



NL Radiation Therapy (RT) Service Plan to 2026

January 2015

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EXECUTIVE SUMMARY

During the years 2008 to 2012, almost 16,000 residents of Newfoundland and Labrador (NL) were diagnosed with cancer. 89% of all new cancer diagnoses were to people aged 50 years and over.

Radiation therapy (RT) is one of the main treatments for cancer. It is cost effective but is also complex and reliant on highly specialized equipment and personnel. Radiation therapy, also called radiotherapy, uses high energy radiation beams or particles to kill tumour cells or shrink tumours. External beam radiation therapy (EBRT), the most common type of radiation therapy, uses a machine, usually a linear accelerator (linac), to direct a beam of radiation through the skin to the tumour.

Cancer radiation treatment was first offered in NL in 1972. All radiation therapy is currently provided, and all specialized radiation oncology personnel are based, at the Dr. H. Bliss Murphy Cancer Centre (BMCC) in St. John's. Cancer patients requiring radiation therapy travel to St. John's for consultation with radiation oncologists and for treatment. Some follow-up radiation oncologist visits are provided either through visiting clinics or teleoncology clinics in regional centres outside of St. John's. Newfoundland and Labrador's Cancer Care Program (CCP) based at St. John's in Eastern Health is administratively responsible for the provision of services to cancer patients throughout the province.

Each series of radiation therapy, called a 'course', can consist of one to 35 visits or 'fractions' depending on diagnosis, each taking about 15 minutes and usually provided one per day. On average, RT patients in NL receive about 16 treatment visits or fractions during one course of treatment.

Ensuring access to radiation therapy services for all cancer patients who need it is a critical priority in cancer treatment service planning. Utilization is measured based on the proportion of cancer diagnosed patients treated with RT and by the ratio of linacs per million population.

The Canadian Partnership Against Cancer (CPAC) publishes radiation therapy utilization information for all Canadian provinces. Of those NL residents diagnosed with cancer in 2010, approximately 31% received radiation therapy during the two years following diagnosis. When compared by province for 2010, rates of radiation therapy use within two years of diagnosis ranged from 29.1% to 35.9%. In 2010, the highest radiation therapy utilization rate was in Prince Edward Island at 35.9%. Published international best practice radiation therapy utilization rates are significantly higher; the Australian best practice rate has been recently revised to 48%.

In 2012, NL had 7.6 linacs per million people, compared with 7.2 linacs per million in Canada. NL's ratio of linacs per population and utilization rate are reasonably comparable with Canadian experience. However, Canada's radiation therapy utilization rate overall, including NL, is lower than international best practice standards.

Historically, because of its technical complexity and capital cost, radiation therapy has tended to be centralized in major centres, usually associated with tertiary care hospitals. Over the past fifteen years, with increasing recognition of the physical and financial challenges faced by patients to access services sometimes many hours travel distance from their homes, the need to distribute radiation therapy has been increasingly recognized worldwide.

NL presents a unique context that has required special consideration in development of this Service Plan. Among the many challenges are its geographic and climatic realities and its population and demography. NL's weather is highly variable and unpredictable during most months of the year, including fog, wind, snow

and rain often making travel difficult. More than 50% of NL's population lives in the St. John's vicinity; much of the remaining population lives in small, widely dispersed communities. NL's population is projected to decrease to at least 2026. A high proportion of the population is elderly now and the overall population continues to age.

Another area of special consideration for NL's radiation therapy service is human resources. Clinical safety is of paramount importance in the delivery of radiation therapy services, and is highly dependent on the availability of qualified, experienced specialized personnel. Staff recruitment and retention of professional RT staff has been a challenge for CCP historically and currently. These challenges are expected to continue in the future with worldwide shortages of these personnel.

The *NL RT Service Plan Study* provides a significant opportunity to reassess the CCP current RT delivery model at a critical time in the evolution of RT services in NL and to proactively plan for future changes to 2026. The Service Plan utilizes cancer incidence projections, utilization rates and planning metrics applied to referral catchment areas to project RT service requirements to 2026.

In 2014, Government of Newfoundland Labrador (GNL) confirmed the addition of RT to Corner Brook, NL, as part of a major infrastructure initiative that includes the redevelopment of the Western Memorial Regional Hospital, cancer facilities and hostel (see *Cancer Centre Western (CCW) Functional Program September 2014*). The new Cancer Care Western (CCW) will be the first distributed RT service within the NL CCP, and will include two linac vaults (bunkers) built on the opening of the new CCW. One vault (bunker) will be fully equipped with a dual energy linear accelerator (linac); the second vault (bunker) will serve as a swing vault to be available for linac replacement or addition of a second linac as required. A CT simulation unit for treatment planning within the CCW will be provided. It is anticipated that this facility will be operational by 2019.

The projected workload for the new CCW based on workload projections targeting higher best practices referral and utilization rates, does not support the need for more than one linac until close to 2026. The Service Plan recognizes that, with only one linac, care continuity becomes a major consideration regarding Linac repairs and performance. Mitigation through careful case selection, advance planning for patient management in event of machine breakdown and maintenance/repair provisions are required.

The Dr. H. Bliss Murphy Cancer Centre in St. John's will continue to provide NL's tertiary and specialized referral RT treatment services including all non-external beam RT, including brachytherapy, infrequent, specialized EBRT procedures (e.g., stereotactic radiosurgery and stereotactic body radiation therapy) that need highly specialized expertise, equipment and supplementary clinical and supportive care; and children needing RT treatments.

The new NL distributed RT site at CCW will gradually evolve over three to five years post opening from being heavily reliant on the tertiary cancer centre in St. John's to becoming substantially more self-reliant with more local expertise. For planning purposes, these two phases of the care model development will be referred to as the 'initial' and the 'established' care models. It is recognized that there will be several intermediate care model stages (i.e., hybrid care models) as the transition proceeds over several years. Safety and high quality services are core drivers that will guide the care model transition from 'initial' to 'established'. Ensuring that high quality RT services can be provided locally without compromising the safety of patients or staff will determine when new RT protocols are introduced locally.

- Under the 'established' model', about 80% of the local cases requiring RT will be managed at a distributed RT site. A lower percentage may be managed locally during the 'initial' stage and may be influenced by the special expertise of staff recruited for the distributed RT service.

- Under the 'established' model, highly complex or low volume cancer cases requiring specialized consultation services and/or equipment will continue to be managed at the tertiary centre. This is expected to involve about 20% of RT patients resident in distributed site's catchment area after about three to five years.

Capital implications identified in this Service Plan include:

- Cancer Centre Western, Corner Brook:
 - Construction of CCW as part of the WMRH redevelopment, including 1 linac and 2 vaults at opening
 - Provision for 2nd linac if care continuity or workload demands
- Dr. H. Bliss Murphy Cancer Centre
 - Continue with RT equipment replacement plan
 - Undertake Master Plan for cancer services on the BMCC site by 2016 to address the need, location and timing for:
 - Addition of one swing vault (bunker) to provide for linac replacement
 - One more additional vault (bunker) equipped with a linac by 2026 or sooner depending on workload
- Additional distributed sites
 - Restrict other RT distributed site expansion until CCW RT service has been operational for at least 3 years and an evaluation has been completed.

A number of actions considered essential in achieving successful outcomes for the NL RT Service Plan have been identified. A viable Medical Physics (MP) staffing, compensation and training plan needs to be resolved and implemented as soon as possible. Development of a comprehensive CCW staffing plan with a focus on core staffing, recruitment and training is required well in advance of CCW opening. Care continuity/risk reduction contingency plans need to be developed and agreed provincially for implementation of the single linac site at CCW. MediTech system integration among all Health Regions is required to enable electronic transfer of data files between CCW and BMCC for service and backup, as well as for effective diagnostic data transfer. A dedicated Project Manager with RT expertise reporting to CCP administration needs to be appointed as soon as possible to provide leadership for the CCW project from design, through construction to operations planning and implementation.

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1.0 INTRODUCTION

Radiation therapy service delivery in Canada's eastern most province of Newfoundland and Labrador (NL) recently reached a significant crossroad. In May 2014, the Government of Newfoundland and Labrador (GNL) announced the addition of a new radiation treatment site in Corner Brook, NL, to be included in new facilities previously approved to replace the Western Memorial Regional Hospital (WMRH). This second NL radiation therapy service site is intended to improve access for cancer patients in western NL to radiation treatment. Cancer patients in western NL are distant from the existing RT services consolidated in the Dr. H. Bliss Murphy Cancer Centre, tertiary cancer centre in St. John's, NL.

Radiation Therapy (RT) services are recognized internationally as providing major therapeutic benefits for cancer patients when correctly and safely delivered. RT uses high energy radiation, usually as one component of cancer treatment, to shrink cancer tumours or kill cancer cells by damaging their DNA. RT has been applied in various forms as a cancer treatment for over 100 years. During this time, RT treatments have become increasingly complex and reliant on highly integrated, specialized equipment and software. RT treatments must be carefully planned and delivered since RT can damage normal as well as cancer cells. Effective and safe radiation therapy is dependent on the expert skills of a multi-disciplinary team of relatively scarce health professionals.

NL's Cancer Care Program (CCP) faces unique challenges in providing RT due to NL's large geographic area, relatively small dispersed aging population, and unpredictable, often extreme weather. Expanding the delivery of RT services outside a tertiary cancer centre to add a new distributed RT site requires extensive planning to develop a safe delivery model. In response to these circumstances, the NL Ministry of Health and Community Services (Ministry) retained Altus Planning Inc. (Consulting Team) in late May 2014 to advise on a future service plan for the delivery of radiation therapy in NL (Study).

1.1 Study Purpose, Scope & Guiding Principles

This report, titled [Newfoundland & Labrador Radiation Therapy Service Plan to 2026](#) (or shortened to [NL RT Service Plan](#)) was prepared to fulfil the following study purpose, scope and guiding principles as set by the Ministry.

Purpose

The Study purpose was to:

- Undertake a comprehensive review of the existing radiation therapy (RT) service model in NL; and,
- Recommend a service plan for the delivery of radiation therapy services in NL to meet cancer needs to 2026.

The proposed service plan is to incorporate, as a first priority, provision for the expansion of RT services at the new WMRH campus within the Western Health Region (WHR) in Corner Brook, NL.

Scope

The Study scope included:

- Identifying and evaluating RT service delivery models in other jurisdictions that could be applicable to NL (relatively isolated geography and dispersed population);
- Documenting existing NL RT service delivery models and opportunities for improvement;
- Assessing RT current and future demand for RT services in NL to at least 2026;
- Assessing the CCP's capacity to meet current and future RT demand to 2026; and,
- Recommending an RT service delivery model(s) that will meet relevant accreditation standards, including:

- Geographic placement of radiation services
- Governance approach
- RT information management/technology requirements
- Staffing strategies to address recruitment challenges & training needs
- Implementation timelines (i.e., estimated phasing by major activity)
- Operational standards and performance benchmarks
- Advice on integration within the broader, current health service delivery model
- Critical success factors, including key strategic considerations


The Study included a supplementary scope of work to prepare a detailed functional program for the new Cancer Centre Western (CCW) for radiation therapy, systemic therapy (commonly called chemotherapy), and related services as part of the new WMRH campus. This supplementary scope of work is presented in a separate, affiliated report titled the **Cancer Centre Western Functional Program (2014)**. The findings and recommendations in this report (i.e., **NL RT Service Plan**) provide the foundation and framework for the CCW functional program report.

Study Guiding Principles

As identified by the Ministry, the provincial RT service plan should enable the following over-arching principles for the RT services provided:

- safe service delivery for patients and staff
- high quality, evidence based, best practices
- accessible
- sustainable
- cost effective

Due to special needs and circumstances, it was acknowledged early in the Study that these guiding principles may 'compete' with each other. Accordingly, a reasonable balance of these principles are required with the Ministry placing a high priority on the first three principles.



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1.2 Study Approach & Challenges

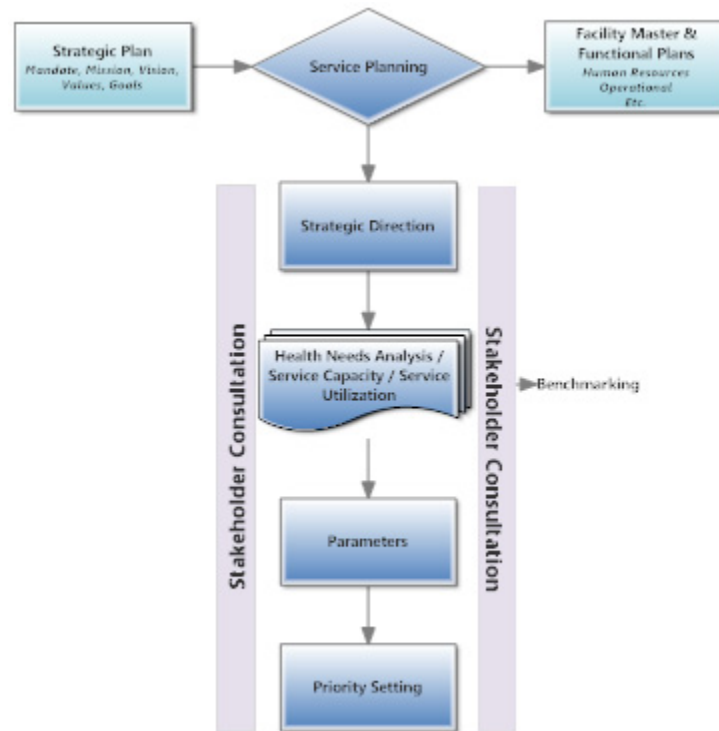
The **NL RT Service Plan Study** provided a significant opportunity to reassess the CCP current RT delivery model at a critical time in the evolution of RT services in NL and to proactively plan for future changes to 2026. To realize this opportunity, the following basic planning approach was adopted and related challenges were managed as outlined during the Study.

Service Planning: A health service planning model, developed by Altus Planning (see Figure 1.1), was adopted to structure the Study work plan. As shown in Figure 1.1, service planning is the essential transition step between strategic planning and functional (programming) planning. Service planning translates strategic directions into service parameters and guidelines. Such parameters enable detailed planning of workload, staffing, space and cost estimates for services.

Service planning requires the concurrent assessment of three core elements (i.e., health needs, service capacity and service utilization). These elements must be benchmarked against evidenced based best practices. The resulting findings then should be to be reviewed in depth with key stakeholders to document key service parameters and priorities. These service parameters create

the framework to answer the key service plan dimensions shown in Figure 1.2. The ultimate aim of service planning is to ensure cost effective use of available resources to best meet health needs.

Figure 1.1: Service Planning Model



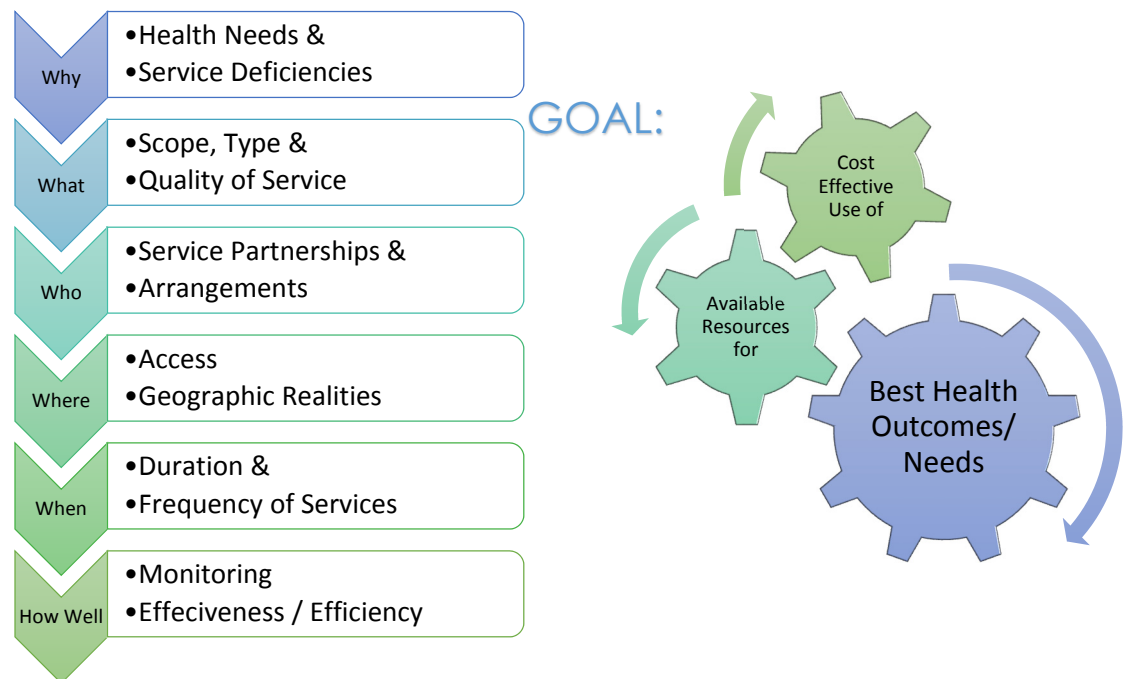
Planning Approach:

Using the service planning model illustrated in Figures 1.1 and 1.2, an emphasis was placed on iterative consultations, in person and by teleconference, with key stakeholders to identify issues and concerns and to present core concepts for feedback within the context of best practice information. This included the following key activities.

- The Consulting Team was supplemented with clinical experts from Alberta Health Services, who had recent direct experience in implementing and managing relatively new, small cancer centres with radiation therapy in the Maritimes, Alberta, and British Columbia.
- Information and data were requested and obtained from the NL's Health and Community Services Ministry and NL's Health Regions (HRs) with a special emphasis on RT information from the CCP.
- A literature review with an emphasis on providing RT in rural and remote areas and RT delivery standards was conducted and used to inform stakeholder sessions about core concepts affecting the RT service model.
- The Associate Deputy Minister, NL Ministry, was regularly involved in stakeholder sessions to ensure consistency with the Study's scope, timeframes and special considerations.
- Tours of relatively new, small RT sites in Lethbridge, Alberta, and Brandon, Manitoba, were organized with key stakeholders from the Eastern Health Region (EHR)/CCP, WHR/WMRH and the Consulting Team on 8-10 July 2014.
- In person stakeholder meetings were held in St. John's, NL, with representatives of the Ministry, EHR, WHR on 26-27 May and 29-31 July 2014, including consultations with statistical

- experts from Newfoundland and Labrador Centre for Health Information (NLCHI) on cancer projections.
- In person meetings with senior representatives of the Central Health Region (CHR), Labrador Grenfell Health Region (LGHR) and Canadian Cancer Society (CCS) - NL Division occurred in St. John's on 29-30 July 2014.
 - User group teleconference meetings were held: 6 & 20 June; 11, 12, 15, 18, 19, 20, 21 August 2014, along with multiple other individual calls to clarify information.
 - Phone consultations occurred with other cancer experts about development of RT service in a smaller, remote community (e.g., Manitoba, Ontario, British Columbia, Nova Scotia, and Alberta).
 - Following in person presentation of the CCW Functional Program on 25 September 2014 in Corner Brook, NL, stakeholder feedback affecting the NL RT Service Plan and CCW FP was reassessed by the Consulting Team, including confirmation of related data. The final **CCW FP** was issued on 31 Oct 2014.

Figure 1.2: Service Planning Dimensions



Study Challenges

Key process and content challenges faced by the Consulting Team during the Study period and how these were managed are listed.

- **Study Schedule:** The initial Study schedule was short (i.e., June to August 2014) due to the completion of the functional program process for WMRH's capital project and selection of the WMRH's design-build consultants during summer 2014. Accordingly, the CCW functional program was required as a draft in June and the final draft by late August 2014 to enable design work for the expanded CCW with RT to proceed along with the WMRH project.

Approach: To manage the complexities of summer schedules, the Team concurrently established the main Study's core concepts and drafted the CCW functional program. This enabled the Consulting Team to test the implications of the Study's proposed core concepts in real time on the new CCW with RT with key stakeholders. This approach allowed the **CCW**

FP to be completed as a final draft in late August 2014 with an extension granted to document the main Study report and concepts thereafter.

- **Unique NL Features:** There is limited national and international experience in providing RT services to a relatively isolated, small, dispersed population as currently served by the WMRH and CCW. This includes the viability of operating a single linear accelerator in a small community over four hours distance from another RT site. (Note: The CCW is approximately 7-8 hours by road from St. John's.)

Approach: A focus was placed on international jurisdictions with relevant experiences (e.g., Australia) and arranging site visits to two small, new Canadian cancer centres with some similar features to assess their experiences and lessons learned (i.e., Alberta and Manitoba).

- **Uncertain Service Population:** Since RT has been centralized in St. John's for decades, the future service population for a new CCW RT service was difficult to quantify (i.e., Will patients attend the CCW only from the Western Health Region (WHR) or will some also come from the Central and Labrador-Grenfell Regions?).

Approach: Insights from health region leaders and knowledgeable cancer patient representatives were used to inform planning assumptions. These were then cross-checked with the Consulting Team's assessment of travel distances and other factors affecting referral patterns.

- **Cancer Incidence Projections:** A validated, comprehensive statistical model to project NL cancer incidence to 2026 was unavailable and could not be developed within the short project timelines.

Approach: Following consultation with the NLCHI's statistical experts, the CCP's epidemiologist and other clinical leaders, a simplified projection methodology was developed and documented in this report. The model uses recent historical NL incidence data and trends, national findings from the Canadian Cancer Statistics annual reports (2014), and other population based drivers (e.g., population's general health status).

1.3 Report Format

The NL Radiation Therapy Service Plan to 2026 consists of the following main sections.

Executive Summary	Synopsis of key findings and recommendations.
1.0 Introduction	Outlines the Study purpose, scope, planning approach and challenges.
2.0 Contemporary RT- Background	Describes international best practice findings on core RT service model elements, including types of RT treatments, utilization metrics, clinical processes, staffing, trends, etc.
3.0 NL RT Service Status	Summarizes NL's current RT service context and model, including workloads, staffing, service capacity, service configuration, challenges, etc.
4.0 NL's RT Service Plan to 2026	Presents the core elements of a future RT service plan for NL, including critical success factors.
Appendices	Details additional information. Please note in particular. Terms & Abbreviations (Appendix A), References (Appendix B), and Literature Review (Appendix D).

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2.0 CONTEMPORARY RADIATION THERAPY - BACKGROUND

Information on radiation therapy is outlined in section 2.0 to set a best practices and trends context for assessing RT services needs and potential directions to 2026 in NL. A review of the international literature with a special emphasis on delivery of RT in relatively isolated geographic areas similar to NL is provided in Appendix D.

2.1 What is Radiation Therapy?

Radiation therapy, also called radiotherapy, uses high energy radiation beams or particles to kill tumour cells or shrink tumours. Radiation can be delivered as an external beam or by internal implants. Sometimes radioactive material is given by mouth or as an injection.

Radiation therapy is used alone to cure many cancers. It is also used in combination with other treatments or therapies such as surgery to reduce the size of tumours before surgery or to destroy any remaining cancer cells after surgery. Radiation therapy is also used in combination with other conventional cancer treatments such as chemotherapy and hormone therapy.

When cure is not possible, radiation therapy can help to alleviate symptoms such as pain, and extend or improve the quality of life for patients. This is often referred to as **palliative radiation therapy**.

The goal of radiation therapy is to give a high enough dose of radiation to kill cancer cells, while limiting the amount of radiation exposure and damage to normal cells. The total dose of radiation is usually divided into a number of smaller doses called fractions so that it kills cancer cells preferentially and therefore causes less damage to normal healthy tissues.

External Beam Radiation Therapy

External beam radiation therapy (EBRT), also called radiotherapy, uses a machine to direct a beam of radiation, usually but not always high energy x-rays, through the skin to the tumour. Most people who have radiation therapy for cancer receive external beam radiation. Note that **x-ray** is simply a name given to photons produced through a certain process/device and are part of the electro-magnetic spectrum that includes heat, light, radio waves, etc.

Linear accelerators (Linacs) or **cobalt machines** are used to deliver external beam radiation. Different models of linear accelerators produce varying accelerating voltages, which in turn determines their energy and therefore ability to penetrate into the body. The kind of machine used depends on the location, depth, type and extent of the tumour being treated.

- **Orthovoltage machines** produce lower energy beams that do not go deeply into the skin. They are used to treat surface tumours like skin cancers.
- **Megavoltage machines** produce higher energy beams that go more deeply into the body. They are used to treat deeper, internal tumours.

Other EBRT types and features of external beam radiation therapy include:

- **Conformal radiation therapy** is a common type of external beam radiation therapy, also called 3D conformal radiotherapy, or 3DCRT. It uses 3D medical imaging, such as that from CT scanners or MRI machines, along with computers and radiotherapy machines to shape the high dose of radiotherapy closely around the tumour. It aims to give a high dose of radiation to the cancer while reducing radiation damage to healthy body tissues and organs.
- **Intensity-modulated radiation therapy (IMRT)** can shape the distribution of radiation even more closely around the tumour than 3DCRT using more advanced computing and delivery methods. It aims the beams at the tumour from many different directions and can vary the

strength of the beams across the tumour during each dose of treatment, thereby giving a precise dose to the cancer or to specific areas within the tumour. Treatment planning still uses 3D CT images and more complex computerized dose calculations to find the dose strength pattern that best matches the tumour shape.

- **Stereotactic radiation therapy** directs beams from more angles than other types of radiotherapy so the overall area gets greater dose than the surrounding tissue, allowing an increase in the amount of radiation delivered per fraction over 3D CRT. This type of treatment requires us to target the tumour even more precisely, given the increase in radiation levels. Treatment planning ensures that the beams are aimed precisely so the tumour receives a very high dose while the surrounding normal tissue is still subjected to an acceptable dose. Stereotactic radiation therapy allows radiation beams to be given to a very specific area of the body, usually the central nervous system, and usually the brain.
 - Stereotactic radiosurgery (SRS) delivers a single high dose of radiation to the tumour (called a single fraction). This treatment doesn't involve surgery. An incision is not made and tissue is not surgically removed.
 - Stereotactic radiotherapy (SRT) gives smaller doses of radiation over a number of treatment sessions (called multiple fractions), until the desired total dose is given.
- **Stereotactic body radiation therapy (SBRT)** or *stereotactic ablative radiotherapy (SABR)* is similar to stereotactic radiosurgery except that it deals with tumours outside of the central nervous system. Because these tumours are more likely to move with the normal motion of the body, and therefore cannot be targeted as accurately as tumours within the brain or spine, high precision imaging is used at the time of treatment for very exacting localization of the tumours in order to treat with a large number of small but highly precise treatment fields. SBRT normally involves the delivery of a few fractionated radiation treatments.
- **Image-guided radiation therapy (IGRT)** uses imaging scans (often a form of CT) performed prior to treatment, although some systems are now using imaging during treatment as well. These imaging scans are processed by computers and inspected by the medical team to identify changes in a tumour's size and location due to treatment or body changes and to allow the position of the patient or the planned radiation dose to be adjusted for treatment as needed. Repeated imaging can increase the accuracy of radiation treatment and may allow reductions in the planned volume of tissue to be treated, thereby decreasing the total radiation dose to normal tissue.
- **Tomotherapy** is a type of image-guided IMRT. A tomotherapy machine is a hybrid between a CT imaging scanner and an external-beam radiation therapy machine. The part of the tomotherapy machine that delivers radiation for both imaging and treatment can rotate completely around the patient in the same manner as a normal CT scanner. Tomotherapy machines can capture CT images of the patient's tumour immediately before treatment sessions to allow for very precise tumour targeting and sparing of normal tissue
- **Electron beams** cannot travel very far through body tissue before they are completely stopped so they are used to irradiate superficial tumours, such as skin cancer or tumours near the surface of the body. Sometimes electron beam therapy is used to give a booster radiation dose to the tumour or the area where the tumour was removed.
- **Intraoperative radiation therapy (IORT)** is an intensive radiation treatment administered during surgery. IORT is used to treat cancers that are difficult to completely remove during surgery and there is a concern that microscopic amounts of cancer may remain. IORT allows direct radiation to the target area while sparing normal surrounding tissue since the normal tissue is physically moved during surgery.
- **Total body irradiation (TBI)** gives a dose of radiation to the whole body. It can destroy cancer cells throughout the body and, alongside high dose chemotherapy, help to kill leukemia,

lymphoma or myeloma cells in the bone marrow. This will be combined with bone marrow donor cells, or autologous stem cell transplant.

- **Proton therapy** is external-beam radiation therapy delivered by proton beams. Protons impart energy as they slow down and travel through the body. They then release most of their energy just before they slow to a stop, allowing the ability to choose energies that cause them to give up this burst of energy at a target point – the tumour. This means they can give a higher dose of radiation straight to the cancer, while completely sparing the healthy tissue beyond their path of travel.

Brachytherapy

Brachytherapy is also called internal radiation therapy, implant therapy or sealed source radiation therapy. In **brachytherapy**, a radioactive substance (radioactive isotope) is placed directly into, or very close to, the tumour. If it is placed permanently in the body it is called an implant; another form uses special tubes that allow the radioactive source to be placed temporarily in to the body, either through a natural opening (e.g. the esophagus or vaginally/rectally) or by inserting the tubes through the skin. A radioactive substance can also be placed in an area where a tumour was removed.

Radioactive substances come in several different forms, including special applicators, thin wires, tubes (catheters), ribbons, needles, capsules or small seeds. Depending on the type of implant, the radiation source will stay in place for minutes, hours, days, or permanently.

Systemic Radiation Therapy

Systemic radiation uses radioactive drugs or radiopharmaceuticals to treat certain types of cancer. These unsealed radiation sources are in the form of a liquid made up of a radioactive substance, which is sometimes bound to a special antibody that attaches to the cancer cells. Radioactive iodine, strontium, and samarium are some other types of systemic radiation used to treat certain types of cancers, such as thyroid, bone and prostate cancers. The radiopharmaceuticals may be given in a vein (IV) or taken by mouth. They travel in the blood throughout the body. They collect at the location of the cancer to give off their radiation and kill the cancer cells.

This treatment is usually provided in the Nuclear Medicine area of a tertiary health facility diagnostic imaging department.

Radiation Therapy Utilization by Type

External beam radiation is the most widely used type of radiation therapy. It is most often provided by linear accelerators (linacs). Linacs require the treatment rooms they are placed in to have a large amount of radiation shielding in their walls, and sometimes specialized shielding, to meet stringent federally legislated safety and licensing requirements.

According to the American Society of Radiation Oncology (ASTRO), in 2004 in the United States, linear accelerators comprised 88 percent of RT treatment courses. More specialized radiation treatment such as brachytherapy and stereotactic radiosurgery made up the remaining 12 percent.

Proton therapy requires a special machine called a **cyclotron** or **synchrotron** which costs millions of dollars and requires highly specialized staff to use and maintain it, and a dedicated treatment facility. Because proton beam therapy is very expensive, few treatment centers in North America offer it and so far none in Canada offer it. More studies are needed to compare outcomes between proton and photon treatment so that each is used for the cancer type for which it works best.

2.2 RT Utilization Rates & Metrics

Core terms and rates widely referenced to compare RT utilization internationally and mostly applicable to linac technology are summarized in the Figure 2.1. Care must be taken in comparing these rates since lack of detail on factors included in the calculations can substantially distort the calculations (see comments on 'Courses' in Figure 2.1). Also the type and age of EBRT technology can substantially impact the calculation (e.g., cobalt versus tomotherapy). Additional information from the literature review is available in Appendix D.

(See next page for Figure 2.1)

Figure 2.1: Key Terms & Definitions

Key terms	Definition	Associated metrics	Metric definition	Examples from other jurisdictions		Comments
				Planning guidelines / recommendations / targets	Actual	
Course	A series of radiation treatments or fractions delivered to a patient for a specific diagnosis and presentation	<ul style="list-style-type: none"> Courses per linac per year 	<ul style="list-style-type: none"> Number of courses provided by one linac in one year 	<ul style="list-style-type: none"> 450 courses per linac/year (ESTRO guideline, 2005; IAEA recommended, 2010) 414 courses per linac/year (NSW guideline, 2007) 450-500 courses per year (NSW planning guideline, 2010) 400 courses per linac/ year (Alberta target for new centres, 2008) 	<ul style="list-style-type: none"> 360 courses per linac/year (Alberta actual, 2005) 384 courses per linac/year (NL actual, 2013) 	Courses provided per linac are directly affected by operating hours and when planned maintenance/ QA time is booked. If hours are extended beyond 8 hours a day, 5 days per week, and QA/ planned maintenance are booked outside operating hours, then more courses can be accommodated.
Retreat course	The second & subsequent courses of radiation treatment delivered to a patient for a single cancer diagnosis	<ul style="list-style-type: none"> Retreat rate 	<ul style="list-style-type: none"> Proportion of new cancer patients who receive retreatment following a first course of RT treatment for a single diagnosis 	<ul style="list-style-type: none"> 25% (ESTRO guideline, 2005) 25% (NSW guideline, 2010) 23% (Alberta RTC guideline, 2008) 	<ul style="list-style-type: none"> 26% (actual Australia, 2010) 20% (actual England, 2007) 	25% retreat rate from Delaney et al is widely quoted as a reasonable benchmark.
Fraction, session or attendance	A patient visit to the cancer treatment centre as part of a course of radiation therapy; each visit comprises a portion of the prescribed full dose of radiation for that course of treatment (Note: some definitions distinguish between fractions and	<ul style="list-style-type: none"> Fractions (or sessions or attendances) per course 	<ul style="list-style-type: none"> Average number of treatment visits per course of treatment for a single cancer diagnosis 	<ul style="list-style-type: none"> 19 attendances per course (NSW planning guideline, 2010) 15.2 attendances per course (England NRAG model, 2007) 17.4 attendances per course (England, Malthus model, 2013) 	<ul style="list-style-type: none"> 16 attendances per course (actual, NL, 2013) 	
		<ul style="list-style-type: none"> Fractions (or sessions or attendances) 	<ul style="list-style-type: none"> Average number of treatment visits 	<ul style="list-style-type: none"> 7300 attendances per linac per year (England 	<ul style="list-style-type: none"> 7333 attendances per linac per year (actual, England, 2012) 	The number of attendances that can be accommodated per linac

Key terms	Definition	Associated metrics	Metric definition	Examples from other jurisdictions		Comments
				Planning guidelines / recommendations / targets	Actual	
	attendances on the basis that fractions may count multiple body parts separately while attendances measure activity based on number of visits. For this report, the terms are used interchangeably.)) per linac per year	per linac per year	NRAG recommended, 2012)		is dependent on linac operating hours.
		• Fractions (or sessions or attendances) per hour	• Average number of treatment visits per linac operational hour	• 4.1 attendances per hour (NSW planning guideline, 2010)		
		• Attendances per population	• Average number of treatment visits per population served	• 60,056 attendances per million by 2026 (England Malthus model projection, 2012)		
Radiation therapy utilization (RUR)	Use of Radiation therapy for the treatment of new cancer related conditions (excluding 'retreats')	• Radiation therapy utilization rate (RUR)	• Proportion of cancer patients who receive at least one course of RT during lifetime or prescribed number of years (e.g., CPAC used within 2 years after diagnosis)	<ul style="list-style-type: none"> • 48.3% best practice rate (Australia, 2014) • 50% (ESTRO guideline, 2005) • 40.6% proposed as best practice rate (Malthus model, England, 2013) 	<ul style="list-style-type: none"> • 38.1% RUR in Australia (actual, 2012) • 30.9% RUR in NL in 2010 (two years from diagnosis, actual, CPAC) • Canadian provincial RUR range from 29.1% to 35.9% (two years from diagnosis, actual, CPAC) 	The actual RT utilization rates in reporting countries, including Canada, have been consistently lower than the proposed best practice rates. Improving the RUR through improving patient access has been a key objective underlying international efforts to bring RT closer to patients' place of residence.
		• Linacs by population	• Average number of linacs per population; or population per linac	• 1 linac per 180,000 people served or 5.6 linacs per 1M population (IAEA recommended, 2010)	• 7.2 linacs per million people in Canada; 7.6 linacs per million in NL in 2012 (actual CPAC)	

2.3 RT Governance and Service Models

Historically, because of its technical complexity and capital cost, radiation therapy has tended to be centralized in major centres, usually associated with tertiary care hospitals. Over the past fifteen years, with increasing recognition of the physical and financial challenges faced by patients to access services sometimes many hours travel distance from their homes, the need to distribute radiation therapy has been increasingly recognized.

In the proceedings from the British Columbia Cancer Agency and Canadian Partnership Against Cancer National Forum on Cancer Care for All Canadians held in 2007, the first key principle was:

'Cancer care is inherently complex. Every cancer patient deserves an integrated person centered, supportive and well-coordinated system of care and services.'

At the same forum, the 'cancer system' was defined as being made up of various oncology specialists, other care providers both paramedical and nonmedical, and agencies concerned with care of the patient throughout the cancer spectrum, from pre-diagnosis through diagnosis and treatment, to post-cancer care, survivorship, palliative care and bereavement.

For complete references, please see Literature Review in Appendix D.

Service Accessibility

In recent years, studies have been conducted in several countries into the effect of distance on RT utilization. In England in 2012, the Department of Health's report on Radiotherapy Service stated that the uptake of radiotherapy treatments was known to diminish with distance travelled by patients to reach a treatment centre. (National Radiotherapy Implementation Group, NHS, 2012) A survey in Italy supported this conclusion and showed that this reduction in RT utilization was greater for patients 70 or more years of age. (Pagano et al, 2007)

In 2007, the National Radiotherapy Advisory Group report advised that, ideally, patients should have no more than 45 minutes travel time to treatment. In Scotland, a maximum travel time of 60 minutes was advised. (Institute of Physics and Engineering in Medicine and College of Radiographers, UK, 2013)

In Australia, the relative risk of dying of cancer within five years of diagnosis has been reported to be 35% higher for those living in remote locations compared with major cities. The reasons for this disparity in cancer outcomes include the long travel distances and lengthy absence from home, family and work for rural and remote residents to access the care they need. (Smith, 2012)

These aspects of service accessibility are of significant concern for NL, in view of the extensive travel distances as well as the aged and aging population.

