



Access to radiation therapy: modelling the geographic distribution of demand

M.R Taylor BSc RTT, P.S. Craighead MBChB FRCPC,*[†] and P.B. Dunscombe PhD FCCPM^{†·‡}*

1. INTRODUCTION

Alberta currently has two comprehensive tertiary cancer centres, the Cross Cancer Institute (CCI) in Edmonton and the Tom Baker Cancer Centre (TBCC) in Calgary, 300 km to the south. These two centres are responsible for providing radiation treatment services to the population of the province. A further fifteen associate and community cancer centres are distributed throughout the province, providing access to follow-up and chemotherapy.

The large geographic area of the province (661,000 km²) means that a significant number of Albertans do not live within daily driving distance of the radiation therapy services in either Edmonton or Calgary. Patients who have to temporarily relocate to receive appropriate treatment face many challenges, including the stress associated with travel and time spent away from local avenues of support¹. They also have additional financial costs in terms of travel and accommodation².

The topic of distributing radiation treatment services throughout a geographic area has been discussed by several authors³⁻⁶. There seems to be little consensus as to which model provides the best access, care system, and support within the resource constraints of a publicly funded health care system. The present study examines alternative service models for radiation treatment in Alberta from the perspective of demand. The relatively simple approach adopted here is readily applicable to the delivery of other health care services beyond cancer care.

2. METHODS

The study was conducted in Canada's western province of Alberta. The cities of Grande Prairie, Lethbridge, Medicine Hat, and Red Deer were identified as additional sites that might have the demand to support a radiation treatment facility. These cities have existing cancer care services that provide new patient consults, follow-ups, and chemotherapy, but not radiation.

We expressed demand in terms of courses according to this formula:

$$\text{Courses} = P_{100} \times I \times C \times (1 + RT),$$

where P_{100} is the population living within 100 km of the city of interest, I is the incidence rate, C is the fraction of new cases referred for radiation therapy at some stage during treatment, and RT is the re-treat rate.

We calculated P_{100} using population data obtained from municipal and 2001 federal census publications⁷. These data do not explicitly specify the number of people living within a 100-km radius of the urban centres of interest. Rather, they provide the populations of various counties, municipal districts, cities, towns, and villages. To calculate the population within 100 km of the major centres, the fractional areas of those counties and municipalities lying within the 100-km radius were estimated. The census data were scaled according to the estimated fractional areas. In addition, any cities, towns, or villages (excluding summer villages, because of the seasonal nature of the population numbers) that fell within the 100 km were added to the total. The study assumed that the population outside of cities, towns, and villages was evenly distributed.

Some areas of overlap exist. For the city of Red Deer, the 100-km boundary overlaps into both the Calgary and Edmonton catchment areas. In these cases, patients that fell within the overlapped areas were assigned to the larger centre. Some boundaries extend into British Columbia, Saskatchewan, and the United States. Patients from outside Alberta were excluded from the analysis. The calculated population totals were then referenced back to Alberta Municipal Affairs data⁷ for accuracy.

The number of new cancer patients per year was calculated for these 100-km radius areas around the cities of interest by multiplying the population (P_{100}) by the cancer incidence rate (I) for the province. The accuracy of our estimates of the number of new cancer patients per year was assessed by comparison with Canadian Cancer Society statistics⁸.

The fraction of the new-patient population expected to benefit from radiation therapy, C in the equation, was set at 0.5. This number is near the lower end of the range widely used in the literature for estimating demand^{9,10}. A proportion of these cases will also require re-treatment, and this number, RT in the equation, was estimated from CCI and TBCC operating statistics.

Our estimates of demand, quantified in terms of courses, is placed in context by comparison with the number of courses of radiation therapy that a linear accelerator can reasonably be expected to deliver in a year. That number was established using TBCC operating statistics for 2004.

The impacts of population growth and changing age distribution were separately incorporated by using provincial projections in repetitions of the preceding calculations¹¹.

3. RESULTS

Alberta has a population of approximately 3.1 million⁷. Currently, 72% of the population lives within 100 km of radiation treatment services.

We validated our population estimates by adding the number of people living within 100 km of the six identified cities to the number of people living outside the 100-km radii. Referencing these figures back to the Alberta Municipal Affairs⁷ data, our calculated total was found to be within 0.1% of the actual population, thus validating our population calculations.

The incidence of new cancer cases in Alberta (I) is 0.4% per year^{8,12}. This incidence rate has remained stable since 1995 (0.395% – 0.404%)⁸.

It was established from TBCC and CCI data that, given present practice patterns, 0.23 of incident cases will require re-treatment (RT).

