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Regional process redesign of lung cancer care: a learning health system pilot project

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ABSTRACT

Background The Ottawa Hospital (TOH) defined delay to timely lung cancer care as a system design problem. Recognizing the patient need for an integrated journey and the need for dynamic alignment of providers, TOH used a learning health system (LHS) vision to redesign regional diagnostic processes. A LHS is driven by feedback utilizing operational and clinical information to drive system optimization and innovation. An essential component of a LHS is a collaborative platform that provides connectivity across silos, organizations, and professions.

Methods To operationalize a LHS, we developed the Ottawa Health Transformation Model (OHTM) as a consensus approach that addresses process barriers, resistance to change, and conflicting priorities. A regional Community of Practice (COP) was established to engage stakeholders, and a dedicated transformation team supported process improvements and implementation.

Results The project operationalized the lung cancer diagnostic pathway and optimized patient flow from referral to initiation of treatment. Twelve major processes in referral, review, diagnostics, assessment, triage, and consult were redesigned. The Ottawa Hospital now provides a diagnosis to 80% of referrals within the provincial target of 28 days. The median patient journey from referral to initial treatment decreased by 48% from 92 to 47 days.

Conclusions The initiative optimized regional integration from referral to initial treatment. Use of a LHS lens enabled the creation of a system that is standardized to best practice and open to ongoing innovation. Continued transformation initiatives across the continuum of care are needed to incorporate best practice and optimize delivery systems for regional populations.

Key Words Learning health system, lean improvement, lung cancer, regional, health information, community of practice, theory of constraints

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INTRODUCTION

Improving access to timely cancer diagnosis requires more than just increasing the volume of patients processed through the system. It requires balance of the timely access to care with the quality of the services delivered within the cost-constrained availability of resources[1,2]. In the Champlain region of Ontario, Canada, cancer diagnosis services are delivered in a variety of hospitals and care settings to a population of 1.2 million people dispersed across 18,000 square kilometres. In the 2014–15 fiscal year, The Ottawa Hospital (TOH) regional cancer program provided 24,000 oncology consults and more than 110,000 patient visits, including new patient consultations for approximately 900 patients with lung cancer. Prior to the redesign project, the median time from referral of a patient with suspicion of lung cancer to initial treatment was 92 days. Referrals were received on a variety of forms, sent to two destinations, and reviewed asynchronously. Variable sets of procedures were ordered and scheduled independently in multiple departments. This report describes a systems approach to redesign care, enabling timely access of patients suspected

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of lung cancer to a centralized speciality service while creating the dynamic adaptability to address both clinical and operational challenges.

Lung cancer is one of the most lethal cancers. More people are expected to die from lung cancer than from colorectal, breast, and prostate cancers combined[3]. Cancer Care Ontario (CCO) has mapped the evidence-informed best practice for the lung cancer diagnostic pathway[4]. The challenge is to build the operational systems that deliver such care in a timely manner. Lung cancer presents a series of clinical management and institutional challenges for both operational and therapeutic delivery of care[5,6]. Such challenges include the requirement for a series of diagnostic and staging tests to be performed and collectively interpreted and the patient triaged, in a timely fashion, to the most appropriate initial providers, such as surgical oncology, medical oncology, radiation oncology, and palliative services. Efficient care is challenged by multiple entry points (i.e., referral from a broad spectrum of other clinical areas) and arrival of patients with variable, possibly insufficient, clinical information. Many of these patients have rapidly progressive symptoms that challenge timeliness of tests and fitness of the patients to attend. Numerous discipline-specific care silos that patients must navigate on their journey bring additional complexity. The time from initial symptoms to definitive treatment was previously documented in an Ontario regional cancer center as a median wait of 138 days for a surveyed group[7].