Following are examples of service delivery and organization (governance) models with application to radiation therapy services:

Service Delivery Models

- Outreach service model: Through an outreach service model, cancer care specialists based in a cancer centre travel to local communities to provide opportunities for patients to visit these specialists closer to their homes. While patients still need to travel to the cancer centre for radiation therapy treatment, this outreach service provides more convenient follow-up care. In addition to minimizing the need for patients to travel for consultation and enabling continuity of care, an outreach service model provides opportunities for cancer specialists to build relationships with referring doctors and other health care providers in the area.

Increasingly, outreach clinics are being provided through teleoncology, contributing to the ability of cancer specialists to meet with patients without extensive travel.

- ***Shared care model:*** Shared care models involve collaboration between the primary care physician and the specialist in the delivery of planned care and have the potential to improve patient outcomes by improving coordination of care at the primary-specialist care interface. This collaboration between primary and specialist care facilitates transition of the patient following treatment back into the home community.
- ***Multidisciplinary care model:*** A multidisciplinary care model for radiation therapy recognizes the need for a comprehensive service, provided by a range of health professionals including medical, technical, nursing and allied health professionals. Clear linkages, either on site or networked, to a number of subspecialty disciplines, such as medical oncology, pediatric oncology, surgical oncology, clinical haematology, palliative care and rehabilitation, are required for a high quality, comprehensive cancer service. As well, radiation therapy services need access to clinical support services, such as diagnostic imaging, nuclear medicine, pathology, pharmacy services, psychosocial and supportive care to support the delivery of high quality services.

Service Organization Models

- ***Centralized service model:*** A centralized service model of radiation therapy focuses development of RT services within a large, usually tertiary level, health centre. The rationale for this approach is that it supports more efficient utilization of expensive equipment and supports the ability to recruit and retain specialized, sometimes scarce, professional staff and physicians. Patients are often drawn from a large geographic area, frequently requiring extensive travel and the need to be away from home for extended periods of time. However with this model, patients can access a full range of cancer service at one location.
- ***Devolved or decentralized model:*** A devolved or decentralized model often develops as a result of recognition of the burden to patients and families of extensive travel and time away from home to receive RT. This is accompanied by the belief that there are advantages to establishing a smaller centre at a distance from the central site to serve these patients. Presenting concerns include the need to assure quality in a smaller centre, potential difficulty recruiting specialized personnel, and potential decreased efficiency of machine use. In England, the Department of Health stated that the priority of assuring access could result in some machine underuse in small centres, but noted that productivity needs to be seen as a balance between the effective use of local resources and the right levels of access to treatment by local populations.²⁰ Such devolution can occur either through a hub and spoke approach or by setting up smaller freestanding centres.
- ***Private Provider Models:*** In the USA, Australia and other countries, there are large and small for-profit companies selling RT and other cancer services to insurance companies and individual patients. Such services cover the full spectrum from small single RT units to RT located in large, tertiary hospitals. The for profit financial model results in different service priorities and factors that often do not align with NL's publically supported RT services models. To avoid distortion of performance measures, such for profit models were not actively included in the study data.

Variations on these service organization options were described in England in the report entitled 'Guidance on the Management and Governance of Additional Radiation Therapy Capacity (Institute of Physics and Engineering in Medicine and College of Radiographers, UK, 2013):

- **Providing additional capacity at an existing centre:** As increased radiation therapy service capacity is required, equipment is added at the existing cancer centre. This approach may not improve patient access to radiotherapy as travelling times for some patients may remain

a problem. As well, if site capacity is limited, providing space for additional construction and/or parking might be difficult.

- Setting up a devolved radiotherapy department with links to a cancer centre at a location based on an acute hospital site: As increased radiation therapy capacity is required, a new, usually smaller, radiation therapy centre is established at an existing acute care hospital. The radiation therapy service benefits from the clinical and support services available at the acute hospital. The devolved RT site retains a close clinical operational link with the cancer centre.
- Setting up a devolved radiotherapy department with links to a cancer centre at a location other than an acute hospital site: As increased radiation therapy capacity is required, a new RT service can be established outside of an acute hospital site. The report noted that this option has considerable implications for patient safety and case selection because of the lack of clinical, professional services and other support available on the site.
- Setting up a fully independent department: As increased radiation therapy capacity is required, a new, fully independent radiation therapy service can be set up having no clinical link with the existing cancer centre.

The approach of a devolved RT site with linkage to the existing cancer centre is often called a 'hub and spoke' model, in which radiation therapy machines are located in regional centres (spokes) with operational linkage with an established cancer centre (hub). The Baume report in Australia (Baume, 2002) recommended this approach for development of its devolved radiation therapy services.

The above referenced report in England also stated a preference for a devolved unit with links to an established cancer centre 'hub'. The group recommended that, if a devolved radiotherapy unit is established with links to a cancer centre, there should be a single management structure with integration of the developed radiotherapy service to facilitate establishment of the essential governance structures. The Royal College of Radiologists in England also recommended that a new radiotherapy service should be integrated into the existing network of cancer services.

In both Norway and Switzerland, 'satellite' radiation therapy sites with clinical linkage to established cancer centres have been established. Similar approaches have been taken in several provinces in Canada.

Single Linac Models

The preferred minimum of two linear accelerators at a radiation therapy site has been widely supported, primarily because of the assurance of continuity of service if one machine is out of service for any reason.

In England, the recommendation of the Royal College of Radiologists was that a linked RT site should have a minimum of two linear accelerators. If a single linear accelerator is provided, a clear plan is required for management of patients during periods of staff shortage or machine maintenance and breakdown. (Royal College of Radiologists, 2004)

In Australia, in early 2000s, with the recognition that small populations lived distant from an RT site, single machine units (SMU) were established and their performance evaluated.

The SMU trial aims were to:

- Improve access to services for people living in rural areas
- Improve utilization rates of radiotherapy as a treatment modality
- Increase the proportion of cancer patients receiving radiotherapy, thereby reducing the economic and social costs associated with other forms of treatment, including surgery

The SMUs operated within a 'hub and spoke' model, linked to one or more larger centre. The model incorporated quality assurance guidelines and strong professional linkages between the hub and spoke sites, and facilitated appropriate treatment and referral practices. SMUs were not expected to provide treatment for complex cancers, and patients with these tumours were to be referred to the hub or other specialist facility. The evaluation of the SMU trial successfully demonstrated that single machine radiotherapy departments lead to more appropriate radiotherapy utilization rates for rural cancer services, while providing quality of care comparable to larger metropolitan centres. (Chapman, 2007)

The evaluation of the SMU trial in Australia indicated that radiotherapy services should initially be established with at least two RT bunkers to allow for service expansion over time, or capacity to ensure that expansion could occur.

In communities where population supports two or more linear accelerators, this approach is preferred. However, as the importance of improving access for smaller, rural populations is recognized, and as experience proves that single machine units are viable and able to provide high quality services, this alternative is increasingly being implemented.

In recent years, single machine units have been established in Canada in Manitoba and Ontario. The travel distance to these existing single machine sites from a tertiary centre is about three hours maximum by ground travel (see Appendix G).

RT Care Continuity

Care continuity is a foundational quality of care consideration and risk factor, particularly for small cancer centres with RT that are geographically distant from other cancer RT services. Planned down time (e.g., staff holidays, regular RT equipment maintenance, staff training, statutory holidays) can be routinely scheduled in advance without adversely affecting RT booked treatment sessions. However, unplanned down time due to equipment failures, staff illness, adverse weather, etc., can be difficult to manage to avoid prolonging the prescribed total duration of a patient's RT therapy.

To control for care continuity implications due to unplanned downtime, professional radiotherapy groups in England and Australia referenced in the preceding sub-section as well as in Scotland (Radiotherapy Activity Planning Steering Group, 2005), have stated that the preferred approach is to have adequate workload at each site to support a minimum of two linacs. This configuration improves backup options for care continuity, particularly with an equipment failure.

Recognition is given, however, to the reality that, in order to improve RT access in isolated areas having a highly dispersed population, single linac sites may be required. Recommendations to mitigate care continuity concerns at single linac sites include:

- Single machine units should be established in a 'hub and spoke' arrangement with larger metropolitan radiotherapy services serving as the hub; the hub provides machine back-up if required, as well as clinical support and advice. Linacs should be matched across networked sites.
- Even if only one linac is installed initially, a minimum of two bunker capacity should be provided.
- A clear plan for the management of patients during periods of staff shortage and machine maintenance and breakdown is essential.

The three professional bodies in England – the College of Radiologists, the Society and College of Radiographers, and the Institute of Physics and Engineering in Medicine – stated that a decision to provide a single linear accelerator service has implications for the scope of practice for such units, noting that UK experience has shown that providing a service with a single linear accelerator will

restrict the range of patients treated due to the increased risk of an interruption in a patient's treatment course. Given this, such units tend to treat Royal College of Radiologists category 2 patients such as those with early breast and prostate cancer. (Institute of Physics and Engineering in Medicine and College of Radiographers, UK, 2013)

To assess this situation in Canada, interviews were conducted with three small cancer sites in Canada (see following sub-section).

In its document entitled 'The timely delivery of radical radiotherapy: standards and guidelines for the management of unscheduled treatment interruptions', the Royal College of Radiologists quantified the matter of treatment interruption and comprehensively addressed its management. (Royal College of Radiologists, 2008) The College's survey of eight cancer centres in 2005 found that unplanned machine break downs accounted for 9% of RT treatment prolongation while public holidays, planned machine service time, and patient matters accounted for 91%.

The report states:

"Good clinical practice dictates the radical courses of radiotherapy treatment should not be interrupted. Where it is not possible, compensatory treatment is required."

"For a wide range of fast growing tumours, there is extensive evidence that uncompensated interruptions to radiation therapy, resulting in prolongation of overall treatment time, increase the risk of local recurrence of these tumours."

Consequently, the Royal College of Radiologists proposed the ideal solution for care continuity:

"Centres treating patients radically should have ready access to a minimum of two fully staffed and operational linear accelerators at all times, either within the centre or at a second centre situated close by, with clear arrangements for transfer. It is vital that centres can provide continuity of care."

Tumours grow at different rates. Tumour volume doubling time is a practical way to assess growth rates. To help manage care continuity risks and compensatory measures, the Royal College of Radiologists developed three categories of cancer patients as summarized in Figure 2.2 based on tumour growth rates to assist care providers to prevent and/or manage unplanned care interruptions.

Figure 2.2: Prioritization of Patients with RT Care Continuity Interruptions

Patient Category	Tumour Type	Treatment Intent	Treatment Duration Prolongation
One	1. EBRT for fast growing carcinomas: e.g., <ul style="list-style-type: none"> squamous cell – head & neck, cervix, esophagus, skin, vagina, vulva non-small cell-lung small cell- lung adenocarcinomas oesophagus medulloblastoma & primitive neuroectodermal short mass doubling time tumour 2. Brachy & EBRT combined for fast growing carcinoma, e.g.,	radical with curative aim	≤ 2 day longer than RT prescription

Patient Category	Tumour Type	Treatment Intent	Treatment Duration Prolongation
Two	<ul style="list-style-type: none"> squamous cell – tongue, cervix EBRT for slower growing tumours: e.g., <ul style="list-style-type: none"> squamous cell-anus adenocarcinomas- breast transitional cell carcinoma-bladder carcinoma- prostate 	radical with curative aim	≤ 5 days longer than RT prescription may not be deleterious, but evidence is not definitive; hence preferably ≤ 2 days longer than RT prescription
Three	EBRT for most tumours	palliative	≤ 7 days longer than RT prescription

The major causes of unscheduled care interruptions listed by the Royal College of Radiologists are:

- machine availability
- staff availability
- transportation problems
- medical problems
- social circumstances that lead to patient's failure to attend for treatment
- public holidays

In applying such findings to NL, the final cause (i.e., public holidays) seems to belong in the “planned downtime” list while “adverse weather” should be added instead.

Unplanned Linac Down Time

Of the preceding major causes of unplanned care discontinuity, machine availability, particularly in a single linac cancer centre is a serious risk. Reliable information on unplanned machine down time is not readily available publically. According to various RT service provider experts questioned during this Study, Linac vendors have reduced this risk over the last decade in a positive way by:

- Implementing software and technology advances and virtual 24/7 support services whereby vendor experts can conduct virtual assessments of the linac function to identify issues, make corrective changes virtually and/or provide remedial instruction to on site client staff;
- Offering limited to comprehensible service support contracts, offering varying levels of client maintenance training sessions to enable local staff to conduct on site linac maintenance and repairs, or a combination of both approaches; and,
- Stipulating that preventive maintenance be conducted on each model at predestined times.

During this Study, information on machine availability was sought from three other sources as described below.

The **British Columbia Cancer Agency (BCCA)** was an early adopter of the newest linac model purchased by CCP and replaced all of its linacs at the Vancouver Island Centre between March 2012 and May 2014 with TrueBeam units. The BCCA representative noted that:

1. Among 5 TrueBeams with more than 1 year of clinical service:
 - 4 had no episodes of unplanned service disruption of greater than 1 day.
 - 1 unit was down for 1 week just beyond the one year in-service date due to a faulty energy switch that required vendor site support.
2. From BCCA service events reported annually to comply with Canadian Nuclear Safety Commission requirements, there were:

- On average, about 50 corrective service maintenance calls to each unit over the interval of a year. The number of corrective service calls per unit was fairly similar (43 to 53 per year). These unplanned service calls were almost always resolved by the onsite, BCCA employed service technicians being able to provide an intervention, with or without back up from the on-line service support available from the vendor. Those approximate 50 service calls per unit per year consumed about 2 cumulative days of service technician time per unit per year. If relatively immediate access to service support was not available, many of these calls may have turned into a day or longer down-time. The service technicians, following training by the vendor, also conduct extensive, scheduled, preventative maintenance on the treatment units.
- On average, 16 instances per machine (range 14 to 19 instances) consuming about 5 cumulative days of service technician time requiring more extensive service involvement of the vendor (either by remote login to the machine or in person). These resulted in no instances of downtime exceeding 1 day (apart from the energy switch issue above).

In a survey of the three **small Canadian Cancer Centres** described in the following section, representatives were asked for information on unplanned machine down time. All responded that they averaged 97 to 98% linac availability (i.e., up-time) overall. More information by sites is presented in Appendix G.

In summary these three sites stated that they averaged about 1-2 episodes per year of unplanned downtime or one full day per machine. In those cases, patients who needed immediate treatment (e.g., cord compression) were sent to the 'hub' site. When asked, most of the other affected patients elected to stay at the local site for their ongoing treatments. Extended hours were implemented as required to recoup the treatments missed.

Canadian Small Distributed RT Models

Starting in 2007/08, the Federal Government sponsored RT Wait Time initiatives with associated funding. This encouraged several provinces to undertake projects to improve RT access. Research for this Study identified distributed RT sites recently opened or planned in four provinces aimed at improving RT access for rural service populations including:

- Ontario: Peterborough and Sault St Marie
- Alberta: Lethbridge, Red Deer and Grande Prairie
- Manitoba: Brandon
- British Columbia: Prince George

In consultation with Study representatives, interview information was gathered from three locations (i.e., Sault St Marie, Ontario; Lethbridge, Alberta; and, Brandon, Manitoba). Tours of the two latter sites were completed in July 2014. The purpose of the interviews was to obtain Canadian based information on approaches to balancing RT access for relatively small service populations (see Appendix G for summary information on key elements).

An overriding challenge noted by representatives of all three RT sites was accurately balancing the projected service population needs, the number of vaults/linacs and cost-effective use of resources. Planning and construction for the Lethbridge Cancer Centre adopted two vaults and linacs on opening since the service population was expected to exceed one linac in a few years by including 40% of the service population for Medicine Hat located about 150 kilometers from Lethbridge. The Brandon and Sault St Marie Cancer Centres opted to open with one equipped vault. A second vault

location was planned for these two cancer centres during the initial development. Their plans provide for construction of the second vault when the workload justifies a second vault or when it will be needed for linac replacement.

In summary, the three Canadian distributed RT service sites assessed during the Study seemed to be functioning well. Although some details of the service models differ, they all identified similar factors as important for success of distributed RT services in NL (interviews with senior site representatives during summer/fall 2014), including:

- Close affiliation, integration and regular interaction with a designated referral (tertiary/regional) cancer centre for clinical backup, quality assurance reviews, referrals, staff support and ongoing education;
- Professional and technical on site staff expertise to deal quickly with RT equipment, safety and related issues. In addition, one site opted for a full service contract for the Linac vendors and another increased its inventory of replacement parts;
- An electronic RT patient and data management system, fully integrated with the referral cancer centre, to enable seamless sharing of clinical data and transfer of patients between the sites, independent of the location of the treatment planning;
- Advance recruitment and detailed staff orientation including time at the tertiary/regional 'hub', cross-training within the local cancer centre, and selected cross-training with staff of the host hospital (e.g., IT). Staff employment terms that included provision to work extra shifts locally or at the 'hub' site as needed to address care continuity issues were included at two sites; and,
- Assignment of an individual with RT knowledge and preferably strong project management skills and/or health facility planning experience to represent and follow-up- on cancer program needs throughout the distributed site development. This continuity to seek and provide coordinated, expert cancer input throughout design, construction and start-up to a new distributed RT site was noted as a major factor for success. This should include development of detailed plans for recruitment, orientation, equipment specifications, quality assurance, operational policies and procedures, integration, host hospital interfaces, risk reduction, budgets and service contingencies.

Moveable Vaults

Several US firms advertise turn-key and temporary vault systems. A few are advertised as being readily assembled (from special blocks) and disassembled to meet temporary needs (e.g., www.radtechnology.com). Cancer Care Ontario (CCO) acquired two 'semi-moveable' vault systems to address special temporary needs at the Sudbury and Ottawa cancer centres while permanent vault facilities were being constructed. One of these vault systems has since been deployed to the Peterborough Cancer Centre as an interim RT vault solution.

A CCO expert advised (fall 2014) that such vault systems are not as readily moveable as was expected. Also, the systems are costly and substantial additional mechanical and electrical site services must be added, significantly increasing the overall costs. The advice given was that a cost benefit assessment for such a vault system should be carefully considered, including the local climate for durability implications, clarifying site and facility servicing costs, and the base vault installation cost.

Travel and Accommodation Support

During recent years, with the recognition that RT is being accessed by fewer patients than are believed could benefit from it, some countries have developed policies and approaches to provide

financial and social supports to improve utilization. In England, as a means to increase the uptake of radiotherapy, the Department of Health encouraged the provision of hostel accommodation, dedicated parking and improved transport systems to support patients who need to travel. As well, it advised that the additional cost to patients of travel during long courses of radiotherapy should be recognized as removing such obstacles and increasing the uptake of radiotherapy. In Australia, compensation of patients for defined travel, accommodation and living costs was recommended where the patient had to travel more than 70 km from home to a treatment centre.

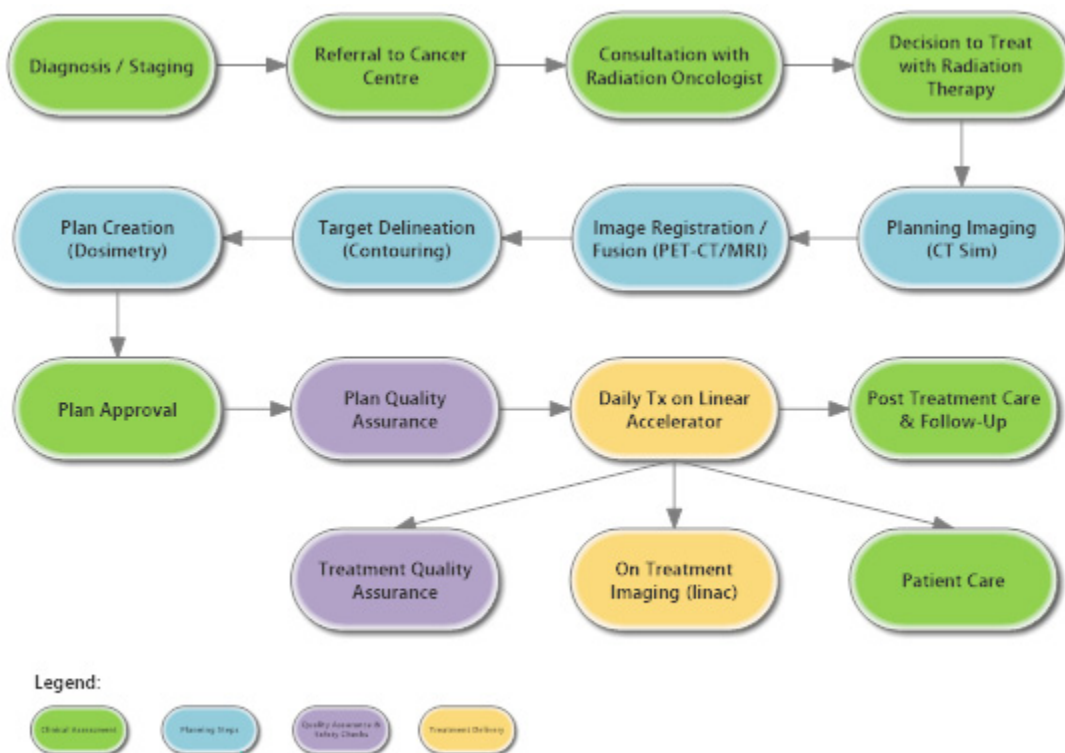
In Norway, at the time of a study in 2009, free hotel accommodation was provided to patients not able to travel back and forth due to distance and travel expenditures were reimbursed. Hospital staff arranged for room and flight reservations as well as addressing other possible barriers. The conclusion from that study was that there was no relevant variation in access when health care providers take care of the cost of travelling and other financial and social burdens. (Neider, 2008)

2.4 RT Treatment Process & Core Elements

Contemporary radiation therapy service delivery is a highly complex clinical process involving multiple pathways, decision points, highly skilled sub-specialized interdisciplinary team members, and technologies.

In Figure 2.3, the basic elements are shown with additional features described.

Figure 2.3: Cancer Patient's Journey from Diagnosis to Follow-Up¹



Diagnosis

Diagnosis is the process of finding the underlying cause of a health problem. If cancer is suspected, the healthcare team will confirm if it is present or not, and, if so, what type of cancer it is. Tests,

including laboratory tests and x-rays, procedures and/or an appointment with a specialist will help to determine the exact diagnosis. The diagnosis of cancer almost always requires an examination of a tissue sample from an abnormal area (biopsy). Examining this tissue can confirm whether or not cancer is present and also what type of cancer it is.

Diagnostic tests are used to:

- Confirm the presence of cancer
- Identify the type of cancer
- Identify the grade of the cancer (how abnormal the cells look and behave)
- Find the site where the cancer started (primary tumour)
- Determine the stage of the cancer (how far the cancer has progressed)
- Help plan cancer treatment
- Monitor response to treatment
- Help determine if cancer has returned (recurred)

Referral & Treatment Options

Cancer treatment may be given for a number of reasons. The goal of the treatment can change over time, including the following.

- Prevention (prophylaxis): Treatment is given to prevent the growth of cancer cells or to remove precancerous tissue that could turn into cancer.
- Cure: Treatment is given to cure the cancer.
- Control: Treatment is given to control the tumour and stop cancer from growing and spreading. It also reduces the risk of the cancer coming back (recurring).
- Palliation (palliative): When cure is not possible, treatment is given to:
 - Temporarily shrink tumours
 - Reduce symptoms, such as bleeding, pain or pressure
 - Treat problems caused by cancer or its treatment
 - Improve a person's comfort and quality of life

When radiation is one of the main cancer treatments, it is usually given once a day, 5 days a week, for about 3–8 weeks, with a rest on the weekend. Giving treatments over several days, rather than a single treatment, allows normal cells to recover and repair themselves.

Occasionally, treatments are given more than once a day or every other day, depending on the type of cancer, the person's overall health, the total dose and fractionation schedule, and whether other types of treatment are being given at the same time.

When radiation therapy is given to relieve symptoms caused by advanced cancer (palliative radiation therapy), the course of treatment is shorter, such as a few days or weeks.

Treatment can be broadly divided into the following types of therapies:

- Local therapy – Local treatments are directed at a specific part of the body and are often used when cancer is limited to that area. Radiation therapy and surgery are both local treatments.
- Systemic therapy – Systemic treatments travel through the bloodstream to reach cancer cells throughout the body. Many chemotherapy drugs are systemic treatments that are absorbed by the body's cells and tissues. Systemic treatments are often used to treat metastatic cancer (the cancer is found in several parts of the body) or to reduce the chance of cancer coming back (as adjuvant treatment).
- Targeted therapy – Targeted treatments directly target the cancer cells while sparing normal cells. Targeted therapy uses a biological agent to zero in on the cancer cell.

If one type of treatment is all that is needed, this is called the main or primary treatment. In other cases, one type of treatment by itself may not work as well and a combination of treatments is used to more effectively control and treat the cancer.

Concurrent therapy is a therapy that is given at the same time as another. Combined modality treatment utilizes radiation therapy in combination with chemotherapy, surgery and other treatment modalities. Concurrent systemic therapy refers to administering medical treatments such as chemotherapy at the same time as other therapies, such as radiation.

When a combination of treatments is used, they may be given together or at different times, depending on the type or stage of cancer.

- Neoadjuvant – Treatment, such as chemotherapy or radiation, is given before the primary treatment to shrink a tumour so that it is easier to treat with the primary therapy.
- Adjuvant – Treatment is given after the primary therapy to control the cancer more effectively, to destroy any remaining cancer cells or to reduce the risk of the cancer recurring.

Simulation and Treatment Planning

A cancer treatment plan is based on each person's unique situation. The radiation oncologist decides on the total dose of radiation that will be given to kill cancer cells and spare normal cells as much as possible. This dose is divided into a number of smaller doses called fractions.

Development of a patient's treatment plan begins with simulation. Simulation is a planning session done before the first external beam radiation treatment is given. It is done to make sure the radiation is aimed at exactly the same area each time treatment is given. Simulation is usually done in one session and may take anywhere from 15 minutes to an hour or more. A machine called a simulator is used to set up the treatment plan and choose the treatment area. The most common type of simulator used is a computed tomography (CT) simulator. It can take images or scans, which give the healthcare team a picture of the part of the body to be treated. These images help the radiation therapy team decide where and how to direct the radiation.

During simulation and daily treatments, it is necessary to ensure that the patient will be in exactly the same position every day relative to the machine delivering the treatment or doing the imaging. Body moulds, head masks, or other devices may be constructed for an individual patient to make it easier for a patient to stay still. Temporary skin marks are used to help with precise patient positioning.

Patients getting radiation to the head may need a mask. The mask helps keep the head from moving so that the patient is in the exact same position for each treatment.

After simulation, the radiation oncologist then determines the exact area that will be treated, the total radiation dose that will be delivered to the tumour, how much dose will be allowed for the normal tissues around the tumour, and the safest angles (paths) for radiation delivery.

Radiation therapy staff use sophisticated computers to design the details of the exact radiation plan that will be used. After approving the plan, the radiation oncologist authorizes the start of treatment. On the first day of treatment, and usually at least weekly after that, many checks are made to ensure that the treatments are being delivered exactly the way they were planned.

RT Treatment – Usual

External beam radiation therapy, the most common type of radiation treatment, is given in the radiation therapy department of a cancer treatment centre, usually on an outpatient basis.

External beam treatment units include:

- Linear accelerators (linacs) are currently the most widely used RT treatment units.
- Cobalt units are largely being replaced by more versatile and higher energy linear accelerators but may still play a limited role in some cancer centres.
- Superficial/Contact X-ray Therapy (CXT) is used primarily to treat skin cancer.

The duration of treatment depends on the cancer type and treatment intent specific to each patient. If the purpose is palliative, a smaller number of treatments is usually required. Protocols with curative intent require a greater number of treatments. Each treatment takes approximately 15 minutes.

During the treatment session:

- The radiation therapist positions the person on the treatment table based on the simulation. Marks made on the skin or alignment lasers help to locate the treatment area. Immobilization devices, forms, foam wedges or rolls may be used to ensure proper position during the treatment.
- Once the person is positioned and the equipment is set up properly, the radiation therapist leaves the treatment room.
- The radiation therapist controls and turns on the machine from the next room. The therapist can watch the person through a window or a monitor and can communicate through an intercom.

During the course of treatment, the radiation oncologist monitors progress and adjusts the dose or length of treatment as necessary. The radiation therapy team often take special x-rays (port films) during treatment x-rays to ensure the treatment beam stays on target.

Radiation therapy may be complete in a single treatment, or delivered daily (Monday through Friday) for several weeks.

Other health-care professionals within the cancer centre, such as nurses, registered dietitians, pharmacists and counsellors will also participate in the patient's care and treatment as required.

RT Treatment – Special

Factors influencing decisions on the location of highly complex and specialized treatments include the following:

- Specialized treatment is consolidated at a referral site when there is reasonable evidence that patient outcomes improve when a larger volume of similar patients are required to maintain workforce skills and expertise; i.e., when the number of specialized cases is small, personnel with the necessary skills and expertise to care for these patients cannot be recruited and/or maintained.
- When there are large infrastructure costs relative to the volume of patients receiving care, these specialized services are consolidated at a referral site.

Examples of radiation treatments that require expensive equipment and highly specialized personnel include stereotactic radiosurgery for brain cancer, total body irradiation for haematological cancer, and proton therapy. Due to their specialized nature and expense, these services are usually located at tertiary referral centres and patients are referred from a large catchment area.

Other radiation therapy treatments are located at referral cancer centres because of the specialized personnel and resources required to support the care of patients. For example, in treating patients with head and neck cancers, a team of specialized medical and radiation oncologists work together to plan and deliver the treatment. Other specialists including surgeons, otolaryngologists, plastic surgeons, dentists, speech therapists and others may also be required to comprehensively address the needs of patients, depending on the location and nature of the cancer. Some of these specialists may only exist at a major acute care referral hospital; thus, bringing the cancer patient to that site offers the best opportunity for comprehensive, best practice treatment and care.

Radiation therapy for pediatric patients is also often located at a referral cancer centre associated with a tertiary pediatric acute care hospital. Cancer care for children requires the availability of pediatric medical specialists, including pediatricians. Depending on the nature of the cancer, the pediatric oncology team may include many other health care providers who specialize in the care of children. Since these specialists may only exist at the tertiary acute care hospital, bringing the pediatric cancer patient to that site ensures the best opportunity for comprehensive and appropriate care for the patient. In this case, the inconvenience of travel to the centralized site is considered warranted in order to ensure the best patient care.

Patient Data Management Systems

Patient data management systems designed to manage and coordinate radiation oncology clinical databases, including data acquisition, storage and transfer, are now integral parts of a functioning radiotherapy service. Large datasets are generated as a core component of the patient treatment process. Computerized information management systems facilitate the direct electronic transfer of complex information. Depending on the service model in use, these could potentially include three different service levels in the health system:

- With other service providers external to the cancer centre;
- Among different services within the cancer centre and the radiation oncology service; and,
- Among different functional areas within the radiation oncology service.

The following computer systems and functions could be included:

- Patient registration and patient information systems
- Storage of diagnostic and RT treatment simulation information including the transfer and archive of patient diagnostic/planning images from CT simulators and imaging devices from the cancer centre services and external health service providers
- Transfer of patient treatment information, including the record and verify system for the treatment machines, to enable accurate, reproducible set-up of patients and a log of all treatment events
- Patient charting, including electronic charts, electronic patient records (EPR) and electronic health records (EHR)
- Department scheduling, including resource scheduling
- Administrative and quality assurance tasks, including generation of management reports, links to cancer registries and implementation of hospital clinical protocols

A devolved radiation therapy service located in an acute care hospital with links to an existing cancer centre will require computer linkage to both the host hospital and the existing cancer centre. Linkages with the host hospital's information technology systems will be required to access host hospital diagnostic services, booking and other services provided to the radiation therapy service by the host hospital.

Computer linkages with the existing cancer centre allow for transfer of clinical data between the linked site and the main cancer centre, facilitating sharing of information and effective consultation between clinical personnel at the devolved site with experts at the main cancer centre.

In some linked RT sites, treatment planning is done at the main cancer centre (hub) and treatment implemented at the devolved site (spoke). In this case, the ability to transfer clinical data between sites is essential. It is also beneficial to have access to the treatment planning system at the main site from the devolved radiotherapy department to aid prompt assessment of treatment plan-related queries during treatment.

Quality Assurance Program

Quality assurance in radiation therapy is defined by the World Health Organization (WHO) as, '*all procedures that ensure consistency of the medical prescription, and safe fulfillment of that prescription, as regards to the dose to the target volume, together with minimal dose to normal tissue, minimal exposure of personnel and adequate patient monitoring aimed at determining the end result of treatment*'. (Canadian Partnership for Quality Radiotherapy, 2013)

The Canadian Partnership for Quality Radiotherapy (CPQR), in its quality assurance guidelines, stated that a quality assurance program must address all aspects of the timely delivery of radiation treatment, including programmatic organization, the qualifications of the personnel involved in radiation treatment, the performance of the planning and treatment equipment, policies and procedures, incident monitoring, and reporting.

In England, the three professional bodies involved in provision of radiotherapy services in England advised as follows regarding quality management for linked RT units: (Institute of Physics and Engineering in Medicine and College of Radiographers, UK, 2013)

- The new radiotherapy service must have an externally audited quality management system in place with clear quality assurance radiotherapy documentation.
- For linked units, it is essential that such documentation is easily accessible across all sites, preferably by information technology systems. The documentation should be consistent across all sites and provide essential site-specific documentation. Time should be allocated to this task to ensure that high standards are maintained, that the documents reflect up to date practice across linked sites, and that the advice contained in them is applicable to all sites.
- A system for radiotherapy adverse event reporting, with reporting of radiotherapy errors and near misses, and analysis should be in place.
- For linked units, the same reporting system as that used in the cancer centre hub should operate, with a shared review process for adverse incidents. Incidents from all sites should be shared to identify trends and to learn from issues that occur.

2.5 Radiation Therapy Staffing Models

Clinical safety is of paramount importance in the delivery of radiation therapy services. In support of clinical safety, the three professional bodies involved in provision of radiotherapy services in England – The Royal College of Radiologists, Society and College of Radiographers and the Institute of Physics and Engineering in Medicine – stated that clear professional leadership, including a lead radiation therapist to manage the service, a lead medical physics expert and a lead radiation oncologist, is essential.

The core radiation therapy team consists of radiation oncologists, radiation therapists and radiation physicists, who work together to decide if radiation therapy will be beneficial and, if so, to design a radiation therapy treatment plan that will be safe and effective for the individual patient's needs.

Other health care professionals within the cancer centre, including nurses, dietitians, pharmacists and counsellors also participate as members of the cancer care team. A summary of these key staff positions, roles, staffing metrics and ratios are summarized in Figure 2.4.

Figure 2.4: Key RT Staff Roles & Metrics

Staff Position	Key roles	Staffing metrics	Examples from other jurisdictions	Comments
Radiation Oncologist (RO)	Medical specialist with postgraduate training in management of patients with cancer involving the use of RT, responsible for assessing the patient by clinical evaluation, establishing a management plan for an individual, working closely with medical physicists and radiation therapists to plan and deliver effective radiation treatment, and providing follow up care	New patient referrals per year	<ul style="list-style-type: none"> One RO FTE per 250 new patients/ year (Australia, planning guideline 2010) One chief oncologist plus one RO FTE per 200-250 new patients/year (IAEA recommendation, 2010) 	
		Radiation oncologist per population	<ul style="list-style-type: none"> 1 RO FTE per 100,000 population (IAEA recommendation, 2010) 	
		Radiation oncologist per linac	<ul style="list-style-type: none"> 2 RO FTEs per linac (Australia/NZ College of Radiologist recommendation, 2010) 	
Radiation Therapist (RTT)	Key member of the RT team, uses radiation to destroy tumours, explain procedures and support patients, ensure proper radiation handling and protection techniques, administer radiation treatments, monitor patients during procedures and provides patient education. In the treatment planning aspects of cancer therapy involving radiation, follow prescription of a radiation oncologist, perform treatment simulations, take measurements, construct and fit accessory devices, determine radiation doses.	Radiation therapist per linac hour/shift	<ul style="list-style-type: none"> 1.06 RTT FTE/linac hours/shift (NSW, planning guideline 2010) 	RTT staffing guidelines vary depending on whether dosimetry is provided by RTTs. In some facilities, dosimetry is provided by dosimetrists who are not included in the RTT FTEs.
		Radiation therapist per linac	<ul style="list-style-type: none"> 8.48 RTT FTE per linac (NSW, planning guideline 2010) 	
			<ul style="list-style-type: none"> 10 RTT FTE per linac (Australia/NZ College of Radiologist recommendation, 2010) 	
Medical Physicist (MP)	Key member of the RT team, has specialized training in the application	Patients per medical physicist per year	<ul style="list-style-type: none"> One MP FTE per 450-500 patients/year (ESTRO, 2005) 	<ul style="list-style-type: none"> MP staffing ratios vary depending on MP role,

Staff Position	Key roles	Staffing metrics	Examples from other jurisdictions	Comments
	of ionizing radiation to the treatment of human disease, normally possesses a PhD degree;		<ul style="list-style-type: none"> One FTE MP per 260 treated cases per year (Canada, Battista et al, 2012) 	including whether role includes that of radiation safety officer
	responsibilities include equipment commissioning and quality assurance, treatment planning, radiation protection, clinical development and training of future radiation specialists. May also be responsible for development and administration of the radiation safety program, including compliance with all regulating and certifying agencies	Medical physicist per RT department	<ul style="list-style-type: none"> At least 2 MP FTE per RT department (IPEM recommendation, 2009) 	<ul style="list-style-type: none"> New technologies & procedures and heightened awareness for quality assurance and safety has resulted in annual treated cases per FTE physicist from 400 in the pre-IMRT era to approximately 280 in the post-IMRT era. (Canada, Battista et al, 2012)
		Medical physicist per linac	<ul style="list-style-type: none"> 2 MP FTE per linac (Australia/NZ College of Radiologists recommendation 2012) 	
Medical Physics Assistant (MPA)	Provides technical assistance directly to medical physicists, performs quality assurance tests and other measurements with the data subsequently reported to a supervisory physicist for review	Patients per medical physics assistant per year	<ul style="list-style-type: none"> One MPA FTE per 700 treated cases per year (Canada, Battista et al, 2012) 	
Medical Dosimetrist (or treatment planner)	Specializes in computerized radiation treatment planning; responsibilities include all aspects of production of patient-specific dose distributions in compliance with protocols specified by radiation oncologists and medical physicists. The administrative reporting lines vary; may have dual reporting to physics on technical issues and to radiation therapy for professional and human resource issues	Patients per dosimetrist per year	<ul style="list-style-type: none"> One dosimetrist FTE per 300 treated cases per year (Canada, Battista et al, 2012) 	Treatment planning may be included in the role of RTTs or provided by a separate category of staff called dosimetrists
Electronics Technician or Engineering Technologist	Provides technical services in maintaining, designing, and constructing the major equipment and devices used in radiation oncology. Responsibilities include response to	Patients per electronics technician per year	<ul style="list-style-type: none"> One electronics tech FTE per 600 treated cases per year (Canada, Battista et al, 2012) 	

Staff Position	Key roles	Staffing metrics	Examples from other jurisdictions	Comments
	accelerator breakdowns and on-site repairs, interfacing with vendors of the equipment, usually receive additional technology-specific training by vendors of radiation therapy-related equipment.			
Information technology specialist	Provides information technology support to the radiation oncology team including for computerized treatment planning systems, record and verify systems (radiation oncology information system), and networks for the transfer, storage, and backup of large datasets used in radiation oncology	Patients per information technology specialist per year	<ul style="list-style-type: none"> One information technology specialist FTE per 2000 treated cases per year (Canada, Battista et al, 2012) 	

Advanced Practice Roles

Advanced practice roles provide the opportunity to improve the quality and efficiency of patient care and to address potential and actual gaps in service delivery in the cancer care system. Advanced practice has developed in response to the desire to ensure that healthcare professionals practice to the fullest scope of their practice.

