

Scientific Article

The Capital Investment Strategy for Radiation therapy in Ontario: A Framework to Ensure Access to Radiation Therapy



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Abstract

Purpose: Ontario Health (Cancer Care Ontario), formerly known as CCO, is the provincial governmental agency in Ontario, Canada responsible for developing radiation therapy-specific capital investment strategies, updated every 5 years, to ensure equitable access and to gain the highest value from these investments in infrastructure. These plans are informed by the changing landscape of health care delivery, technologic advancements affecting radiation therapy care, patient desire for care closer to home, and expected increases in utilization of radiation therapy services. In this article, we describe the development, model, and final recommendations of CCO's fifth radiation therapy capital investment strategy.

Methods and Materials: A panel of multidisciplinary provincial experts, in combination with 2 patient and family advisors, developed planning principles to guide the development of a patient-centered strategy. Adaption of the previously used model for radiation therapy planning was used.

Results: The development of the capital investment strategy took place from fall 2017 to fall 2018. The model included 3 main factors: patient demand (including utilization targets), machine throughput, and machine demand and supply. The final recommendation is for an investment of 26 new radiation therapy machines in the province by 2028.

Conclusions: The strategy plans for continued province-wide access to quality radiation therapy care and ensures machines are added to the system at the right place and in the right time. Ongoing data collection throughout this period is necessary to ensure the strategy achieves its goals and to allow for planning of future strategies.

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Introduction

Cancer rates continue to rise globally, with 18 million new cases and 9.6 million cancer-related deaths in 2018.¹ These rates are expected to rise dramatically, with an anticipated 70% increase in the global cancer incidence anticipated by 2030.¹⁻³ This increased oncologic burden will strain all aspects of cancer care, including access to radiation therapy. Ontario is Canada's highest populated province with more than 14 million residents⁴; more than 90,000 individuals will be diagnosed with a malignancy, and more than 30,000 people will experience cancer-related deaths in 2018.⁵

Ontario has a single-payer government-funded system with all residents insured for medically necessary care under the Ontario Health Insurance Plan. Provincial cancer care, including radiation therapy, is overseen by a

Crown Agency, Ontario Health (Cancer Care Ontario) and formerly known as CCO, and funded (through CCO) by the Ministry of Health and Long-Term Care. Radiation therapy is delivered at 17 provincial facilities, connected to 14 regional cancer centers (RCCs; Fig 1). External beam radiation therapy is delivered via 107 linear accelerators currently operating within this system.

CCO is responsible for capacity planning for the cancer system including developing capital investment strategies to ensure equitable access to radiation therapy services and to gain the highest value from these investments in infrastructure. Issues that must be considered include the changing landscape of health care delivery, technologic advancements affecting care, patient desire for care closer to home, and expected increases in the need for radiation therapy services. To date, CCO has developed 4 capital investment plans, released in 1992, 1998, 2005, and 2012. These plans provided an