The grave nature of lung cancer survival statistics suggests an urgency to reduce the length of the journey from referral to treatment. The five-year overall survival for patients with non-small cell lung cancer (NSCLC) is 15%[3]. Stage IV NSCLC is the most common presentation of lung cancer patients by the time patients are referred to consult and constitutes 37% of presentations at TOH. The median survival of untreated patients with stage IV NSCLC is 3.9 months[8], indicating that a journey to treatment approaching or exceeding 90 days represents a highly significant interval for these patients. In the last month of life, patients can become too sick to benefit from systemic treatments, despite evidence that these interventions may improve both survival and quality of life[9,10]. Patients must be seen sooner regardless of their stage because, for discrete disease subgroups, the implementation of molecular diagnostics and access to new therapies can extend survival from weeks or months to years. It is imperative for regional care that lung cancer patients access rapid diagnostics and triage to appropriate providers in order to optimize their outcomes, including access to novel therapies and the early introduction of palliative care[8].

Practical Development of a Learning Health System in Cancer Services

The Ottawa Hospital defined the delays to timely lung cancer care as a system design problem by recognizing the patient need for an integrated journey. Incorporating the interconnectivity and dependencies of the multiple regional and hospital-based components is essential for transformation to a high-performance system. In addition, merely hard-wiring a system to today's imperatives is a forecast for obsolescence; further adaptation to changing environmental, scientific, technological, and clinical factors will be required. The fundamental capacity of a system to adapt, change, and build trust develops through learning. These concepts have been endorsed by the Institute of Medicine (IOM) and the National Health Services (NHS) as fundamental to sustainability of health care and requiring the development of use cases and practical examples of deployment[11,12]. The LHS model has gained increasing relevance as health informatics has rapidly developed, driven by a core feedback of utilization of operational and clinical information to drive system innovation[13]. The LHS puts major emphasis on the alignment of different health care system properties such as research, informatics, and a culture of shared responsibility[12,14–16]. Systematic harnessing of the power of data and analytics to feed knowledge about performance back to stakeholders, creating cycles of continuous improvement and innovation, constitutes the essential attributes of a LHS as described and recommended by the IOM[12]. The quest for unifying frameworks to implement the LHS vision has been challenging. A recent review proposes a framework to guide implementation of a new LHS as well as further LHS evolution at the level of a single organization, a regional, or national health system[17].

A collaborative platform is essential to create and sustain systemic change in health care because it provides the fundamental connectivity across silos, organizations, and professional groups that enables learning[18]. A collaborative platform enables the implementation of best practice engineering and process improvement methods across the continuum of care[19]. The Ottawa Hospital has been at the forefront of implementing such a platform, the Communities of Practice (COP) model in cancer, for more than a decade. The COP platform provides essential components of the LHS through its attributes as a "learning organization": promoting individual competence, systems thinking, cohesive vision, team learning, and integrating different perspectives[20]. A COP, in this context, is a collective of multiple stakeholders outside of the hierarchy of their institution, considered equal, and sharing a common goal of learning and sharing in order to improve something, in this case, lung cancer care. Application is described in detail in our previous publications[21–25]. This has provided the regional foundation for the awareness and trusted relationships necessary to create positive perceptions of change, commitment, and ownership of large scale improvements. There has been a call to realize the LHS vision through practical implementations[26], and oncology has made an effort to answer this call. However, gaps remain[27,28].

The Ottawa Health Transformation Model (OHTM)

To operationalize LHS thinking, we developed the Ottawa Health Transformation Model (OHTM) as a coherent regional approach for large-scale change integrating the patient journey with best practice. The OHTM provides a process to align organizational and practitioner interests in a systematic manner. The OHTM is based on the alignment of the key domains: people (attitudes and cultural norms), processes (redesigned care protocols and revised performance standards), and technology (process-aware measurement and automation) to form a cycle that drives a learning health system that increases adaptability and performance. The OHTM is illustrated in Figure 1. The components of the OHTM and the application in the project are summarized in Table I.

The OHTM was conceived as a consensus-driven approach that could address institutional process barriers, resistance to change, and conflicting targets and priorities inherent in regional cancer care. The framework is scalable, replicable, and simple enough to facilitate common understanding among stakeholders, including patients. It was accepted by leaders of the academic and community hospitals and an iterative feedback loop was established between resource providers and clinicians for individual and aggregated operational and clinical data. The iterative feedback loop forms the core resilience of the platform by uniting the care community in a common desire to learn and optimize patient care while providing a platform for continued adaption to changing operational factors, including incorporation of clinical advances. This paper demonstrates the application of the OHTM to create effective redesign of the regional system for lung cancer diagnostic services.