A number of principles underlie the concept of advanced practice:

- Improved outcomes for patients, whether through enhanced access, quality of care or satisfaction with the care is a fundamental and central principle of advanced practice in any profession.
- Core components of advanced practice are critical thinking and responsibility for complex decision making.
- An increased level of autonomy, with greater independent contribution to the multidisciplinary care of the patient, characterizes an advanced practice role.
- Advanced practitioners are expected to develop in their capacity as leaders, advocates and mentors to improve the delivery of care.

The Canadian Association of Medical Radiation Technologists (CAMRT) has defined advanced practice in Medical Radiation Technology as '*a higher level of practice wherein clinical responsibilities routinely exceed the current principal expectations of practice; require analytical skills to synthesize evidence-based knowledge to autonomously work towards optimal patient outcomes*'.

In 2004, Cancer Care Ontario, in collaboration with the Ministry of Health and Long-Term Care, began developing an advanced practice role for Radiation Therapists known as Clinical Specialist Radiation Therapist (CSRT). The stated goals of the project were decreased wait times, improved access to radiation treatment, improved patient satisfaction and team acceptance of the CSRT role. Odette Cancer Centre in Toronto piloted and subsequently fully implemented CSRT roles in Palliative Radiation Therapy and Skin Cancer in 2011. A subsequent evaluation showed that the

integration of the CSRT role had positively impacted the patient and the interprofessional team, increasing access to care, optimizing the use of resources and achieving desired outcomes.

In oncology, advanced practice roles for nurses have also been developed. In Ontario's cancer system, the skills of a number of advanced practice nurses are being utilized. Advanced practice nursing, according to the Canadian Nurses Association, is *'an umbrella term describing an advanced level of clinical nursing practice that maximizes the use of graduate educational preparation, in-depth nursing knowledge and expertise in meeting the health needs of individuals, families, groups, communities and populations; involves analyzing and synthesizing knowledge, understanding, interpreting and applying nursing theory and research, and developing and advancing nursing knowledge and the profession as a whole'*.

While evaluation of advanced practice roles appears to have supported their beneficial contribution to oncology care, the number of qualified advanced practitioners in oncology in Canada is still very limited.

Supply of Radiation Oncology Workforce

The demand for radiation therapy has been projected to increase more rapidly than the supply of radiation oncologists. Critical shortages of radiation therapy medical physicists have also been reported. Radiation therapists are also in short supply. Lack of professionally trained oncology personnel severely limits the ability to provide these highly specialized services and to ensure that radiation therapy continues to be widely accessible with acceptable wait times for cancer patients requiring it.

With this workforce shortage, existing and new cancer centres find themselves in competition with each other to recruit essential personnel. At this time and into the future, creative and energetic recruitment and retention strategies are critical to the successful establishment and operation of a radiation therapy service.

2.6 Teleoncology & Radiation Therapy

The use of telecommunications for the provision of health services has been increasing internationally, offering opportunities for improved patient care, often linking locations distant from each other. The province of Newfoundland and Labrador has been a leader in the use of telecommunication in health services and in cancer services

Teleoncology is the use of telecommunications for provision of cancer services. Three levels of teleoncology applications are:

- **Level 1-Video conferencing:** supports consultations of oncology care providers with patients, as well as physician and staff videoconferences for education and quality assurance purposes. It can include display of radiotherapy images and dose plans.
- **Level 2-Remote treatment planning:** involves replication of selected data from the radiotherapy database facilitating remote treatment planning and evaluation. This level of teleoncology allows for sharing of oncology treatment information between sites, including the option of completing treatment plans at one site and implementing the treatment of another site.
- **Level 3- Real time, remote operations:** allows sharing of information during the actual performance of the process; for example, target volume delineation and treatment planning performed by the team at the linked site under supervision and guidance from more experienced colleagues at the main cancer clinic.

Experience in Norway found that the main problem for implementation of teleoncology was not technological but rather the socio-psychological challenges from the staff members involved.

Therefore, in addition to providing the information technology infrastructure, successful implementation of telemedicine requires focus on educating and motivating the staff in utilizing the technology prior to its installation.

2.7 Emerging Trends (to 2026)

Cancer care, including radiation therapy, has evolved rapidly as research presses forward to improve outcomes for the over 100 different types of cancer.

Comprehensive Cancer Services

Increasingly the importance of cancer services being comprehensive and interdisciplinary is being recognized. This concept emphasizes the use of multidisciplinary teams in diagnosis, treatment and management. Accreditation Canada guidelines state that the cancer care team will use an interdisciplinary approach to deliver cancer care and oncology services. The interdisciplinary team includes people with different roles and from various disciplines. Depending on the needs of the client and family, as well as the service setting or location, the team may include psychosocial professionals, primary care providers, specialists (e.g. surgeons and oncologists), pharmacists, radiation therapists, administrators, nurses, allied professionals including nutritionists, occupational and physical therapists, interpreters, client advocates, and volunteers. The team may also include representatives from community partner organizations that the team works with closely.

Radiation Therapy Technology

Innovative, complex, integrated technologies continue to be introduced into cancer care. Innovations that are considered advanced today may be obsolete in five years. Continuous on-the-job training, more formal education, and continual review and redesign of work processes are required, while continuing to address patient needs, work efficiencies and quality assurance. Technological advances improve the capability to provide more precise treatments and better patient outcomes, but may also add to treatment planning time and increase staff workloads.

The continually increasing use of Intensity modulated radiation therapy (IMRT) is an advance in technology that is having significant impact on delivery of radiation therapy services. It is now recommended that all patients who have radiation therapy should have access to IMRT where clinically appropriate. While the benefit to patient care is recognized, such new developments often require additional clinical oncology input and increase treatment planning time. As well, the training investment to support the local workforce to acquire and integrate these new skills needs to be recognized.

Proton Therapy

Proton therapy is external-beam radiation therapy delivered by proton beams. Protons impart energy as they slow down and travel through the body. They then release most of their energy just before they slow to a stop, allowing for the selection of energies that give up this burst of energy at a target point – the tumour. This means they can give a higher dose of radiation straight to the cancer, while completely sparing the healthy tissue beyond their path of travel. Over the last decade, 'proton therapy' has been proven effective for relatively rare, low volume, selected tumour types and such installations have high capital costs of \$150-\$250M. More recently, 'small' portion therapy installations are being developed in Europe at estimated costs of less than \$80M. Canada does not yet have a Proton Therapy service installation and Canadian patients are usually sent to the US for such treatments as warranted, based on comments received from RT and medical physics experts interviewed.

Linac and Magnetic Resonance Imaging Technology

Merging of linac and magnetic resonance imaging (MRI) technology for real time imaging of a patient's tumour during RT is a research area receiving increased attention at RT related conferences. None of these combined linac and MRI research prototypes has received regulatory approval for human studies and their application to standard clinical use, if proven technically and clinically successful, are five to eight years way from standard use (RT and MR experts).

Information Technology

Information technology has become an essential and integral component of the functioning of a radiotherapy service both for clinical service provision as well as for administrative and patient information purposes. For linked radiation therapy sites, information technology linkages with the cancer centre hub, the local host hospital, and other service providers are essential.

Aging of the Population

The proportion of the Canadian population that is elderly is increasing. Age is an important consideration in projecting future cancer incidence since the majority of cancer patients are over fifty years of age. Shifting of the age of the population towards a higher proportion of elderly people will not only increase the crude incidence of different cancers but also affect the age at presentation of cancer patients. This could affect the proportion of patients presenting with co-morbid conditions, the choice of treatment prescribed and needs for supportive care.

Survivorship & Quality of Life

In cancer, the concept of survivorship is to describe the physical, social, psychological, and spiritual impact of cancer on patients' lives and help them understand these factors. Cancer survivorship is a continually evolving process starting from the moment of cancer diagnosis and occurring over the course of the remainder of life and can be defined as the experience of 'living with, through or beyond cancer'.

Treatment successes are leading to an ever-growing number of cancer survivors. Since many people receive care in their local community, increasing survivorship and new treatment options require greater integration of cancer care into both acute care and community settings and the management of cancer as a progressive chronic disease.

With increasingly positive survival statistics for individuals diagnosed with cancer and resulting years of life post treatment, quality of life many years after diagnosis is becoming increasingly important. Quality of life and survivorship are strongly dependent on care provided in the multidisciplinary environment, often beyond the traditional cancer realm of radiation oncology, medical oncology and surgery. Support for these individuals in their home communities, through primary, community based care providers, is essential.

Improved Access

Over recent years, concern about inequitable access to RT due to distance from a treatment centre has been documented. In several countries, distributed cancer treatment centres have been established with the objective of bringing services closer to the residence of patients. As well, efforts have been made to remove financial and other barriers to patients who are required to travel to access care due to their location of residence. These trends are expected to continue in future.

The preceding review of published international experiences shows a growing consensus on core development principles essential for the ongoing development of RT services, including the

successful implementation of small RT sites in a region such as NL. These findings form the foundation for the proposed NL service plan to 2026 outlined in Section 4.0.

KEY FINDINGS

RT remains a cost effective cancer treatment, expected to remain relevant for the next several decades.

RT performance measures are useful to assess and project RT capacity and workloads; however, care is required in their application as definitions and data used may not be comparable between jurisdictions.

Achieving a workable balance among patient access, best practices and cost effective operations remains a challenge.

Developing small cancer centres with one or two operating linacs has become a viable option in the last decade with advances in RT technology and IT to enable clinical and maintenance supports.

A small cancer centre needs to be fully integrated and electronically linked to a major cancer centre.

First and foremost, a well-trained, core complement of multidisciplinary staff on site is essential.

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3.0 NL's RADIATION THERAPY SERVICE STATUS

To advance the NL RT Service Plan development, information on RT services for NL were assessed. These include:

- NL's unique context;
- NL's RT service configuration and service model;
- NL's RT utilization rates;
- NL's RT service capacity (facilities, equipment, staff); and,
- NL's RT challenges and opportunities.

These key factors affecting NL's future RT service plan are benchmarked with Canadian and international trends where available.

3.1 NL's Unique Context

Historically, needs of a service population for radiation therapy and most health services have been primarily driven and shaped by major geographic features and demographic patterns (i.e., size, age and distribution). Geography features determine the site of resource based industries and transportation routes. These directly influence development of infrastructure and distribution of the service population.

NL has several unique features that form the foundation for this service plan. These are summarized under the following inter linked subheadings.

Geographic & Climatic Realities

Located on the northeastern corner of North America, the Strait of Belle Isle separates Canada's eastern-most province of NL into two different geographic areas: Newfoundland, a large island in the Atlantic Ocean, and Labrador, a large land area incorporated into mainland Canada. Together, both parts of NL total 405,720 square kms (i.e., Island of Newfoundland – 111,390 sq. km; Labrador – 294,330 sq. km) or about 4.1% of Canada's total land mass. With an estimated 526,673 residents in 2014, NL's population density is on average 1.4 people per square km, the lowest in Canada excluding the Territories. (Note: The next closest is Manitoba with 2.2 resident on average per square Km.)

Due to its geography (e.g., covering 5 degrees of latitude), NL has six different climate types. These can be summarized as: a) Newfoundland island having cool, summer subtype of humid continental climate due to the ocean's moderating influence being within 100 km of any part of the island; b) southern Labrador has a subarctic climate; and, c) northern Labrador has a polar tundra climate.

NL's geography and climate contribute to:

- Highly variable weather conditions across different areas of NL on the same day during most months, including fog, wind, snow and rain.
- Limited major transportation routes often involving costly, multiple means of transportation, including road, ferry and air transportation.
- High costs per population to maintain basic transportation and communications infrastructure.

Population and Demographics

NL's population and demographics present a number of challenges which must be addressed in planning and delivering of health services:

- More than 50% of NL's population lives in the Avalon Peninsula around St. John's. This leaves many small, widely dispersed communities heavily concentrated around the shore (periphery) of NL.
- With over 4% of the Canada's land mass and less than 1.5% of the national population, NL faces inherent difficulties in achieving cost effective sub-populations (i.e., critical mass) to ensure reasonable access to specialized services, whether they are health care, education, social services, etc.
- A high proportion of NL's population is elderly now and will become increasingly elderly in future
- The population residing in the province is projected to decrease to at least 2026 while the overall population continues to age.

Economy

For decades, NL's largely natural resource based economy faltered with high levels of unemployment. A low point occurred in the early 1990s with the collapse of the NL cod fishery and a net loss of about 60,000 residents over the next 15 years (i.e., about 11% of NL's 568,474 total population in 1991) as NL residents left to find employment elsewhere. NL's economy experienced a major turnaround over the last decade with substantial capital investments in major oil and mining projects. NL has now shed its 'have not' provincial status as illustrated by NL out performing all the provinces with a Real GDP growth rate of 5.9% in 2013 (NL Government, 2014). Associated challenges for service planning include:

- Many local economies, especially in rural NL, are still in transition following failure of the fishery industry and the new oil and mining economic drivers.
- Although NL's unemployment to October 2014 reached its lowest rate at 10.7% since 1973, it still remains the highest among Canada's provinces, with the Canadian average at 6.0% (Statistics Canada, November 2014).
- The boom and bust cycle of energy and mining industries is difficult to predict as the basis for long term planning, including implications for government revenues, capital expenditures and health service planning.
- Significant fluctuations can occur in the workforce needed for major resource development projects, often in relatively isolated and changing areas.
- A large number of NL's younger to middle age adults moved away from NL for work in 1990s. There is now some indication that many may be returning to NL to retire. Cancer rates are highest among those over age 50 years.

3.2 Newfoundland and Labrador Cancer Care Program Overview

Newfoundland and Labrador's Cancer Care Program (CCP) is responsible for the provision of services to cancer patients throughout the province. At this time, the CCP provides oncologist consultations, systemic therapy, radiation therapy, breast, colorectal and cervical screening, supportive care, clinical trials and patient navigation for the four regional health authorities in the province.

Historic Cancer Care Key Milestones

Gaining Ground – A Provincial Cancer Control Policy Framework for Newfoundland and Labrador was completed in 2010 (GNL, 2010). This report outlines the GNL's response to the burden of cancer in NL going forward. Key historic milestones for NL cancer services listed in the report are included below with a few updates to 2014.

- 1971** Newfoundland Cancer Treatment and Research Foundation established
- 1972** Cancer radiation treatment offered in NL
- 1980** A cancer clinic established in St. John's to provide outpatient chemotherapy
- 1985** Chemotherapy outpatient services extended to Central NL
- 1994** Dr. H. Bliss Murphy Cancer Centre was officially opened in St. John's
- 1995** Medical Oncology Program established in St. John's
- 1996** Breast Screening Program officially launched in St. John's
- 1999** NL Alliance for the Control of Tobacco (ACT) was established
- 2000** Cancer Centre in Western NL opened
- 2001** Stem cell transplants began to be performed in the province
- 2003** Cervical Screening Initiatives Program launched
NL acquired its first CT scanner for radiation treatment simulation
- 2005** Cancer Care Program at Eastern Health was established
- 2006** Teleoncology Program was launched.
New cancer centres in Grand Falls-Windsor and Gander
- 2007** HPV Vaccination Program was launched
- 2009** Daffodil House, new hostel for cancer patients and operated by CCS, was opened in St John's
Cameron Inquiry report received
- 2010** *Gaining Ground – A Provincial Cancer Control Policy Framework for Newfoundland and Labrador* was completed
- 2012** Colorectal Cancer Screening Program Launched
Patient navigation program launched
- 2013** Construction of a new PET facility approved to support cancer diagnose and other diseases
- 2014** Integrated Oncology Patient Information System (electronic registration, scheduling, treatment planning, health record, etc.) fully implemented for cancer patients at the BMCC.

First NL distributed RT service approved as part of the new Western Memorial Regional Hospital and scheduled to open in 2019

Cancer Control Policy Framework

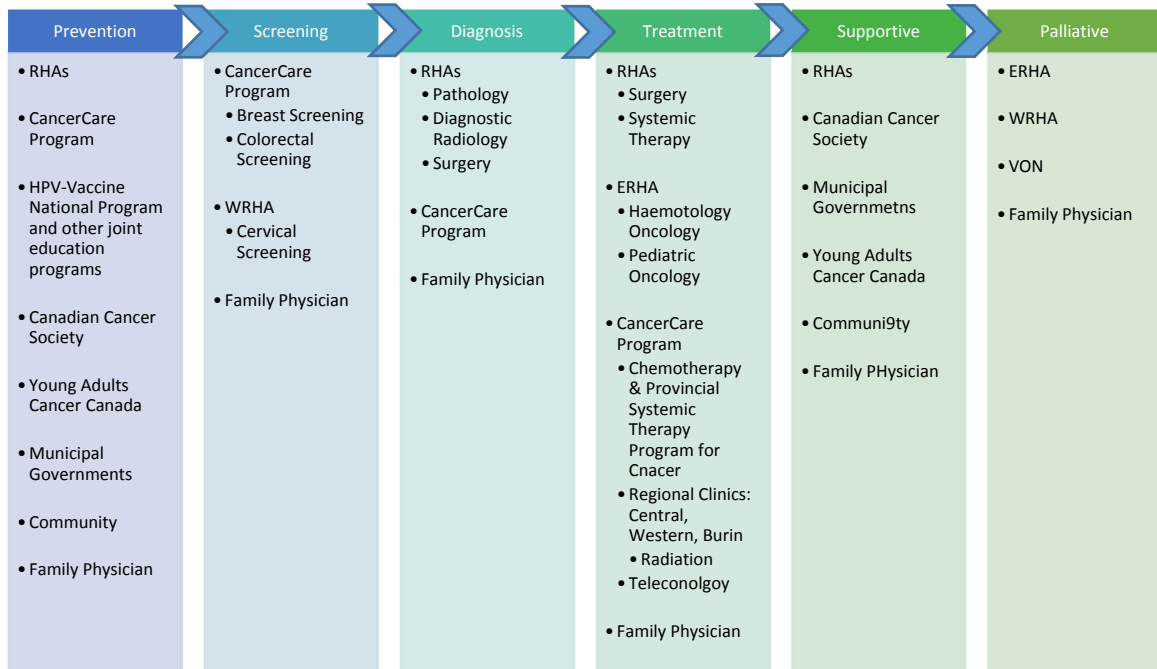
The 2010 *Gaining Ground* report forms the strategic framework for the NL's RT service plan. Prepared in response to the *Canadian Strategy for Cancer Control (2006)*, the goal of the *Gaining Ground* report is to provide a policy:

“Foundation upon which the Provincial Government, Regional Health Authorities, and community based organizations can build specific actions plans that will strategically focus on advancing and improving cancer control in NL.” (GNL, 2010, p.1)

The guiding principles from the *Gaining Ground* (p. 7) framework have been applied and supplemented for the NL service plan (see section 4.0).

Figure 3.1 "Partners in Cancer Care Along the Cancer Control Continuum", replicated from the *Gaining Ground*, summarizes the key roles in cancer control for NL. In this summary, radiation therapy is shown as one of the key cancer services offered only by the CCP.

Figure 3.1: Partners in Cancer Care along the Cancer Control Continuum¹



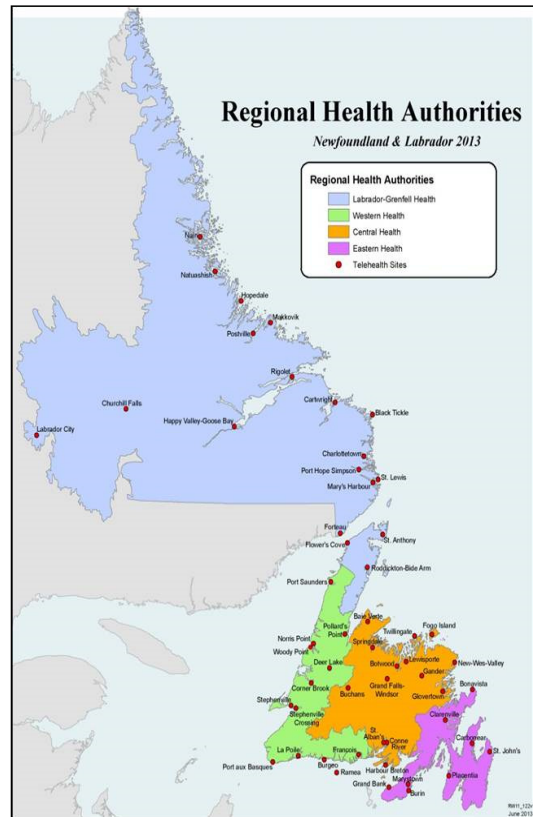
Notes:

1. Source: *Gaining Ground – A Provincial Cancer Control Polity Framework for Newfoundland and Labrador*, 2010, pg. 5. (Newfoundland Labrador).

CPP Organization Structure

NL's health services are responsible to the GNL's Minister of Health and Community Services under the Regional Authorities Act Chapter R.7.1 (SNL 2006, Amended 2010-c35). Management of NL's health services is delegated to health region authorities (see map Figure 3.2) under this legislation. These health regions include Eastern Health (EH), Central Health (CH), Western Health (WH) and Labrador Grenfell Health (LGH).

Figure 3.2: NL Regional Health Authorities, 2013

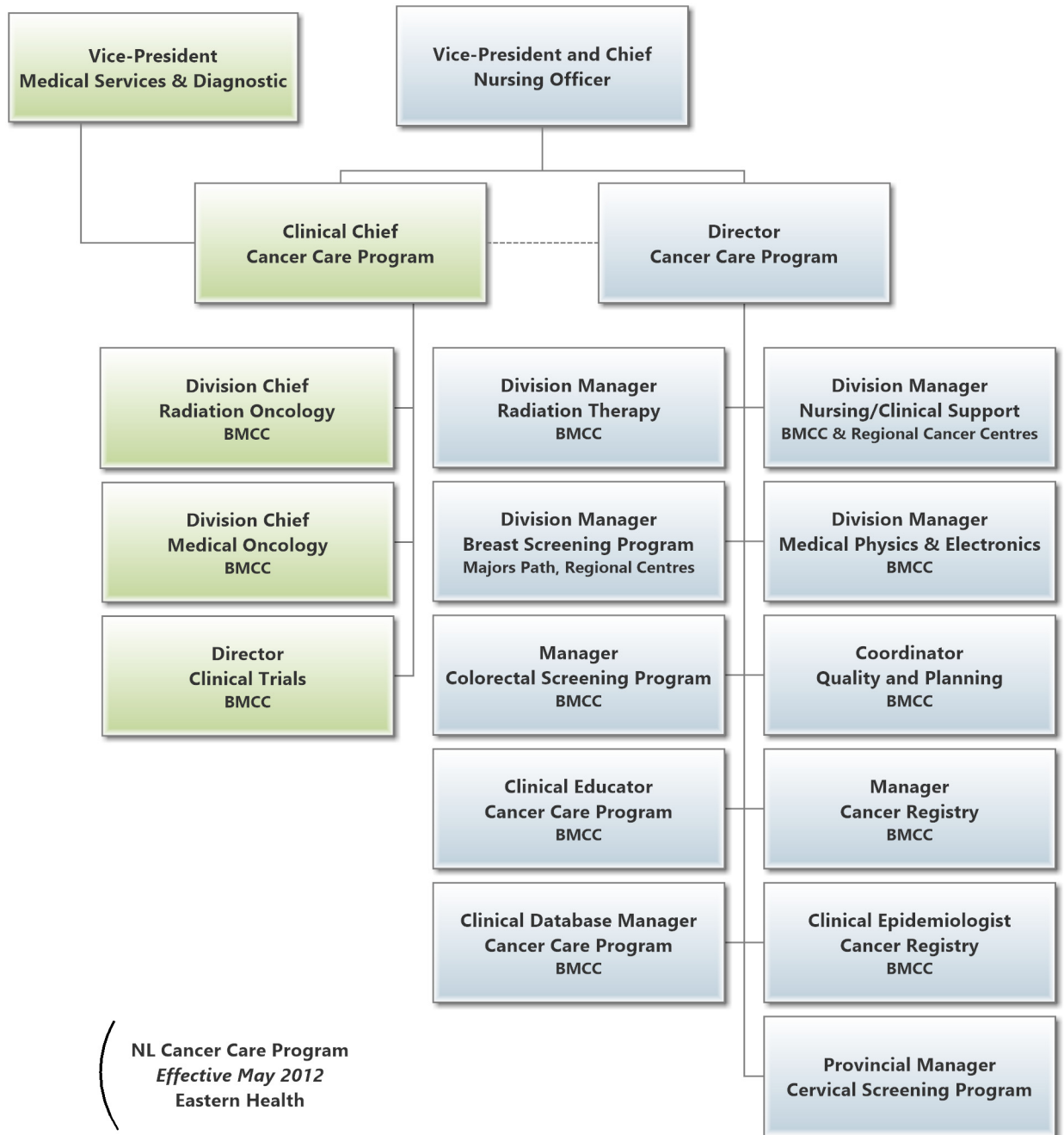


The four cancer centres in NL, which include the Dr. H. Bliss Murphy Cancer Centre (BMCC) in St. John's and the three regional cancer centres in Gander, Grand Falls and Corner Brook, report directly to the CCP.

The CCP is operated under the Eastern Health (EH) portfolio. The provincial nature of the CCP involves ongoing collaboration with the other regional health authorities (RHAs). Consideration of the policies and processes of these respective RHAs adds a level of complexity to the planning, operation and evaluation of cancer care services, implementation of quality initiatives and ensuring standardized care across the province.

The 2012 CCP organization chart is shown in Figure 3.3.

Figure 3.3: NL Cancer Care Program Organizational Chart, 2012



Notes:
BMCC=Dr. H. Bliss Murphy Cancer Centre

3.3 RT Service Model

Radiation therapy was first provided as part of NL cancer services in NL beginning in 1972. The current configuration and scope of these RT services is described.

Service Configuration

The Dr. H. Bliss Murphy Cancer Centre (BMCC), NL's tertiary cancer facility, is affiliated physically and clinically with the St John's Health Sciences Centre and the Janeway Children's Health and Rehabilitation Centre in St John's, NL. These health facilities and ancillary diagnostic and support services are co-located with a shared hostel facility. Currently, BMCC is the only location in NL where radiation therapy is provided. The BMCC provides only ambulatory cancer services. Inpatient beds, diagnostic services, other treatment and support services are provided by the associated tertiary care health facilities on the site,

All of the radiation therapy treatment units in the province are situated at the BMCC. All radiation oncologists are based at, and work out of, the BMCC and all RT treatment visits occur there. Radiation oncologists also see patients at peripheral clinics provided in regional centres at Gander, Grand Falls and Corner Brook. Teleoncology is used as a vehicle to provide services to patients in many areas of the province.

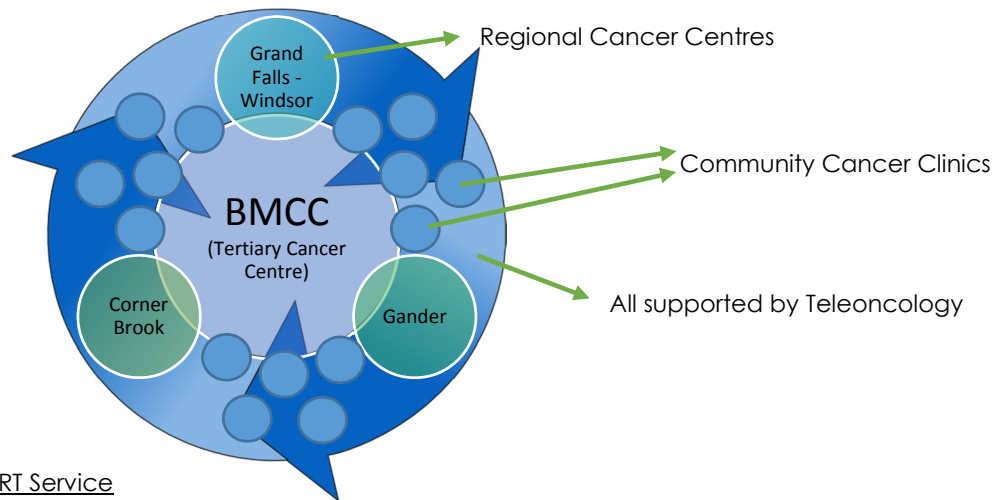
Historically, RT has been the last of the core cancer treatment services (i.e., surgery, systemic (or commonly referred to as chemo) therapy, radiation therapy and supportive care) to be considered for decentralization away from the tertiary service centres. This has been primarily due to the cost and complexity of the RT technology to operate, staff and maintain, including quality assurance to meet practice and radiation safety standards.

As shown conceptually in Figure 3.4, CCP currently operates three regional cancer centres outside the BMCC in St John's. These centres focus on systemic therapy (chemotherapy) and outpatient assessment clinics, staffed by CCP employees. In addition there are 15 community cancer clinics distributed in health facilities around the regions that administer systemic therapy. While CCP is responsible to set the provincial cancer care standards and treatment protocols, staff in these small cancer clinics are employees of and responsible to the local host health facility/region.

Currently, cancer patients who may need RT are referred to the BMCC for an initial radiation oncology consult. If it is determined that the patient requires RT, the radiation oncologist writes a RT prescription and the patient's treatment planning and RT treatment sessions are booked to occur at the BMCC.

Following RT treatment, patients receive a prescribed number of follow-up outpatient visits, the number of visits being dependent on the type of tumour and clinical protocol. Follow-up visits after RT treatment is completed may occur at the BMCC. Increasingly, these follow-up visits are being conducted in the regional cancer clinics either by oncologists visiting the regional centre in person or as a teleoncology 'visit'. For teleoncology follow-up visits, the patient attends the regional cancer centre and the oncologist is located at the BMCC; the visit occurs via videoconference.

Figure 3.4: NL Cancer Care Program, 2014



Distributed RT Service

In 2014, GNL confirmed the addition of RT to Corner Brook, NL, as part of a major infrastructure initiative that includes a new hospital, cancer facilities and hostel (see *Cancer Centre Western (CCW) Functional Program September 2014*). The CCW functional program recommended that the site include the addition of two vaults (bunkers) and one linac to meet service population needs to 2026. It is anticipated that this facility will be operational by 2019.

The scope of services for the new CCW, including RT, are described in detail in the *CCW Functional Program (September 2014)*. The CCW RT services as described were developed in accordance with the proposed NL RT Service Plan in section 4.0.

CCP RT Service Scope

As currently structured clinically, the CCP provides comprehensive RT services as listed at the BMCC and /or in association with other service providers on the Health Science Centre site in St John's.

Core RT Services provided by CCP for adults and pediatric patients include:

- Ambulatory, multidisciplinary clinics for initial consultations, treatment reviews & monitoring during RT, and follow-up visits post treatment
- Treatment planning and plan checking
- RT therapy treatments, including IMRT, IGRT and Stereotactic Radiosurgery (SRS) cases
- Concurrent RT and systemic (chemo) therapy treatments
- Safety monitoring and compliance
- Oncologist and nurse practitioner consultations, including radiation oncologist sub-specialisation in most areas including pediatrics, neuro, breast, head & neck, gynaecology, urology/prostate, melanoma, gastro-intestinal, lung and others
- On-call emergency radiation oncology consultation 24/7
- Teleoncology program for patient related consultation, patient and family education and staff training
- Other clinical and support ambulatory services, including nursing, dietician, psychologist, social work, patient navigation, registration and health record management, including a fully electronic health record system
- Cancer Registry for NL, including RT patient information
- RT equipment service specialist for monitoring, preventative maintenance, repairs including:
 - EBRT
 - Brachytherapy High Dose Rate (HDR)

- CT Simulator
- Superficial X-Ray
- Other radiation safety and support equipment
- Testing and Commissioning of new RT equipment
- Initiation and management of RT clinical trial for NL patients
- Clinical training rotations for local RT professional education programs including radiation oncology residents, radiation therapists, and medical physicist (MP) CCPM certification (Note: MP training requirements are changing in January 2016)

Most of the above RT services are closely integrated with the systemic therapy and other CCP cancer services, including sharing of some spaces, staff and programs.

Excluded RT Related Services Obtained from EH: CCP receives clinical and support services from the EH for RT services including:

- Diagnostic services including diagnostic imaging, nuclear medicine (with a new PET service under development), laboratory medicine, etc.
- Other clinical and support services including pharmacy; surgery; inpatient beds for adult, pediatric and palliative care; rehabilitation medicine; speech therapy; information technology (IT); data centre; housekeeping; material management; emergency care
- Haematology oncology ambulatory, inpatient and systemic therapy
- Limited hostel services on the Health Sciences site

RT Services Obtained Out of Province: CCP has routinely referred rare tumour cancers needing specialized care out of NL to other centres in eastern Canada and some USA centres for care. These including the following:

- Special RT diagnostic tests not available in NL and viewed as best practice for selected tumours, e.g., PET scan
- Total body radiation associated with bone marrow transplantation
- Proton therapy (to USA)

(**Note:** For regional centres, other host regions also provide similar clinical and support services for visiting RT specialist clinics and Tel-oncology programs.)

RT Service Contingency Plan: CPP has resorted in the last few year to sending patients out of province for RT treatments to reduce the load to safe levels due predominantly to critical staff shortages. Most recently this involved sending patients to other provinces for Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy as a result of vacancies and inexperience among its medical physics staff.

3.4 Radiation Therapy Historical Incidence and Utilization

Data describing recent RT utilization trends and patterns within NL are presented. Key observations from these data are listed at the end of this section.

Figure 3.5 presents, for all of NL from 2008 to 2012, the total number of patients diagnosed with cancer in a specific time period (i.e., one year) for a specific service population (i.e., all of NL). This represents NL's historic annual raw (not standardized) "cancer incidence". Over 15,700 NL residents were diagnosed with cancer between 2008 and 2012.

Figure 3.6 breaks down the cancer diagnoses by health region of residence at time of diagnosis. As illustrated in the figure, the proportional distribution of these cancer diagnoses by health region

closely mirrors the proportional distribution of the NL population by health region. As shown, there appears to be a nominal increase in cancer incidence over this period, excluding 2012, which reflects a relatively stable aging, total provincial population (see Appendix E).

(Note: Typically there is lag in documenting cancer diagnoses. Hence the most recent year of incidence data (i.e., 2012) tends to be low when first reported and gradually increases as reporting becomes more complete over a few years.) CCP relies on reporting from various diagnostic laboratories in each region. Unlike many other provinces, reporting on cancer diagnosis is not mandatory within NL under provincial legislation and regulations. Hence, for some data variations noted during this Study, verification to determine whether these were due to reporting or actual incidence differences was difficult or not possible.)

Figure 3.5: Cancer Diagnoses in NL

	2008	2009	2010	2011	2012	Total
Patients diagnosed with cancer ¹	3126	3109	3157	3276	3092	15760

Notes:

1. Source: Clinical Epidemiologist, Cancer Care Program, Eastern Health, June 2014

Figure 3.6: Cancer Diagnoses in NL by Health Region

NL RHA ¹	Total cancer diagnoses 2008-2012 ²	% of all cancer diagnoses ²	RHA population as % of NL population 2014 ³
Central	3225	20%	18%
Eastern	9105	58%	60%
Labrador	736	5%	7%
Western	2694	17%	15%
TOTAL	15760	100%	100%

Notes:

1. Health region of residence at time of diagnosis
2. Source: Clinical Epidemiologist, Cancer Care Program, Eastern Health, June 2014
3. Source: Newfoundland/Labrador Department of Finance Economic Research and Analysis Division Population Projections updated April 2014

Cancer incidence increases with age: those aged 50 years and older account for about 89% of the new invasive case cancer annually while those 0-49 years account for about 11% (Canadian Cancer Society, 2015, p. 27). This distribution of cancer diagnoses is supported in historical NL incidence data. 89% of all cancers diagnosed in NL between 2008 and 2012 were to people 50 years of age and older.