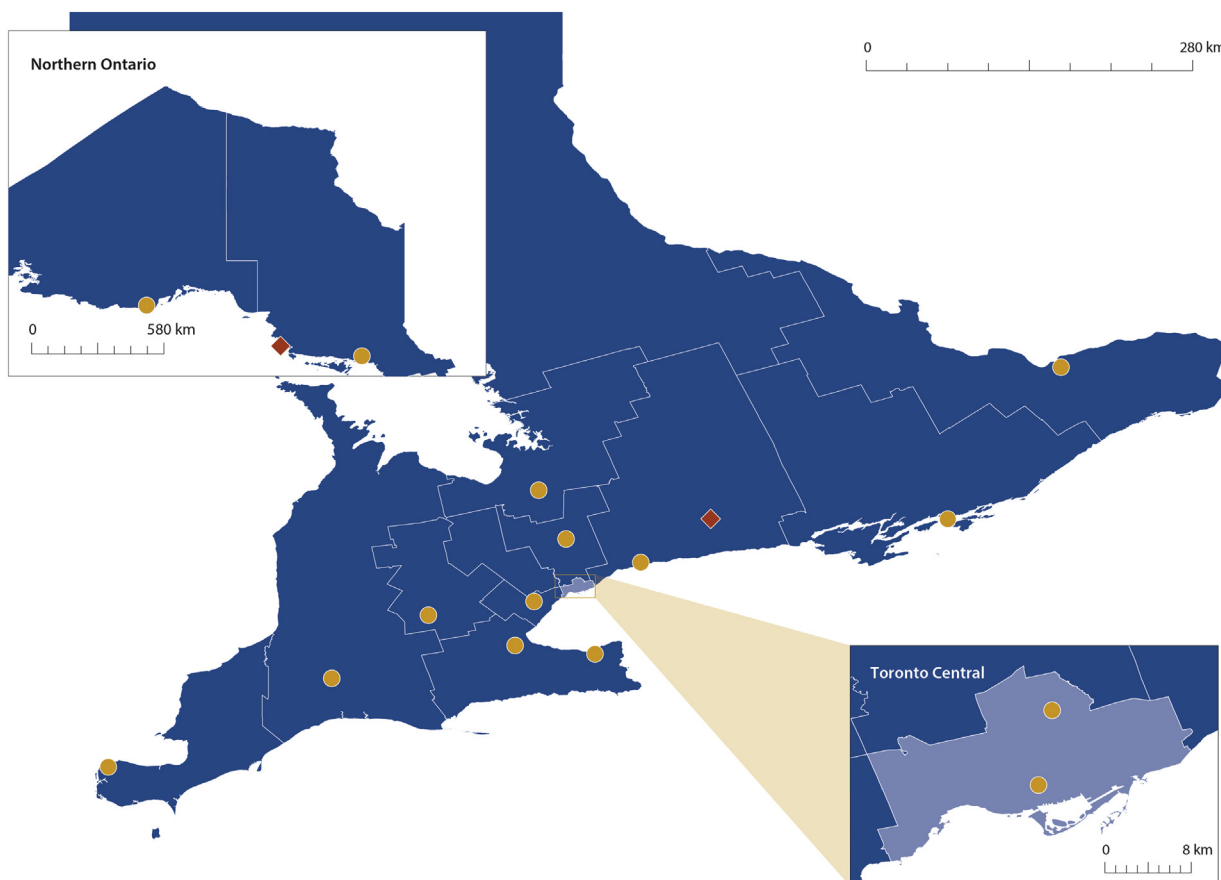


Figure 1 Map of radiation treatment facilities in Ontario.

assessment and projection of the radiation therapy investment needs, demands, and regional requirements that were appropriately timed and strategically placed to ensure Ontarians continue to receive high quality care. They are based on a model that is continuously updated and modified to reflect changes in patient factors including the rising incidence of cancer and rising radiation therapy usage and changing radiation machine factors. The fifth strategy outlines the investment needed to ensure equitable access to radiation therapy for all Ontarians from 2018 until 2028.⁶ The model used has been adapted from prior strategies.

The importance and development of strategic planning in medicine is becoming more widely recognized and described in the medical literature.^{3,7-10} In addition, some jurisdictions publish their radiation therapy capital investment and strategic plans online for public viewing.¹¹⁻¹⁵ However, information in the medical literature about the process of capital investment strategies in medicine, and specifically radiation oncology, is scarce.^{16,17} This article provides a high-level overview and description of the development, model, and importance of CCO's radiation therapy capital investment plan.

The capital investment strategy framework presented herein focuses on the needs for high energy external beam radiation therapy. Brachytherapy and low energy treatment machines were out of scope for this work and are excluded.

Methods and Materials

Model development

A multidisciplinary provincial expert panel led the development of the capital investment strategy. Members included CCO staff representatives with experience in system and infrastructure planning in addition to senior epidemiologists, radiation oncologists, medical physicists, and radiation therapists from across the province. In addition, 2 patient and family advisors were included on the expert panel to help ensure development of a patient-centered strategy, in keeping with CCO's person-centered care strategy.¹⁸

The expert panel developed key planning principles to guide the development of the strategy. These were created with alignment to the vision, mission, and values of CCO.

The planning principles included (1) continuing to improve timely access to care for cancer patients, ensuring treatment machine capacity matches the need; (2) ensuring value for investment of existing infrastructure; (3) keeping pace with advancing technology to improve the delivery of safe, quality care; and (4) minimizing costs through centralized planning and procurement processes.

This article focuses on describing the first 2 planning principles. Principles 3 and 4 are currently being addressed through the implementation of a province-wide procurement strategy to ensure facilities get the best price for the equipment and access to advancing technology.