METHODS

Application of the framework began with an environmental scan. A qualitative and quantitative assessment of the current process, from referral to treatment, was completed by a transformation and design team that included health care professionals, patients, and family members. A sample of 68 key influencers, including health care professionals, patients, and caregivers, was selected to represent the greatest variety of organizational and individual perspectives, and

FIGURE 1 The Ottawa Health Transformation Model. The learning system is established by the iterative interaction of people, process, and technology domain approaches used to solve the delivery challenges. Learning is enabled at the system, unit, and individual level.

this group was engaged through semi-structured interviews and stakeholder mapping. The common purpose uniting the transformation team was standardization and integration of the patient journey to improve both timeliness and adherence to evidence-based care guidelines.

People

A regional COP in lung cancer of up to 100 members was established to engage multiple and diverse stakeholders from academic and community institutions into the system redesign. It was used as a validating and change platform for the redesign work done by a transformation change group. The change group, some 40 members within the larger COP collective, included personnel fully dedicated to the transformation initiative as well as clinical and operational partners. Key change leaders in the group included clinicians, administrators, IT leaders, process experts, data analysts, nurses, and patient family members. The group united clinical, strategic leadership with key management from the operation and business analysts with expertise in operational improvement. The change group focused on integrating care processes and best practice evidence into disease subtype specific pathways, building the case for change, modeling, and advocating for change at individual departmental and operational levels such as medical imaging, surgery, respirology, pathology, and hospital executive management.

Process

Process improvement tools derived from Lean thinking, systems thinking, and the Theory of Constraints are the second leg of the OHTM[29,30]. Concept maps and system diagrams facilitated an understanding of the internal and external interdependencies and linkages in the regional diagnostic system. The application of process improvement tools to clinical practice provided learning opportunities for practitioners to update their clinical and non-clinical knowledge[31–33]. The patient value outcomes were defined as improvement in the provincial metrics for timely diagnosis (the diagnostic assessment program [DAP] performance metric) and access to consults for treatment (the Referral to Consult metrics). As these metrics capture discrete segments of the patient journey, the total duration of the patient journey from referral to receiving a cancer treatment (systemic, radiation, surgery, or palliative care) was also defined as a primary outcome of the project. The goal was to provide treatment (surgery, medical, or radiation oncology) to 90% of patients within a locally defined cumulative target of 49 days from the date of referral for diagnosis. Secondary outputs included improvements in overall lung cancer diagnostic system capacity, efficiency, and coordinated service delivery.

Technology

The learning cycle was enabled by implementation of improved process monitoring and business intelligence tools that integrate process-related data into structured views to provide insights on the system performance. Locally generated performance dashboards for provincial performance metrics enabled visibility to generate timely corrective action. The business intelligence software moves patient records forward for timely decision-making and triage

TABLE I Ottawa Health Transformation Model Components. The basic content of each component is described (left), along with the learning that is built into the system through that domain (middle) and the areas of application in the lung diagnostic service redesign project (right).

Domain	Description	Learning health system	Lung redesign application
Process	Processes across the care continuum standardized and streamlined end-to-end using management tools including Lean and constraint theory	Learn and build capacity to apply system thinking and principles of effective management.	Lean optimization of diagnostic procedures and patient education including coordinated referral review and integrated navigation day of services
		Create an integrated and dynamic view of patient journey	
People	A CoP of clinicians and administrators and a patient participation program provide guiding input. Implementation by core team of dedicated personnel, operational and clinical leaders	Care redesign, as well as creation and adoption of best practice	Incorporate patient priorities in design of integrated care. Operationalize best practice care pathway in order sets, triage algorithm, interdisciplinary codesign of new workflows, and procedures
		Patients as equal partners.	
		Cross-functional learning about interconnected roles.	
		Promote positive change and sustainability	
Technology	Appropriate measurement methods to monitor performance. Sustainable automated technology solutions	Identify and formulate care gaps based on operational and clinical data obtained from electronic health records.	Timely display performance data on corporate dashboard.
		Create a transparent view of the patient journey and flow	Business process modelling software linked to an electronic health system

CoP = community of practice.

to the most appropriate providers[34,35]. Business process modelling (BPM) technology (IBM) migrated the redesigned processes into an automated workflow management system that created visibility of patients during all parts of their journey. In our project, the BPM software orchestrated both clinical and non-clinical workflows to generate a clinical groupware for users at multiple sites in 18 disciplines. The output generated by the analysis of the process-related data was used to generate alerts, dashboards, and ad-hoc queries to monitor individual and team performance.