Figure 3.7: Age Group at Diagnosis for Cancers Diagnosed in NL

Age Group, 2008 – 2012	Cases Diagnosed in NL	Percent of All Cases
15-49 years of age	1729	11%
50+ years of age	14031	89%
TOTAL	15760	100%

Figures 3.8 & 3.9 present the number of RT patients and the number of RT courses provided by region of residence of the patients from 2011 to 2013.

Note that these data report the number of discrete patients treated in the calendar year (counted only once in the calendar year), the RT courses provided in that calendar year, and the number of fractions provided in the same calendar year. Some patients receive more than one course of treatment in a calendar year.

Over the years 2011 to 2013, between 2% and 3% of all RT patients treated at BMCC in St. John's had out of province addresses.

Figure 3.8: RT Patients by Health Region

NL RHA ^{1,2}	2011	2011	2012	2012	2013	2013
	Patients	%	Patients	%	Patients	%
Central Health	267	19%	286	20%	245	17%
Eastern Health	820	58%	845	60%	817	58%
Labrador Grenfell Health	95	7%	84	6%	109	8%
Western Health	195	14%	172	12%	209	15%
Out of Province	35	2%	31	2%	37	3%
TOTAL	1412	-	1418	-	1417	-

Notes:

1. Health region of residence of the patient at time of diagnosis
2. Source: Division Manager of Medical Physics, Eastern Health Cancer Care Program, email dated August 2014

Figure 3.9: Courses of RT Treatment by Health Region

NL RHA ^{1,2}	2011	2011	2012	2012	2013	2013
	Courses	%	Courses	%	Courses	%
Central Health Region	283	18%	308	20%	262	17%
Eastern Health Region	919	60%	917	60%	895	58%
Labrador Grenfell Health Region	98	6%	91	6%	112	7%
Western Health Region	201	13%	181	12%	221	14%
Out of Province	37	2%	35	2%	44	3%
TOTAL	1538	-	1532	-	1534	-

Notes:

1. Health region of residence of the patient at time of diagnosis
2. Source: Division Manager of Medical Physics, Eastern Health Cancer Care Program, email dated August 2014

Figure 3.10 shows the approximate number of treatments or fractions provided annually from 2011 to 2013 by residence of the patients receiving treatment.

Figure 3.10: RT Fractions by Health Region

NL RHA ^{1,2}	2011	2011	2012	2012	2013	2013
	Fractions	%	Fractions	%	Fractions	%
Central Health Region	5300	21%	5100	20%	4200	17%
Eastern Health Region	15000	58%	15100	59%	14800	58%
Labrador Grenfell Health Region	1500	6%	1700	7%	2100	8%
Western Health Region	3500	14%	3300	13%	3900	15%

NL RHA ^{1,2}	2011	2011	2012	2012	2013	2013
	Fractions	%	Fractions	%	Fractions	%
Out of Province	500	2%	300	1%	300	1%
NL TOTAL	25800	-	25500	-	25300	-

Notes:

1. Health region of residence of the patient at time of diagnosis
2. Source: Division Manager of Medical Physics, Eastern Health Cancer Care Program, email dated June 2014

The average number of fractions per course for NL overall is shown in Figure 3.11.

Figure 3.11: Average RT Fractions Per Course

	2011	2012	2013
Average # of fractions per course	17	17	16

Figure 3.12 provides data regarding the radiation therapy provided at the BMCC in St. John's from 2011/12 to 2013/14 by type of treatment.

Figure 3.12: BMCC RT Treatment Statistics

BMCC Radiation Therapy Treatment Statistics	2011/12	2012/13	2013/14
High Dose Rate (HDR) Brachytherapy cases	54 Gyne: 53 Breast: 1 Prostate: 0	73 Gyne: 47 Breast: 0 Prostate: 26	46 Gyne: 39 Breast: 0 Prostate: 7 ¹
HDR Brachytherapy treatments (fractions)	184 Gyne: 174 Breast: 10 Prostate: 0	202 Gyne: 176 Breast: 0 Prostate: 26	138 Gyne: 131 Breast: 0 Prostate: 7 ¹
Stereotactic Radiosurgery (SRS) cases	11	17	5 ²
SRS treatments	11	17	5 ²
Initial Computerized Tomography (CT) Simulations	1533	1529	1525
Superficial X-ray (SXR) treatments	1178	991	972
SXR Clinical Mark-up (CMU)	111	104	98
Linear Accelerator Treatments (Fractions)	25951	25588	25221
Linear Accelerator Courses	1571	1580	1573

Notes:

1. Prostate brachytherapy program was on hold for 5 of the 12 months temporarily due to Medical Physics staffing/skill mix issues. The prostate brachytherapy program has now resumed and will continue in future.
2. SRS program was on hold for 7 of the 12 months temporarily due to Medical Physics staffing/skill mix issues. SRS is still on hold; work is actively underway to transfer the program from the Trilogy to TrueBeam. Resumption of SRS is anticipated in late 2014, and an SBRT program anticipated to be added in early 2015.

Observations from the data:

- The number of patients diagnosed with cancer remained relatively stable between 2008 and 2012.
- The distribution of RT patients, treatment courses and fractions closely reflects the proportion of the NL population resident in the respective health regions. (See Population information in Appendix E).
- 89% of all cancer diagnoses in NL between 2008 and 2012 were to people age 50 and over, the same as the rest of Canada.

- Between 2011 and 2013, 2% to 3% of all RT patients treated in NL were from outside of the province. They received 1% to 2% of all RT treatments.
- The number of linear accelerator courses remained relatively stable over the years 2011/12 to 2013/14.
- Overall, the average number of fractions per course in NL decreased from 17 in 2011 to 16 in 2013.
- Medical Physics recruitment issues have caused temporary holds on prostate brachytherapy and SRS programs during 2013/14. Go-forward planning is contingent on adequate Medical Physics staffing.

3.5 Radiation Oncology Staffing Model

Currently, all Radiation Oncology physicians and staff in NL are based at the Dr. H. Bliss Murphy Cancer Centre in St. John's. The radiation oncology physicians and staff as of July 2014 are shown in Figure 3.13.

Figure 3.13: Radiation Oncology Budgeted Staff per Cancer Care Program^{1,2,3}

Radiation Oncology Physicians & Nurse Practitioner (based in St John's)	FTE
Radiation Oncologist	9.0
General Practitioner Oncologists (GPO), Radiation Oncology	2.0
Nurse Practitioner	1.0
TOTAL	12.0

Radiation Therapy Staff (BMCC)	FTE
Manager of Radiation Therapy	1.0
Radiation Therapist III (Supervisor)	1.0
Radiation Therapist II	6.5
Radiation Therapist I	19.0
Radiation Therapy Clinical Coordinator (student)	0.5
Radiation Therapy Clinical Trials	0.5
Booking Clerks (WPEO)	3.0
Personal Care Attendants (includes portering)	2.0
Secretary (shared with MP staff)	0.5
TOTAL	34.0

Medical Physics Staff (BMCC)	FTE
Manager of Medical Physics & Radiation Safety Officer	1.0
Medical Physicists	5.0
Dosimetrists	5.5
Biomedical Engineering Technologists	2.0
Secretary (shared with RT staff)	0.5
TOTAL	14.0

Notes:

1. Based on CCP Budgeted FTEs 2013/14.
2. Chemotherapy Certified Registered Nurses and Clerical Support Staff are employed by Eastern Health.

- Nursing, allied health and clerical staff support RT service delivery. A number of departments at the tertiary site also provide service and support in the care of patients receiving RT. These positions are funded directly by Eastern Health and/or the designated Regional Health Authority.

Staff recruitment and retention affecting different professional staff has been a challenge for CCP historically and currently. The staff group experiencing the greatest instability for the last few years and currently is the Medical Physicist department. See section 3.7 Specialized Human Resources for additional information.

3.6 RT Facility & Infrastructure Capacity

The Dr. H. Bliss Murphy Cancer Centre, opened in 1994, is located in St. John's, attached to the northwest corner of the St John's Health Sciences Centre. As an outpatient facility, it is open weekdays, excluding statutory holidays, from 0830 to 1630 (about 40 hours per week).

All radiation therapy equipment in NL is situated at the BMCC. Current RT equipment is listed in Figure 3.14:

Figure 3.14: BMCC RT Treatment Equipment & Facilities

BMCC RT Equipment	Number of Units
Linear Accelerators	4
Brachytherapy Units	1
Superficial X-Ray Unit	1
CT Simulators	2

The RT equipment inventory, including manufacturer, model, installation year and estimated retirement year, are presented in Figure 3.15.

Figure 3.15: BMCC RT Equipment Inventory

Type	Manufacturer	Model	Installation Year	Estimated Retirement Year
Linear Accelerator	Varian	TrueBeam StX	2013	2027
Linear Accelerator	Varian	Trilogy	2008	2022
Linear Accelerator	Varian	Clinac iX	2008	2022
Linear Accelerator	Varian	Clinac 21EX	2001	2015
HDR Brachytherapy	Varian	GammaMedPlus	2006	2021
SXR	Gulmay	Xstrahl D330	2011	
CT Simulator	GE	RT Lightspeed 16	2009	2019
CT Simulator	GE	RT Lightspeed 16	2010	2020
NOT IN USE				
Co-60 ¹	Nordion/Theratronics	780E	1978	2011

Notes:

- The Co-60 is no longer in use: CCP will be decommissioning and disposing of this unit.

In 2014, the average RT equipment age was 6.2 years. CPP is approved for replacement of the 13 year old Clinac 21EX in 2015. If this upgrade proceeds in 2015, the average age of CPP's RT equipment (excluding the CT Simulator) will be approximately 4 years. The average age of the ST Simulator is 4.5 years.

As well as providing information about the average age of the equipment, this inventory illustrates the importance of achieving consistency with vendors to simplify staff training, inventory of spare parts and clinical processes, all positive factors for quality assurance outcomes.

The existing Cobalt vault is not large enough nor is it shielded to accommodate new linac units. Decommissioning of cobalt units has become complex and costly (e.g. \$130,000 to \$170,000). This process has been deferred by CCP to deal with other higher priorities, including senior Medical Physics staffing shortages.

CCP has four vaults that are sized and shielded for current general use linacs. These are fully deployed currently. This means replacing a linac requires the decommissioning and removal of the old linac and renovations for the new linac must proceed before the new linac can be installed and commissioned. Several detailed licence applications to CNSC and substantial commissioning/testing of the new units are required. This work necessitates the extensive involvement of a senior medical physicist, including a certified CNSC radiation safety officer, RT equipment service specialist and others. Depending on staffing resources and construction process, this whole process can remove a linac and vault from clinical use for 4-8 months.

All space within the BMCC available for RT use is fully used and several areas are quite crowded (e.g., dosimetry, medical physics workshop, RT maintenance work areas). Options to expand into other space within the BMCC are not feasible as the BMCC systemic therapy and support spaces are also fully utilized and seeking expansion space.

The number of RT treatments or fractions provided by each linear accelerator from 2011/12 to 2013/14 at BMCC is shown in Figure 3.16.

Figure 3.16: Radiation Therapy Utilization by Linear Accelerator

Linear Accelerator Type	2011-2012 Fractions	2012-2013 Fractions	2013-2014 Fractions
Trilogy	6216	8101	7104
Clinac iX	7288	8666	7251
Clinac 21 EX	6240	8317	6431
TrueBeam	--	--	4439

Notes:

1. Use of the TrueBeam commenced in June 2013

Figure 3.17 shows the current capacity of the existing four linear accelerators at BMCC based on the assumption that each linac provides 400 courses per year, and the actual current utilization. Overall, BMCC RT service is operating at a high level of efficiency at 384 courses per linac per year in 2013, and is operating at very close to capacity. This level of efficiency usually requires most of the QA and planned maintenance to be done outside regular working hours.

Figure 3.17: NL's (BMCC) Linear Accelerator Capacity

BMCC capacity	2013	
	Capacity	Actual Utilization
Linear accelerators	4	4
Courses	1600 ¹	1534
Courses per linac	400 ¹	384
Fractions	25600 ²	25300

Notes:

1. Capacity based on an average of 400 courses per linac per year.
2. Capacity based on an average of 16 fractions per course.

In 2014, NL had access to one linear accelerator per approximately 132,000 population. This compares favorably with the Canadian ratio of 1 linac per approximately 140,000 population. (Canadian Partnership Against Cancer, 2014)

Figure 3.18: Linear Accelerators by NL Population

Linear Accelerators by Population	
NL Population, 2014	526,673
Linear accelerators, 2014	4
Population/Linear accelerator	131,668

3.7 RT Special Challenges

Newfoundland and Labrador faces many unique challenges in delivery of RT and other health services due to its geographic, climate, demographics, and economy. While many of these overlap, the key factors are listed and direct implications for RT services are identified.

Access Due to Geographic, Demographic & Climactic Realities

Similar to other Canadian provinces and countries with sparsely populated, large land areas, and severe unpredictable weather patterns (see section 3.1), and service accessibility is a significant challenge in NL. This is especially problematic for technologically complex and costly services such as RT, which are needed by a patient population that is relatively frail and proportionally older.

With RT being provided only in St. John's, many cancer patients live great distances from treatment. For example, Labrador City in Labrador is 2096 km from St. John's. Driving time, including a ferry crossing, takes approximately 29 hours. Corner Brook is 690 km from St. John's with a driving time of approximately 8 hours. (See travel distances and time in Appendix E4.)

NL RT utilization data were assessed regarding potential regional disparities in access to RT.

In 2012, the proportion of RT patients by RHA of residence closely reflected the population distribution. The proportion of RT patients residing in Western Health and Central Health was 2% and 3% less than the proportion of cancer diagnoses in those RHAs respectively.

Figure 3.19: Percentage of RT Patients, Population and Cancer Diagnoses by Health Region

NL RHA of Residence	RT patients as % of all RT patients 2013	RHA population as % of NL population 2014 ¹	Cancer diagnoses as % of all cancer diagnoses ² 2012
Central	17%	18%	20%
Eastern	58%	60%	58%
Labrador Grenfell	8%	7%	5%
Western	15%	15%	17%
Out of Province	3%		
NL TOTAL	100%	100%	100%

Notes:

1. Source: Newfoundland/Labrador Department of Finance Economic Research and Analysis Division Population Projections updated April 2014
2. Source: Clinical Epidemiologist, Cancer Care Program, Eastern Health, June 2014

These data show that CCP and other stakeholders seem to have been effective in achieving reasonably balanced access to RT across the regions. However, feedback from senior representatives of the NL Cancer Advisory Committee and the Canadian Cancer Society - NL Division identified travel costs and stress with personal arrangements (family and work) arising from being long distances from home for prolonged RT treatments and other cancer treatments the most frequently heard concern raised by cancer patients. Data on the financial and personal costs to residents from outside of the EH are unavailable. However, NL's key contributors to this challenge (i.e., geography, climate, demographics) will continue well past 2026.

Specialized Human Resources

The preceding factors have also contributed to historical difficulties in recruiting and retaining trained and skilled staff without competitive salaries and benefits to offset costs of living in NL. This is especially true if such staff do not have family links to NL. Historically and currently, the CCP has struggled and is struggling with this challenge as follows:

- **Sub-specialization:** Due to the existence of over 200 different types and four stages of cancer, best practice RT requires sub specialized staff in the following: multiple radiation oncology subspecialists, medical physicists (clinical and safety), radiation therapists, dosimetrists, nurses, equipment service specialists, social workers, pharmacists, dieticians, physical therapists, IT and others depending on the type of cancer.
- **Cyclical Shortages:** Like other relatively small professional groups, international cycles in staff availability are ongoing with at least one category of oncology staff being in short supply at any time since human resource recruitment has become international. Over the past decade this has affected radiation oncologists, radiation therapists and medical physicists staffing levels in the CCP.
- **High Impact - Low Availability:** Due to the multidisciplinary and highly specialized nature of RT therapy, shortages in one staff group can affect the safe delivery of services. This has resulted in closure of selected CCP services with cancer patients being sent out of province temporarily. This situation is costly and highly disruptive to patients and staff.
- **Instability of Medical Physics:** Currently this situation is having significant detrimental impact on the CCP's medical physics staffing due to international shortage and stringent educational/clinical internship requirements effective in 2016 as well as other factors as listed:

- NL is particularly vulnerable since there are no education programs in NL for the highly specialized medical physicist staff category. By 2016, the Canadian College of Physicists in Medicine (CCPM) certification requirements will include undergraduate and graduate degrees and an accredited two year residency medical physics program before completing the oral and written certification exams. On average, this will require 11-13 years of post-secondary formal university study.
- Beginning in 2000, the NL government and health providers approved stop gap 'market adjustment' measures to deal with major oncology recruitment and retention compensation differences affecting Radiation Therapists, Dosimetrists and Medical Physicists. While the situation has temporarily stabilized for the Therapists/ Dosimetrists, major issues continue for the Medical Physicists.
- NL's Medical Physicists remain the lowest paid within Canada. While the market adjustment factor is helpful, Government policy makes this factor non pensionable, subject to a six month return of service for each bi-annual payment (i.e., renewal must be sought every two years) and has continued to result in a high rate of MP staff turnover.
- The NL Government's 2013 Job Evaluation System failed to address this matter with Medical Physicists. When another down cycle occurs with the RT therapists /Dosimetrists, this situation could also quickly deteriorate.
- There does not seem to be a staffing model and human resources plan for Medical Physics that is jointly accepted and supported by CCP, EH and the Ministry.
- **CCP Management Capacity:** During the NL RT service Plan Study, CCP staff were receptive, knowledgeable and helpful. However, it was a struggle for them to manage the extra Study workload in addition to their already heavy administrative and clinical duties. Scheduling meetings before and after regular working hours and having staff cancel days off were often the only means to achieve participation by key staff. At this time, CCP has insufficient administrative spare capacity to manage the implementation of a RT service plan including planning for a new RT site and the associated multiple tasks involved.

Travel and Accommodation

The extensive travel and the need for overnight accommodation present significant challenges for many NL cancer patients to access RT.

Daffodil House in St. John's, operated by the NL Canadian Cancer Society, provides accommodation for cancer patients at a charge of \$25 per day including meals and transportation to the BMCC. There is a substantial waiting list to access the current 24 beds, and an estimated need for double the current number of beds.

The NL Canadian Cancer Society identified the biggest issue from cancer patients in NL is the cost of travel, accommodations and food when away from home for treatment.

3.8 Strengths & Opportunities

During the Study, several strengths and opportunities were identified with implications for the RT Service Plan.

Provincial Health Technology & IT

- Improved provincial revenues have enabled a significant re-investment by the Ministry in health technology and IT systems.
- The Ministry, in association with other stakeholders, has begun to merge NL's MediTech based health data systems which were developed originally as independent systems for each health region (i.e., multiple different systems). In 2013/14, the EH and LGH MediTech

systems were merged. Ongoing integration of the MediTech system is planned. Such work is very important to ensuring effective management of clinical and diagnostic data for CCP RT particularly for distributed RT sites such as the CCW.

RT Technology & Data Management

- With effective long term planning and capital equipment decisions, the NL CCP has been farsighted in effectively using constrained capital resources in association with its IT colleagues in EH.
- CCP appears to have been strategic in achieving standardization with RT technology and software to simplify staff training and maintenance considerations.
- The CCP has shown effective leadership in moving the cancer program toward a fully electronic health record for the BMCC site in 2014 with plans to advance this to the regional centres. This significant advancement was heavily dependent on previous work to standardize RT technology and software and operational integration with diagnostic support services.
- The installation of the TrueBeam STx technology allows for shorter patient treatments and improved patient access. This advanced technology improves the existing treatments including Stereotactic Radio surgery and allows for the implementation of best practices with the development of the Stereotactic Body Radiation Therapy Program.

Wait Time Management

- The NL Cancer Care Program has consistently achieved national benchmarks for access to Radiation Therapy services with 96% to 98% of newly diagnosed cancer patients required radiation therapy commencing radiation treatment within the 28 day benchmark,

Teleoncology

- NL's teleoncology service was deemed a leading practice nationally following an environmental scan commissioned by the Canadian Partnership Against Cancer to implement best practices to enhance patient flow.

Collaboration

- NL Health Regions seem to be receptive to and encouraging of the CCP's role in setting provincial cancer care standards, based on feedback from interviews conducted during the Study. Improved health professional education/training and compliance monitoring may benefit from more in-depth collaboration.
- CCP seems to have excellent communications and an effective working relationship with the Canadian Cancer Society - NL as confirmed by CCS senior leadership.
- The Provincial Cancer Control Advisory Committee seems ready to move forward to fill its advisory role to the GNL on cancer control.

RT Human Resources:

- With the exception of Medical Physics staff shortages, the CCP seems to have reasonably stable, well qualified and experienced staff.
- The CCP's clinical and administrative leaders are strongly committed to doing what seems most beneficial for their patients and families.

KEY FINDINGS

NL's unique geographic, climatic, demographic and economic realities present significant challenges for health service delivery.

Based in St John's in Eastern Health, the NL Cancer Care Program is responsible for provision of services to cancer patients throughout the province.

At this time, all radiation therapy treatment services are provided at the Dr. H. Bliss Murphy Cancer Centre in St. John's. Radiation oncologists also provide outreach clinics in person or through teleoncology to patients at locations throughout Newfoundland.

The total number of persons diagnosed with cancer and the total number of patients treated with radiation therapy has remained relatively stable during the years 2008 to 2012.

The proportion of patients treated with RT by health region of residence is reasonably consistent with the proportion of cancer diagnoses by health region.

89% of all cancer diagnoses in NL between 2008 and 2012 were to people age 50 and over, the same as the rest of Canada.

The RT service at BMCC is operating at a high level of efficiency at 384 courses per linac per year and is operating at very close to capacity.

CPP has and is struggling with difficulties in recruiting and retaining trained and skilled staff. Medical Physics recruitment issues have caused temporary holds on prostate brachytherapy and SRS programs during 2013/14.

While utilization data show that cancer patients from all NL regions are accessing RT reasonably equitably, extensive travel and the need for overnight accommodation are reported to present significant challenges for many NL cancer patients accessing RT.

The CCP has shown leadership and innovation in teleoncology and wait time access.

4.0 NL's RADIATION THERAPY SERVICE PLAN TO 2026

Under section 4.0, the proposed NL RT service plan to 2026 is described. Building on RT best practices (section 2.0) and NL's Cancer Care Program's RT status (section 3.0), core RT service determinant (drivers), significant gaps, proposed planning metrics, basic components and critical considerations are presented. These elements form the framework (i.e., NL's RT province wide service plan) to enable detailed program, capital, technology, human resources and operational planning to successfully meet RT needs moving forward to 2026.

4.1 RT Service Plan Principles

Building on *Gaining Ground* (2010), NL's cancer control policy framework, the following principles presented in Figure 4.1 are proposed to guide the NL RT Service Plan.

Figure 4.1 RT Service Plan Principles to 2016¹

Focus	Statement
Accessible	Promote reasonable access to appropriate care, regardless of patients' place of residence, social or economic circumstances.
High Quality	Use evidence based, best practices that are first and foremost safe for patients and staff.
Population Health Based	Apply both patient orientated and population elements of cancer control.
Sustainable	Promote a cost effective approach to the use of cancer control resources while ensuring the integrity and continuity of local services
Integration	Collaborate to develop well-coordinated, seamless, timely and responsive patient centred services that effectively apply the expertise of different service providers province-wide
Research & Innovation	Foster a culture that values innovation and promotes research as the basis for informed decision making to improved cancer control
Multidisciplinary	Value and enable the multidisciplinary contributions of team members
Learning	Foster informed patients, communities, stakeholders and staff by promoting ongoing learning and clear communications
Accountable	Encourage individual accountability for effective use of resources to control cancer among all participants (patients, families, communities, staff, stakeholders) by clarifying roles, responsibilities and measures, and then constructively communicating outcomes

Notes:

1. Modified and expanded from *Gaining Ground* (GNL, 2010).

4.2 Core Determinants of Future Service Need to 2026

Key factors proposed to directly shape RT service need 20 214 are summarized.

Demographic Patterns

Newfoundland and Labrador's population patterns are largely determined by NL's geography, climate and natural resource based economy. The resulting demographic pattern impacting RT services are listed:

- **Population Distribution:** The island of Newfoundland and mainland Labrador have a combined area of approximately 405,000 square kilometers and a total population of 526, 670.

- o In 2014, approximately 60% of NL's population (about 317,000) resided within Eastern Health (EH). EH is geographically the smallest region with less than 1/15th of the NL's land mass (about 27,000 sq. km. and a population density of about 11.7 residents/sq. km). The remaining 40% NL residents, (about 210,000) live throughout about 378,000 sq. km. in the remaining three NL health regions with an average density of 0.6 people/ square km (see Figure 4.2)

Figure 4.2: 2014 population distribution by Health Region^{1,2}

NL RHA	2014 population	2014 population proportion by RHA
Central	93,750	18%
Eastern	316,930	60%
Labrador Grenfell	37,836	7%
Western	78,157	15%
NL TOTAL	526,673	100%

Notes:

1. Source: NL's Department of Finance Economic Analysis and Research Division <http://www.economics.gov.nl.ca/POP-projections.asp>
2. NL's current population estimates for 2014 were taken from the medium scenario of the NL's Department of Finance Economic Analysis and Research Division's population data.

- **NL's population projection** between 2014 and 2026 in Figure 4.3 shows:
 - o NL's population is projected to decrease by 0.7% overall.
 - o Projected population change ranges from a decrease of 7.5% for Central Health to an increase of 1.8% for Eastern Health.
 - o A gradual population shift from small outlying communities around the shores of the Island of Newfoundland to larger inland communities is expected to continue in response to the continuing transition away from the fishing industry.

(Note: Detailed population information is provided by Health Region in Appendix E.)

Figure 4.3: NL Population Projections to 2026 by Health Region^{1,2}

NL RHA	2014	2026	Change 2014 to 2026
Central	93,750	86,684	-7.5%
Eastern	316,930	322,702	1.8%
Labrador Grenfell	37,836	38,246	1.1%
Western	78,157	75,245	-3.7%
NL TOTAL	526,673	522,877	-0.7%

Notes:

1. Source: NL's Department of Finance Economic Analysis and Research Division <http://www.economics.gov.nl.ca/POP-projections.asp>
2. NL's current population estimates for 2014 and projections to 2026 were taken from the medium scenario of the NL's Department of Finance Economic Analysis and Research Division's population data.

- **NL's Projected Age Distribution:** Percentage changes in age of the population of the four Health Regions' were assessed between 2012 and 2026 with key findings noted (see Figures 4.4 & 4.5):
 - o In NL overall, residents aged 50 years and older will increase by 20%.

- The projected increase in residents 50 years and older will range from a low of 16% in Western and Central Health to a high of 27% in Labrador Grenfell Health.
- During the same period, those aged 0-49 years are projected to decrease 15% in NL overall, ranging from a decrease of 10% in Labrador Grenfell Health to a decrease of 30% in Central Health.
- In 2026, 49% of the population of NL will be 50 years of age and over, higher (older) than the Canadian average and similar to the other Atlantic Provinces.
- The proportion of the population that will be 50 years of age and over in 2026 will range from a low of 40% in Labrador Grenfell to a high of 59% in Central Health.
- In 2026, 18% of NL's population will be aged 70 or over. Similar to the preceding pattern, Labrador Grenfell Region has the least percentage of their population in this older age group (i.e., 12%) while Central Region has the highest percentage at 23 %.

Figure 4.4: NL Population Projected Change to Age Groups

NL RHA	% Change for Age Groups between 2012 and 2026		% of population aged 50+	
	0 to 49 years	50+ years	2012	2026
Central	-30%	16%	46%	59%
Eastern	-11%	23%	38%	46%
Labrador Grenfell	-10%	27%	32%	40%
Western	-22%	16%	44%	54%
NL TOTAL	-15%	20%	40%	49%

Figure 4.5: Percentage of NL Population Aged 70 and Over

NL RHA	% aged 70 and over 2026
Central	23%
Eastern	17%
Labrador Grenfell	12%
Western	22%
NL TOTAL	18%

Cancer Incidence Projections

The number of new cancer cases per year in a defined population (i.e., cancer incidence) is the primary driver of cancer service workloads, including RT. Due to delays in receiving cancer diagnostic reports, at least 18 months of follow-up is needed to ensure reasonably accurate reporting for the most recent year so that cancer incidence reporting can lag by about 2 years.

- **Historical NL cancer incidence:** Data for the past five years regarding new cancer cases by year of diagnosis by RHA of residence are shown in Figure 4.6.
 - Cancer incidence projections for NL are based on the yearly average of diagnosed cancer cases from 2010 to 2012. This approach is warranted due to the relatively small number of cases and to minimize unusual short term fluctuations.
 - Over a three year period with a relatively stable total population, NL's average number of new cancer cases (excluding non-melanoma skin cancer) was 3175 cases per year.

- o Over these three years, cancer incidence ranged from a high of 3267 cases (2011) to a low of 3092 cases (2012). The pattern shows a gradual overall increase except for 2012, which may be due to incomplete reporting for this most recent year.

Figure 4.6: New Cancer Cases by Year of Diagnosis¹

NL RHA	2010	2011	2012	Total	Yearly Average 2010-2012 ²
Central	687	653	652	1992	664
Eastern	1751	1916	1794	5461	1820
Labrador Grenfell	169	159	135	463	154
Western	550	548	511	1609	537
NL TOTAL	3157	3276	3092	9525	3175

Notes:

1. Source: Clinical Epidemiologist, Cancer Care Program, Eastern Health. Invasive cancers. Excludes NMSC.
2. Yearly average new case incidence for 2010-2012 was used as base for incidence projections to 2026.

- **Approach for NL cancer incidence projections:** Long term cancer incidence projections for NL had not been completed prior to this Study and timelines did not allow for validation of a comprehensive statistical projection model to adjust for some historic cancer data limitations. Consequently, Altus Planning consulted with CCP, EH, GNL and representatives from the Newfoundland & Labrador Centre for Health Information (NLCHI) to develop an easily reproducible approach. This cancer incidence projection is based on well documented cancer projection factors and trends in Canada. A key factor in Canada is that those aged 50 years and older account for about 89% of new invasive cancer cases annually while those 0-49 years account for about 11% (CCS, 2015, p 27). This distribution is supported in NL's historical cancer incidence experience (see Figure 3.5). These factors were then applied to NL's health regions to developed cancer incidence projections to 2026 as follows.
 - o CCP's historical incidence data (i.e., yearly average incidence between 2010-2012).
 - o GNL's population projections and percentage changes in the 0-49 years and 50 & over age groups by health region.
 - o Estimated Provincial Age Standardized Incidence Rates (ASIR) changes between 2008-2012 and 2023-2026 based on preliminary ASIRs projected by NLCHI's statistical experts.
 - o Cancer incident trends and key factors from the literature review.
 - o Findings that NL's population performs poorly on lifestyle factors contributing to higher age-sex standardized cancer incidence rates (CCS, 2014, p 27)
- **NL projected incidence:** Findings, including the effect of key factors, are summarized in Figure 4.7 with the following highlighted (see Appendix F.2 for additional information on the methodology used):
 - o Total new invasive cancer cases are projected to increase from 3,175 (average per year during 2010-12) to 4,190 new cancer cases in 2026.
 - o This equals a 32% increase over 14 years while the NL population becomes older overall and decreases in total by about 1%.
 - o The cancer incidence increase is attributed to an estimated 13% increase in the NL Age Standardized Incidence Rate (ASIR) over this period (NLCHI, May 2014) while the average ASIR trend in Canada shows a small yearly decrease between 2000 - 2010 (CCS, 2014, p 27).

- o NL's ASIR increase is based on historical trends and its poor performance on life style factors that are expected to continue for at least the next 15 years before cancer prevention initiatives improve cancer ASIRs materially.

Figure 4.7: Projected Incidence of New Cancer Cases in Newfoundland & Labrador¹

NL RHA	Average cancer cases (2010-12) ¹	Add 13 % growth for cancer incidence ²	Total baseline cases (2010-12 average plus 13% growth)	Projected increase in 89% of cases (aged 50+) based on projected pop. growth in this age group to 2026 ³	Projected decrease in 11% of cases (aged 0-49) based on projected pop. decrease in this age group to 2026 ³	Total projected cases to 2026 based on cancer incidence & population change ⁴
Central	664	86	750	107	-19	838
Eastern	1820	237	2057	421	-22	2456
Labrador	154	20	174	42	-2	215
Western	537	70	606	86	-12	681
TOTAL	3175	413	3588	656	-55	4190

Abbreviations: Pop=Population; ASIR= Age standardized incidence rate for cancer per 100,000 population; NL= Newfoundland & Labrador.

Notes:

1. Average number of cancer cases per year by region per Appendix F.2.
2. Source of ASIR change: Research & Evaluation Department, Newfoundland & Labrador Centre for Health Information (NLCHI), May 2014
3. Source of percentage cancer incidence by age group: CCS, 2014, p.27; source of changes in identified population age groups: GNL projected population changes to 2026.
4. Add preceding three columns to obtain projected total new cancer cases in 2026. See Appendix F for detailed methodology.

- **Cancer Prevalence:** Prevalence is defined as the number of 'cases' of a disease present in a defined population at a given time. For cancer prevalence, such cases can be measured by the number of living individuals previously diagnosed with cancer or the number of cancer cases diagnosed in such individuals (as some may have had more than one type of cancer) within a defined time period.
 - o A comprehensive Canadian study (Canadian Cancer Statistics, 2014, p.70) found that 2.4% of the Canadian population had been diagnosed with cancer in the 10 years preceding 2009.
 - o Prostate (21.0%), Breast (18.8%) and Colorectal (12.5) cancer account for about 52% of this total.
 - o Such affected individuals were undergoing treatment, recovering from its affects or still dealing with the physical and emotional consequences of the cancer.
 - o The 10 year prevalence peaked in those older than 60 years.
 - o As Canada's and NL's populations age, the number of individuals affected is expected to gradually increase.
 - o If this prevalence average rate of 2.4% is applied to NL in 2026, this equates to about 12,550 residents (2.4% x 522,877 projected NL population by 2026) having been diagnosed with cancer in the preceding 10 years.
 - o If survival rates continue to improve, this factor will increase and related supportive care needs will add to the overall cancer care workload.

New Treatment Options

Due to the nature of RT and major safety considerations, RT is heavily dependent upon advances in costly hardware and software. The literature and expert consultations indicate that major advances in RT to 2026 affecting NL's RT Service Plan will likely include the following trends.

- **Technological advances** are expected to include incremental advances in RT equipment hardware and software with improved imaging to concentrate radiation therapy on the tumor cells and lessen damage to surrounding health tissue.
 - To ensure access by NL's population to evolving best practice RT treatments, CCP needs to continue regular RT technology upgrades and ensure reasonable access to improved imaging modalities. Such an example is the new PET facility being constructed on the St John's Health Sciences campus near the BMCC and expected to be operational by 2015/16.
 - The technological feasibility of merging MR and Linac to enable concurrent imaging during treatment is being researched/tested internationally. However, the implications for routine RT remain uncertain and are likely at least five to seven year away.
 - CCP needs to monitor strategically such evolving research applications to inform the GNL about pending developments and retain options to receive new technology while limiting related construction costs.
- **Expanding combined treatment protocols**, including surgery, RT and/or systemic therapy are expected to increase.
 - Such growth will continue to increase the need for comprehensive coordination of treatment pathways and multidisciplinary team members at different locations.
 - Effective means (e.g., electronic health record) and coordinated processes (e.g., teleoncology, patient navigator) to share diagnostic and treatment information become critical to the success of such protocols.
- **Increasing Treatment Options:** The above trends are expected to provide an overall increase in the number of treatment protocol available for some of the many cancers for which historical there have been few clinically tested options available.

Prevention

Cancer prevention initiatives by CCP and other stakeholders remain the best way going forward to 2026 to reduce the overall cancer workload in NL. Researchers have indicated that with comprehensive cancer screening, disease prevention and promotion of health life could reduce cancer incidence by 30 to 50%. NL stakeholders have made substantial progress in developing and implementing various programs, but there is significantly more to do and such measures are unlikely to materially impact cancer rates for over a decade.

RT Utilization Standards

- The distribution of the RT treatments currently provided in NL reasonably correlate with population and cancer diagnoses distribution as shown in Section 3.7, Figure 3.19. However, the NL RT utilization rate or 'RUR' (i.e., proportion of new cancer patients who receive at least one course of RT during their lifetime or a prescribed number of years e.g., CPAC used within 2 years after diagnosis) appears to be lower in comparison when compared with best practice recommendations.
- In 2005 in Australia, Delaney et al proposed 52.3% RT utilization rate (RUR) as best practice. This rate was updated in Australia in 2012 to 48.3%. The Malthus model developed in England in 2013 proposed an RUR of 40.6%.
- Actual experience has shown that many countries fall significantly short of the 'best practice' rate. In Australia in 2012, the actual RUR was 38.1%. In Canada, CPAC reported a

range of RURs by province in 2010 between 29.1% and 35.9% based on receipt of RT within two years of diagnosis.