An average megavoltage treatment unit at TBCC delivers 360 courses per year (new and re-treat). This number was used to establish a context within which to evaluate the sustainability of treatment facilities in other urban centres.

Figure 1 illustrates the number of radiation courses (both new patient and re-treat) that are expected within 100 km of the six identified cities for the year 2005 (smallest number). Increasing numbers represent projections based on simple population growth estimates for 2015 and 2025.

Several models for service provision within Alberta are worthy of consideration:

- **Current model:** Radiation therapy at TBCC and CCI only (the current radiation service model); 72% of Albertans live within 100 km of the two existing centres.
- **Model 1:** One treatment unit is installed in Red Deer. The unit would be fully utilized. Lethbridge and Medicine Hat patients are referred to the TBCC

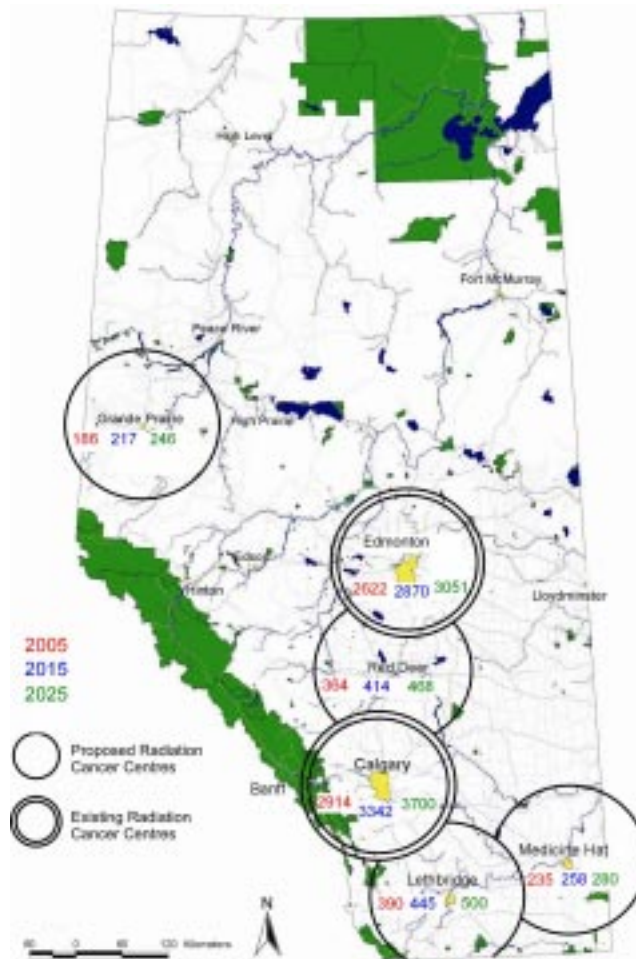


FIGURE 1 Number of projected radiation therapy courses within 100 km.

for radiation therapy and Grande Prairie patients are referred to the CCI. With this service model, 76% of Albertans would live within 100 km of a radiation treatment facility.

- **Model 2:** One treatment unit is installed in Lethbridge. The unit would be fully utilized. Red Deer and Grande Prairie patients are referred to the CCI. Medicine Hat patients are referred to Lethbridge or TBCC for radiation therapy. With this service model, 77% of Albertans would live within 100 km of a radiation treatment facility.
- **Model 3:** Clinics are added to both Red Deer and Lethbridge (models 1 and 2 combined). With this service model, 82% of Albertans would live within 100 km of a radiation treatment facility.
- **Model 4:** As per model 3, but with an additional clinic added in Medicine Hat. With this service model, 85% of Albertans would live within 100 km of a radiation treatment facility. Alternatively, a second treatment unit could be added in Lethbridge to accommodate patients from Medicine Hat. Although the Lethbridge unit would be

beyond Medicine Hat's 100-km radius (160 km away), it would be closer than the unit at TBCC (290 km away).

The city of Grande Prairie is 450 km northwest of Edmonton. If, in addition to model 4, radiation services were to be introduced there, then 87% of Alberta's population would be within 100 km of a treatment facility. However, at a capacity of 360 courses annually, a unit in Grande Prairie would not currently be fully utilized.

The age distribution of the population is another factor to consider when quantifying demand for cancer services. Figure 2 shows the percentage of the population over the age of 65 years in the selected areas in 2005 and the change expected for 2015 and 2025¹¹.

To create an approximation good enough for the present purpose, we divided the total population into two groups: those over 65 years of age ("over-65s"), and those under 65 years of age ("under-65s"). The cancer incidence rate is assumed to be 2% for the former group and 0.2% for the latter. These numbers are broadly consistent with available statistics^{8,12} and yield an overall incidence rate of 0.38% when over-65s constitute 10% of the population. This number is very close to the 0.4% level currently seen in Alberta, with an over-65s population of 10.4%¹³. Predictions suggest that, in 2025, in some areas, close to 20% of the population will consist of over-65s (Figure 2).