RESULTS

Implementation

The implementation of change combined the efforts of the CoP with the change group to operationalize into practice the best practice guidance of the CCO lung cancer diagnostic pathway[4]. The Lung Cancer CoP members played an important role in validating algorithms for review of lung cancer referrals and standardized diagnostic procedures. The CoP discussed review of referrals and generated the standardized order sets that would be used. A common regional triage algorithm was defined to direct the most appropriate referrals with curated diagnostic information to treatment providers. The change group completed the work of system redesign and reconnection of clinical information systems, decision support analytics, and workflows across the hospital. For example, to develop improved review of patient referrals, the change group met regularly for weeks to negotiate the timing of review, who would participate, how many cases, how clinics would be affected, and other issues. The final stage was to design and implement the BPM automated solution to track the tasks of the patient journey.

The LHS approach was key to all of these changes. Learning was supported with regular Continuing Professional Development (CPD) accredited CoP meetings, which allowed participants to review individual case- and team-based performance data and brainstorm new ideas.

In a series of rapid improvement cycles, 12 major processes in referral, review, diagnostics, assessment and triage, appropriate first provider consult, and first treatment were redesigned; 270 constraints were resolved to support 57 process changes in workflow ranging from system issues to organizational and individual flows. Regional processes for diagnostic imaging became better integrated to allow for the shared use of resources between academic and community health systems. The stages of the patient journey and the implemented interventions are shown in Figure 2.

Implemented Changes

Central Intake

A centralized regional process for review and processing of all lung cancer surgical and non-surgical referrals.

Joint Review

Daily multi-disciplinary review of lung referrals by thoracic surgeon and thoracic radiologist. Creation of a standardized process including physician order sheet, standardized clinical patient note, and physician duty roster. Additional changes included development and routine implementation