- The actual RT utilization rates in reporting countries, including Canada, have been consistently lower than the proposed best practice rates. Improving the RUR through improving patient access has been a key objective underlying international efforts to bring RT closer to patients' place of residence.
- For NL, CPAC reported that 30.9% of persons diagnosed with cancer in 2010 received radiation therapy within two years of diagnosis. (CPAC, 2014)
- **Target NL RUR:** For purposes of RT planning in NL, a target RT utilization rate of 44% was determined to be reasonable for planning purposes. Addition of a distributed centre at CCW is expected to improve access and contribute to an increased utilization rate.
- If cancer patients relapse with the same cancer type, they are often successfully retreated with a course or prescription for RT. This retreat rate is defined as the proportion of new cancer patients who receive retreatment following a first course of RT treatment for a single (same) diagnosis.
- A range of 20-26% for the 'retreat rate' has been published (actual and best practices; see figure 2.1) with the heaviest concentration around 25%.
- Reliable, comprehensive data regarding retreated patients for NL RT was not available.
- **Target NL Retreat Rate:** Following consultation with experts and CCP representatives, a 25% retreat rate is proposed as the NL target for future utilization planning.

If, in 2010, the RUR in NL had been at the target of 44% that is being used in this Service Plan rather than the actual 30.9% RUR, it is estimated that 414 additional cancer patients would have received RT in that year.

CONSIDERATIONS & RECOMMENDATIONS

NL's population distribution pattern is unlikely to change materially to 2026, resulting in a continuing challenge in balancing RT access and cost effective, high quality services outside EH;

NL's cancer incidence patterns are likely to continue until at least 2026 due to prevalent life style factors and the long lead time for cancer prevention measures to have an impact. Prevention programs already underway and planned to expand in NL are unlikely to materially affect cancer incidence rates before 2026;

Staff recruitment and retention of professional RT staff has been a challenge for CCP historically and currently. These challenges are expected to continue in the future with worldwide shortages of these personnel (e.g., Medical Physicists are going from masters to doctorate requirements);

While similar to the actual Radiation Utilization Ratio (RUR) in Canada, NL's RUR is significantly lower than internationally accepted best practice rates. In 2010, NL's RUR at 30.9% resulted in 414 fewer patients being treated than would have been treated if this Study's target RUR of 44% had been met.

Recommendation: Efforts to expand and developed comprehensive cancer screening and health lifestyle programs should be strongly supported;

Recommendation: GNL should amend legislative regulations to make reporting of pathology report confirming a cancer diagnosis mandatory in NL within a defined time period to ensure comprehensive and timely reporting;

Recommendation: The Ministry, CCP and NLCHI should, in collaboration with the CPAC, develop a comprehensive cancer incidence projection methodology for NL that can be routinely updated for cancer planning purposes every 3-5 years; and,

Recommendation: GNL and CCP adopt the following RT utilization standards as best practice improvement targets to 2026 and for planning purposes: RT Utilization Rate of 44%; and RT Retreat Rate of 25%.

4.3 Service Population & Workloads

The following parameters are proposed under the NL RT Service Plan to quantify other aspects affecting the RT workload determination to 2026.

General Planning Assumptions

- Only one new RT distributed site will be developed in NL between 2014 and 2026.
- Triage and initial bookings for RT referrals and bookings will be centralized and coordinated from the BMCC site. Some local triage should be considered in association with patient navigation and scheduling after the first year of operation of a new distributed RT site.
- For RT services available regionally, patients will be encouraged to travel to the nearest facility (i.e., BMCC or CCW).

- Social support factors (e.g., having family or friends living there, etc.) will be assessed with the patient as part of the referral decision.
- All NL patients will continue to travel to the BMCC for those RT tertiary level services which are provided in NL.
- All patients needing highly specialized RT tertiary services not available in NL will be assessed initially at the BMCC prior to referral out of province.

Service Populations

Service areas and populations for provision of RT in NL were developed. These were informed by literature review findings about effect of travel distance on RT referral patterns, NL's travel distances and means of travel, and input from senior representatives of all RHAs on expected travel behaviours of their regional residents.

Planning principles and assumptions used to determine RT service areas were:

- Of new cancer cases requiring RT, 20% are estimated to require specialized services and complex care provided only in the tertiary centre. Therefore, 20% of new cancer cases residing in the CCW catchment area identified as requiring RT will receive treatment at the Dr. H. Bliss Murphy Cancer Centre (BMCC) in St. John's.
- When the CCW is fully operational, most residents of Western Health will access RT at CCW except for those requiring specialized services and complex care only available at the tertiary centre.
- From Labrador Grenfell Health, approximately 60% of residents of Labrador South and the Northern Peninsula will access RT services at CCW. Labrador residents will be more likely to attend CCW during the months that the ferry is in operation. This equates to approximately 20% of the total population of Labrador Grenfell Health.
- From Central Health, approximately 60% of residents of the Green Bay, Exploits, Lewis Port, Baie Verte and Grand Falls Windsor areas of Central Health will access RT services at CCW. This equates to approximately 30% of the population of Central Health.

More detailed information regarding travel distances and referral assumptions is provided in Appendix E3.

With the decision that RT will be provided at CCW in the future, the future service areas and related service populations (i.e., percentages of the RHAs' total cancer patients referred for RT treatments) for RT services at BMCC are summarized in Figure 4.8 and were defined as follows:

- 100% of RT patients residing within Eastern Health
- 20% of RT patients residing within Western Health, particularly those cases that require specialized services or complex care
- 70% of RT patients residing within Central Health, particularly those living in the central and eastern parts of the region
- 80% of RT patients residing in Labrador Grenfell Health, particularly those living in the central, western and northern parts of Labrador.

Figure 4.8: Percentage of Health Regions' Referral Populations by RT Site

Region	To BMCC		To CCW	
	% RT Referrals	RT Service Type	% RT Referrals	RT Service Type
Eastern	100%	regional & tertiary	0%	-
Central	70%	regional & tertiary	30%	Regional
Western	20%	tertiary	80%	Regional
Labrador & Grenfell	80%	regional & tertiary	20%	Regional

A complementary service area for the CCW with RT and the related service populations as summarized in Figure 4.9 were determined to be:

- 80% of Western Health's RT patients from all areas;
- 30% of Central Health's RT patients, particularly those living in CH's western area nearer the border with WH; and,
- 20% of Labrador Grenfell Health's RT patients, particularly those living in the Newfoundland's north peninsula area (by driving to Corner Brook) and the Labrador South area (primarily during late spring to late fall by taking the ferry to Newfoundland and then driving to Corner Brook).

Productivity Metrics

The following productivity metrics are proposed for the NL Service Plan to estimate the number of cancer cases that can be treated within specified time periods by core RT equipment (i.e., patient throughput). Similar to other aspects, the productivity metrics are a combination of best practices (section 2.0) and NL CCP current operations (e.g., contract terms per holiday and working hours/ day per section 3.0). These include the following assumptions and key metrics:

- **Machine preventative maintenance** will be booked in advance during or before regular working hours, over lunch breaks or on evening and weekends to prevent disruptions to regular patient booking time during regular working hours.
- **Routine machine quality assurance** processes will be completed before or after the usual treatment schedule by phasing staff start and finish hours.
- **Worked Days per year** will be 240 days (i.e., calculation = 52 weeks X 5 days per week = 260 minus 11 statutory holidays & unavailable days due to severe weather disruptions, equipment repairs etc.)
- **Worked hours per day** will be 8 hours (0830 to 1630); patients will be booked for 7 of the 8 worked hours per day.
- **Bookable hours per year** for RT fractions will be 1680 (240 days per year X 7 hours per day).
- **Courses per Linac/year** will be 400 courses.
- **Fractions per course** (complexity factor) will be 16 fractions on average.
- **Utilization factor** will be 95% to provide for unexpected machine downtime and potential variations in patient demand.
- **Linac throughput** will be 4 fractions per hour on average; 6400 per year (240 days X 7 hours per day X 4 fractions per hour X 0.95)

Provincial RT Workload Projections

The preceding parameters and productivity metrics were applied to the projected NL cancer incidence to 2026 to determine the number of linacs needed at the CCW and BMCC by 2026. These estimates are presented in Figure 4.9.

Figure 4.9: NL Actual & Projected Linac Accelerators to 2026

	Bliss Murphy Cancer Centre		Cancer Centre West		Total NL
	Capacity	Actual 2013	Projected 2026	Projected 2026	Projected 2026
Linear Accelerators	4	4	4.61	1.15	5.76
Courses ¹	1600	1534	1843	461	2304
Fractions ²	25600	25300	29488	7376	36864

Notes:

1. Course capacity calculated at 400 courses per linac.
2. Fraction capacity calculated at 16 fractions per course.

CONSIDERATIONS & RECOMMENDATIONS

- Linac productivity for NL is based on multiple elements as listed above.

Recommendation: EBRT-Linac through-put for planning purposes should be based on 400 courses per machine per year with a regular work day if relatively new linac technology is being used.

- The projected workload for the new CCW (the first distributed RT site determined by the GNL) with workload projections targeting the higher best practices referral and utilization rates of 44% for all new invasive cancer cases and a 25% retreat rate to 2026, does not support the need for more than one linac until close to 2026. However, with only one linac, care continuity becomes a major consideration regarding Linac repairs and performance. Mitigation through careful case selection, advance planning for patient management in event of machine breakdown and maintenance/repair provisions are required.

Recommendation: GNL should construct two RT vaults for the CCW and equip one on opening with a high performance dual energy linac with modern imaging and treatment capacities and software. This Linac and related treatment planning system must technical ly match with at least one linac and the treatment planning system at the BMCC.

Recommendation: Experienced, well trained staff must be located on site at CCW to expedite repairs of the Linac and CT Sim and to conduct regular preventative maintenance as proposed in the staffing model for as distributed site. These staff may not be fully deployed with the RT service so that cross- training with WH staff should be explored to be mutually beneficial to CCP and WH.

Recommendation: The RFP process for the acquisition of the CCW linac and CT Sim should enable purchase of extra parts and a comprehensive service contract to expedite repairs. Also close collaboration and back-up from the BMCC must be part of the care continuity planning.

Recommendation: Substantial advance planning is essential to achieve the above recommendations and risk reduction contingency plans. In addition, development of focused health professional information materials/ sessions and communications are required to change referral patterns and to encourage patients to use CCW from CH and LGH. This involved detailed planning for support services (e.g., hostel, high quality care, timely bookings, transportation etc.) is required to achieve the projected workloads and effectively use the specialized equipment and staff to be based in future at CCW.

Recommendation: Care continuity special contingency plans and funding must be accessible with automatic, timely, effective processes and terms approved in advance between the Ministry and EH/CCP to enable rapid transfer of RT patients to other sites for care as applicable if there are care continuity risks at the CCW. The specific terms applicable to equipment failure, staffing inadequacies and other factors need to be clearly documented in advance of opening.

- CT Sim equipment is essential for effective treatment planning for RT. The CT Sim at the CCW will not be fully utilized for the RT work.

Recommendation: Advance planning should focus on collaboration with WMRH Diagnostic Imaging to secure a CT Sim that will first address the RT service need and second serve as back-up to the WMTH diagnostic Imaging workload as applicable. This will require the purchase of some additional accessories.

4.4 Governance & Service Model

The following key principles and planning assumptions on RT governance and service configuration form the foundation for the NL RT Service Plan to 2026.

General:

- Safety and high quality services are overarching drivers of the RT care model. RT facilities and equipment will adhere to all applicable provincial and national radiation safety legislation and regulations including the Canadian Nuclear Safety Commission (CNSC) and GNL regulations.
- A province wide cancer care service model, under the governance responsibility of Eastern Health (EH) will include all RT services.
- The BMCC will continue to function as the tertiary centre for RT (and other cancer) services province-wide. It will also provide regional cancer centre RT services to others within its service population.
- The new CCW RT service, approved by the GNL in May 2014, will serve as the first RT regional service in NL, clinically and administratively responsible to the BMCC.
- The Cancer Care Program (CCP), under the auspices of EH, will have the ongoing leadership role and responsibility in providing all NL RT services in association with other cancer services and networks. This leadership role will include:
 - Development and implementation of cancer care guidelines and standards for delivery of high quality RT and other cancer service to all NL residents
 - Monitoring and quality assurance reviews to ensure compliance with standard RT treatment guidelines approved through applicable CCP Tumour Groups and clinical practice processes for NL
 - Development of and compliance with CCP's safety/quality assurance protocols and equipment standards
 - Convenient access to teleoncology services to support distance consultations with subspecialists and special education services for patients and staff at other locations
 - Determination of when cancer patients should be referred out of province for specialized RT services that are not provided in NL and ongoing follow-up as applicable
- Current and future RT treatment services will be functionally integrated with other cancer services on the site (e.g., outpatient clinics, systemic therapy and supportive care) for coordination of services to patients and optimal use of space and staff.
- Current and future RT treatment services will be located within host acute care hospitals. CCP staff will work in partnership with host hospital administration to develop service agreements covering service access and funding responsibilities for local support services (e.g., infection prevention & control, pharmacy, diagnostic imaging, laboratory, rehabilitation, maintenance, laundry, housekeeping, special education & training facilities, data centre, IT, security, etc.).

Radiation Therapy Services

- The Dr. H. Bliss Murphy Cancer Centre in St. John's will continue to provide NL's tertiary and specialized referral RT treatment services including:
 - All non-external beam RT, including brachytherapy;
 - Infrequent, specialized EBRT procedures (e.g., stereotactic radiosurgery and stereotactic body radiation therapy) that need highly specialized expertise, equipment and supplementary clinical and supportive care; and,
 - children needing RT treatments
- The new Cancer Care Western (CCW) located in Corner Brook will be the first distributed RT service within the NL CCP, and will include:

- Two linac vaults built on the opening of the new CCW with one vault fully equipped with a dual energy linear accelerator (linac)
 - CT Simulation unit for treatment planning within the CCW, which can be a back-up for the WMRH if needed
- Linac(s) at distributed RT sites will be matched with linac(s) at the BMCC to expedite contingency plans if there are temporary service continuity issues.
- Triage of all RT referrals will be managed centrally at BMCC, at least when the distributed RT site is initially established. With more experience, some local triage should be considered in association with patient navigation functions and bookings within the CCW.
- New NL distributed RT sites will gradually evolve over three to five years post opening from being heavily reliant on the tertiary cancer centre in St John's to becoming substantially more self-reliant with more local expertise. For planning purposes, these two phases of the care model development will be referred to as the 'initial' and the 'established' care models. It is recognized that there will be several intermediate care model stages (i.e., hybrid care models) as the transition proceeds over several years.
- Safety and high quality services are core drivers that will guide the care model transition from 'initial' to 'established'. Ensuring that high quality RT services can be provided locally without compromising the safety of patients or staff will determine when new RT protocols are introduced locally.
- Under the 'established' model', about 80% of the local cases requiring RT will be managed at a distributed RT site. A lower percentage may be managed locally during the 'initial' stage and may be influenced by the special expertise of staff recruited for the distributed RT service.
- Under the 'established' model, highly complex or low volume cancer cases requiring specialized consultation services and/or equipment will continue to be managed at the tertiary centre. This is expected to involve about 20% of RT patients resident in distributed site's catchment area after about three to five years.
- The following guidelines apply to care delivered at a distributed RT site:
 - The RT care model will focus predominantly on standardized RT treatments for patients within the following major Tumour Groups:
 - breast
 - gastrointestinal (GI)
 - genitourinary (GU) (e.g., prostate)
 - lung
 - palliative care RT for most local cancer patients and tumour groups
 - RT services for other Tumour Groups may be phased in after a few years of safe operations, depending on the local specialist expertise and following detailed consultation/evaluation with provincial cancer care service leaders.
 - RT services generally should exclude RT involving: stereotactic, brachytherapy, total body irradiation, pediatric, head/neck, sarcoma, central nervous system and most cervical cancers.
- The onsite staffing model for distributed RT sites will be based on generally accepted ratios of specially trained RT staff related to the patient workload. This staffing model will include the following RT core staff being onsite:
 - Medical and Radiation Oncologists
 - Medical Physics (with radiation safety) & Medical Physics Assistant staff
 - Radiation Therapists/ Dosimetrists
 - RT Bio-Medical Equipment Specialist
 - RT Nurses
 - Supportive care staff

- Dual energy linear accelerator(s) or linac(s) with intensity modulated radiation therapy (IMRT) and image guided radiation therapy (IGRT) capability will be standard for RT equipment throughout to CCP. Such equipment and software will be compatible between the tertiary site and distributed sites to promote clinical integration and collaboration province-wide.
- Equipment and staffing models will enable simulation and treatment planning to occur locally for most RT services. Selected, specialized treatment plans may be planned at the tertiary centre for quality control purposes. Following consultations for complex patients at the BMCC, treatment planning may then occur at the distributed site to share workload provincially.
- Integrated IM/IT RT Data Plan: Comprehensive, verified integration of RT related diagnostic, treatment planning and treatment record data for each patient between the distributed site(s) and the tertiary centre (BMCC) is essential to enable effective referral of patients and treatment planning information between sites. This IM/IT plan needs to interface with the local host hospital IM/IT systems for receipt of diagnostic imaging and other such information and for inclusion of other non RT cancer treatment data.
- IT infrastructure will enable distributed site(s) RT treatment planning data to be accessed by and stored with the BMCC's data in St. John's. This approach will ensure fail safe mechanisms to protect these data in the event of system failures.
- RT Inpatient Needs: Approximately 7% of the cancer patients undergoing a course of RT at the distributed site(s) may require inpatient care in the host hospital. The associated average length of inpatient stay is expected to be about 13-14 days.
- Contingency Plans for Care Continuity: Depending on the individualized treatment protocol, a cancer patient may need one to 35 plus separate RT treatment visits (fractions) within a deliberate time sequence to comply with established best practice protocols. These protocols sometimes involve other therapies. Contingency plans to manage care continuity issues with a single linac site, pending sufficient workload to support a second linac, is an essential advance priority for operations planning for RT distributed sites. These care continuity contingency plans should address planned/unplanned staff absences, holiday coverage, unplanned machine down time, processes with the tertiary site, communications procedures with patients, and other stake holders (out-of-province cancer centres), transportation, and major equipment vendors.

Criteria for Adding a 2nd Linac to CCW

The decision making process for determining the need for the second linac at the CCW must be clear, timely and agreed to in advance by key decision makers. The decision should be based on weighing/balancing several factors using actual operations data. While others may be added by the approved decision makers, the following key criteria are recommended. These recommendations have been developed as a result of consultation with other Canadian sites.

1. Key Factors/Criteria:

- **Technology Reliability**: Technology stability issues are more common during the first year of operation for some linacs. Hence, phasing additional tumour sites is recommended so that there is extra capacity in the first year to reschedule patients.
Criteria: If a unit experiences more than three instances of a full day or more of unscheduled downtime in a 12 month period with routine maintenance being undertaken as specified, then reliability of that unit is a risk.
- **Workload**: In larger cancer centres, it is feasible on the short term until other measures can be introduced to operate with extended working hours to accommodate RT workload up to about 500 courses/year per linac (i.e., 125% of a linac's capacity based a regular working

hours). Following deliberation, the consulting team feels this is risky in a small RT centre like the CCW because of resulting sustainability pressures that might jeopardize a stable staffing model and extended time for remedial actions.

Criteria: Exceeding 90% of the CCW's linac booking capacity for three months due to usual referrals (and not machine failures at the BMCC, CCW, etc.) warrants assessing the need for the second CCW linac, especially since the procurement, installation and commissioning will likely take a minimum of 8-12 months. It also becomes difficult to accommodate this workload at another site if there is an unplanned machine failure.

- **Replacement timing:** The reliability of linacs tends to follow an 'S' curve of maintenance needs over time. During the first year, there may be stability issues as the RT staff become familiar with each machine's unique 'aspects'. A high level of reliability with routine maintenance generally follows for the next 5-7 years. A decline in reliability and increase in maintenance needs follow during the latter part of the linac's life cycle with a high drop off in reliability when key components start to fail. This pattern varies somewhat according to the vendor and model. Hence, detailed maintenance records and reassessment of linac maintenance and workload patterns are essential. The longevity of a Linac operating 20 hours per week is likely to differ from one operating 50 hours/week.

Criteria: If the preceding criteria have not been triggered before, then by about 6-7 years post operation of the first linac, planning for installation of the second linac to eventually replace the first linac should be initiated.

2. Linac Tender with Options: It is recommended that tendering for the CCW linac should be completed well in advance of opening (i.e., at least three years). Pricing options should allow for basic purchase with discounts for another 1-2 linacs (depending on the CCP's linac replacement plan) within a specified time period (including technological upgrades over this period) as incentive for better pricing. Provisions for unique servicing options and for stocking more parts at CCW that are subject to failure, etc. should be included.

4.5 Staffing Model

Quality and clinical safety is of paramount importance in the delivery of radiation therapy services. Qualified, experienced, specialized personnel are essential to achieve and maintain safe, high quality RT services. Clear professional leadership, including a lead radiation therapist to manage the service, a lead medical physics expert and a lead radiation oncologist, are essential.

Radiation therapy staff complements will be based on generally accepted ratios of specially trained RT staff related to the patient workload. The staffing model includes the following core RT staff being onsite:

- Medical and Radiation Oncologists
- Medical Physics (with radiation safety) & Medical Physics Assistant staff
- Radiation Therapists/ Dosimetrists
- RT Bio-Medical Equipment Specialists
- RT Nurses

Other professional personnel on the cancer care team include:

- Social workers
- Pharmacists
- Dieticians
- Physical therapists
- Information management/information technologists

A summary of the key staff positions, roles, staffing metrics and ratios are summarized in Figure 2.4.

Staffing ratios used for projection of RT staffing requirements are as follows:

- One Radiation Oncologist per approximately 220 new patients per year
- One Medical Physicist per approximately 220 new patients per year
- One Radiation Therapist per approximately 55 treatment courses per year

Recruitment and retention of health care professionals across jurisdictions has the potential to significantly affect access to care. The Canadian Partnership Against Cancer Joint Committee on the Cancer Workforce has identified that sustainability of the cancer workforce will continue to be a major concern for cancer facilities. With the number of cancer patients requiring treatment increasing in the province and with the introduction of distributed RT services outside of St. John's, workforce stability and recruitment challenges are anticipated. Therefore, supply, recruitment, and retention of staff require focus and attention. To ensure a stable and sustainable workforce across the tertiary and distributed sites, a staffing complement that is consistent with the projected workload, provides professional development and satisfaction, and has opportunity for enhanced, expanded, advanced, and innovative practice is critical.

In view of the worldwide shortage of specialized RT personnel, creative strategies for human resources acquisition and management are essential. A detailed recruitment and retention plan is needed, including working with educational programs, encouraging internal candidates, advertising at professional conferences, working jointly with the WH to address staffing needs for the new CCW as well as for the ongoing operation of the BMCC.

Providing competitive salaries & benefits which recognize the cost of living in NL is a key factor for successful recruitment and retention of highly specialized staff.

Selected schools providing professional education to RT personnel are listed in Appendix H.

4.6 Capital Implications

The NL RT Service Plan to 2026 includes considerations for new or renovated facilities, capital equipment and special infrastructure. These are outlined in Figure 4.11.

Figure 4.11: Main RT Capital Considerations to 2026

Focus	Facilities	Major Equipment	Infrastructure
CCW	New construction, to include 2 RT vaults (bunkers) and other cancer services; part of new WMRH	<ul style="list-style-type: none"> • 1 Linac on opening • 1 CT Sim • Provision for 2nd Linac if care continuity or workload demands 	<ul style="list-style-type: none"> • Ongoing MediTech system integration completed by 2019 • High speed data communication link with BMCC for shared workload and data backup/storage • EH Data Centre has capacity, but extra servers needed
BMCC	New or decanting of other services and renovations likely needed for 2026 for: <ul style="list-style-type: none"> • 1 vault (bunker) for increased workload • 1 swing vault (bunker) for Linac replacement 	<ul style="list-style-type: none"> • Continue with RT equipment replacement plan • Add 1 additional Linac by 2026 or sooner depending on workload growth 	

Focus	Facilities	Major Equipment	Infrastructure
	<ul style="list-style-type: none"> Additional Medical Physics, electronics and other support space Other expanded cancer services (e.g., systemic therapy, support services) Recommend completion of Master Plan for Cancer services on the BMCC site by 2016		
Other	Restrict other RT distributed site expansion until CCW RT service has been operational for at least 3 years and an evaluation completed.		

4.7 NL RT Gap Assessment to 2026

Following from the RT best practices review (section 2.0), CCP's current status (section 3.0), and NL projected RT workloads, important gaps in RT services to 2026 are summarized in Figure 4.12.

Figure 4.12: RT Service Plan - Gap Summary

Factor	Challenge-Weakness	Opportunity - Strength	Outcome- Direction
CCW RT Technology	Essential that CCW linac and treatment planning systems directly align (i.e., 'matched' linacs) technically with at least one similar linac and the treatment planning system at BMCC.	Strategic, well executed, technology upgrade plan gives a solid basis from which to integrate to CCW	GNL needs to commit to a long term regular replacement plan. EH procurement processes needed to enable RT technology consistency as key to risk reduction for patient safety and service continuity.
Referral Patterns	Historic RT referral patterns from WH, LGH, CH are to BMCC. Referral patterns must change to ensure a critical mass of RT patients at CCW.	Health regions and CCS-NL are supportive of enabling patients to have RT closer to home and willing to help.	CCP needs to develop and lead a detailed communications strategy in close collaboration with affected regions and CCS-NL to inform health providers and communities regarding future availability of RT at CCW.
Geography & Distances	Even with one new distributed site, travel distances for RT patients outside EH will exceed the recommended 100 Km travel distance recognized in many jurisdictions.	GNL has approved a new 48 bed hostel for the WMRH campus, accessible to RT patients. CCS-NL has recent experience in developing a hostel facility & has a support program in WH.	CCP should lead planning for a collaborative effort with CCS, WH & other stakeholders to ensure the hostel and related services (food, driving, etc.) are adequate to meet the needs of cancer patients traveling long distances.
Integration of NL Health Information	The MediTech system used by NL health regions for recording diagnostic & other patient care information is not integrated province wide. Only EH & LGH are currently integrated.	CCP has developed a fully electronic health Record (EHR) for cancer patients managed within BMCC. EH has high quality Data Centre space to store all CCW records.	Integration of all health regions MediTech systems is needed to effectively access EHR information for cancer patients from other regions. This is essential between EH and WH to ensure effective support for the new CCW RT service before 2019.

Factor	Challenge-Weakness	Opportunity - Strength	Outcome- Direction
CCP Management & Clinical Leadership	CCP management and clinical leaders have no direct experience with opening a new RT distributed site or spare capacity to apply the continuity & dedicated time needed to plan and implement the new CCW and to modify related CCP processes & procedures.	CCP has highly committed, experienced management and clinical leaders.	CCP needs to second and back fill or hire an experienced person with strong clinical and project management expertise as a dedicated position reporting to senior CPP leader(s) to provide ongoing project leadership and coordination, including seeking and confirming input from Users to the CCW design and equipment & furnishings planning; developing detailed plans for communications, recruitment, etc.; and functioning as CCP's senior lead for the project.
Communications	With a province-wide program like cancer, clear regular communications with key stakeholders and CCP staff on service plan changes is challenging and time consuming. The RT program must be integrated with other cancer services, many involving host health facility in all four regions.	Some mechanisms for such communications exist Strong teleoncology program to enable consultation with others	Clarification of roles is the foundation for clear communications. CCP needs to address this first with the CCW site and then build its communication plan around key messages for different 'audiences'; support by the regions and other stakeholders is needed.
Medical Physics (MP)	Existing GNL compensation policies, including temporary market adjustment factor, have seriously compromised CCP's ability to recruit and retain senior MP staff. This issue is compounded because: <ul style="list-style-type: none"> • RT cannot be safely provided without qualified MP on site • Experienced, qualified MP staff are in short supply worldwide • Certification & education processes are changing with potential candidates now requiring 11-13 years post high school to be qualified as a MP • BMCC does not have spare MP capacity needed now to support detailed work with CNSC required for CCW planning and design. 	Some options exist; require advanced planning and additional funding.	A detailed comprehensive plan is needed to address the current urgent situation at BMCC. An extra MP position is required to support the CCW project and planning around education needs and long term recruitment including for the CCW.
CCW Staff Recruitment	Recruiting a new multidisciplinary team for a new service, distant from the main cancer centre needs a comprehensive advanced plan, including consideration of local training options, career advancement, ongoing education, etc.	With the exception of MP, BMCC staffing seems to be fairly stable. There is advance time (i.e., 4 year before the opening of the CCW).	CPP must develop a detailed recruitment and retention plan, including working with educational programs, encouraging internal candidates, advertising at professional conferences, working jointly with the WH, etc. to address staffing needs for the new CCW.
Projected Workload & BMCC Facilities	BMCC facilities are fully used: many areas are over committed beyond the planned occupancies. There is no space	The new CCW RT service if opened 2019 with reconfiguration of RT referrals will provide some	Service planning for other cancer services should be merged with the RT service plan to inform the development of a master plan for the

Factor	Challenge-Weakness	Opportunity - Strength	Outcome- Direction
	for extra vaults and repurposed support space without decanting others.	interim capacity relief to BMCC.	BMCC and other facilities as applicable on the Health Science Campus within the next two years.

4.8 Critical Success Factors

The actions considered essential in achieving successful outcomes for the NL RT Service Plan are presented. Since the BMCC program is well established, these focus mainly on the new distributed CCW RT service. Several of the critical success factors interface with others.

Figure 4.13: Critical Success Factors

Factor	Description	Responsible
Viable Medical Physics (MP) staffing, compensation and training plan.	<ul style="list-style-type: none"> A nationally competitive MP compensation plan needs to be resolved as soon as possible, based on a recategorization and/or moving MP to excluded staff (similar to other provinces). Joint agreement by CCP and the Ministry on a staff model such as proposed in the study Development of interim and longer term "local" training options with special funding per Section 4.5. 	<ul style="list-style-type: none"> GNL, Ministry, CCP/EH and Medical Physics group to find a workable staff categorization solution and funding. CCP/EH to develop MP training options with other stakeholders
Development and implementation of a comprehensive CCW staffing plan with a focus on core staffing, recruitment and training.	<p>Core staff for opening CCW as outlined in Section 4.5 must be recruited and trained including:</p> <ul style="list-style-type: none"> Resolution of Medical Physics compensation inequities on a permanent basis Implementing ongoing "local" training options for certified Medical Physics (MP) Early hire of senior MP (early 2015) to enable development of CCW vault designs for CNSC submissions Early hire of project manager with RT and planning experience 	<ul style="list-style-type: none"> Ministry to provide start-up funding to enable advance hires and staffing plan CCP/EH to initiate two early hires ASAP to advance other planning for CCW.
Care Continuity/Risk Reduction Contingency Plans	<p>The Project Manager will work with CCP leaders and stakeholders to prepare detailed operating policies and procedures to minimize disruptions in care for patients from multiple factors, including:</p> <ul style="list-style-type: none"> Planned and unplanned machine downtime Staff unavailability Weather disruptions <p>Contingency plans will include:</p> <ul style="list-style-type: none"> Service backup plans from BMCC 	<ul style="list-style-type: none"> Ministry to provide start-up funding and support to enable advance planning and agreements with other parties to proceed as a priority Ministry to ensure emergency care continuity funding is readily accessible if needed. CCP/EH authorizes and supports planning work as high priority, including

Factor	Description	Responsible
	<ul style="list-style-type: none"> • Cross-training of staff within CCW and with WMRH • Out-of-province RT back-up service; • Emergency transportation plans • Special vendor service contracts 	<p>changes to existing BMCC policies and procedures</p>
<p>Infrastructure— MediTech Integration</p>	<p>Continuation of MediTech system integration among Health Regions to enable electronic transfer of large data files between CCW and BMCC for service and backup, and for effective transfer of diagnostic data for the Electronic Health Record for patients for LGH and CH treated at CCW.</p> <p>WH and EH/LGH integration is the highest priority followed by CH.</p>	<ul style="list-style-type: none"> • Ministry to provide special funding for cancer system integration (estimated at about \$250,000 per health region) exclusive of other associated costs related to implementation of the MediTech system. • CCP/EH incorporate detailed IT/data management plan to integrate BMCC with CCW for effective functioning of CCP's Electronic Health Records
<p>Responsive, Effective Management Structure for CCW Project</p>	<p>Dedicated CCP Project Manager with RT expertise to be appointed ASAP to assume leadership responsibility for the CCW project from design, through construction, to operations planning. This position will report to CCP Administrative and Clinical leaders.</p> <p>This Project Manager should represent CCP/EH on WMRH Project Steering Committee, all planning meetings, coordinate all CCP user input and responses, take a leadership role in preparing all detailed CCW plans for opening with consultation with other stakeholders.</p> <p>Ministry will designate a senior staff member to have overview responsibility for cancer services, including CCW project, to expedite resolution of issues affecting related plans for opening with other regions.</p> <p>Project Manager will provide regular updates to Cancer Control Advisory Committee on progress with CCW plans for opening.</p>	<ul style="list-style-type: none"> • Ministry to provide funding for early hiring • CCP/EH to recruit and support incumbent in filling this key role

4.9 Phasing & Implementation

Phasing and implementation of NL's RT Service Plan cannot be separated from development in other core elements of CCP's services. With the assumption that other cancer services will also be assessed and modified as needed (e.g., systemic therapy), implementation of the RT Service Plan is divided into two parts: the CCW and the BMCC/other. The CCW's implementation will be largely driven by the overall WMRH Project. The WMRH Project Schedule was evolving during the Study; therefore estimated timing is shown in Figure 4.14 and should be modified as the WMRH Project Schedule changes.

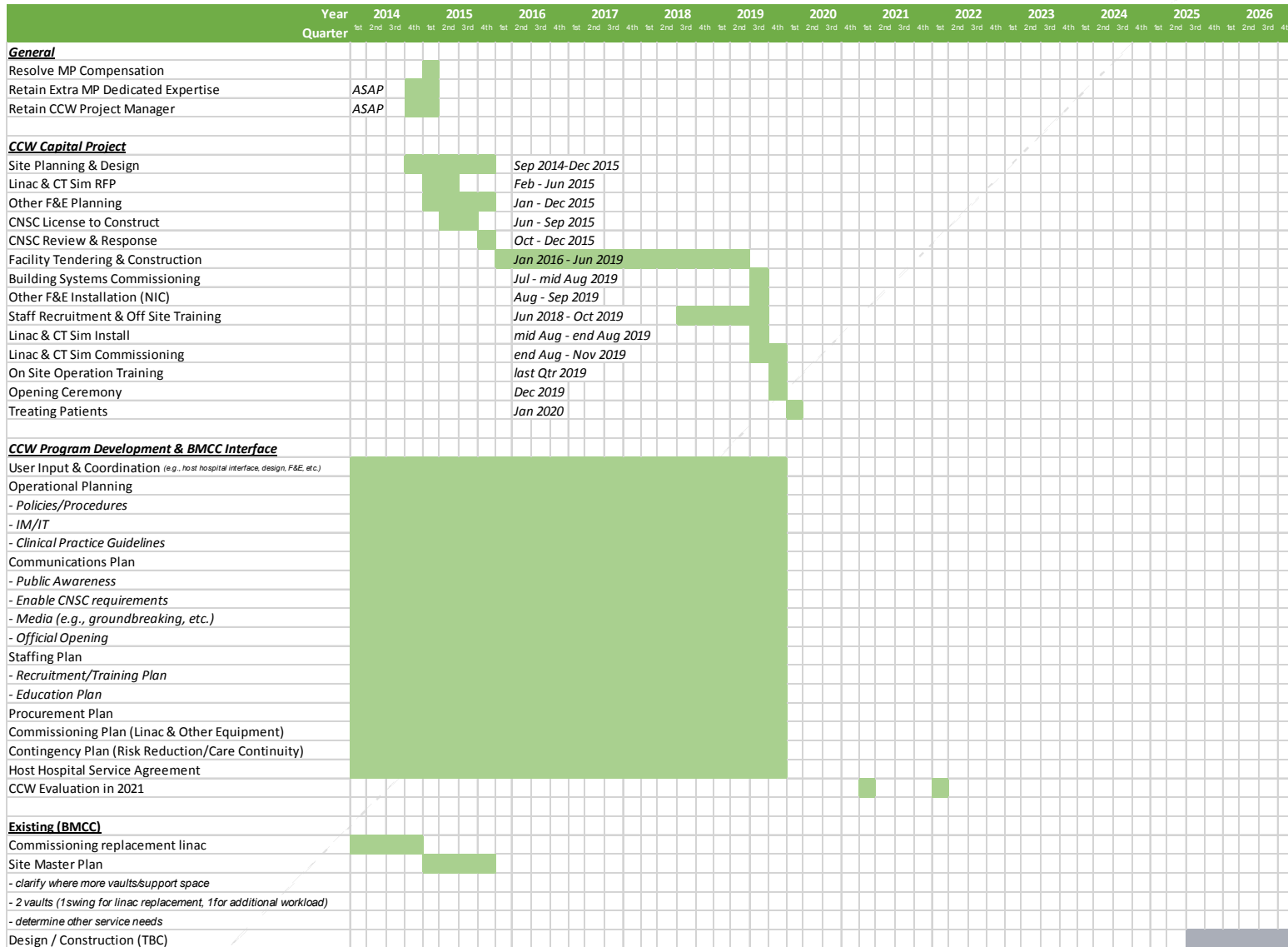
CONSIDERATIONS & RECOMMENDATIONS

- 'CCW Program Development & BMCC Interface' planning as shown on schedule will be ongoing over the duration of the CCW Capital Project and will inform the CCW Capital Project work.

Recommendation: Resolution of the MP compensation matter needs to be a priority focus to stabilize the BMCC and enable work for the CCW to proceed.

Recommendation: An evaluation of the CCW project is recommended to occur at least one and preferably two years post opening. This evaluation should focus on lessons learned, facility functionality and patient/staff satisfaction.

