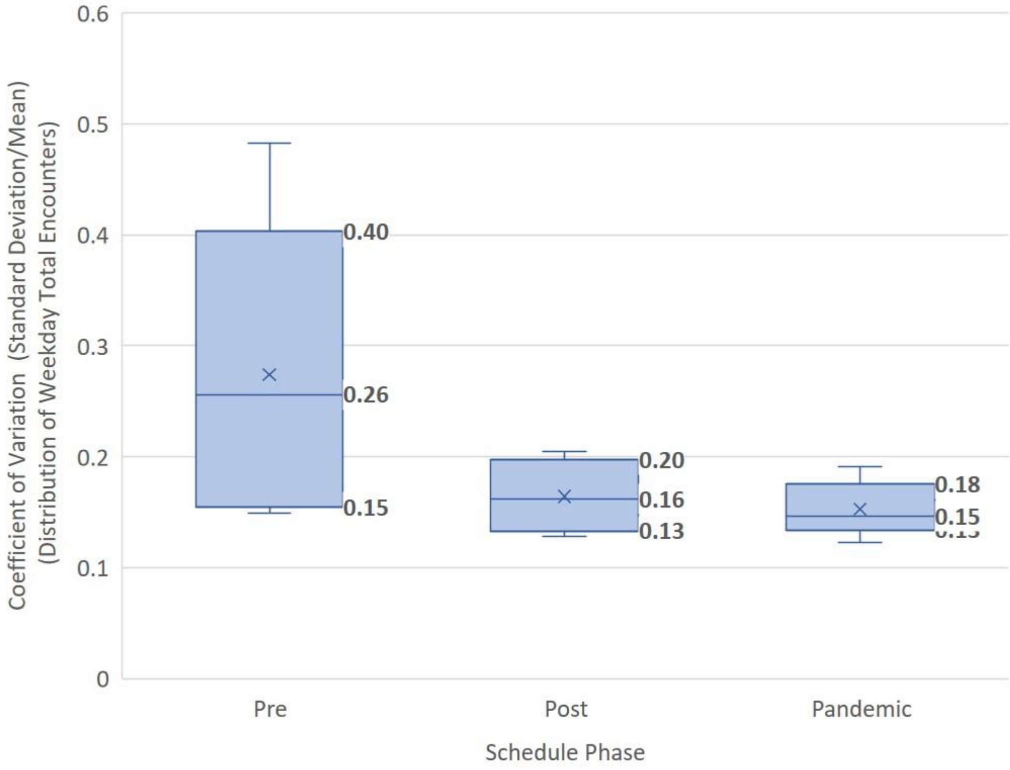

Figure 5. The variability of clinic encounters each weekday complicates staffing and was reduced across all weekdays and clinic locations. The median weekday coefficient of variation was reduced from 0.26 to 0.15. This promotes better care and value.

4. Discussion

Cancer centers are universally plagued with competing demands, from patient volume, treatment complexity, and allocation of resources within an established budget. The specialized match of availability and need between disease specific providers and patients, and the value of continuity of care, add profound complexity to the standard challenges of operating a large medical operation. An optimized system must be self-aware (data driven) and adaptable to ongoing variability and challenges or wasteful utilization will creep back in. The ability to respond, to learn and to adapt and redesign our processes in a dynamic fashion is an essential component of achieving a truly high-performance cancer service delivery system and is the essential quality of a learning health system. [21] [22] [23] [24].

The realignment of the cancer center capacity and resources into operational disease site teams is a fundamental step in our journey to integrate disease site clinical pathways and operations across our population, anchored by the physical cancer center. This inherently creates the capacity for us to integrate the continuum of care across screening, diagnostic and surgical groups involved in the multiple disease sites distributed across the region. These premises were the driving force to the initiation of the changes described here.

Translation of learning health system concepts to implementation within a hospital ambulatory department compelled us to describe guiding concepts for our cancer system redesign vision. The ability of systems, teams and individuals to analyze, deepen insights, learn and to implement solutions collectively in response to changing environments and clinical care needs is a guiding approach and builds on our previous report [3].

4.1. Operational Excellence through Caseload Management by Disease Site

We have demonstrated that a systems approach and operational performance principles can be applied successfully to a large, multidisciplinary cancer center to address space and provider resource allocations, budget alignment and disease site specific acuity demands.