Planning model

Planning models from previous capital investment strategies were adapted for use (Fig 2), taking into account patient demand, machine throughput, machine demand and machine supply. Each of these factors is described herein.

Patient demand

Cancer incidence

Data on projections of cancer incidence were obtained from CCO's Surveillance Unit and included projections of total cancer incidence at a census division level, which was incorporated into the determination of patient demand, in addition to benchmark radiation utilization rate, retreat factor, and catchment areas.

Radiation utilization

CCO currently measures and reports yearly on the provincial utilization of radiation treatment, which is defined as the proportion of patients who would benefit from and receive radiation treatment if there were no barriers to access. The radiation treatment utilization rate is the proportion of patients who receive at least one course of radiation treatment during their lifetime. CCO's target utilization rate is 43%, which has been developed using a benchmark approach reflecting data from Ontario communities identified to have little to no barriers to access.¹⁹ This target is similar to international reports for radiation therapy utilization rates.¹⁶ Provincial data demonstrates that in 2016, the actual radiation therapy utilization rate was 39%, representing a gap of 4%, or approximately 4500 patients annually, who should receive radiation therapy services who currently do not (internal data, CCO, unpublished, 2016/17). The target utilization rate is used in the model to ensure proper access to radiation therapy for all patients who would benefit from it, by gradually increasing utilization to reach the target by 2028.

Retreat factor

Approximately half the courses of radiation therapy delivered in the province are for palliative intent (internal data, CCO, unpublished, 2012-2016). With improvements in systemic therapy, patients with metastatic malignancies are living longer and may need more courses of palliative radiation therapy to the same or different

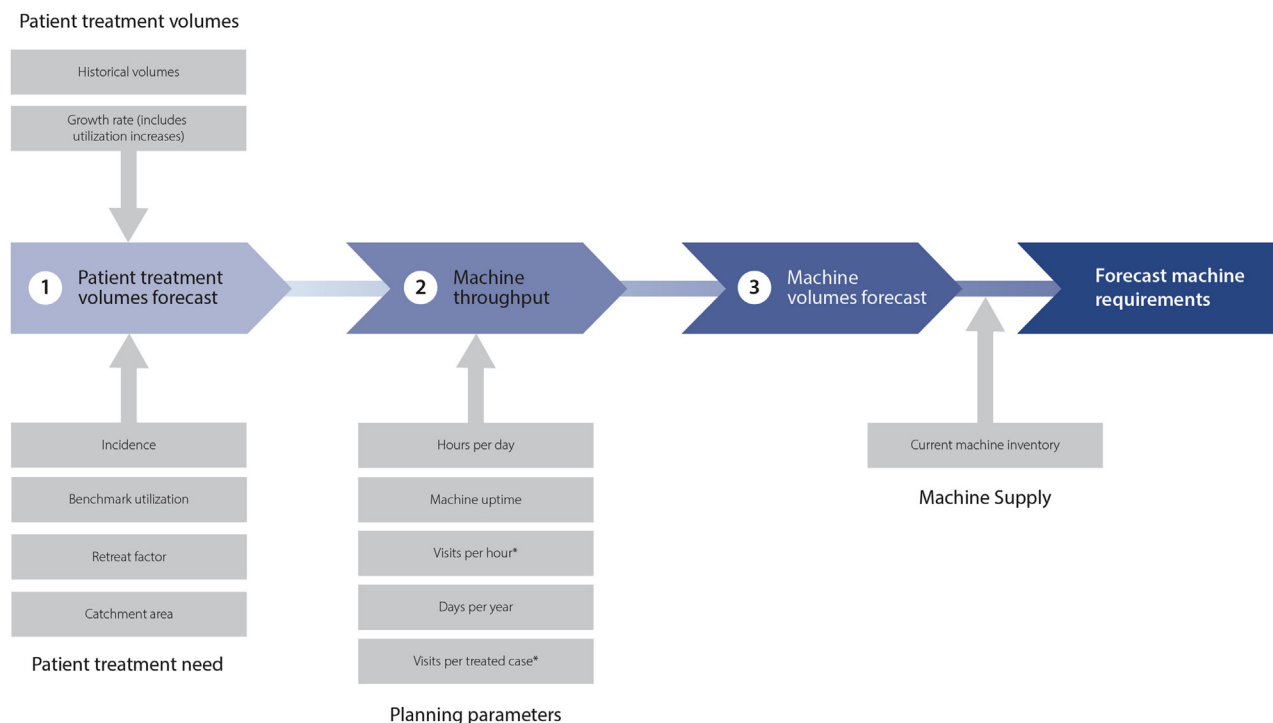


Figure 2 Model architecture to forecast machine requirements.