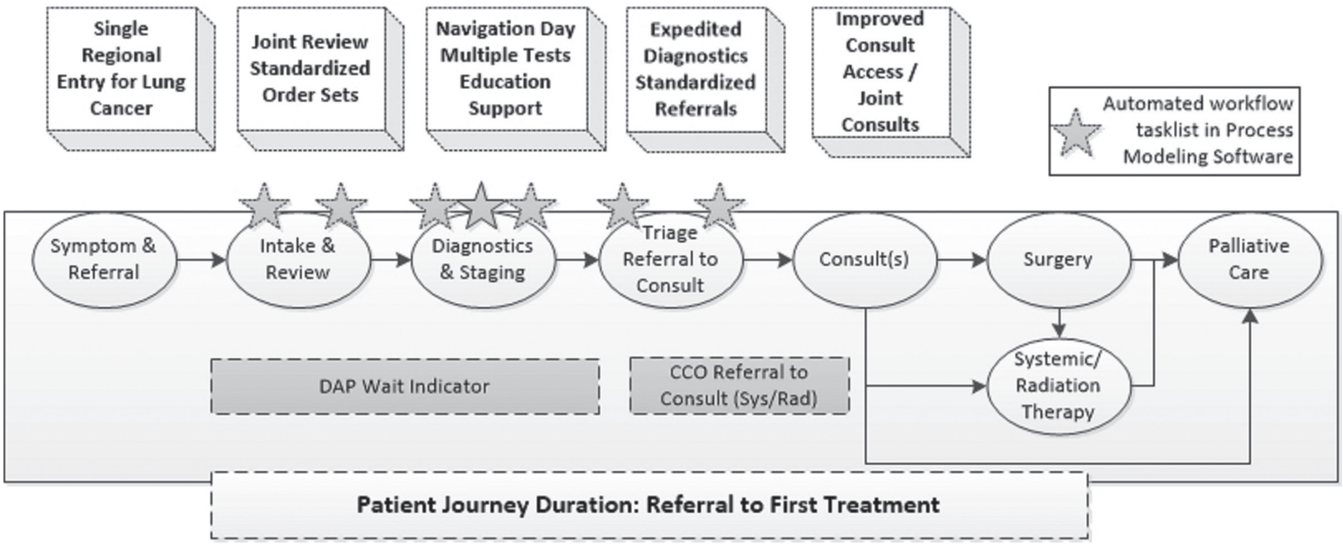

FIGURE 2 Schematic of the patient journey, the redesign interventions, and project metrics. The interventions are listed above the patient journey (solid lines) and were supported by improvement of automated workflow management throughout the diagnostic service pathway (dotted lines). The patient wait time metrics (dashed lines) include the time to diagnosis (DAP), the Cancer Care Ontario (CCO) wait time metric from diagnosis to consult, and the total referral to treatment metric defined for the project.

of standardized internal guidelines in thrombosis, cardiology, and neurology for patients with comorbidities. Variability in anti-coagulation protocols was impacting preparation for lung biopsy and had hampered patient flow through the diagnostic process.

Navigation Day
A single day for coordinated completion of positron emission tomography (PET) scan, pulmonary function test (PFT), magnetic resonance imaging (MRI), and blood work. Patients also participate in nursing assessment and teaching, social work, supportive and palliative care, and smoking cessation education.

Testing Wait-Times
Introduction of efficiencies in diagnostic testing and reporting.

Triage
Standardized process for the review of results and algorithms for consult referrals.

Automated Workflows
Implementation of BPM software linked to electronic health records to increase transparency and improve patient flow.

Access to Consult
Corporate dashboard for monitoring of referral to consult wait time driving improved management of patient flow. Implementation of improved process for consult scheduling, including physician availability management.

Joint Consult
Interdisciplinary concurrent consults with both Medical and Radiation Oncology for the 85% of lung cancer referrals made to both specialties.

Evaluation
The earliest changes implemented operationally were improvements to the process for scheduling consults and monitoring the provincial metric of referral to consult for systemic therapy and radiation therapy. The access to consult for both systemic and radiation therapy was improved above the provincial target of 85% of patients being seen within 14 days from referral. In 2012, the median time to access a consult was 12 days in radiation oncology and 13 days in medical oncology. In 2015–2016, the median time to access a consult had improved to 8 days and 7 days, respectively, while volumes of consults had increased 15% in each specialty compared with the earlier period. Improvements in process monitoring supported process improvements that resulted in the sustained improvement shown in Figure 3.

The improvements and changes made to the lung cancer diagnostic process are captured by the provincial metric for lung cancer Diagnostic Assessment Programs (DAPS). The Ottawa Hospital now ranks first in providing patients with timely lung cancer diagnosis among the 14 Ontario regional cancer centres on the annual scorecard of the Cancer Quality Council of Ontario[36]. Improvement has been sustained as the region, at 80% in fiscal year (FY) 15–16, has the highest rate of timely diagnosis in the province. The percentage of patients across the province of Ontario diagnosed within the target (28 days) was 57% in the same period. Performance in the Champlain region after transformation is statistically improved compared with the province as a whole and the region prior to transformation ($p < 0.0001$), as shown in Figure 4.

The target goal set for the project was to shorten the time to treatment for the 90th percentile of patients to less than 49 days. This was an ambitious goal that reflected the influence of patient and family advocates within the transformation team and the strong desire of the entire team to improve care for the whole population of lung cancer patients. The project was successful in shifting the median time to treatment below 49 days, demonstrating that it is realistic and attainable for the majority of patients to be served within that timeline. The improved process time to initiation of treatment has been sustained over several years of increasing volumes and organizational challenges. The 90th percentile was reduced from 117 days in 2010–2012 to 88 days in FY15–16. Factors contributing to unusually long delays in treatment initiation include patients with complicated social, medical, and individual characteristics. No cases have been excluded from these calculations. The 48% reduction in the cumulative median wait times from referral to initial treatment is shown in Figure 5. The percentage of diagnosed patients that received no treatment (surgical, systemic, radiation, or palliative) decreased from 22% in 2014 to 16% in 2016, suggesting that reduction in total time to treatment facilitated access to treatment for more patients.