Figure 4.14: NL RT Service Plan Phasing & Implementation Schedule



APPENDICES

Appendix A: Abbreviations & Definitions

~ (Approximately)

AC (Ambulatory Care Services): health care services provided by medical and/or other health care professionals to ambulant patients; while this term usually applies to outpatient services, it often includes services provided jointly to ambulant inpatients and outpatients

Adjuvant: Treatment given after the primary therapy to control the cancer more effectively, to destroy any remaining cancer cells or to reduce the risk of the cancer recurring

ALOS (Average Length of Stay)

ASIR (Age standardized incidence rate)

Access: physical relationship among areas, which are categorized as follows:

- **Adjacent** –components that must be physically adjacent or connected by internal circulation (i.e., non-public)
- **Near** –physical access between components is via the minimal use of horizontal and/or vertical circulation
- **Convenient** –physical access between components is via the use of horizontal and/or vertical general circulation such as public corridors or elevators connecting spaces

BCCA (British Columbia Cancer Agency)

BGSM (Building Gross Square Metres or Building Gross Area): the sum of all building floor areas measured to the outside face of exterior walls for all stories or areas having floor surfaces; building gross area includes component gross areas, general circulation, mechanical and electrical space and exterior walls.

BMCC (Dr. H. Bliss Murphy Cancer Centre)

Bunker = Vault

Ca (Cancer)

CCW (Cancer Centre Western)

CGSM (Component Gross Square Metres): the portion of a building assigned to a specific component (department), including net areas, internal circulation, partitions and small mechanical shafts; CGSM is measured to the inside face of exterior walls and to the centre line of partitions adjoining other components or general circulation space (i.e., NSM times a circulation factor)

CH (Central Health)

CMU (Clinical mark-up)

CSRT (Clinical Specialist Radiation Therapist)

Capacity: maximum volume of service needs (workload) which can be effectively managed within generally acceptable facility, operational and clinical standards

(RT) Cases: Patients receiving RT treatment

Children's (Pediatric) Services: health services provided to children 0-17 years (i.e., less than 18 years old)

Clinical Research: research for the purpose of testing new concepts in health care or monitoring/evaluating health care processes; this form of research will typically involve direct contact with patients or specimens or information thereof and may include:

- epidemiological information gathering and analysis
- development of new techniques in prevention, diagnosis, and treatment
- evaluation of treatment programs

CT (Computerized tomography)

(RT) Courses: a course of radiotherapy is the series of treatments required to fulfill one prescription by a radiation oncologist. The difference between courses and patients is that an estimated 25% of patients have more than one course (usually as their disease advances) and it is the courses (including length and complexity) that drives workload.

If a patient comes back for a second course, a new prescription and treatment preparation activities (including one or more of immobilisation, simulation and dosimetry) are required.

DI (Diagnostic Imaging)

Demographic Data: the structure and growth dynamics of a population of interest

Department/Program: term used to designate an administrative grouping of activities

EBRT (External Beam Radiation Therapy)

EH (Eastern Health)

EHR (Electronic Health Record)

EMR (Electronic Medical Record)

Electronic Health Record: the relevant medical history on an individual to allow further management decisions to be optimized

Electronic Medical Record: the electronic format of the complete chart of a patient as kept by each relevant care provider; the medical legal document that reflects care episodes with each care provider.

Emergency Services: diagnostic and treatment interventions provided through an emergency department.

FP (Functional Program)

FTE (Full-time Equivalent)

Fractions: treatment sessions or visits

GNL (Government of Newfoundland & Labrador)

HDR (High Dose Rate)

Health Education: the sum total of all influences that collectively determine knowledge, belief and behaviour related to the promotion maintenance and restoration of health in individuals and communities. These influences comprise formal and informal education in the family, in the school, and in society at large, as well as in the special context of health service activities.

Health Promotion: the process of enabling people to increase control over, and to improve their health. Health promotion comprises efforts to enhance positive health and reduce risk of ill health through three overlapping spheres of activities: health education, prevention and health protection.

IGRT (Image Guided Radiation Therapy)

IM (Information Management)

IMRT (Intensity Modulated Radiation Therapy)

IP (Inpatient Services)

IPU (Inpatient Unit)

IS (Information Systems)

IT (Information Technology)

Implementation: the act of carrying out or fulfilling an established plan

Incidence: the frequency of new cases of a disease or condition in a specified population

Inpatients: patients who are admitted to the hospital for care and to whom inpatient beds, cribs, bassinets or incubators have been assigned – usually for more than 24 hours

LGH (Labrador-Grenfell Health)

Linac (linear accelerator)

MO (Medical Oncologist): a graduate of the Royal College of Physicians & Surgeons first level post graduate training program in internal medicine and the two year Medical Oncology sub-specialty training program

MP (Medical Physicist)

MPA (Medical Physicist Assistant)

MRI (Magnetic Resonance Imaging)

NLCHI (Newfoundland & Labrador Centre for Health Information)

NL (Newfoundland & Labrador)

NP (Nurse Practitioner)

NSM (Net Square Metres – Net Area): the horizontal area of space assignable to a specific function; the net areas of rooms are measured to the inside face of wall surfaces (i.e., room space only - no circulation)

Neoadjuvant: Treatment, such as chemotherapy or radiation, given before the primary treatment to shrink a tumour so that it is easier to treat with the primary therapy.

New Cancer Cases: total new invasive cancer cases (i.e., new primary cancer site) plus in situ, borderline, and neuro benign tumours (i.e., other) included in the Cancer Registry database

New Cancer Case Referrals: new Cancer Cases referred to clinics; 'referred' is defined by a patient attending a Cancer Centre at least once for consultation and/or treatment involving a physician.

New Cases Treated: new case referrals who receive a course of radiation therapy or chemotherapy or both

New Consults: new case referrals seen by a specific oncology sub-specialty group (e.g., radiation, medical or pediatric) in a Cancer Centre regardless of whether the patient was seen by another sub-specialty group or received treatment; only one new consult is counted for each new cancer case referral to a specific sub-specialty group (e.g., Medical Oncology).

OI (Oncologic Imaging)

OP (Outpatient Services): health diagnostic and treatment interventions provided by medical and/or other health care professionals to patients who are not currently registered as an inpatient in an acute care (hospital) or continuing care program/facility

OPU (Outpatient Unit)

Out-of-Region: non-residents of the local health region who present or are referred for health diagnostic or treatment services at facilities/programs managed and/or funded by the local Regional Health Authority in the local region

Outcome: the consequence or impact of a service that may be intended and/or unintended

Parameters: parameters are guidelines, assumptions, principles, features, or service characteristics that define the level and scope of services, or the function of, a facility, an organization, agency or service provider; for example:

- Role
- The size of a population served
- Development priorities
- Specific programs or services provided (i.e., the scope or type)
- Access characteristics

Planning Team (Consultants)

Practice Pattern: approaches, clinical methodologies, community services, technologies and consultation strategies used by health professionals to manage health concerns of patients

Prevalence: the number of cases of a disease present in a specific population at a given time

Program: a coherent series of activities planned in response to an established need, and which are directed toward improving the status of the target population

Proton therapy: external-beam radiation therapy delivered by proton beams

Pt (Patient)

RHA (Regional Health Authority)

RO (Radiation Oncologist): a graduate of the Royal College of Physicians & Surgeons first level post graduate training program (usually in internal medicine) and the four year Radiation Oncology sub-specialty training programs

RT (Radiation Therapy)

Referral Population: a community, or the proportion of its population, are considered part of an agency's referral patterns based upon the proportion of cases or clients attributed to it from historical data

Service Plan: a plan that operationalizes the strategic or business plan by describing what (specific health services) will be provided to whom (service population) by whom (service providers) and where (service site)

Service Utilization: the consumption and patterns of use made of regional health services

Simulation: a CT simulator is used to determine the radiation treatment fields and the treatment plan; the radiation oncologist and technologists view the area to be treated, obtain and transfer images to the planning system, create a virtual 3-dimensional image of the patient, thereby developing the treatment delivery plan

SRS (Stereotactic Radiosurgery)

STU (Systemic Therapy Unit)

SXR (Superficial X-ray)

Systemic Therapy Unit: unit providing chemotherapy and non-chemotherapy treatments to cancer patients on an outpatient basis

TBC (To Be Confirmed)

TBD (To Be Determined)

Teleoncology: the use of telecommunications for provision of cancer services

Tx (Treatment)

Target Population: the unit (persons, households, organizations, communities) to which an intervention is directed

Technology: the drugs, devices, and medical and surgical procedures used in medical care and the organizational and supportive systems within which such care is provided

Vault = Bunker

WH (Western Health)

WMRH (Western Memorial Regional Hospital)

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Appendix D: Radiation Therapy Literature Review

(See next pages)

Radiation Therapy Service Delivery Models Literature Review

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1.0 Executive Summary

Radiation Therapy Services are an essential component of a comprehensive cancer program. Radiation oncology has been recognized as a highly effective and cost effective therapy for both curative and palliative cancer treatment.

Much work has been done internationally over the past decade to quantify the radiation therapy requirements to meet the needs of cancer patients. Due to the length of time needed to plan and develop a radiation therapy service, forward planning is imperative to ensure that service capacity is available to meet the changing needs of cancer patients. In many countries, underutilization of radiation therapy services has been documented, and solutions proposed and sought.

Considerable study has been done regarding problems of access and their mitigation. Recommendations include provision of financial and social supports for people residing long distances from radiation therapy services, use of outreach and shared care models and support through patient navigation as well as developing radiation therapy services closer to patients' homes.

Historically, because of its technical complexity and capital cost, radiation therapy has tended to be centralized in major centres, usually associated with tertiary care hospitals. Over the past fifteen years, with increasing recognition of challenges for patients to access services sometimes many hours travel distance from their homes, efforts to distribute radiation therapy through devolved or decentralized models have been undertaken. Devolved centres were developed and evaluated in Australia in the early 2000s. Recognizing the need to expand radiation therapy capacity in the United Kingdom, the Royal College of Radiologists, Society and College of Radiographers, and Institute of Physics and Engineering in Medicine have published guidelines for the management and governance of such facilities. Other countries, including Canada, Switzerland, and Norway have published their experiences in developing decentralized radiation therapy services in their jurisdictions.

Considerable literature addresses the importance of technology in provision of radiation therapy services, including the evolving role of tele-oncology, particularly related to devolved services. In general, the literature advises that tele-oncology offers an essential and valuable opportunity to support high quality radiation therapy services in decentralized sites.

Metrics for radiation therapy utilization, machine throughput and human resource ratios in the recent literature provide benchmarks for service planning.

2.0 Purpose of the Literature Review

This literature review was done in support of the development of a Provincial Radiation Therapy Service plan for Newfoundland and Labrador. The Provincial Service Plan will include a comprehensive review of the radiation therapy service delivery model, focusing on assessing the current and future demands for radiation therapy in the Province; and identifying, analyzing and evaluating models of service delivery in other jurisdictions that could have application to the Province.

The objective of the literature review was to obtain the most recent available documented information regarding the delivery of radiation therapy services, both nationally and internationally. For that reason, the literature search was limited to the past five years. Literature prior to that timeframe was obtained and reviewed when recent literature continued to reference it.

Literature of particular interest to this review included planning approaches, parameters and metrics related to radiation therapy utilization, access, delivery models and workforce. Some of the literature was selected for review because it seemed of relevance to Newfoundland and Labrador, including provision of radiation therapy services to rural and remote populations, distributed and devolved service models, use of technology / tele-oncology and

services to aboriginal people. Selected cancer concepts and trends were also included, particularly those that seemed most relevant to Newfoundland and Labrador.

3.0 Concepts and Trends in Cancer Care

3.1 Comprehensive Cancer Services

The importance of cancer services being comprehensive and interdisciplinary has been documented in recent literature.

The New South Wales Radiotherapy Services Plan states that comprehensive cancer care services provide multidisciplinary care, comprising complex subspecialty surgical oncology, medical oncology, haematological oncology, radiation oncology, psycho-oncology, and research, supported by pathology, imaging and other related services such as intensive care, operating theatres, and allied health. Education and training, strong links with inpatient and community palliative care services and patient support are other important elements of a comprehensive service. This approach facilitates the use of multidisciplinary teams in diagnosis, treatment and management to the highest possible standard of care.¹

Accreditation Canada guidelines state that the cancer care team will use an interdisciplinary approach to deliver cancer care and oncology services. The interdisciplinary team includes people with different roles and from various disciplines. Depending on the needs of the client and family, as well as the service setting or location, the team may include psychosocial professionals, primary care providers, specialists (e.g. surgeons and oncologists), pharmacists, radiation therapists, administrators, nurses, allied professionals including nutritionists, occupational and physical therapists, interpreters, client advocates, and volunteers. The team may also include representatives from community partner organizations that the team works with closely.²

The Australian and New Zealand Tripartite Group representing the providers of radiotherapy services stated that collaborative approaches to cancer care will continue to grow and strengthen, and that multi-disciplinary care is an important component of national and jurisdictional cancer care frameworks. Multidisciplinary teams are an essential element of quality patient care delivery and the emphasis on multidisciplinary care is expected to continue and grow. It was noted that multi-disciplinary management of patients often results in increased referrals for radiotherapy treatments as it increases knowledge amongst other clinicians about the benefits of radiotherapy.³

The importance of allied health services as a recognized part of holistic cancer care was emphasized, including the need for their inclusion in planning a comprehensive cancer care system. Absence of allied health services such as psychologists, social workers, physiotherapists, occupational therapists, speech pathologists, exercise physiologists and dietitians and nurses, can result in cancer patients' management being fragmented, and experiencing treatment-related problems such as social and emotional consequences. Access to allied health services was felt to be improving in the cities in Australia, particularly in the larger cancer centres, but was still deficient for rural and regional patients.³

New South Wales expressed support for the national planning approach that radiotherapy services are best delivered through an integrated and multidisciplinary model, with clear linkages to a number of subspecialty disciplines, such as medical oncology, paediatric oncology, surgical oncology, clinical haematology, palliative care and rehabilitation, as part of a quality comprehensive cancer service. Radiotherapy services need to have an appropriate level of clinical support services, such as diagnostic imaging, nuclear medicine, pathology, intensive care unit and pharmacy services to support the delivery of quality services, and the skilled workforce necessary to provide a quality sustainable service. On-site or networked services in supportive care, psychosocial assistance and

pharmacy services were also identified as being required. This comprehensive service model is provided by a range of health professionals including medical, technical, nursing and allied health professionals.¹

3.2 Technological Change

In 2010, the Canadian Association of Provincial Cancer Agencies (CAPCA) stated that cancer care is continually accessing intricate and innovative technology and new, expensive equipment continue to be introduced. These innovations that, while considered advanced today, may be obsolete in five years. New technology necessitates continuous on-the-job training, more formal education, and continual review and redesign of work processes, while continuing to address patient needs, work efficiencies and quality assurance. While technological changes increase the capacity to plan more precise and personalized treatments, it may add to the planning time; however, patients and workers share the rewards of better patient outcomes.⁴

3.3 Health System Reform

CAPCA identified the following health system reform issues to which people working in cancer control are needing to adapt⁴:

- Implementation of the electronic health record
- Need to balance training on new equipment and meeting wait time guarantees
- Move to inter-professional education and team-based approaches to providing care
- Reorganization of health care into, and now out of, regional health care authorities
- Need to provide better care to rural, remote and aboriginal communities.

3.4 Survivorship and Quality of Life

The Australian and New Zealand National Strategic Plan defined survivorship as a term that represents how a person's life fares following a diagnosis. In cancer, it is a concept which can be used to describe the physical, social, psychological, and spiritual/existential impact of cancer on patient's life and help understand these factors. Cancer survivorship can be viewed as a continual evolving process starting from the moment of cancer diagnosis which occurs over the course of the remainder of life and can be defined as the experience of 'living with, through or beyond cancer'.³

CAPCA points out that treatment successes are leading to an ever-growing number of cancer survivors. Many people receive care in their local community. Increasing survivorship and new treatment options mean greater integration of cancer care into both acute care and community settings and the management of cancer as a progressive chronic disease.⁴

The increasingly positive survival statistics for individuals diagnosed with cancer indicating increasing lengths of survival mean that quality of life many years after diagnosis is becoming increasingly important. Quality of life and survivorship are strongly dependent on other treatments provided in the multidisciplinary environment and cannot be relegated to the silos of radiation oncology, medical oncology, surgery or haematology. These issues need to be addressed in context of the multidisciplinary team, and the radiation oncology team must have awareness of and sufficient resources to contribute to this process.³

3.5 Aging of the Population

Demographic studies in Europe showed that the age distribution in the population will shift towards a higher proportion of elderly people in the coming years. It was pointed out that aging of the population will not only increase the crude incidence of different cancers but will also affect the age distribution at presentation of the cancer patients. This could affect the proportion of patients presenting with co-morbid conditions and the choice of treatment prescribed.⁵

3.6 Pediatric Oncology

In New South Wales, the policy has been stated that radiotherapy treatment for the majority of paediatric patients should be undertaken at selected sites, specifically by those centres which are co-located with specialist Children's Hospitals. This is based on the rationale that the treatment of children with radiotherapy poses special challenges for the radiation therapy team, as the numbers of child patients are small and their needs are often quite different to an adult patient, hence, the benefits of established clinical relationships during this period of care.¹

3.7 Patient Navigation

The Canadian Partnership Against Cancer (CPAC) defined patient navigation as a process that provides support and information to cancer patients, their families, survivors and health professionals through the cancer continuum.⁶ CPAC reports that the literature demonstrates that patients experiencing barriers associated with language, cultural beliefs, literacy, and ethnicity experience have difficulties accessing cancer screening and the cancer system. Patient navigation is a strategy to improve access and minimize disparities among diverse populations. Patient navigator / navigation programs have been used since the early 1990's to target diverse populations as they navigate the maze of the cancer system.⁶

3.8 Aboriginal Cancer Services

Concern regarding cancer services to its indigenous population has been documented in literature from Australia. In addition to making cancer services more available, it has been pointed out that there is a need to better address issues of Indigenous cultural safety and risk reduction in the Aboriginal population.

Australia's population is concentrated around the better-watered coastal regions, leaving vast expanses of the interior unpopulated. Some mining communities of several thousand people are located fifteen hundred kilometres and more from definitive cancer care services. Even patients from large regional centres with greater than twenty five thousand inhabitants have to travel to their nearest capital city to access specialist surgical, medical and radiation oncology treatment.⁷

Financial burdens to patients and their families are significant, especially considering the typically lower socio-economic status of rural and remote compared to metropolitan populations. Because of these contributing factors, cancer patients in rural and remote areas often present with a later stage of their disease and have lower survival rates compared to those from major cities. For Indigenous Australians, for example, the higher cancer mortality rate is explained by their greater likelihood of being diagnosed at a location where the prospect of accessing treatment is poorest or being diagnosed at an advanced stage of the disease when the chances of survival are less.⁷

Approaches such as outreach services and telemedicine have been proposed. In addition, however, a culturally safe environment needs to be created, which has been defined as 'an environment which is safe for people, shared respect, shared meaning, shared knowledge and experience, of learning together with dignity and truly listening'.⁷

It is noted that such models require cultural adjustments and re-education of the existing workforce, as well as changes in traditional models of undergraduate health professional education aimed at contextualising health, health care and health professional practice in a broader setting. The foundation of integrated and managed care pathways is a well-developed primary health care system. Primary care has a role in reducing the risk of cancer, early detection, access to specialist treatment, support for patients living with cancer and, particularly, reducing inequalities for people living in poorer resourced rural areas.⁷

With the goal of offering radiotherapy services to Aboriginal and Torres Strait Islander patients in a culturally appropriate and respectful way, the Australia and New Zealand Tripartite Group made the following recommendations:³

- A focus on improving Indigenous patients' outcomes in cancer control and radiotherapy specifically, including:
 - Better data collection on Indigenous access to oncological services
 - Assessment of specific barriers to service access
 - Evidence-based strategies to improve access to treatments
 - Improved engagement between the hospital system, local communities and community controlled Aboriginal and Torres Strait Islander health services

4.0 Service Planning

4.1 Service Planning Principles

The New South Wales Radiotherapy Service Plan outlined its service development principles as follows:¹

- Radiation oncology is to be provided as part of a comprehensive and multidisciplinary approach to cancer care that supports optimal cancer management. This provides an organizational framework to ensure that the needs of cancer patients and their caregivers are met through networking of cancer and support services.
- Radiotherapy services should be integrated with a number of subspecialty disciplines such as medical oncology, surgical oncology, clinical haematology, palliative care and rehabilitation, as part of a quality comprehensive cancer service. On-site or networked services in supportive care, psychosocial assistance and pharmacy services will also be provided by a range of health professionals.
- Sites for radiation oncology services need to have a sufficient level of clinical services, such as diagnostic imaging, nuclear medicine, pathology, intensive care and pharmacy services.
- Appropriate outreach services should be provided to improve access to patients living in rural and more remote areas through both locally based and outreach services.
- Radiotherapy is part of a service continuum, which should be inclusive of primary care providers. Therefore, recognition of the roles of GPs, community-based services and other non-institutional-based care is essential.
- Appropriate support should be provided, including low cost accommodation near to the service for rural patients and carers.
- Provision should be made for appropriate maintenance, upgrade, and replacement of all equipment involved in the provision of this service.
- Expansion of services will be based on the consideration of a range of factors including increasing geographical access, workforce supply, critical mass, and increasing treatment rates.
- A mechanism for collaboration and effective working relationships between the private and public sectors, particularly in regard to planning future services and data collection and reporting, should be established at all levels.
- Formalization of cancer service networks should be undertaken.

The New South Wales Radiotherapy Service Plan notes that radiotherapy services need to have a critical mass threshold which necessitates a minimum throughput that is large enough to ensure that appropriate levels of clinical staff are available and professionally supported; that there is effective employment of these staff; and that the service is able to be developed with other complementary clinical services.¹

4.2 Demand Analysis

In a study in the United States published in 2010, the authors projected that, between 2010 and 2020, the demand for radiation therapy during the initial treatment course would increase by 22% as a result of the aging and diversification of the US population. The disease sites projected to have the most rapid relative increase in use of

radiation between 2010 and 2020 were prostate (35% increase), stomach (27% increase), liver (26% increase), lung (26% increase), and pancreas (25% increase). They projected that, between 2010 and 2020, the number of adults age 65 years and over treated with radiation therapy during the initial treatment course would increase by 38% (from 282,000 to 388,000), compared with a 1.7% increase (from 188,000 to 191,000) for individuals younger than age 65 years treated with radiation therapy.⁸

A population-based study conducted in Canada concluded that radiation oncology workload increased at faster rates than the population or incidence of cancer. The rates of increase in consultations and total commencements were greater than the rates of increase in the total population, the population over age 50 years, or the incidence of cancer. Implementation of stereotactic radiosurgery and increased brachytherapy treatments were believed to explain much of the increased workload.⁹

- Total new-to-doctor consultations increased 30% from 2000 to 2009.
- Total treatment commencements increased 35% over the same time.
- Simulations per linac course and radiation computer plans per linac course increased at steady rates of 3.6% and 3.2% annually, respectively.
- Linear accelerator (linac) commencements increased at a slower rate of 2.0% annually.
- The number of fractions per linac patient declined by 2.6% annually.
- Portals (fields) per linac treatment course increased exponentially after the implementation of intensity-modulated radiotherapy.

4.3 Service Planning Process

World Health Organization Framework for Planning Radiotherapy Services

The World Health Organization (WHO) devised a stepwise framework for use in planning radiotherapy services at a national level for the development of national cancer control programmes.¹⁰

During the assessment phase, obtaining accurate information is essential, including addressing the question of the current status of cancer services. This assessment should include an epidemiological map of the incidence, types and geographical distribution of cancer, the infrastructure and resources currently available to cope with these patients and the current radiotherapy utilization rate (RUR) in a country. The WHO planning process advised the need to quantify the number of existing machines and radiotherapy fractions given per year per million people, the number of fractions delivered per year by each machine and variation in treatment protocols as measured by the number of fractions given for common indications. This dataset can then be benchmarked with similar information from other countries with a similar health economic landscape.¹⁰

Questions to be addressed during the assessment phase include:¹⁰

- Where are we now? Assess the present state of the cancer problem and cancer control services or programs
- Where do we want to be? Formulate and adopt policy, including defining the target population, setting goals and objectives and deciding on priority interventions across the cancer continuum
- How do we get there? Identify the steps needed to implement the policy

The WHO recommends the development and implementation of a radiotherapy strategy through a stepwise framework:¹⁰

- Core Implement interventions in the policy that are feasible now, with available resources

- Expanded Implement interventions in the policy that are feasible in the medium term with a realistically projected increase in or reallocation of resources
- Desirable Implement interventions in the policy that are beyond the reach of current resources, if and when such resources become available

Regional Service Planning

The Australia and New Zealand Tripartite Committee stated that models of care are best if locally tailored and appropriate to rural and regional areas³:

- Design models of care appropriate to the regional area and its population needs, including linkage to major radiation oncology centres
- Adopt a national planning approach (facilities, workforce and services) with input from regional and rural stakeholders
- Regional facility development should focus on patient care outcomes and experiences
- Establish access to specialist services through the Cancer Care Network and links between regional and comprehensive metropolitan cancer care services
- Accommodate needs for future expansion and uptake of technology in regional facility planning and development

The International Atomic Energy Agency (IAEA) advised that radiotherapy centres should follow the population concentration distribution in a country.¹⁰ A single centre may suffice in small countries or even in large countries with a small population if transport services between centres of population are adequate. In general, however, a network of oncology services will be required, with a radiotherapy centre within each region of a country. For those patients living at a distance from the radiotherapy centre, funding will have to be set aside to pay for the costs of transport and accommodation facilities. In countries having a significant proportion of the population living at a distance or geographically isolated from the main centres, implementation of consultation clinics as focal points for further referral (primary care clinics can fulfill this role), or alternatively, facilitate patient commuting through organized transport services may be considered.¹⁰

In New South Wales, it was noted that planning for new rural and regional centres needs to include a detailed scoping of services to be provided on site and where required, networking arranged with a principal referral hospital for more complex services. Planning includes consideration of overall service needs of the residents including establishing referral pathways and clinical networks for complex radiotherapy treatments; and developing service level agreements for the delivery of a range of services such as clinical peer support, emergency treatments, education, and crisis management. Further work will be undertaken for new centres to establish formal cancer networks that link rural and regional cancer services with principal referral hospitals where required, taking into consideration the overall service needs of residents. Partnering arrangement will have an impact on workload and resource requirements.¹

In terms of deciding the location of radiotherapy facilities, a number of factors need to be considered including population distribution and size, relationships with clinical and support services, workforce training and availability, maximization of patient access, and clinical viability. In line with the service configuration requirements, proposed radiotherapy facilities need to be part of comprehensive integrated cancer care services.¹

4.4 Service Planning Metrics

Examples of Service Planning Projections Using Metrics

In New South Wales in 2010, the Radiation Oncology Reform Implementation Committee Planning Forum supported the adoption of the Collaboration for Cancer Outcomes Research and Evaluation recommendation of

52.3% radiotherapy utilization rate for planning purposes. This research, completed in 2003, using evidence available to that time, estimated that overall 52.3% of all cancers would benefit with radiotherapy treatment. NSW follows this planning parameter.¹

In addition, the NSW Radiotherapy Strategic Plan used the following planning parameters:¹

- 25% re treatment rate
- 19 attendances per course
- 4.1 attendances per hour
- 8 operating hours per day
- 240 working days per annum

These parameters resulted in an expected throughput of 414 total courses per linear accelerator per annum, comprised of 331 new courses of treatment, and 83 retreatment courses. While many radiotherapy treatment centres operated extended hours and on weekends, and attendances and throughputs may vary, these metrics were recommended as the basis for planning. The need to have accurate, comparable workload data so as to review and refine the parameters was recognized as an important objective.¹

In 2012, the Australia and New Zealand Tripartite Committee, representing the three key professions: the Faculty of Radiation Oncology (FRO) and Royal Australian and New Zealand College of Radiologists (RANZCR); the Australian Institute of Radiography (AIR); and the Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) stated that:³

- Planning of radiation oncology services must be based upon achieving the agreed optimal target utilization of radiotherapy for new cases of cancer (currently set at 52.3 %).
- The commitment needs to be made now so that the target optimal utilization rate for radiotherapy can be met by 2022.
- Radiation oncology service planning needs to occur:
 - Regularly on a long-term basis and coordinated at a national level.
 - With reference to other cancer therapies.
 - Ensuring that patients have clinically appropriate and affordable therapies.

Projections of the Australian Institute of Health and Welfare used cancer incidence data (all cancers excluding basal and squamous cell carcinomas of the skin), and a target radiotherapy utilization rate for new cancer cases of 52.3 % for notifiable cancers. For each year between 2012 and 2022, the utilization rate was applied to the projected incidence of new cancer cases to obtain the number of new cases to receive radiotherapy. This result was increased by 25 % to account for retreatments, and by 10 % to account for treatment of non-notifiable disease.^{3,11}

Australian projections of the number of linacs required to serve patients were calculated based on the industry accepted average number of courses of treatment each linac can accommodate per year, stated to be 414, acknowledging that linac throughput can vary based on the case mix of patients and service-related factors. The useful life of a linac was assumed to be 10 years.^{3,11}

The actual radiotherapy utilization rate in Australia in 2012 was noted to be 38.1 %, observed to be significantly below the optimal target. Recognizing the current shortfall, linac availability was calculated over the next 10 years based on 3 scenarios as follows:³

- target – optimal rate of 52.3 % by 2022
- halfway rate of 45.2 % by 2022
- maintenance of current under-utilisation rate 38.1 %

In a report in 2005, the European Society of Radiotherapy and Oncology (ESTRO) based its national guidelines for infrastructure and staffing for radiotherapy on the following planning factors:^{12,5}

- A radiotherapy utilization factor of 50 %
- A retreatment factor of 0.25
- One linear accelerator per 450 patients
- One radiation oncologist per 200-250 patients
- One physicist per 450-500 patients (or one per linac)

The ESTRO stressed that these were crude guidelines and that the actual needs heavily depend on population structure, cancer incidence and treatment strategies, which differ between the various countries.

In Alberta in 2005, the incidence of new cancer cases was noted to be 0.4 % per year and this incidence rate had remained stable since 1995. Review of treatment data from the two existing cancer centres showed that, given existing practice patterns, 0.23 of incident cases required retreatment. At that time, an average megavoltage treatment unit at the Tom Baker Cancer Centre in Calgary delivered 360 courses per year (new and retreat).¹³

Radiotherapy Utilization Rate

The IAEA defined the Radiotherapy Utilization Rate (RUR) as the proportion of a specific population of patients with cancer that receives at least one course of radiotherapy during their lifetime, calculated as the number of patients treated with radiotherapy for the first time divided by the total number of new cases.¹⁰

A study done in Australia¹⁴ in 2005 found that, for every 1000 cancer cases in a population, 523 patients would need radiation as an optimal part of their management based upon the results of this project (calculated optimal radiotherapy utilization rate of 52.3 %). A further 120 patients, of the above 523 patients, would require retreatment (based upon an actual retreatment rate of 23 %). This means that an estimated 643 courses of treatment would be required for every 1000 cancer patients diagnosed with a registered cancer.¹⁴

The New South Wales 'Improving Radiotherapy Roadmap' published in 2009 reaffirmed support of the treatment benchmark rate for radiotherapy of 52.3 % of patients with notifiable cancer, approximately 25 % of whom would require retreatment. NSW Health recommended a throughput rate of 331 new patients treated with radiotherapy per linear accelerator per year.¹⁵

In England in 2013, the predictions of radiotherapy demand developed through their Malthus model were compared with those from the earlier National Radiotherapy Advisory Group (NRAG).¹⁶ The Malthus models some reduction in indications for radiotherapy, principally in respect of lung cancer and rarer tumours. An estimated 40.6 % of new cancer patients were shown as requiring radiotherapy at some stage of their illness; this is lower than previous estimates of about 50 %. Compared with the NRAG model, the Malthus model predicts lower access rates for lung and pancreatic cancer with increased use of chemotherapy and changes in case selection. Reduced use of radiotherapy is also modelled for cancers of the oesophagus, stomach, rectum, and most of the rarer cancers. For breast and head and neck cancer, access rates were little changed. For endometrial cancer, clinical trial results have reduced the role of radiotherapy. For prostate cancer, the Malthus model predicts that fewer patients should receive radiotherapy, but models more attendances per episode so that attendances increase by 32 % compared with NRAG.¹⁶

While the radiotherapy utilization rate is lower under the Malthus model, the number of services increases. The evidence-based fractionation modelled for all those who are treated (including re treatment) increases from 15.2 attendances per episode in the NRAG model to 17.4 in the Malthus model.¹⁶

CPAC's 2014 Cancer System Performance Report¹⁷ provides an indicator measuring the percentage of cancer incident cases that received radiation therapy for any reason within two years of diagnosis. It noted that radiation therapy use varied only slightly by province for the 2010 diagnosis year and rates had remained relatively stable between 2007 and 2010. When compared by province for 2010, rates of radiation therapy use within two years of

diagnosis ranged from 29.1 % to 35.9 %. In 2010, the highest radiation therapy utilization rate was in Prince Edward Island at 35.9 %.¹⁷ In Newfoundland in 2010, the radiation therapy utilization rate was 30.9 %.¹⁷

In a study completed in 2012¹⁸, the Australian Radiotherapy Utilization Rate (RUR) of 52.3 % published in 2003 was revisited, and a revised optimal RT rate of 48.3 % published. In this study, the RUR is the proportion of new cases of cancer that were found to have an indication for external beam radiotherapy at least once at some time during the course of their illness. The change to the rate was stated to be caused by changes in epidemiological data, changes in radiotherapy recommendations and structural changes in the model. The authors pointed out that the optimal rate excluded cancers that are not notified to cancer registries such as non-melanomatous skin cancers, benign conditions and retreatment of previously diagnosed cancers that had received radiotherapy at an earlier date.¹⁸

The study also found that, overall, 8.9% of all cancer patients in Australia have one indication for concurrent chemo-radiotherapy during the course of their illness.¹⁸

Retreatment Rate

Retreatment by radiotherapy makes up a substantial proportion of clinical and treatment activity and retreatment rates are critical to estimate demand and to assess activity. If retreatment is not identified in activity estimates, demand will be underestimated.

A study done in Australia looked at the actual retreatment rates of patients receiving radiotherapy between 1997 and 2006.¹⁹ The mean number of retreatments was 26 per 100 patients. Depending on the year of first treatment and, hence, the length of follow-up, the mean number ranged from 20 per 100 for those first treated in 2006 to 34 per 100 for those first treated in 1997- 1999. This shows the difficulty of estimating the mean number of retreatments per lifetime in cohorts with limited follow-up. The mean varied markedly by tumour site, ranging from 3 per 100 for brain to over 100 per 100 for myeloma. Bone treatments predominated in retreatment patients. Not surprisingly the tumour sites with the highest retreatment proportions were those that are usually treated palliatively, such as lung, or metastasise to bone, such as prostate or myeloma.¹⁹

In a survey in England in 2007, 20 % of patients receiving 8 % of fractions were identified as having previously been treated with radiotherapy. Analysis of these results showed that 86 % of these retreated patients were receiving palliative treatment, and 14 % were receiving radical treatment.²⁰

Radiotherapy Use for Non-Notifiable Conditions

There are other uses for radiotherapy that were not included in the radiotherapy estimate developed through the Delaney study that need consideration when planning radiotherapy resources.⁴

Radiotherapy has an established role in management of non-malignant conditions (benign tumors and noncancerous conditions) as well as a role in the management of nonregistered cancers such as non-melanomatous skin cancers. The overall need for radiotherapy resources is difficult to estimate for these nonregistered conditions, as the overall incidence of these conditions is unknown, and evidence-based treatment guidelines do not exist for most of these conditions. Data obtained from selected hospitals in Australia showed that around 11 % of patients who receive external beam radiotherapy are treated for non-notifiable conditions. This additional workload needs to be considered in resource planning.⁴

The New South Wales 'Improving Radiotherapy Roadmap' published in 2009 noted that conditions treated by megavoltage radiotherapy that were not notifiable to the NSW Cancer Registry included non-malignant diseases such as pituitary tumours or non-melanoma skin cancers, as well as conditions that require radiotherapy to prevent bone ossification after hip replacement surgery. These were calculated to make up 11 % of all cases treated by linear accelerators.¹⁵

Attendances and/or Fractions Throughput

The National Radiotherapy Data Set in England defined activity as attendances. Fractions, on the other hand, may count multiple body parts separately and therefore produce a higher total count than do attendances. In 2006, the National Radiotherapy Advisory Group said that each machine should average 8000 fractions, which would be equivalent to 6800 to 7200 attendances.²¹

It was estimated that the service workload would increase to 8300 fractions (7000 to 7500 attendances) by 2010/11, and 8700 fractions (7400 to 7800 attendances) by 2016. It was noted that at the time of the study in 2012, each linac delivered an average of 7333 machine attendances per year.²¹

In recent years, new developments have improved the quality of radiotherapy but often they reduce patient throughput, certainly during the implementation phase. IMRT was initially slower than conventional treatments and can now be delivered faster on newer machines. Similarly, the assessment of images prior to therapy required for IGRT can slow throughput while enhancing quality and solutions are being developed to overcome this.