area as previous radiation treatment, defined as a retreatment. Based on provincial trends (internal data, CCO, unpublished, 2012-2016), the rate of radiation retreatment is approximately 20%, in keeping with rates reported in the literature.^{20,21}

Catchment areas

To transform census division level projections to facility level projections, the referral patterns from 2016 and 2017 were used to estimate the patient demand by RCC and are assumed to be stable through the planning horizon. The projected annual growth rate for radiation treatment volumes across RCCs to achieve the benchmark utilization rate by 2028 varies from 2% to 5%.

Machine throughput

Machine throughput is the number of treated cases per radiation treatment machine per year. It was derived from 5 planning parameters: (1) the average number of hours each treatment machine operates in a day; (2) the average number of days each treatment machine operates in a year; (3) the average number of radiation treatment visits per hour on a treatment machine; (4) the percent of time a treatment machine is providing treatment in a year; and (5) and the average number of radiation treatment visits per treated case. Machine throughput was calculated as per the equation:

$$Machine\ throughput = \frac{\frac{Hours}{Day} \times \frac{Days}{Year} \times \frac{Visits}{Hour} \times Machine\ Up\ Time}{\frac{Visits}{Treated\ Case}}$$

The first 3 parameters were derived from 2016 and 2017 facility-level estimates based on actual patient treatment data submitted by RCCs to CCO’s cancer data repository (Table 1). The fourth parameter (machine up time) was assumed to be 95%. The fifth parameter (number of radiation treatment visits per treated case) was taken from the 2016 and 2017 Ontario weighted average of treatment visits per treated case (Table 1). For the purposes of capacity planning, the machine throughput was calculated by setting the operating hours to 12 hours per weekday (for large centers, defined as a site with 6 or more machines), or 11 hours per weekday (for small centers, defined as a site with less than 6 machines), corresponding to the recommended operating hours in the 2012 capital investment strategy. The strategy plans for recommended operating hours rather than current hours of operation to maximize value for investments in alignment with Planning Principle 2, before the addition of new equipment is recommended for a facility. The machine throughput was calculated as 459 treated cases per machine per year for large centers and 421 treated cases per machine per year for small centers.

Machine demand and supply

In alignment with planning principle 1, the number of machines required to satisfy the demand for radiation

Table 1 Ontario 2016 and 2017 median and range of values for the average number of hours each treatment machine operates in a day (hours per day), the average number of days each treatment machine operates in a year (days per year), the average number of radiation treatment visits per hour on a treatment machine (visits per hour), and the average number of radiation treatment visits per treated case (visits per treated case)

	Median	Minimum	Maximum
Hours per day	9.3	7.7	10.8
Days per year	252	236	257
Visits per hour	2.6	2.3	3.6
Visits per treated case	15.8	13.7	20.4

treatment in the region (machine demand) is calculated as the number of patients who annually require radiation (patient demand) divided by the machine throughput. Machine demand forecasted to 2028 was compared with the existing machine supply at each RCC and was used to outline when treatment machines should be added to the system. This timeline must be considered in the context of local-regional implications such as how and where the new treatment machines will be added within the regional cancer program's catchment area, construction timelines, replacement machine timelines, patient travel time, and regional hospital supports and partners.

Results

Recommendation

Based on the constructed model (Fig 2) using the variables outlined earlier, it was calculated that by 2028 Ontario requires 26 additional radiation therapy machines to meet radiation treatment needs assuming radiation utilization reaches the benchmark rate of 43%. If utilization rates remain at current levels (39%), then 15 additional machines are required to ensure continued access to radiation therapy until 2028. These machines will be equipped with up-to-date technology including image guided radiation therapy and stereotactic capabilities. From a fiscal perspective and to ensure value for investment of existing infrastructure, machines will first be added to available bunkers in existing RCCs, followed by a review of the need for additional centers.⁶