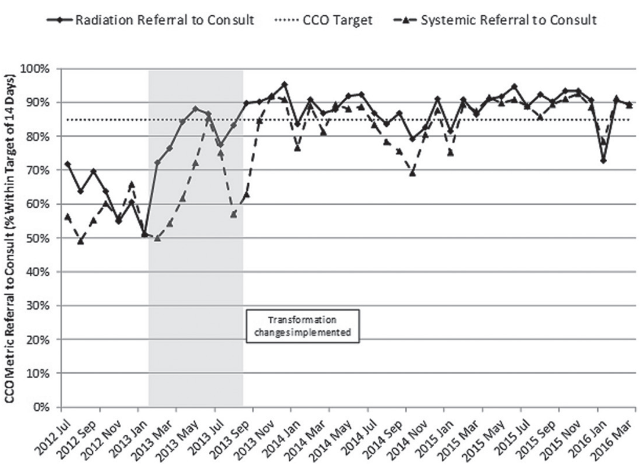

FIGURE 3 Access to Consult Provincial Metric. Access to systemic and radiation oncology consults was improved with implementation of real-time monitoring as well as process improvements. Performance is evaluated against the Cancer Care Ontario (CCO) target (dotted line) stating that 85% of patients should receive their consult within 14 days of referral after diagnosis.

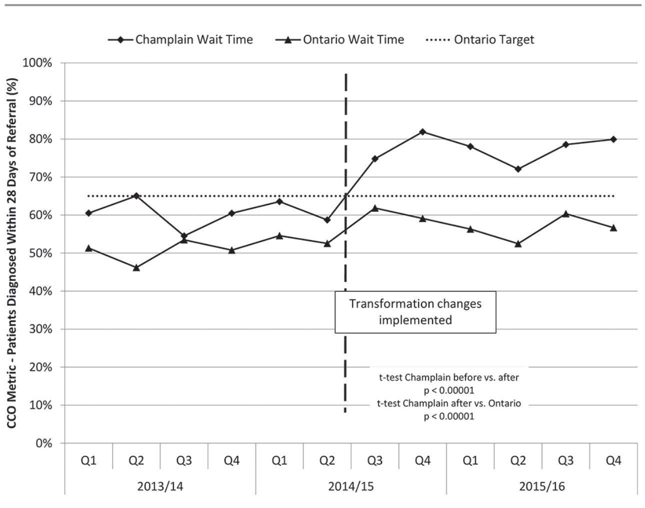

FIGURE 4 Lung Cancer Diagnostic Assessment (DAP) Performance. Champlain regional DAP performance compared with Ontario against target (dotted line) stating that 65% of patients should receive diagnosis within 28 days from referral. Implementation of transformation changes is indicated by the vertical dashed line.

DISCUSSION

As health care improvement models evolve from simple fixes to more complex mixed-method approaches, a learning health system (LHS) emerges as a new paradigm. However, there is a lack of evidence on implementation of the LHS vision[37]. Our report is one of a few that demonstrate the feasibility of a LHS vision and measurable benefits in its application to a specific care problem, in our case, timely access to lung cancer care. Reports on reduction of waiting time for cancer patients consist largely of single interventions for care coordination, task automation, and organizational restructuring. These include multidisciplinary clinics, nurse-led care coordination, telemedicine, and standardized expedited diagnostic processes[38–40]. Most of these isolated interventions fail to improve the total wait time of the entire patient journey to treatment. It appears that shortening the time from referral to diagnosis has led to the transposition of wait times to other parts of the diagnostic and treatment trajectory, without changing the overall wait time for treatment[37]. All components of the care process have to be examined to address the complexity of health systems and to improve patient experience of a whole health system rather than its isolated parts[49–45].