A throughput indicator of 7300 attendances average across the department was felt to be in line with other countries. Therefore, the National Radiotherapy Implementation Group in England recommended that the machine throughput metric be retained at 7300 attendances as an indicator of capacity for machines working a standard day, five days per week.²¹

In England, Malthus, a decision aid for planning and commissioning radiotherapy services at the local or regional level, modelled the following projected requirement for radiotherapy attendances per million population:²¹

- 2010 48,035 attendances per million population
- 2016 55,206 attendances per million population
- 2026 60,057 attendances per million population

Wait Time

Although the average increase in risk per month of delay in the individual patient is not large, it has the potential to have a very important detrimental effect on the overall value of an RT program as all patients on the wait list may be affected. Shortening wait times represents an opportunity to improve local control rates. A systematic literature review showed that an RT program with chronic waiting list could expect to achieve an absolute increase in local control of 5 % and 10 % in head and neck cancer simply by reducing its wait time by 6 weeks.²²

In view of this, how long is it reasonable for patients to wait for RT? Given that there is no theoretical reason to believe that there is a threshold below which delay is safe, the principle should be that delays in RT should be As Short As Reasonably Achievable (ASARA).²²

In December 2005, the Provincial and Territorial (PT) health ministers established a benchmark for radiation therapy wait times for cancer and all provinces have implemented initiatives to measure and improve their wait times. The national target was for patients to start radiation therapy within four weeks (28 days) of being ready to treat. Provinces targeted a reduction in wait times for 90 % of patients to below the national four week benchmark.

Some have proposed shorter targets. For example, the Canadian Association of Radiation Oncologists set a target of 10 working days (14 calendar days) from the day of consultation or requisition to the start of therapy.¹⁷

The Canadian Partnership Against Cancer (CPAC) reported that, in 2011, 97.3 % of all cancers in Newfoundland and Labrador were within the target wait time of 28 days. The median wait time was seven days.¹⁷

Calculating Spare Capacity to Provide for Variation in Referral Patterns

The UK Royal College of Radiologists stated that queuing theory shows that capacity needs to exceed mean demand, to keep waiting time to treatment short. The percentage of spare capacity required for a matched pair of linacs, in a department that closes on bank holidays and compensates for category 1 patients by treating twice before or after the break, about 10 % spare capacity is required to ensure that 86 % of patients are able to start radiotherapy within a week of completing the treatment planning process. If a machine is booked as a single (unmatched machine), an additional 3 % spare capacity is needed. If all bank holidays in the year are worked, then about 3 % less is needed.²³

Cancer Council NSW stated that linear accelerator capacity should exceed demand by 10 % in order to meet variation in referral patterns.¹⁵

Linear Accelerator Capacity

- The 2010 NSW Radiation Service Plan used the European Society for Therapeutic Radiology and Radiation Oncology (ESTRO) guideline of one linear accelerator per 450-500 patients per year.¹
- The IAEA recommended 1 linear accelerator per 450 patients per year for general use, and 1 per 400-450 patients per year with increasing complexity.¹⁰
- The IAEA recommended 1 linear accelerator per 180,000 persons for general use, or 1 per 160,000-180,000 with increasing complexity.¹⁰
- In a project in Holland, radiotherapy cases were weighted based on the relative costs of the four types of treatment. The number of required linear accelerators was calculated based on an average number of 500 weighted treatment series per machine.²⁴
- A project conducted in Switzerland looking into radiotherapy in low to middle income countries used the ratio of 1 linear accelerator to 450 patients as the basis for planning.²⁵
- CPAC reported that the number of linear accelerators in 2012 ranged from 4.5 per million persons in Alberta to 13.8 per million persons in Prince Edward Island with a Canadian average of 7.2 per million.¹⁷ In NL, there were 7.6 linear accelerators per million persons in 2012.¹⁷

5.0 Access to Radiotherapy

5.1 Travel distance

A study by Mackillop et al²⁶ published in 1997 investigated whether a highly centralized radiotherapy system such as the one in existence at that time in Ontario, Canada, provided adequate and equitable access to care for the province's dispersed population. While recognizing that the results could be slightly underreported due to incomplete data, the study found that the proportion of cancer incident cases treated with radiotherapy was 23.7% at 1 year, 25.8% at 2 years, 28.2% at 5 years, and 29.1% at 8 years, much lower than accepted national and international targets. As well, the rate of radiotherapy use at one year was found to vary significantly from county to county across Ontario with the highest being recorded in communities close to radiotherapy centers. Based on these findings, the authors concluded that low and uneven rates of radiotherapy use across the province indicated that Ontario's centralized radiotherapy system did not provide adequate or equitable access to care.²⁶

The Department of Health report on Radiotherapy Service in England 2012 stated that the uptake of radiotherapy treatments by patients was known to diminish with the distance travelled by patients to reach a radiotherapy centre.²¹ In England, the 2007 National Radiotherapy Advisory Group report advised that ideally patients would have no more than 45 minutes travel time to their treatment, recognizing that, for some highly specialized services, patients may need to travel further. In Scotland, a maximum travel time of 60 minutes has been advised.^{21, 27}

A survey in Italy showed that the utilization rate decreased in relation to the distance between a patient's residence and the nearest radiotherapy service, and this reduction was greater for patients 70 years of age and over. Patients resident in areas with no RT service showed a lower probability of accessing RT. Utilization levels decreased significantly with increasing distance from the nearest RT service, distance being a barrier to access particularly for older persons.²⁸

A study in Norway demonstrated that utilization of palliative radiotherapy in a health care system without financial barriers does not vary with distance between residence and home. All study patients were treated in northern Norway and had unlimited, rapid access to treatment. The patients were divided into three groups according to travel distance. No statistically significant differences in the utilization rates were detected. The median age of the irradiated patients in the three groups was similar.²⁹

In Norway at the time of the study²⁹, all oncology services were provided through the national public insurance system. Free hotel accommodation was provided to patients not able to travel back and forth due to distance and travel expenditures were reimbursed. No significant differences in palliative radiotherapy utilization were found in regions with different distances to the RT treatment facility although the highest utilization rates were seen in the region closest to the hospital. All patients requiring it had free access to treatment, housing and travel. Hospital staff arranged for room and flight reservations as well as other possible barriers. The conclusion from the study was that there is no relevant variation in access when health care providers take care of the cost of travelling and other possible burdens.

5.2 Age and RT Access

The National Radiotherapy Data Set in England showed lower uptake of radiotherapy per incident case in patients aged over 75 years, and stated that co-morbidities and clinical factors may play a part in explaining the difference for a proportion of these patients.²¹

In Italy, the utilization rate decreased in relation to the distance between a patient's residence and the nearest radiotherapy service, and this reduction was greater for patients 70 years of age and older.²⁸

5.3 Mitigating Barriers

Financial and Social Supports

In England, as a means to increase the uptake of radiotherapy, the Department of Health encouraged the provision of hostel accommodation, dedicated parking and improved transport systems to support patients who need to travel. The Department of Health advised that the additional cost to patients of travel during long courses of radiotherapy should be recognized and stated that removing such obstacles should increase the uptake of radiotherapy.²¹

In Australia, the Baume report³⁰ recommended that each new patient should to be entitled to financial compensation for defined travel, accommodation and living costs, with the following comments:³⁰

- This support should be more generous for this class of patient than current schemes and should not be limited to patients living in remote or regional areas
- Financial support should be available for initial assessment and treatment where the patient has travelled more than 70 km one way

Following the Baume Report in Australia, patient accommodation and travel schemes that partially reimbursed patients for out-of-pocket expenses were made available in all Australian States and Territories. For example, in New South Wales, under the Isolated Patients Travel and Accommodation Assistance Scheme, eligible patients could receive various types of assistance. However, the conditions of eligibility were described as flawed and gaps remained for some patients. Where a patient chose not to access the nearest possible specialist treatment, they became ineligible for assistance under the scheme.⁷

The Australian and New Zealand Tripartite Group representing radiotherapy providers stated that strategies to ameliorate the financial and social impact of cancer on patients and caregivers in rural and regional areas should include actions that would prevent decisions regarding treatment from being influenced by financial considerations. This should include reimbursement of out of pocket expenses incurred by those who are forced to pay more because of their place of residence.³

Radiotherapy planning in Scotland³¹ emphasized the importance of accommodation for RT patients. Patients living a considerable distance from radiotherapy facilities, for example in the Northern or Western Isles, were found to be offered some type of accommodation for the duration of their treatment. However, for patients living in closer proximity to a treatment facility, accommodation was not routinely offered despite the recognized physical, emotional and financial costs of daily commutes. Some patients attend daily for up to 8 weeks of treatment. Side effects such as fatigue or nausea can become more pronounced as treatment progresses, and daily commutes may significantly impact both the patient and caregiver. It was noted that existing accommodation facilities were barely adequate to meet the demand of patients from remote areas, resulting in some patients choosing to delay the start of treatment until accommodation became available. For patients living less remote to radiotherapy facilities but still having to undertake a relatively strenuous daily commute, the option of accommodation was not normally considered. Based on these observations, the 2011 to 2015 Scotland RT Plan³¹ recommended that accommodation facilities be reviewed with a view to extending and enhancing them, including increasing access for a greater number of patients.³¹

Outreach and Shared Care Models

The Baume report³⁰ in Australia recommended outreach services operating in each health region, stating that these have been shown to be effective in increasing patient use of radiation therapy, even where a radiotherapy facility is not located nearby. The timing of visits should be frequent enough to build relationships with the referring doctors in the area and to minimize the need for patients to travel for a timely initial consultation and enable continuity of care. The outreach service should become the gateway to multidisciplinary team care for the patient.³⁰

While outreach programs were felt to improve general practitioner-specialist communication and to enhance patients' treatment experiences, Smith⁷ expressed the expressed that they result in increased costs and that there is no evidence of improved health outcomes. Shared care models which involve collaboration between the primary care physician and the specialist in the delivery of planned care have the potential to improve the coordination of care across the primary-speciality care interface and to improve patient outcomes; however, similar to outreach programs, it was observed that there is little evidence to date of a demonstrable benefit.⁷

While outreach and shared care models are useful, Smith⁷ stated that more is needed to address the inequity in outcomes for rural and remote cancer patients in Australia. Development of a culturally safe and appropriate environment for Indigenous people and new models of multidisciplinary care with close links with major metropolitan specialist services are required. Opportunities for greater support and education for rural cancer patients and their families, improved access to high level diagnostic and treatment technology, and facilitating the development of new and expanded health care roles were noted as being required.⁷

Patient Navigation

In Canada, a report regarding cancer services to residents of the Nunavik, Nunavut and Inuvialuit Settlement Region³² states that navigation services are provided through nurse case managers to these residents of remote communities while receiving care outside of their communities. This includes direct services to patients while they are in the south, visiting patients in the hospitals as well as at boarding homes or accommodations.³²

Devolved or Decentralized Radiotherapy

To provide additional capacity in locations closer to the residence of patients, devolved radiotherapy departments with links to a cancer centre hub can be established.³³

In England, the Department of Health advised that it is important to ensure that capacity is in the right place to optimize access, recognizing that this may result in small centres having machines that are relatively underused. It noted that productivity needs to be seen as a balance between the effective use of local resources and the right levels of access to the treatment in local populations.²¹

Managing Treatment Interruptions

The Royal College of Radiologists in England, in its 2008 standards and guidelines for the management of unscheduled treatment interruptions³⁴ stated that 'Good clinical practice demands that radical courses of radiotherapy should not be interrupted', noting that prolongation of any radiotherapy treatment may adversely affect patient outcomes. The effect of treatment prolongation is of particular concern in fast-growing tumors. The Royal College of Radiologists developed three groups for purposes of prioritizing patients according to the need to manage interruptions as follows:

- Category one patients have rapidly growing tumors such as squamous carcinomas, and are being treated with radical intent. For these patients, treatment duration must not be prolonged by more than two days over the original prescription.
- Category two patients have slower growing tumors, usually adenocarcinomas, and are being treated with radical intent. While there is no evidence that prolongation of five days is deleterious, the clinical advice remains that treatment not be prolonged more than two days over the original prescription.
- Category three patients are those being treated with palliative intent for whom overall time is less critical although prolonged interruptions may require compensation, especially if longer than seven days.

Several reasons for treatment interruption were identified, including public or statutory holidays, machine service time and machine breakdown as well as patient related reasons such as radiotherapy reactions and patient unwillingness. Of these, in three surveys done in 2005, the main causes of treatment interruption were found to be public or statutory holidays which caused 39% of the interruptions, and machine service time which caused 35% of the interruptions. Machine breakdown was found to cause 9% of all treatment interruptions.³⁴

The Royal College of Radiologists recommended the following approaches to manage and/or mitigate unavoidable and unscheduled interruptions:³⁴

- Working across public or statutory holidays as a norm
- Scheduling machine servicing and quality assurance activities so that they do not interfere with patient access to treatment
- Provision of adequate resources in terms of machines, staff and training
- Contingency plans for patient transport if this becomes necessary

Transfer of patients to a matched linear accelerator on the day of interruption was noted to be the ideal approach. Where this was not possible, the following approaches were recommended:³⁴

- For patients who missed appointments on a weekday, there should be ability to provide treatment on the weekend
- Patients can be treated twice daily with a minimum of six hours between therapies
- Use of biologically equivalent dose calculations to derive an alternative schedule involving a modified number of treatment fractions
- Addition of extra treatment fractions where compensation cannot be achieved within the original overall planned time

Public Awareness

In England, the fact that radiotherapy was underutilized when compared with international benchmarks was thought to be the result of its low profile and poor understanding by the general public. In 2010, the National Radiotherapy Awareness Initiative²¹ was established to improve the awareness of radiotherapy services across the

UK. A national survey confirmed these impressions and an awareness campaign making 2011 the 'Year of Radiotherapy' was created. A repeat survey carried out 12 months later indicated that there had been an improved perception of radiotherapy as an effective modern cancer treatment.²¹

6.0 Devolved or Decentralized Radiotherapy

6.1 Cancer Care to Residents of Rural and Remote Communities

'Rural/Remote' refers to the fact that, for many Canadians, primary cancer care often is delivered in a major cancer centre situated in a large urban setting and distant from the patient's/family's place of residence. This can impose a range of burdens on patient and caregivers. In a summary of the meeting proceedings from the 'National Forum on Cancer Care for All Canadians: Improving Access and Minimizing Disparities for Vulnerable Populations'⁶, it is stated that the care provision community has a responsibility to find innovative ways to provide support to Canadians struggling with these burdens, whether the need arises at the time of diagnosis, treatment onset, or post treatment. The various levels of health care provision, including the professional cancer care community need to ensure that comprehensive supportive care be available to all Canadians.⁶

In Australia, the relative risk of dying of cancer within five years of diagnosis has been reported to be 35 % higher for those living in remote locations compared with major cities. The reasons for the disparity in cancer outcomes for metropolitan versus nonmetropolitan Australians are varied. In general, rural and remote residents have to travel long distances and stay away from home, family, and work for long periods of time to access the care they need. Hence, distance is the overriding barrier to access, compounded by the financial costs and disruption to family life, and the endemic lack of specialist medical and allied health workforce outside the major cities. The financial costs of accessing cancer care, including loss of income as well as out of pocket expenses, can be of critical importance, as well as being disruptive to family life.⁷

Fundamental cultural issues and beliefs also have a powerful influence on patients' choices regarding the health care they access. Smith⁷ points out that rural and remote Australia is 'sociologically, culturally, economically and spiritually different from metropolitan areas', which influences the 'way health and medical care is provided'.⁷

Some rural and remote Australians choose to compromise, accessing whatever care they can locally rather than having to travel. For them, this is a quality of life decision; however, it contributes to the need to provide high quality cancer care services close to where people choose to live and die, to deal with the complex morbidities associated with the various cancers.⁷

In 2014 in British Columbia, a project was undertaken by Santibáñez et al³⁵, the purpose of which was to develop a quantitative approach to determine optimal locations and catchment areas of RT facilities with respect to patient travel for a large geographic region. Configuration scenarios were limited to existing locations of acute care hospitals and adequate utilization in each potential RT facility to support either 1 or 2 linacs at minimum. The work focused on the percentage of patients living within a 90-minute drive of an RT facility, with a secondary consideration of average travel time. The proposed framework and model provided a data-driven means to quantitatively evaluate alternative configurations of a regional RT system, on the basis that the choice of location for future centers can significantly improve geographic access to RT.

6.2 Experience in Alberta

Craighead and Dunscombe³⁶ wrote regarding learnings from the planning of small city radiotherapy departments in Alberta. They described the three critical drivers that they had observed need to be addressed to maintain quality and safety in devolved cancer care across the province. The article was published during the planning of the Alberta sites, and, therefore, addressed the planning approach as well as the understandings and assumptions used in planning.

- Driver 1: Connectedness to Tertiary Sites and Audit Mechanisms*

They identified the link between tertiary and smaller city RT departments as an important element requiring careful attention if radiotherapy is to be safely devolved. This link was seen as critical for maintenance of quality of care and support of peripheral departments. In the Alberta planning, interviewees and discussion groups suggested that small departments should have autonomy in service delivery, but that strong interdependence was required between small departments and tertiary centres if quality standards were to be maintained across the province. Support from tertiary centres was also considered important for staff retention at small centres, as it would provide opportunities for advancement and participation in academic aspects of care. A formal network arrangement was viewed a superior model, allowing establishment of, and adherence to, common clinical and technical guidelines. The elements that need to be addressed within such a network include reporting relationships, functional electronic pathways, innovative telehealth, and a transparent audit mechanism.
- Driver 2: Factors Determining the Size and Location of Departments*

Critical concerns connected with sizing and siting small-city departments were identified to include electronic platforms for health records, transmission of imaging data, and availability of planning systems province-wide.

A second broad area needing a clear decision was defining the acceptable minimum size of a small-city department. For example, while the Australian and French experiences suggest that single-machine units (SMUs) are safe and practical, Craighead and Dunscombe³⁶ stated most internal respondents felt, at that time, that having more than one unit is optimal because of greater cost effectiveness, benefits to retention of staff, and mitigation of treatment delays when a single unit has to be taken down for service or repairs. They stated that some international experts have supported the establishment of SMUs, but only in the presence of a strong connection with a tertiary facility. The authors expressed the view that, after radiotherapy is established in mid-sized cities in Alberta able to support more than one linear accelerator, it is possible that SMUs will be considered again.³⁶

In Alberta, factors such as community acceptance, distance from a tertiary site, and resources required to retain staff in a local community were components of the decision making regarding location. Using this model, three viable sites for small departments were selected that could support a minimum of 2 linear accelerators in each centre. There was support from respondents for a CT simulation function rather than a conventional simulator and for a provincially integrated planning approach. It was emphasized that that this function should be networked, to ensure that smaller departments have the ability to offer conformal and intensity-modulated radiotherapy.³⁶

- Driver 3: Personnel Issues*

The authors reported that serious concerns about the ability to attract and retain an appropriate workforce for small departments have been raised. Staffing concerns for devolved radiotherapy services included the following:³⁶

 - The lack of a consistent national supply of medical physicists and radiation therapists
 - The need to have training approaches that attract local students from the communities developing small RT departments to pursue training in the needed disciplines.
 - The importance of selecting sites for the new RT departments in which the local community culture is attractive and encourages retention and recruitment
 - The need for adequate support for smaller operations, meaning that tertiary specialists are willing to help out when personnel numbers are compromised

6.3 Experience in England

The Royal College of Radiologists concurred that a new radiotherapy service must be integrated into the existing network of cancer services. If the devolved radiotherapy unit is established with links to a cancer centre, there should be a single management structure with integration of the devolved radiotherapy service. This will facilitate the essential governance structures.²⁷

The Royal College of Radiologists in England recommended that a new unit should have a minimum of two linear accelerators and the building plan should consider the possible future need for additional accelerators. A new radiotherapy service must be integrated into the existing network of cancer services and advanced workforce planning is needed to secure adequate radiotherapy staffing.³³

Further, the Royal College of Radiologists stated the view that a unit with only one linear accelerator is more vulnerable in many ways. Machine servicing and breakdown may cause difficulties; re providing treatment in a timely way will mean transporting patients to an adjacent cancer centre. It will be difficult to redeploy staff effectively, for example to extend working hours at the cancer centre. In addition the small number of staff will mean that it is difficult to compensate at short notice for sickness or other absence. It is essential that there is a service level agreement with an alternative provider to cover service provision during both planned and unplanned downtime and staff shortage.³⁷

Recommendations of the Royal College of Radiologists were that:³⁷

- A linked unit should aim to acquire a minimum of two multi-modality linear accelerators (preferably with electrons), one simulator (CT or conventional) and a treatment planning system together with appropriate staff. If equipment for full simulation and treatment planning is not purchased, the consequences of this decision for patient management should be worked through in detail with the cancer centre.
- If a unit has only one linear accelerator, there should be a clear plan for the management of patients during periods of staff shortage and machine maintenance and breakdown

A joint publication representing the three professional bodies involved in provision of radiotherapy in England stated that there should be access to treatment simulation (CT simulation) at the linked unit unless a treatment-only unit is planned. Mould room facilities should also be considered.²⁷

The three professional bodies in England – the College of Radiologists, the Society and College of Radiographers, and the Institute of Physics and Engineering in Medicine – stated that a decision to provide a single linear accelerator service has implications for the scope of practice for such units, noting that UK experience has shown that providing a service with a single linear accelerator will restrict the range of patients treated. The risk of an interruption in a patient's treatment course is increased in such a unit. Given this, such units tend to treat Royal College of Radiologists category 2 patients such as those with early breast and prostate cancer.²⁷

The likely case mix for a single machine unit would include:²⁷

- Early breast cancer
- Prostate cancer

The majority of these will be fit patients with few medical comorbidities.

The wish to improve patient access to radiotherapy will mean that most radiotherapy units will also wish to treat patients with:²⁷

- Lung cancer (palliative and radical without concurrent chemotherapy)
- Bladder cancer
- Rectal cancer

and those needing

- Palliative radiotherapy for metastases from common solid tumors
- Radiotherapy for myeloma or lymphoma

These patients will require an enhanced level of clinical support. It is essential that a risk assessment for each patient is undertaken to ensure that their likely clinical needs can be met.

Patients requiring more complex management such as those with²⁷:

- Head and neck cancer
- Gynecological cancer needing combined external beam radiotherapy and brachytherapy
- Lung cancer with concurrent chemotherapy
- Esophageal and upper gastrointestinal cancer
- Sarcomas
- Pediatric cancers

These will need an increased level of clinical support that may only be available at a comprehensive cancer centre.

6.4 Experience in Australia and New Zealand

In 2001, the Radiation Oncology Inquiry was conducted in Australia, resulting, in 2002, in the Baume Report entitled 'A Vision for Radiotherapy'.³⁰

This report supported the 'hub-and-spoke' model of service provision in principle, with an expectation that the interim results of the Victorian single machine unit (SMU) trial should be assessed in 18 months by a national body, which then would make a decision about supporting further SMU facilities in Australia. It was emphasized that all rural radiotherapy facilities should be networked with a larger, urban facility by the end of 2003.³⁰

Recommendations of the report included that any proposal for a regional facility should be assessed to address the following points:³⁰

- That the area of need is clearly demonstrated, preferably having been identified in the State or Territory strategic plan
- That it has strong links with a larger urban centre, with the nature of the services supplied by the larger centre being specified
- That appropriate medical support is available
- That arrangements are in place to ensure multidisciplinary care for patients
- That there is adequate workforce, appropriately qualified to staff the unit, and other facilities have not been greatly disadvantaged by losing staff

The Baume report³⁰ stated that, if the national body supported an increase in the number of SMU locations, opportunities existed to take advantage of developments such as data networking and tele-radiology. The hub-and-spoke arrangements envisaged involved placing machines in regional centres, but also that each facility would be linked closely with an established and recognized cancer centre.

The Baume report³⁰ proposed that the patient should be initially assessed in the larger facility (the hub), which would be part of a comprehensive cancer care centre featuring at least one multidisciplinary team. The prescription for radiation therapy and probably the treatment simulation and planning would be done at the hub and sent electronically along the spoke, closer to the patient's home. This means that the overall treatment plan (eg, surgery and radiotherapy) and the highly complex process of planning radiotherapy would be performed at centres with high patient throughput and assured quality. The less complex task of actually delivering treatment, which takes far more time, will be done closer to the patient's home. It was noted that this may be a potential disincentive in recruitment of radiation therapists, as it would remove the link between treatment and planning.

The Baume report³⁰ stated that SMU facilities might not have a radiation oncologist on site, though it would be expected that the spoke would be a logical site for outreach clinics providing regular visits by a radiation oncologist. It was suggested that it might be possible for such centres to treat 'routine' problems which have been seen and assessed properly but whose treatment can be undertaken by a team led by an experienced radiation

therapist. It was, however, suggested, that there needs to be at least someone available immediately to deal with radiation side effects. Such a person might need to qualify or show formal competence in some other way, but may not need to be a radiation oncologist (for example, some patient reviews in public hospitals are already done by registrars). It would be necessary to have in place at such facilities all necessary arrangements for treating adverse radiation reactions and other complications as they arise. There would also need to be adequate arrangements for rapid communication with the cancer centre. For other involvement of medical colleagues, it might be necessary and possible to use video-conferencing and other applications of telemedicine.³⁰

The Baume report recommended that, subject to adequate quality standards and guidelines being in place, the 'spoke' facility should be developed with a radiation oncologist presence but not require a radiation oncologist always on site. The 'spoke' facility may be run by a team led by a highly qualified radiation therapist. However, medical support must be available to treat radiation toxicity or any other medical complication.

A National Single Machine Unit (SMU) Radiotherapy Trial was established as a joint initiative between the Australian and Victorian Governments following recommendation in the 1998 Review of Radiotherapy Services in Victoria. The trial included sites at Ballarat, Bendigo, and in the Latrobe Valley. The trial aims were to:¹

- Improve access to services for people living in rural areas
- Improve utilization rates of radiotherapy as a treatment modality
- Increase the proportion of cancer patients receiving radiotherapy, thereby reducing the economic and social costs associated with other forms of treatment, including surgery

The SMUs operated within a 'hub and spoke' model, linked to one or more larger centre. The model incorporated quality assurance guidelines and strong professional linkages between the hub and spoke sites, and facilitated appropriate treatment and referral practices. SMUs were not expected to provide treatment for complex cancers, and patients with these tumours were to be referred to the hub or other specialist facility.¹

The Victorian Department of Human Services undertook an evaluation of the Single Machine Units to assess how well the trial aims were met. The Single Machine Unit Trial successfully demonstrated that single machine radiotherapy departments lead to more appropriate radiotherapy utilization rates for rural cancer services, while providing quality of care comparable to larger metropolitan centres.³⁸

The development of the SMUs led to substantial increases in demand for other cancer services within the local region, including increases in allied health referrals and significant increases in demand for chemotherapy. In addition, as patients from further afield were referred for radiotherapy, suitable patient and caregiver accommodation services were required. In most instances, pre-existing patient accommodation was not sufficient to meet the additional demand from the radiotherapy service. These broader impacts require consideration in the development of regional radiotherapy services.³⁸

To address the matter of quality of care delivered in SMUs, radiation oncologist clinical practice was externally audited using the Royal Australian and New Zealand College of Radiologists Peer Review Audit instrument. This tool splits RO clinical practice into documentation/quality assurance criteria and decision-making criteria. Over the four sites, 130 patients were randomly selected for audit. At hub sites, 79.6 % of all criteria audited were adequate, compared with 84.4 % of criteria audited at SMUs. This difference was largely because of better adherence to documentation/quality assurance criteria at the SMU sites. Radiation oncologist decision-making and protocol adherence were routinely very high and consistent with other clinical practice audits. There were no significant differences between hubs and SMUs for adherence to decision-making criteria; however, the few potential deficiencies in patient care identified occurred only at the hub sites. This audit found that SMUs provide as high a standard of radiotherapeutic care as larger hub departments. The findings also emphasize the need for all departments to target clinical documentation.³⁹

The evaluation of the trial indicated that radiotherapy services should initially be established with at least two bunkers to allow for service expansion over time, or capacity to ensure that expansion could occur. By the end of

the trial in 2008, each of the SMUs was anticipating expanding to two linear accelerators in the near future. The Trial Steering Committee noted that single machine services could be considered as interim stages in the development of larger services. This position supported the NSW service development position.¹

Single machine units face a number of potential problems.³⁸ These include the absence of back up equipment (for use in the event of machine breakdown), the potential difficulty in attracting and maintaining staff at smaller facilities, and more limited opportunities for practitioners to discuss cases with colleagues. The establishment of the SMUs in a hub and spoke arrangement with larger metropolitan radiotherapy services was designed to overcome or ameliorate these potential problems and maintain an appropriate quality of service. In addition to providing a back-up machine, the hub facility supports the SMU through providing a forum for the discussion of cases, relief staff and clinical and quality protocols to help ensure an effective high quality service.³⁸

Victoria's smaller size compared to other states, with few major regional towns more than a three hour drive from Melbourne, removes the obstacle of excessive distance for services operating as hub-spoke models. This improves the direct support capacity for regional radiotherapy services from hubs and provides a back-up for patients in the event of SMU breakdown. Contracted services, such as some equipment maintenance, with specialist support staff located in Melbourne are able to perform site visits to the SMUs within reasonable timeframes.³⁸

In 2011, a Radiotherapy Clinical Expert Panel⁴⁰ for Northwest Tasmania developed key principles for establishing a safe and sustainable regional radiotherapy service, based on published literature and consensus discussion. In summary, these principles were:⁴⁰

- Demand and capacity
 - Sufficient local need to justify costs; at minimum, 400 courses per year for reasons of economy and efficiency and to ensure economies of scale
 - Two bunker capacity even if only one linac is installed initially; linacs matched across networked sites
 - Enhanced local health service support (general and specialist surgical and medical services, nursing services, diagnostic services, allied health services, psychosocial support services) with the increasing caseload and complexity of cases treated locally with addition of RT
- Linkage
 - RT unit developed in conjunction and with strong operational link with a major established radiation oncology service; linkage into a networked arrangement with a service provider of sufficient size to support an outreach facility and with equal responsibility for patient outcomes held by both the metropolitan cancer centre and the networked regional service partner
 - Major established radiation oncology service to which unit is linked to have demonstrated capacity to sustain professional and service related linkages over long distances, experience in providing outreach services and sustaining collegial relationships by telemedicine and videoconference
- Operating principles
 - Service level agreements between networked centres regarding service provision and standards, responsibilities and costs, and other operational arrangements
 - Access to broader body of medical physics expertise for resolution of difficult or unusual physics problems and for cross checking of quality assurance
 - Detailed contingency plans in place for machine breakdown and patient transfer
 - Adequate staffing levels to support service capacity living; innovative approaches and incentives for recruitment and retention of staff
 - Adequate funding for travel and inter-centre links including IT linkages with system redundancy and communication technology to support videoconferencing and treatment planning
 - Adequate local resources to support administrative, staffing and technical requirements

- Provision of best practice care
 - Multidisciplinary care, including medical, allied health, palliative care, cancer imaging, pathology services
 - Working within capability of the local RT unit; patients requiring complex treatments and specialized care needs referred to major cancer centre
 - Detailed protocols to ensure standards of care
 - On-site patient accommodation and patient transport options for patients and caregivers who have to travel for treatment⁴⁰

6.5 Experience in Scotland

In 2005, the National Health Service in Scotland prepared a Radiotherapy Activity Plan³¹ for Scotland for the years 2011 to 2015. One component of this plan was to address the provision of radiotherapy services in the geographically remote Highland region of that country.

The Department of Clinical Oncology at Raigmore Hospital in Inverness was noted as being the smallest oncology department in the UK. The justification for such a department was identified as being mainly geographical, due to the Highland region being the most remote part of the UK with parts of it remote even from Inverness.

At that time, Raigmore Hospital had one modern linac as well as an older machine that was not expected to be replaced when it failed. Decommissioning of the older machine had been delayed to provide emergency back-up; however, the machine was nearly obsolete and the manufacturer had advised that spare parts were no longer available.

The 2011/2015 Plan³¹ recognized that the need for a continuing non-surgical oncology service in Highland was strongly supported in terms of both geography and political will, and that there may be a far reaching impact on the sustainability of other specialist services should this oncology service be withdrawn. Having a minimum of two compatible linacs was felt to be optimal so that a back-up service would be available if one machine broke down or needed servicing. The option of transferring patients to Aberdeen or Dundee in the event of machine failure was felt to present an unattractive option especially since many patients already travelled considerable distances to access Raigmore. Also, transferring a patient workload to another busy centre may result in prolonging treatment time and adversely impact the service provided in that area.

Inverness appeared to be the most reasonable option to ensure that patients in the Highlands were not disadvantaged. A second linac at the Inverness site would therefore provide an additional resource across the North of Scotland and ensure that the Highland service was sustained. Grampian, Highland and Island NHS Boards were projected to require, between them, one additional linear accelerator. Since the single machine at Inverness was felt to be vulnerable to disruption for patients in the event of machine failure, the view was that the additional machine might logically be placed there rather than in Aberdeen. On a population basis and with the current catchment area, however, the argument for a second machine was difficult to justify. The dilemma was that the configuration of workload at that time was insufficient to justify a second machine but, if Inverness were not sustained as a viable long term cancer centre, the distances that patients in the northwest of Scotland would have to travel for radiotherapy could be severely detrimental to their care. The travel times for patients in the north-west and Islands would be prohibitive if services were not available in Inverness.

The 2011/2015 Plan recommended that the Grampian, Highland and the Island Health Boards be formally advised to further develop their review of existing working practices and referral patterns to ensure the sustainability of radiotherapy services in particular and tertiary cancer services in general in Inverness, with a specific focus to provide appropriate capacity for patients across the North of Scotland regional cancer network area for the future. The planning model suggested that an additional machine would be required either in Aberdeen or Inverness but not both, and agreement needed to be reached between Grampian and Highland Health Boards as to the most

appropriate location for this as well as the patient areas that should go to each Centre regardless of Health Board boundaries.

In addition to addressing referral patterns and service areas, the Plan recommended that consideration be given to expanding the hostel capacity in Inverness to allow patients to come from further afield without requiring a hospital bed. It was noted that such accommodation was widely used and had been found in Scandinavia, for example, to show success.³¹

7.0 Workforce

7.1 Workforce Issues

Training

The Radiation Oncology Tripartite Committee in Australia, representing the three key professions: the Faculty of Radiation Oncology (FRO) and Royal Australian and New Zealand College of Radiologists (RANZCR); the Australian Institute of Radiography (AIR); and the Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) stated that concentration of radiation oncology workforce training in metropolitan centres potentially impacts the availability of workforce to staff regional cancer centres. It emphasized the importance of training being extended to rural and regional locations. However, this must be done in a sustainable and clinically appropriate way, so that patient care is not compromised and to ensure appropriate level of training and supervision.³

Retention

The Tripartite Committee stated that retention of a skilled workforce in regional and rural areas similarly requires a proactive approach and planning. Personal, professional and service-related considerations play a part. Its' consultation findings suggest that these considerations in radiation oncology include:³

- Level of workload
- Quality of service and the availability of modern techniques and technologies
- Incentivized payment structure for staff
- Access to and ability to participate in clinical trials and research
- Professional development opportunities (such as conference attendance)
- Career progression opportunities

Building a sustainable regional workforce in radiation oncology requires a calculated approach, which takes into account service expansion, current capacity to train new workforce and incorporates strategies to make regional facilities attractive places to.³

Need for Protected Time

The 2010 CAPCA cancer workforce scoping report⁴ stated that cancer control workers are stretched to the limit. Their regular working hours are consumed with the ever-increasing clinical demands from the growing number of patients and survivors. Protected time for workers has rapidly dwindled, if it exists at all. CAPCA states that this time is essential and must be consciously built back into the system. Protected time makes possible:⁴

- Ongoing training to learn new procedures and equipment
- Being a preceptor for students and on-the-job trainees
- Coaching, mentoring and supervision to develop administrative and managerial skills for tomorrow's leaders
- Ongoing and continuing education to keep up with new knowledge
- Participating in research projects to document better ways to provide cancer control services

- Making presentations and publishing leading practices
- Assessing and designing new processes that ensure effective quality control, effective job design and shift scheduling for cancer control medical and professional staff.