In our pre-state, the clinic was organized primarily according to historical allocation of resources. This was rigid, only loosely connected to disease site demand, and not routinely data-informed. In spite of this, our cancer center performance was consistent with similar Ontario academic health science centers. Legacy workflows clouded clear identification of the underlying issues and appeared to restrict the options for any future solution. This required a phased approach with an initial resolution of operational challenges to create necessary conditions for the fundamental operational change. Strategic choices were also required to create the solution framework. Consistent with feedback from stakeholders and core principles of oncological care, we identified the following key strategic choices for any future solution:

- Support care continuity for patients and their provider team within the context of disease site group accountability for regional service demand
- Reformat teams and supporting structures to support this format including nursing allocation and clerical resources
- Support allocation of resources according to patient acuity by identifying patient segments with different care needs
- Acknowledge need for iterative reset quarterly to plan human resource staffing and any necessary change to services due to patient demographics or medical science
- Unify these concepts into a framework of caseload management by disease site at the individual practice, disease site group and program management levels

Implementation of the block schedule reduced variability within and between each weekday. Inability to shift staffing in response to variable service volumes causes either overworked or under-utilized personnel. Consistent service volume between weekdays promotes full-time interprofessional team members while variable volume requires more part-time and casual personnel that can respond to fluctuating volumes. Predictable and consistent volumes are supportive for a knowledgeable, consistent and experienced clinical workforce that can best support patients.

The block schedule supports caseload management by disease site as it aggregates clinic resources explicitly around management of distinct patient populations. Designation of nursing and clerical resources to the disease site management increases the clustering of an interdisciplinary care team around similar patients, promoting coordinated, timely care.

4.2. *Change Management*

This complex change was made possible through a series of purposeful and discrete steps driven by our overarching systems framework. We built credibility and trust among stakeholders through incremental pilots addressing prerequisites for the initiative. These impacted the role of the clerk, nurse, admin, and IT systems. Significant medical and administrative leadership was essential from both formal and informal leadership, including key opinion leaders. Our nursing team reworked legacy systems to more team and disease site-based focus. Our physicians courageously adapted through this change and also the simultaneous implementation of the new EMR.

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There were a number of challenges during the process of implementation. Coordination of individual practice preferences, nursing perspectives on optimized professional practice, and system demands for decreased variability and team-based care required intensive communication and adjustments. These dynamic requirements speak to the need for ongoing iterative redesign which we are now positioned to respond to. The block schedule is comprised of quarterly PDSA cycles and has allowed us to adapt and adjust dynamically. This together with disease site and divisional team engagement supports our capacity to adapt to changing practices and HR requirements. The implementation of nursing disease site teams now creates a fertile ground for interdisciplinary quality improvement and operational initiatives across the system.

Improved clinic function was augmented by response to the COVID pandemic and implementation of the new EMR. Use of telemedicine was already increasing and the pandemic further improved flexibility by permitting telephone visits (not requiring prebooked telemedicine visits). Virtual care enables rapid capacity adjustments such as an extra clinic on short notice, since it requires no exam rooms and minimal nursing support. The addition of these appropriate telephone encounters has provided additional flexibility and access to care. Implementation of the new EMR improved pre-planning of clinics and partial charting in advance.

System enhancements recently implemented include interactive dashboards displaying outpatient clinic metrics by division, disease site, and provider. These provide performance feedback and a learning loop to inform the quarterly development of operational targets. Current optimization is focused on mathematical modelling to automate the dynamic allocation workflow. This will reduce the required effort, enhance transparency and equity, and further optimize resource utilization.

5. Conclusions

The application of a systems vision with a structured operational improvement framework as a collective project across a whole ambulatory cancer center clinic has resulted in increased operational agility and efficiency. This supports a dynamic response to service demands while enhancing a disease site group management approach. This approach is predictive, iterative but not prescriptive – the final decision of what is deployed incorporates significant input to account for the nuances of individual physician practice, nurse clinicians, HR needs and disease site service demands.

The ability to iteratively review data as an integrated team and adjust several times a year to the unique demands of the center underscores our support for the learning health system vision of building dynamic teams that are adaptable to the changing environment. This offers us the opportunity to create more capacity for complex visits, such as clinical trials, and for the redesign of care for low acuity care within and outside the cancer center along the structured disease site pathways.

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