Our conceptual contribution to the LHS thinking is focusing on a "health region" as a major implementation unit. The LHS literature is primarily concerned with institutional and system level frameworks. Organizations such as Kaiser

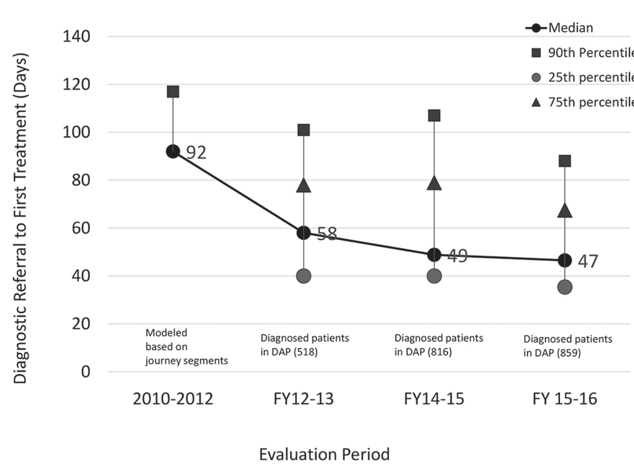

FIGURE 5 Patient Journey Referral to Treatment. Duration of patient journey referral to initial treatment by surgery, systemic therapy, radiation therapy, or palliative care (days) during fiscal year periods (FY). The median time from referral with suspicion of lung cancer until starting first treatment decreased from 92 to 47 days. Patients who did not ultimately receive any recorded treatment are excluded. The number of patients served by the DAP (noted by year) increased with centralized regional referrals.

Permanente, Geisinger Health System, and the US Veterans Administration provide examples of micro-LHS changes that use the power of data and Lean thinking to improve institutional learning[46,47]. Nationwide networks such as CancerLinQ enable system-wide learning using common infrastructure, governance, and incentive structures[48].

The key contribution of the LHS approach to health care delivery is the creation of a system that is both optimized to best practice and open to ongoing innovation. The dynamic adaptability of the LHS paradigm offers the promise of an organization that can achieve long-term excellence by self-aware continuous improvement in response to new evidence and information.

The OHTM proposes a consensus framework for implementation of the LHS vision for a disease entity at a regional level. It is scalable and simple enough to allow different improvement methods and approaches to be used in a cogent and flexible way depending on culture and organizational capacity. Several recent reviews of health care improvement initiatives indicate that various improvement frameworks such as Lean, Six Sigma, Theory of Constraints, and Model for Improvement can all be helpful when applied diligently and appropriately[49,50]. To this end, the OHTM model prioritizes People-Process-Technology alignment to provide a common understanding for the key stakeholders in the health care system.

Our implementation of the LHS paradigm utilizes regional COPs to facilitate group learning and peer-to-peer knowledge sharing. Fundamentally, the OHTM is a relationship-based platform that allows everybody to be engaged equally and learn about parts of the system, patient flow, and perspectives they did not know existed. Within the LHS context, this approach helped to encourage system thinking and generation of collective insights on how to provide timely access to care and efficient use of resources without compromise to patient outcomes.

The three pillars of people, process, and technology are all essential to this design as there can be no adaptable redesign without human creativity applied throughout the process, and the innovation cannot be consistently implemented without updating technology and infrastructure through constructive methods of process re-design.

Generalizability and Further Directions

Key enabling factors for success included alignment within the organization on the transformation goals, including the senior management team and the board of directors. This support was essential for allocation of the required resources including a small team of dedicated project personnel as well as implementation of the BPM software. This political alignment enabled the horizontal integration to occur across divisions and professional groups. The lived experience of improved system functionality, collegial teamwork, and learning have dominated the problem-solving perspective and integrated the OHTM concepts into routine operations. The cultural, systemic, and technical hardwiring of practice change across the delivery teams has enabled sustainability over several years, despite challenges in resource allocation.

Continued transformation initiatives across the entire continuum of care are needed to implement best practice and optimal delivery systems for regional populations. We believe that the essential concepts and measures of outcomes presented here are applicable to other regional care system redesign initiatives. We recognize that challenges exist within large health care organizations to accommodate system change. Active negotiation and escalating demonstration of value across the system in an iterative cycle of change creates momentum and releases resources for repurposing required to facilitate ongoing deployment.

The TOH Cancer Transformation program to date has focused on the lung cancer diagnosis from referral to treatment. Next steps include extending standardized end-to-end integration to the treatment phase, integration of interdependencies and linkages with clinical trial recruitment and research, integrating molecular laboratory data, and other enhancements.

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CONFLICT OF INTEREST DISCLOSURES

We have read and understood *Current Oncology*'s policy on disclosing conflicts of interest, and we declare that we have none.

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