Interpretation

Although prior radiation therapy capital investment strategies have been very effective at closing the gap between radiation treatment demand and capacity across the province, in this new plan CCO aimed to ensure full access to radiation therapy by 2028 for all Ontarians

who may benefit from treatment. Throughout the past decade, there has been a substantial and sustained drop in wait times for radiation treatment, and the province has consistently been within the Canadian national wait time targets. According to the Canadian Institute for Health Information, since 2013, Ontario has had 98% or more of its patients receive radiation therapy care within the Canadian benchmark of 28 days, as measured from the time a patient is ready to treat until they begin radiation therapy treatment.²² In 2017, 50% of patients were treated within 8 days and 90% of patients were treated within 15 days.²² Additionally, Ontario has met its internal target of 85% of patients to start treatment from the time they consent to radiation therapy of 1, 7, and 14 days based on emergent, urgent, and standard radiation therapy indications for the 5 fiscal years preceding this strategy (internal data, CCO, unpublished, 2012-2017). This represents a substantial improvement compared with the wait time crisis facing Ontarians receiving radiation therapy in the 1990s,²³ in large part due to Ontario's monetary investment based on the recommendations from CCO's first radiation therapy capital investment strategy released in 1992. Based on continuous data collection of patient and radiation machine factors, and monitoring of strategy assumptions, CCO has been able to continue to plan for the future to ensure continued access to radiation therapy care.

Limitations

There are 5 main limits of the model and the calculations. First, based on the 2012 Capital Investment Strategy, recommendations were made to extend treatment hours in some RCCs to 12 hours per day. This strategy maintained these recommendations of extended treatment hours, as extending operating hours can be a cost-effective way to increase capacity, depending on the local capital and human resources investments.²⁴ Furthermore, there are concerns extended treatment hours may effect machine life-years and result in machine reliability issues if standard machine life-years are used for replacement. CCO works with the regional cancer programs to monitor equipment performance and changes to recommendations of operating hours and machine throughput calculation can be revised if needed; this would result in alterations to subsequent machine recommendations.

Second, given patients are living longer with metastatic disease (likely owing to new systemic treatments, including targeted and immunotherapies), and there is increased recognition of the role of palliative radiation therapy in relieving symptoms and improving overall survival for patients with oligometastatic disease,²⁵ the number of courses of radiation therapy delivered per patient (retreat factor) has been increasing (internal data, CCO, unpublished, 2012-2017). Therefore, our planning

strategy could underestimate the number of treatment units required. CCO re-evaluates the capital investment strategy every 5 years, and alters it as necessary to account for the changing landscape.

Third, the role and use of SBRT as a treatment of multiple malignancies is expanding, for example as treatment for early stage nonoperable nonsmall cell lung cancer,²⁶ renal cell carcinoma,²⁷ and prostate cancer.²⁸ Patients may therefore require fewer radiation treatment sessions compared with conventional fractionation schemes, although generally each SBRT fraction requires significantly more time in the radiation therapy unit for patient set-up and treatment delivery, thus effecting our planning strategy.

Fourth, the radiation treatment target utilization rate is set at 43% in this strategy, which is lower than prior strategies, with a target of 48% determined from prior research.¹⁹ However, this conservative target is higher than Ontario's current utilization rate of 39%. This rate was determined based on internal data from Ontario communities identified to have little to no barriers to access and is in keeping with some international reports¹⁶; however, other jurisdictions maintain a 50% target utilization rate.^{2,29,30} The target utilization may require further modification in the future based on internal provincial data and emerging global data, which will subsequently affect provincial radiation capacity.

Fifth, this strategy focuses on radiation machine need only. However, investments in treatment machines and facilities must be aligned to investments in health human resources to ensure success.^{31,32} CCO is concurrently conducting work on health human resources planning to ensure alignment with this capital investment strategy.

Conclusions

To our knowledge, this is the first publication of the development of a radiation therapy capital investment strategy in the medical literature. This description of the development of a capital investment strategy, and the assumptions and calculations that form the base of the strategy, may be beneficial to radiation therapy organizations worldwide as a framework for understanding radiation therapy machine requirements. The strategy recommends adding 26 linear accelerators to Ontario RCCs by 2028, to achieve barrier-free access to radiation therapy services across the province. With increasing recognition of the lack of global access to radiation therapy,^{2,33} other jurisdictions may use the general model presented in this strategy, adapted to their population-specific assumptions and data, as a foundation to help plan their radiation program. Overall, the goal of CCO's capital investment strategy aims to ensure there is continued province-wide access to quality radiation therapy care.

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