

Background

- Radiotherapy is a common treatment for many cancers, but up-to-date estimates of the cost of radiotherapy are lacking.
- In Canada, three-dimensional conformal radiotherapy (3D-CRT) had been the most common technique, but intensity-modulated radiotherapy (IMRT) has become the more popular choice due to higher efficacy and reduced toxicity.
- Previous cost studies that assess or compare IMRT and 3D-CRT have used inconsistent methodologies and included different costs in their calculations, which makes it difficult to build a consensus around the respective costs or how they compare.
- Activity-based costing (ABC) has been promoted as the optimal way to determine the real cost of radiotherapy¹, but there have been very few attempts to use this methodology.

Objective

To develop an ABC framework that can estimate the costs of IMRT and 3D-CRT for various disease sites and settings by adjusting treatment times and fractions per treatment accordingly.

Methods

- An ABC model with five activities (Table 1) was built to estimate costs of 3D-CRT and IMRT in prostate cancer, and subsequently modified for breast and head and neck cancers.
- Activity times and unit costs were provided by three Ontario radiation treatment centres and a physicist survey by the Physics Professional Advisory Committee.
- Supporting infrastructure costs that fell outside of the five core activities were obtained from hospital cost centres.
- Key assumptions were varied to test the sensitivity of our results.

Table 1. Overview of ABC – MoHLTC perspective

Activity	Included Costs
1. Consultation	Radiation oncologist, nurse, gold seed insertion
2. Computed tomography (CT) simulation	Therapist, CT simulator, immobilizer, information system (patient management)
3. Dosimetry	Therapist, planning system, radiation oncologist, information system (patient management)
4. Physics QA	Physicist, physics associates (IMRT only), specialized QA equipment (IMRT only), planning system, information system (patient management)
5. Treatment QA and delivery, review visit(s)	Therapist, linear accelerator, radiation oncologist, nurse, information systems (patient management; record or verify)

Results

- IMRT was more costly than 3D-CRT in prostate cancer (\$12,834 vs. \$12,452 per patient; incremental: \$381); head and neck cancers (\$14,155 vs. \$12,536 per patient; incremental: \$1,619); and breast cancer (\$8,853 vs. \$8,659; incremental: \$193).
 - IMRT required more resources than 3D-CRT for dosimetry and physics QA in all disease sites; for head and neck cancers, IMRT also required more resources for treatment preparation, delivery, and review visits (Table 2).
- Costs were higher from the perspective of the Ministry of Health and Long-Term Care (MoHLTC) than the radiation treatment program (not shown) because the MoHLTC covers physician fees and capital costs (acquisition and construction) of equipment such as linear accelerators and CT simulators.

Table 2. Costs per patient by disease site

Activity	Prostate			Head and neck			Breast		
	IMRT	3D-CRT	Incremental	IMRT	3D-CRT	Incremental	IMRT	3D-CRT	Incremental
1. Consultation	\$409	\$409	–	\$292	\$292	–	\$292	\$292	–
2. CT simulation	\$426	\$426	–	\$574	\$574	–	\$426	\$426	–
3. Dosimetry	\$1,623	\$1,487	\$136	\$1,623	\$1,487	\$136	\$1,357	\$1,222	\$136
4. Physics QA	\$421	\$176	\$245	\$491	\$220	\$271	\$203	\$146	\$57
5. Treatment QA and delivery, review visit(s)	\$7,973	\$7,973	–	\$9,193	\$7,980	\$1,213	\$4,592	\$4,592	–
Supporting infrastructure*	\$1,982	\$1,982	–	\$1,982	\$1,982	–	\$1,982	\$1,982	–
TOTAL	\$12,834	\$12,453	\$381	\$14,155	\$12,536	\$1,619	\$8,853	\$8,659	\$193

*Hospital administration, building service, security, laundry, medical records, porters, social work, clerical, clinical nutrition, utilities, housekeeping

Sensitivity analysis

- Increasing the amount of time required for dosimetry (base case: 2.5 hours; sensitivity: 3.75 hours) and physics QA (base case: 0.5 hours; sensitivity: 2 hours) for IMRT to reflect the learning curve of initial implementation increased the incremental cost of treatment for prostate cancer (\$381 vs. \$816).
- Adding volumetric arc therapy (VMAT) to IMRT, which reduces minutes per fraction and overall treatment time (base case: 9.75 hours; VMAT: 6.5 hours) significantly reduces the incremental cost to make IMRT cost-saving in prostate cancer (base case: \$381; VMAT: -\$1,773).
- Similar results were found in breast cancer and head and neck cancers.

Discussion

- IMRT was generally more costly than 3D-CRT, but costs per patient were highly variable depending on disease site.
- The incorporation of VMAT reduced IMRT treatment times such that it became cost-saving compared to 3D-CRT.
- Our study was based on mature programs; applying this framework when a technique is brand new could capture higher treatment times and costs when staff are still learning.
- The findings of this study were based on the workflow of specific sites, so further validation will ensure costs are representative.

Conclusion

This work demonstrates that accurate radiotherapy costing varies depending on disease site and technique, and provides a costing framework that can account for the relevant differences in complexity.²

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References

- 1Lievens, Y., et al. Activity-based costing: a practical model for cost calculation in radiotherapy. *Int J Radiat Oncol Biol Phys* 2003;57:522-35.
- 2Yong, J., et al. Estimating the costs of IMRT and 3D-CRT in Ontario. *Curr Oncol* 2016; in press.