Based on these simple approximations and projections, the foregoing change in the two-component age-structure model alone—that is, without an increase in the total population—will lead to an increase in the overall cancer incidence rate by almost 50% in the next 20 years. Our conclusions about the adequacy of demand to support radiation facilities in Red Deer

and Lethbridge/Medicine Hat are reinforced by this observation. However, the Grande Prairie region still could not fully utilize one machine until about 2025.

The population of Alberta is predicted to grow by 25% over the next 20 years. With no change in the age structure, or any other factors that influence cancer incidence, demand for radiation would increase at the same 25% rate.

4. DISCUSSION AND CONCLUSIONS

Based on a simple quantitative approach, we estimated the geographic distribution of demand for radiation therapy services in Alberta now and into the future. This method can, in principle, be applied throughout the health care system; it is not restricted to radiation services. Although our conclusions about where fully utilized machines should be placed are not affected, we consider that the predicted change in age distribution will have a potentially significant impact on demand for services (number of treatment units installed).

The provision of low-volume procedures such as brachytherapy may not be feasible at smaller centres. Patients requiring these forms of therapy would probably still need to be referred to a tertiary centre. Because the number of such patients is small, our general conclusions are not compromised by the omission of these low-volume procedures.

The study does not address the supply side of this issue, apart from placing demand in the context of the capacity of a fully-utilized treatment unit. In distributing the provision of radiation services, factors including maintenance of professional competence and local availability of new, highly-complex techniques such as intensity modulated radiation therapy would need to be taken into account to ensure referrals from community physicians. However,

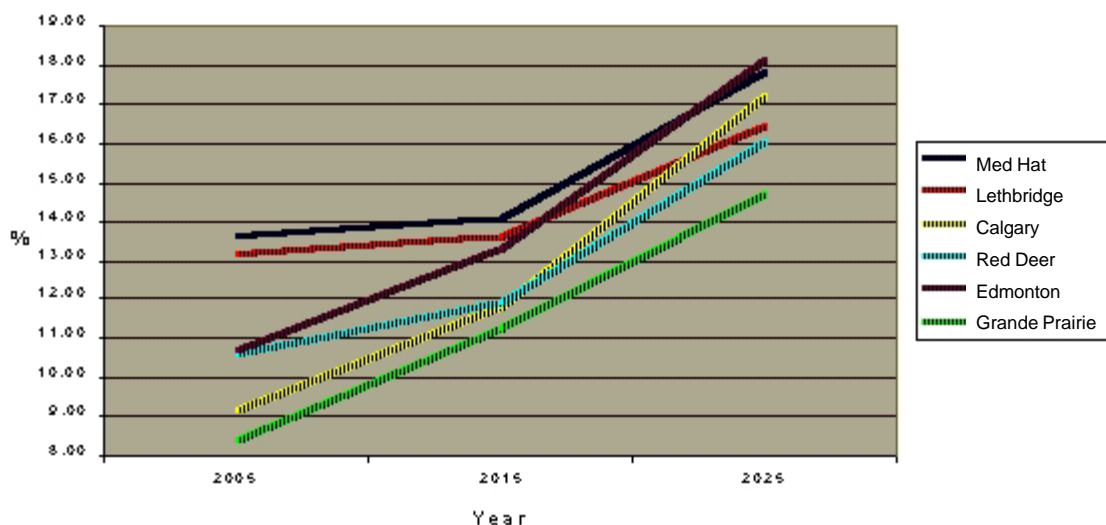


FIGURE 2 Percentage of population 65 years of age and older.

a move away from a centralized service delivery model, as suggested by Roberts *et al.*⁶, would certainly be beneficial in some form for the 28% (approximately 875,000) of rural Albertans who currently live more than 100 km from existing radiation therapy services. Advances in technology and communication may enable service providers to overcome many of the obstacles traditionally associated with decentralized radiation therapy.

5. ACKNOWLEDGMENT

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Corresponding author: Michael Taylor, Department of Radiation Oncology, Tom Baker Cancer Centre, 1331 29th Street NW, Calgary, Alberta T2N 4N2.

E-mail: michaelt@cancerboard.ab.ca

* Department of Radiation Oncology, Tom Baker Cancer Centre, Calgary, Alberta.

† Department of Oncology, University of Calgary, Calgary, Alberta.

‡ Department of Medical Physics, Tom Baker Cancer Centre, Calgary, Alberta.