7.2 Radiation Oncologists

Supply of Radiation Oncologists

Discordance has been projected between the growth in demand for radiation therapy and growth in supply of radiation oncologists. Alignment of supply with demand had been noted as critically important to ensure that radiation therapy continues to be widely accessible with acceptable wait times for all patients with cancer.⁸

In the United States, the demand for radiation therapy is expected to increase by approximately 22 % over the next decade, whereas supply of radiation oncologists is expected to increase by only 2 %.⁸

Radiation Oncologist Workload

In England, the need to consider the full implications of increased complexity of radiotherapy planning has been documented, observing that new techniques including image modulated radiation therapy (IMRT) and Stereotactic Ablative Radiotherapy (SABR, also called Stereotactic Body Radiotherapy SBRT) demand additional clinical oncology input compared with conventional radiotherapy planning techniques (2 hours compared to 30 minutes). As well, there have been changes in technology that might enable both a more effective use of workforce and higher quality assurance, such as outlining tools, particularly for normal tissues and target volumes. One of the challenges to the implementation of new technologies is adequate time for Clinical Oncologists for radiotherapy planning and development in their job plans. The impact of all of these developments needs to be evaluated alongside patient pathways as part of national workforce planning mechanisms to enable the right investment in training provision to support local workforce development.²¹

Other aspects of clinical oncologist workload that are time consuming include the selection, assessment and consent of patients, many of whom have comorbidities and combined modality therapy, which has become standard in many curative treatments.²¹

Radiation Oncologist Staffing Formula

- The Australian Health Ministers' Advisory Council report¹ indicated that the maximum number of new patient referrals that each radiation oncologist can manage was 250 per year. Almost fifteen years later, the RANZCR also determined 250 new cases per year as the acceptable workload for a radiation oncologist.¹
- The International Atomic Energy Agency (IAEA)¹⁰ report recommended one radiation oncologist in chief per program, and one additional staff radiation oncologist for each 200-250 patients treated annually. No more than 25-30 patients should be under treatment by a single physician although higher numbers of predominantly palliative patients could be managed.¹⁰
- The IAEA report¹⁰ recommended 1 radiation oncologist per 100,000 persons, or, with increasing complexity, one per 80,000-100,000 persons
- The Royal Australia and New Zealand College of Radiologists recommended a planning ratio of 2 radiation oncologists per linear accelerator¹¹

7.3 Radiation Therapy Technicians

RTT Roles

The UK National Radiography Advisory Group recommended implementation of the four-tier career progression model for therapeutic radiographers to ensure that all workforce skills are utilized most effectively. The framework

proposed career progression levels including consultant radiographic practitioners, advanced practitioners, and assistant practitioners. Therapeutic radiographers can train to become supplementary prescribers, supporting their increasing role in radiotherapy treatment review and follow-up of patients.²¹

In Ontario, the Radiation Therapy Integrated Practice model⁴¹ was developed based on the philosophy that radiation therapists' clinical roles need to be integrated with other areas of expertise, such as research, education, leadership and informatics. As part of the model, effort was made to promote an interprofessional working approach with equal opportunities (including access to academic activities) for all three of the primary professions (radiation therapists, radiation oncologists, and medical physicists), reorganizing the operational program into 'super teams'. These are four anatomically defined site teams which consist of an equal number of members from each of the three main professional groups. It was expected that team members would integrate and work together in smaller groups in order to optimize services provided to patients by their particular team. Members were expected to innovate, problem solve, and implement evidence-based service improvements as a result of their collaborative work. Each super team has a team coordinator who combines clinical practice with day to day operational responsibilities.⁴¹

In discussing the practice model, it was noted that the evolution of clinical practice, specifically the implementation of high precision techniques such as Intensity Modulated Radiation, 3D planning, and Image Guided Treatment Delivery, has had a substantial impact on professional roles. Radiation therapists have become more autonomous in planning and delivering treatment due to the increased emphasis on precision and complexity. The multidisciplinary team-based approach was noted as having provided a workable platform for the evolution of roles requiring increased depth of specialized knowledge and the development of individual expertise. In addition, the team approach allowed radiation therapists to develop leadership skills by providing term assignments as leaders within defined areas of clinical expertise (planning, treatment, etc).⁴¹

The clinical practice role of the radiation therapists have been integrated with other areas of expertise to create a number of blended roles for radiation therapists. Integrating clinical practice with research activities into blended clinician researcher roles has allowed radiation therapists to become actively engaged in research and development that focuses on their practice (eg, developing and adopting new technology and techniques). Integrating clinical practice with education activities into blended clinician-educator roles has allowed staff to remain current by continuing to practice in their subject area. Integrated clinical practice/IT roles have helped to develop technology testing and implementation that is focused on safe clinical use. Working closely with radiation therapists or the multidisciplinary teams, radiation oncologists and medical physicists have a better understanding and appreciation of the abilities and contributions of radiation therapists.⁴¹

RTT Staffing Formula

The following guidelines have been documented in the literature regarding RTT staffing:

- 1.06 FTE RTT per linac hour (calculated at the level of a shift; 8.48 FTE per linac for 8 hour shift); assumes 1720 hours per year and an 8 hour working day for RTTs. This formula excludes kilovoltage and brachytherapy services (planning and treatment) as well as stereotactic radiosurgery/radiotherapy, total body irradiation, IMRT and pediatrics (planning only)¹
- A study of workforce supply and demand in Victoria, Australia, recommended a planning ratio of 10 radiation therapists per linear accelerator, with the understanding the RTTs, in conjunction with the Radiation Oncologists, are responsible for the design, accurate calculation and delivery of a prescribed radiation dose over a course of treatment to the patient.¹¹

7.4 Medical Physicists

Staffing ratios for medical physics in the literature varied widely from those based on the 2005 ESTRO-QUARTS recommendations^{12,5} of about 450-500 cases for medical physics FTE to those developed by Battista et al⁴² at 260 cases per medical physics FTE.

Battista et al⁴² stated that the rapid implementation of new technology along with a heightened awareness for patient-specific quality assurance and safety has escalated the workload per case considerably. In accordance with these findings, they updated the staffing algorithm based on a grid of FTE coefficients for each type of staff functioning as a team providing medical physics services in a radiation treatment program. The algorithm was tested with data from 32 centers across Canada and proved to be sensitive to local situations including clinical services, academic and training activities, and administration. Using the calculated full time equivalent (FTE) complement for a wide range of staff and cancer centers, they determined staffing ratios (treated cases per FTE) that could be used for large scale planning at provincial or national levels. They recommended the use of a detailed workload specific algorithm for local staff planning, while simple FTE caseload ratios may be used for larger-scale planning, observing that the ultimate goal of any staffing plan is to offer cancer patients state-of-the-art radiotherapy in a timely and safe manner.

Medical Physicist Role

The UK Institute of Physics and Engineering in Medicine (IPEM) states that the Medical Physicist Expert (MPE) should be available on site for at least part of the day, wherever radiotherapy is carried out. The first role of the MPE is to ensure the accurate calibration of the treatment equipment. This involves the establishment of the protocols for dosimetry within the centre and an active involvement in the process of definitive calibration of the equipment.⁴³

The MPE must be personally involved in the assessment of competence of staff carrying out calibrations, as the level of supervision required will depend on their individual competence. Calibration extends to the provision of beam data for all dose calculations. A MPE must supervise and take full responsibility for the measurement and analysis of these data.⁴³

The process of treatment planning is becoming increasingly complex. Ideally a Medical Physics Expert should have full responsibility for the scientific aspects of the treatment planning process including setting up protocols for standardized treatments. Input from a MPE is particularly important in the introduction of new equipment and techniques. A MPE must be closely involved in the establishment of all new techniques and with any deviation from standard practice, including when an individual patient treatment requires an unusual setup. Where functions are devolved to other staff groups it remains necessary for the MPE to provide appropriate supervision in order to be 'closely involved' in the treatment. Such supervision is best applied when physicists work alongside their radiographic and technical colleagues so that they fully understand the detail of the processes being applied.⁴³

Minimum Number of Medical Physicists / Satellites

IPEM recommended that there be at least two clinical scientists qualified as Medical Physics Experts (Radiotherapy) in each department, of whom one should be appointed at Consultant Clinical Scientist level, to be Head of and be professionally accountable for, the service.⁴³

For local circumstances such as multi-sited organizations, the IPEM has not given special consideration, stating that, in such arrangements, it may be appropriate to treat each site as an independent centre for staffing calculation purposes.⁴³

Medical Physics Staffing Formula

- In 2011, for large scale forecasting of human resource requirements, Battista et al⁴² in Canada recommended 260 treated cases per full time equivalent medical physicist. For centre specific human resource planning, they proposed a grid of coefficients addressing specific workload factors.
- The European Society for Therapeutic Radiology and Radiation Oncology (ESTRO) guidelines developed in 2005 suggested one physicist per 450-500 patients (or one per linear accelerator)¹
- The 2010 IAEA report referenced the ESTRO QUARTZ report of 2005^{12,5} in its recommendation of 1 medical physicist per 450-500 patients per year, or 1 per 180,000- 200,000 persons¹⁰
- In 2012, the Royal Australia and New Zealand College of Radiologists recommended a planning ratio of 2 medical physicists per linear accelerator¹¹

Medical Physicists and Clinical Trials

IPEM states that national and international trials involving radiotherapy require detailed implementation by a Medical Physics Expert and draw on the resources of the general radiotherapy staffing. For the initial set-up and maintenance of clinical trials, IPEM estimated that one full time equivalent staff member is required for every 8 clinical trials in which the radiotherapy centre participates. Centres need to carefully consider the staffing requirements for trials on an individual basis.⁴³

Battista et al Staffing Model

In Canada, in 2011, Battista et al⁴² calculated requirements for each medical physics department staffing type based on caseload, equipment inventory, quality assurance, educational programs and administration through a workload specific algorithm. For centre specific human resource planning, they proposed a grid of coefficients addressing specific workload factors for each staff group. For larger scale forecasting of human resource requirements, they proposed the following values:

- Medical Physicists: 260 cases per FTE
- Physics Assistants: 700 cases per FTE
- Dosimetrists: 300 cases per FTE
- Electronics Technologists: 600 cases per FTE
- Mechanical Technologists: 1200 cases per FTE
- Information Technology Specialists: 2000 cases per FTE

IAEA Staffing Model for Two Linac Unit

The International Atomic Energy Agency recommended staffing for a facility with two radiotherapy machines is shown in the table below. These human resources could treat on average about 1000 patients per year by extending operations to a minimum of 12 hours per day.¹⁰

Personnel requirements for clinical radiation therapy¹⁰

Category	Staffing
Radiation Oncologist in Chief	One per program
Staff Radiation Oncologist	One additional for each 200-250 patients treated annually. No more than 25-30 patients under treatment by a single physician. Higher numbers of predominantly palliative patients could be managed.
Radiation Physicist	One per centre for up to 400 patients annually. Additional in ratio of 1 per 400 patients treated annually
Treatment Planning Staff	
Dosimetrist or Physics Assistant	One per 300 patients treated annually

Category	Staffing
Mould Room Technician	One per 600 patients treated annually
Radiation Therapy Technologists (RTTs)	
Supervisor	One per centre
RTT	Two per megavoltage unit up to 25 patients treated daily per unit, 4 per megavoltage unit up to 50 patients
RTT Simulation	Two per every 500 patients simulated annually
RTT Brachytherapy	As needed
Nurse	One per centre for up to 300 patients treated annually and an additional one per 300 patients treated annually.
Social Worker	As needed to provide service
Dietitian	As needed to provide service
Physical Therapist	As needed to provide service
Maintenance Engineer / Electronics Technician	One per two megavoltage units or one megavoltage unit and a simulator if equipment is serviced in-house.

8.0 Equipment

8.1 Linear Accelerator Replacement

In England, the Department of Health recommended that linear accelerators should be replaced at ten years of age, stating that this timeframe is important to ensure appropriate radiotherapy capability and the latest techniques.²¹

8.2 Intensity-Modulated Radiation Therapy Availability

The Australian and New Zealand Tripartite Group stated that Intensity-Modulation Radiation Therapy (IMRT) should be available in all centres that offer radiation therapy including rural, metropolitan, and in both public and private facilities. All patients who have radiation therapy should have access to IMRT where clinically appropriate.³

8.3 Equipment at Devolved or Linked Units

Linear Accelerators

The three professional bodies involved in provision of radiotherapy services in England – The Royal College of Radiologists, Society and College of Radiographers and the Institute of Physics and Engineering in Medicine – stated that the linacs at a devolved or linked unit do not necessarily have to match those at the cancer centre. However, the benefits of matching equipment must be considered in the decision process for example:²⁷

- A possible reduction in linac and planning system model commissioning time
- The familiarity of equipment if staff are rotating between units
- Quality assurance / servicing protocols are already likely to be in place
- If treatment planning is carried out at the cancer centre for a linked unit, planners need to be familiar with a smaller range of linac characteristics
- Plans created for the linked unit will be valid for the cancer centre hub, enabling patient transfer in the case of breakdowns if necessary

Scanning Capability

The three professional bodies involved in provision of radiotherapy services in England stated that it was not necessary for radiotherapy scanning equipment in the linked unit to match that in the cancer centre; however, this

could result in problems in transferring complete plans. Therefore, if treatment planning is to be carried out at the linked unit, the group advised that there were distinct benefits of having matched equipment, including for training and for familiarity of use.²⁷

Even if treatment planning will not be carried out at the linked site, it was stated that there are benefits to having access to the cancer centre's treatment planning system to aid prompt assessment of treatment plan-related queries during treatment. In this case, if staff at the linked unit are not experienced in treatment planning, safeguards should be in place to ensure that an inexperienced user cannot inadvertently alter a treatment plan.²⁷

The benefit of a unit having its own CT simulation is that the department is essentially autonomous and patient travelling is minimized.²⁷

An alternative to having CT simulation equipment dedicated to the linked unit is to secure access to an existing diagnostic CT scanner for radiotherapy patients. In this case, issues that need to be considered include the need to upgrade the scanner to make it suitable for scanning patients for RT planning (with a flat top, lasers and any other essential requirements for RT planning). Links to the treatment planning system would need to be established. A dedicated therapeutic radiographer would also be required to be present.²⁷

9.0 Technology / Tele-oncology

9.1 England

The three professional bodies involved in provision of radiotherapy services in England – The Royal College of Radiologists, Society and College of Radiographers and the Institute of Physics and Engineering in Medicine – made the following observations regarding information technology:²⁷

RT Planning

- Given that information technology (IT) is an integral component of the functioning of a radiotherapy service, it is imperative that a lead IT professional is identified and involved from the onset of the project. This will enable correct procurement and implementation of IT systems and ensure that IT support staff have good understanding of the importance and intricacies of radiotherapy systems.²⁷

Host Hospital Considerations

- The radiotherapy service will need access to the acute hospital information technology systems for pathology and radiology results and the acute hospital patient electronic record.
- Access to the host hospital IT intranet will be essential for booking of hospital services.
- Compatibility issues between the IT systems in the radiotherapy unit and the host hospital which will require IT solutions can be anticipated.²⁷

IT Links

- Links to the relevant radiology and pathology services in the network, the cancer centre hub where applicable, and the local host hospital are essential.
- Even if treatment planning is not carried out on the new site, it is beneficial to have access to the treatment planning system at the main site from the devolved radiotherapy department to aid prompt assessment of treatment plan-related queries during treatment.²⁷

9.1 Australia

In Australia, limitations due to common problems in the past included unreliability of equipment and connections, negative opinions about the need for telemedicine, and instability of management structures in health care, with a high turnover of personnel. The new generation fast broadband technology and the gradual roll-out of the optic-fibre Australian National Broadband Network, capable of downloading up to 100 megabits per second depending on the available technology, was seen to open new horizons in telemedicine. The view was expressed that the

increasing complexity of information shared across cyberspace will transform case management of cancer in non-metropolitan areas, adding value to existing and future models of care.⁷

The Australian and New Zealand Tripartite Group also stated the belief that the use of technology to enable better communication and information transfer will intensify. Radiation oncology uses some of the most advanced information technology infrastructure in the healthcare system to support its data and imaging needs. The need to use telemedicine in patient management across Australia will increase dramatically as the number of cancer centres, particularly in regional areas, increases. With a mobile patient population, increasing numbers will present following initial treatment to a different radiotherapy centre and require re treatment with radiotherapy or develop a second malignancy requiring treatment with radiotherapy. Technological solutions to expedite the transfer the relevant imaging and previous radiotherapy treatment details to the treating radiotherapy centre will be important. The utilization of telemedicine in radiation oncology is expected to intensify due to the changes in service provision and models of care.³

9.2 Norway

The desire for access to advanced radiotherapy services close to home may appear to create conflicting interests. Satellite radiotherapy units have been established by larger cancer centers during the past decade. In rural areas, in countries like Norway, telemedicine provides an important role in breaking professional isolation within radiology and pathology. Treatment planning and verify-and-record solutions were reported to be mostly standardized in Norway in 2000. Together with a nationwide telemedicine network, this was seen as facilitating exchange of radiotherapy data also between larger cancer centers.⁴⁴

The most evident role for tele-radiology has been found to be in treatment planning and simulation in individual patients. Remote consultation may be of clinical importance in identifying and delineating cancerous tissue from CT, MR, ultrasound, and PET images. At smaller radiation therapy clinics, the required expertise may not be available, in which case, tele-radiology was presented as a helpful tool.⁴⁵

In 2001, the Norwegian Radium Hospital opened its first radiation therapy satellite unit at Kristiansand followed by a second one in 2002 at Gjøvik. Both satellite units are operated by the main centre, which also has the responsibility for the radiation therapy services. The staff at these units was employed by the main clinic. The satellite units were established to provide decentralized radiation therapy, primarily for palliative cancer care and standard curative radiation, such as breast cancer. Telemedicine services were established to maintain high clinical quality services at smaller radiation therapy units which cannot have the full range of clinical competence normally found at a comprehensive cancer centre.⁴⁵

Both radiation therapy satellite units and the main clinic were equipped with identical software solutions for maximum connectivity and uncomplicated communication and data transfer. Dedicated radiation therapy DICOM-databases were installed at both satellite units as well as the main clinic, and transfer of all radiation therapy data from the satellite units to the main clinic was performed daily. On a regular basis, tumor boards were held with the satellite unit staff involved. These sessions included discussions of treatment plan evaluation and follow up. Weekly educational sessions involved staff at both the satellite units and the main clinic.⁴⁵

Real-time consultations, for example, regarding delineation of cancerous tissue were rarely performed, not due to the lack of need, but rather due to time concern and barriers in using the new technology. Current state telemedicine in radiation therapy represents not primarily technological but socio-psychological challenges. Successful implementation of telemedicine in radiation therapy, for example, in distributed clinical services, requires more focus on educating and motivating the staff in utilizing the technology for changing working practice. This requires an altered mind set.⁴⁵

General lessons learned from the Norwegian experience were:⁴⁵

- The main problems for implementation of tele-radiology are not technological

- The most serious obstacles are socio-psychological challenges from the staff members involved
- Therefore, successful implementation of telemedicine requires more focus on educating and motivating the staff by, for example, educating staff in utilizing the technology prior to installation.
- Alter the mind set

Specific lessons learned were:⁴⁵

- To overcome problems with interoperability, the radiation therapy satellite units and the main clinic are equipped with identical software solutions for maximum connectivity and uncomplicated communication and data transfer
- For continuous safe data flow, transfer of all radiation therapy data from the satellite units to the main clinic is performed daily
- Weekly tumor board sessions are held with the satellite unit and main clinic staff including discussions of treatment plan evaluation and follow-up
- Educational sessions are held weekly with the staff at the satellite units and the main clinic
- Real-time consultations, regarding, for example, delineation of cancerous tissue, are rarely used. The reason for this can be time concerns or “mental barriers”

9.3 Switzerland

The Centre for Radiation Oncology at Kantonsspital Aarau (KSA) is one of the five top radiation oncology centres in Switzerland. It is the only radiation oncology centre in the Canton Aargau and serves not only a population of around 630,000 inhabitants of the Canton but also neighbouring Cantons and countries. The Centre has recently established a satellite radiation oncology centre at Kantonsspital Baden (KSB) within the Canton Aargau and proposes to link the centre with telemedicine network, especially designed for radiation oncology purposes. In the process of modernization, three new state-of-the-art radiotherapy units would be installed at KSA, while the fourth unit placed at KSB would be provided with the oncology information system (OIS) for patient scheduling, electronic patient record, DICOM imaging data and record and verify system and radiotherapy treatment planning system (TPS) from a common data centre.⁴⁶

Except for stereotactic treatments which will be offered only at KSA, patients will be able to obtain all other treatments at either location. The treatment planning for complex treatment plans (intensity modulated radiotherapy, volumetric modulated arc therapy, stereotactic body radiotherapy and stereotactic radiosurgery) will be performed centrally at KSA while simple treatment planning (2D, 3D) will be undertaken directly at the respective location at KSA or KSB. The location at KSB can thus be operated with reduced staff. Case discussions and presentations of treatment plans will be carried out daily between the two sites and also in interdisciplinary periodic virtual tumor boards via an online collaboration platform.⁴⁶

Both sites would work independently on a common infrastructure and all necessary data and applications for the radio-therapeutic treatment would be stored on centralized servers and made available at both locations in real-time. The hardware infrastructure would have at least two data centers in Switzerland, in order to guarantee data retention and data protection according to Swiss regulations. The network would enable sharing of infrastructure and the reduction of costs for both partners. Joint use of shared resources would lead to a reduction of capacity requirements, thereby reducing the overhead and costs of all cooperation partners compared to providing the full infrastructure for each site. This ensured increased service quality in terms of reliability and performance, as it would not be possible otherwise for smaller sites to realize this individually. In principle, a centralized hosting of dedicated software modules for radiation therapy centers at national or international level is possible. This is technically feasible with increasing number of participants; thereby the cost for each participant would reduce.⁴⁶

9.4 United States

In a pilot study at Memorial Sloan-Kettering Cancer Centre (MSKCC)⁴⁷ in the United States, an inexpensive, integrated telemedicine platform for radiation oncology was developed using a Microsoft-based operating system and basic video-conferencing software. This allowed for simultaneous display and review of radiology images, radiation treatment volumes and plans, and portal images by physicians at remote MSKCC sites. The platform enabled physicians and physicists to remotely discuss and interact with details of cases efficiently. After 3 months, physicians at two MSKCC sites were successfully able to implement the proposed telemedicine platform. A small sample of cases (prostate, breast, head and neck, and anal cases) were tested. Radiology images, radiation treatment volumes and plans, and portal images were reviewed. Side-by-side comparison of contouring techniques was performed. The platform allowed physicians to remotely review details of cases efficiently. The interactions of the telemedicine platform improved clinical understanding of each case and often resulted in contouring changes.⁴⁷

A planned expansion of the concept to develop a virtual tumor board for radiation oncologists, involving visual display of additional data portals including patient face photo, pathology, gross tumor images/photographs, and archived videos of procedures. The goal of the radiation oncology telemedicine platform was to foster a higher level of interaction and integrated care by physicians, physicists and staff at MSKCC and its regional sites. The authors felt confident that this platform would increase the level of oncologic care for patients, decrease medical errors, and improve clinical outcomes.⁴⁷

9.5 Three Levels of Applications

Three levels of telemedicine requirements and applications have been described in the literature as follows:⁴⁴

- Level 1: Video conferencing and display of radiotherapy images and dose plans
- Level 2: Replication of selected data from the radiotherapy database ± facilitating remote treatment planning and evaluation.
- Level 3: Real time, remote operations, e.g. target volume delineation and treatment planning performed by the team at the satellite unit under supervision and guidance from more experienced colleagues at the main clinic

A prerequisite for establishing satellite units has been stated to be an efficient and reliable system for communication between the main center and its satellites. Reliability includes the accessibility and up-time of the telemedicine network as well as fidelity of data transfer.⁴⁴

9.6 Three Tier Radiotherapy System with Tele Radiotherapy Network

At the 2014 International Conference on E-Health and Telemedicine, a three-tier system consisting of a primary, secondary and tertiary radiotherapy centre, linked with a tele radiotherapy network was described.⁴⁶

- A primary radiotherapy centre would have a radiotherapy unit and be able to deliver radiotherapy. Treatment planning and simulation would be carried out at the next higher level centre. This primary centre would be located close to the patient's home, which would save patients and families both money and time. The primary centre would be the focal point for cancer prevention and education programs.
- A secondary radiotherapy centre would provide radiotherapy, brachytherapy, and treatment planning system. It would carry out the simulation and treatment planning for patients referred from the primary centre who would then be sent back to the primary centre for radiation treatment. Brachytherapy for common cancers could be provided by the secondary centre, or referred to the next higher centre. In clinical situations, where the secondary centre feels that the patient needs an advanced radiotherapy treatment facility not possible at the secondary centre for either part or the entire treatment, these could be referred to the tertiary radiotherapy centre.

- The tertiary radiotherapy centre would be a centre of excellence having state-of-the-art technology namely – 3D conformal, intensity modulated radiotherapy, stereotactic radiotherapy, stereotactic radiosurgery, and advanced brachytherapy techniques. The tertiary centre could be located at a tertiary care teaching hospital with proper infrastructure and also support services. The tertiary centre would also be involved in formulating various research protocols and trials, both clinical and translational, based on the needs and problems of the particular geographical area.
- The primary, secondary and tertiary centres would be linked through a tele-radiotherapy network: All the three level radiotherapy centres could be integrated to facilitate the clinical, teaching, quality assurance and research activities of these centres. Since in radiotherapy most of the images are compatible with Digital Imaging and Communications in Medicine (DICOM), its radiotherapy extension (DICOM-RT) and HL-7 (Health Level-7), effective exchanges between these centres could be seamlessly integrated through the network. The other telemedicine activities like tele-pathology, tele-radiology, tele-consultation (with multidisciplinary tumour boards) and tele-education through a virtual class room concept could be included as well to create an integrated tele-oncology network. The tertiary radiotherapy centre could be considered as the primary hub and terminals at the primary and secondary radiotherapy centres could constitute the secondary hubs linked through either Integrated Services Digital Network (ISDN) or satellite or cloud computing. For health providers, reduction of operating costs could be achieved through centralization and optimization of resources, reduction in cost of training and updating skills of the technical staff and physicians without any travel and absence from their place of work.

10.0 Research

In its strategic plan for radiation oncology, the Tripartite Group in Australia and New Zealand made the following statements regarding planning for research in all radiotherapy infrastructure, at the jurisdiction, state and national levels:³

- Dedicated radiation oncology research equipment and staff time are included into national service planning:
 - Infrastructure planning at jurisdiction, state, and national level needs to accommodate research requirements
- Access to clinical radiation oncology equipment time for (translational and implementation) research is factored into facility service planning:
 - Facility planning needs to accommodate research requirements including discovery, translational and implementation research
- Research is recognized as part of core business for all radiotherapy facilities:
 - The importance of research positions needs to be recognised:
 - research career path must be developed
 - radiation oncology services should support research activities within their facilities
 - Programs should be developed (if not yet in place) that combine professional with academic (doctoral or masters) qualifications
 - Mentorship programs must be introduced to link experienced researchers with early career professionals
 - The ethics and governance approval process needs to be streamlined to enable efficient collaboration
 - Professions must build ethics and governance literacy amongst their members
 - It is essential that healthcare consumers are involved in the development of trials and represented on decision-making bodies

11.0 Governance

The three professional bodies involved in provision of radiotherapy services in England – The Royal College of Radiologists, Society and College of Radiographers and the Institute of Physics and Engineering in Medicine – stated that, for a clinically safe and effective organization to provide radiotherapy service, it is essential to put in place the following:²⁷

- Clear professional leadership, with a lead therapeutic radiographer managing radiotherapy services, a lead medical physics expert and a lead clinical oncologist
- Comprehensive Ionizing Radiation (Medical Exposure) Regulations 2000 (IR(ME)R) documentation for the new service
- A quality management system, with a process for QA in radiotherapy
- A system for reporting radiotherapy errors and near misses and analysis in line with best practice
- A consistent approach to patient care so that a high level of clinical service is maintained
- Structures and systems to support the continuing education and development of the workforce to meet changing service need

Further, the group recommended that, if a devolved radiotherapy unit is established with links to a cancer centre, there should be a single management structure with integration of the developed radiotherapy service. This will facilitate establishment of the essential governance structures.²⁷

12.0 Quality Management

Quality assurance in radiation therapy is defined by the World Health Organization (WHO) as, ‘all procedures that ensure consistency of the medical prescription, and safe fulfillment of that prescription, as regards to the dose to the target volume, together with minimal dose to normal tissue, minimal exposure of personnel and adequate patient monitoring aimed at determining the end result of treatment’.⁴⁸

The Canadian Partnership for Quality Radiotherapy (CPQR), in its quality assurance guidelines, stated that a quality assurance program must address all aspects of the timely delivery of radiation treatment, including programmatic organization, the qualifications of the personnel involved in radiation treatment, the performance of the planning and treatment equipment, policies and procedures, incident monitoring, and reporting.⁴⁸

In England, the three professional bodies involved in provision of radiotherapy services in England advised as follows regarding quality management for linked RT units:²⁷

- The new radiotherapy service must have an externally audited quality management system in place with clear quality assurance radiotherapy documentation.
- For linked units, it is essential that such documentation is easily accessible across all sites, preferably by information technology systems. The documentation should be consistent across all sites and provide essential site-specific documentation. Time should be allocated to this task to ensure that high standards are maintained, that the documents reflect up to date practice across linked sites, and that the advice contained in them is applicable to all sites.
- A system for radiotherapy adverse event reporting, with reporting of radiotherapy errors and near misses, and analysis should be in place.
- For linked units, the same reporting system as that used in the cancer centre hub should operate, with a shared review process for adverse incidents. Incidents from all sites should be shared to identify trends and to learn from issues that occur.²⁷

13.0 Project Methods

13.1 Search Methodology

Comprehensive search strategies were developed by an information specialist (TD) using a combination of subject headings and keywords and adapted for 4 electronic bibliographic databases. Searches were conducted in the following electronic databases: Ovid MEDLINE 1946 to current (June 24, 2014), Ovid MEDLINE In-Process & Other Non-Indexed Citations (June 23, 2014), CINAHL (EBSCOhost, 1937 to June 2014), Business Source Complete (EBSCOhost, 1886 to June 2014)

For the search strategies, a combination of subject headings and keywords were developed for each electronic resource including the following terms: neoplasms, cancer, tumor, tumour, malignancy, carcinoma, lymphoma, leukemia, leukaemia, myeloma, patient care, aftercare, ambulatory care, long-term care, palliative care, terminal care, hospice care, time-to-treatment, radiotherapy, continuity of patient care, patient care management, patient-centered care, medical oncology, radiation oncology, oncology nursing, patient(s), end-of-life, survivor, survival, health facilities, academic medical centers, ambulatory care facilities, health facility administration, hospitals, oncology service, cancer care facilities, health services, community health services, home care services, rural health services, health services accessibility, delivery of health care, distance, travel, geospatial, geographical, small, remote, rural isolated, satellite, and health planning.

The search was limited to English and covered 2009 to June 25, 2014. The search was not limited by study design or publication status.

Grey literature was searched for radiation oncology and radiation therapy service delivery and relevant material. Additional articles were found through the search technique of pearl growing or snowballing in the review of the reference lists of included articles.

References were managed using Reference Manager, Version 11 bibliographic software (Thomson ISI ResearchSoft, Carlsbad, CA).

13.2 Study Selection

Electronic search strategies are presented in Appendix 1.

An article flow chart is presented in Appendix 2.

A two-step process was used for article screening. First, one reviewer (TD) screened the titles and abstracts (when available) to determine if an article met the general inclusion criteria.

General inclusion criteria included any aspect of radiation therapy or radiation oncology service delivery including models and guidelines (nonclinical), administration, administrative guidance, oversight, trends, geographic distribution, technology (diagnostic or treatment), and staffing and personnel.

Each article that was determined to be either unclear or included by TD, was then further screened by a second reviewer (JA). Full text of articles that were screened as included or unclear by JA were retrieved for formal review.

14.0 Conclusions

Through review of both published and grey literature, this report has presented a summary of information regarding radiation therapy service delivery both nationally and internationally. Literature reviewed has been selected because of their perceived relevance to radiation therapy service planning in Newfoundland and Labrador.

The amount of literature able to be reviewed has been limited by time available related to completion of the NL Provincial Radiation Therapy Service Plan. While not an exhaustive search, the intent of the review has been to inform the planning work with recent experience, concepts and parameters related to radiation therapy service delivery with particular attention to provision of RT services to small, geographically dispersed populations.

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Abbreviations & Definitions

ACPSEM	Australasian College of Physical Scientists and Engineers
AIR	Australian Institute of Radiography
ASARA	As short as reasonably achievable
CAPCA	Canadian Association of Provincial Cancer Agencies
Course	A series of radiation treatments (i.e., fractions) prescribed and delivered to a patient for a specific diagnosis and presentation <ul style="list-style-type: none"> • New Course - The first course of radiation treatment delivered to a patient for a single diagnosis • Retreat Course - The second and subsequent course(s) of radiation treatment delivered to a patient for a single diagnosis
CPAC	Canadian Partnership Against Cancer
CPQR	Canadian Partnership for Quality Radiotherapy
ESTRO	European Society of Radiotherapy and Oncology
FRO	Faculty of Radiation Oncology
FTE	Full time equivalent
IAEA	International Atomic Energy Agency
IGRT	Image Guided Radiotherapy
IGRT:	Any imaging at pretreatment and delivery, the result of which is acted upon, that improves or verifies the accuracy of radiotherapy.
Intensity Modulated Radiotherapy:	IMRT is a high precision form of radiotherapy. It enables the shape and dose of the radiation to conform precisely to the volume of tumour tissue that needs to be treated.
IMRT	Intensity Modulated Radiotherapy
IPEM	Institute of Physics and Engineering in Medicine
MPE	Medical Physicist Expert
NRAG	National Radiotherapy Advisory Group
Radiation Treatment Program:	The personnel, equipment, information systems, policies and procedures, and activities required for the safe delivery of radiation treatment according to evidence-based and/or best practice guidelines
Radiotherapy Utilization Rate:	The proportion of a specific population of patients with cancer that receives at least one course of radiotherapy during their lifetime, calculated as the number of patients treated with radiotherapy for the first time divided by the total number of new cases
RANZCR	Royal Australian and New Zealand College of Radiologists
RT	Radiation therapy or radiotherapy
RTT	Radiation Therapy Technician
RUR	Radiotherapy Utilization Rate
SABR	Stereotactic Ablative Radiotherapy, also called SBRT (Stereotactic Body Radiotherapy)
SBRT	Stereotactic Body Radiotherapy, also called SABR (Stereotactic Ablative Radiotherapy)
WHO	World Health Organization

Appendices

Appendix 1: Electronic Search Strategies

Topic: A literature review of radiation therapy (RT) service delivery models.

Databases: MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, CINAHL, Business Source Complete

Limits: 2009-current (June 2014) (last 5 years)

Language: English

Study design/publication type: no limits

Search Summary

Database	Results	Duplicates between databases removed (de-duped)
MEDLINE	804	801
MEDLINE In-Process & Other Non-Indexed Citations	126	126
CINAHL	608	396
Business Source Complete	108	98
TOTALS	1520	1421

Search Strategies

Ovid MEDLINE 1946 to present, Ovid MEDLINE In-Process & Other Non-Indexed Citations, June 23, 2014

Version: OvidSP_UI03.12.00.116, SourceID 60384

Search date: 24.06.2014

Limits: 2009-current, English

Results: MEDLINE: 804 De-duped: MEDLINE: 678

 In-Process: 126 In-Process: 126

1. exp Neoplasms/ep, rt, sn, sd, th [Epidemiology, Radiotherapy, Statistics & Numerical Data, Supply & Distribution, Therapy]
2. (cancer\$ or tumor\$ or tumour\$ or neoplas\$ or malignan\$ or carcinoma\$ or lymphoma\$ or leukemia\$ or leukaemia\$ or myeloma\$).tw.
3. or/1,2
4. Patient Care/mt, st, sn, td, ut
5. Aftercare/ma, mt, og, st, sn, sd, td, ut
6. Ambulatory Care/ma, mt, og, st, sn, sd, td, ut
7. Long-Term Care/ma, mt, og, st, sn, sd, td, ut
8. Palliative Care/ma, mt, og, st, sn, td, ut
9. Terminal Care/ma, mt, og, st, sn, td, ut
10. Hospice Care/ma, mt, og, st, sn, td, ut
11. Time-to-Treatment/og, st, sn, td, ut
12. exp Radiotherapy/ma, mt, st, sn, sd, td, ut
13. "Continuity of Patient Care"/og, st, sn, td
14. Patient Care Management/mt, og, st, sn, td, ut
15. Patient-Centered Care/ma, mt, og, st, sn, td, ut
16. Medical Oncology/ma, mt, og, st, sn, td, ut
17. Radiation Oncology/ma, mt, og, st, sn, td

18. Oncology Nursing/ma, mt, og, st, sn, td
19. ((patient or after or followup or follow-up or ambulatory or long-term or palliative or terminal or hospice or end-of-life or continuity or survivo\$) adj2 care).tw.
20. or/3-19
21. Health Facilities/ma, mt, st, sn, sd, td, ut
22. exp Academic Medical Centers/ma, mt, og, st, sn, sd, td, ut
23. exp Ambulatory Care Facilities/ma, mt, og, st, sn, sd, td, ut
24. exp Health Facility Administration/ma, mt, st, sn, td
25. exp Hospitals/ma, st, sn, sd, td, ut
26. Hospitals, Animal/
27. 25 not 26
28. *Oncology Service, Hospital/og, st, sn, td, ut
29. Cancer Care Facilities/
30. or/21-24,27-29
31. Health Services/ma, mt, st, sn, sd, td, ut
32. Community Health Services/ma, mt, og, st, sn, sd, td, ut
33. Home Care Services/ma, mt, og, st, sn, sd, td, ut
34. exp Rural Health Services/ma, og, st, sn, sd, td, ut
35. ((cancer or rural) adj2 (hospital\$ or unit? or servic\$ or facilit\$ or centre? or center?)).tw.
36. ((health or homecare or "home care" or "community health") adj2 (unit? or servic\$ or facilit\$ or centre? or center?)).tw.
37. or/31-36
38. Health Services Accessibility/og, st, sn, td, ut
39. *"Delivery of Health Care"/mt, og, st, sn, sd, td, ut
40. *"Delivery of Health Care, Integrated"/ma, mt, og, st, sn, td, ut
41. ((access\$ or delivery or utilization) adj2 (care or service?)).tw.
42. ((service or care) adj2 (delivery or system?)).tw.
43. (distance or travel or geospatial or geo-spatial or geographical).tw.
44. ((small or remote or rural or isolated or satellite) adj2 communit\$).mp.
45. or/38-44
46. or/20,30,37,45
47. Program Development/mt, st, sn
48. exp *Health Planning/ma, mt, og, st, sn, sd, td, ut
49. ((cancer or service or care) adj2 plan\$).tw.
50. or/47-49
51. and/3,46,50
52. limit 51 to last 5 years
53. limit 52 to english language
54. remove duplicates from 53

Sub-headings:

ma	manpower	sn	statistics and numerical data
mt	methods	sd	supply & distribution
og	organization & administration	td	trends
st	standards	ut	utilization

CINAHL Plus with Full Text (Cumulative Index to Nursing and Allied Health Literature)

Interface - EBSCOhost Research Databases

Search Mode – Boolean/Phrase

Search date: 25.06.2014

Limits: 2009-current, English

Results: 608 De-duped: 608

#	Query
S23	S3 AND S21 AND S22
S22	S7 OR S12 OR S18
S21	S19 OR S20
S20	(TI cancer N2 plan* or service N2 plan* or care N2 plan* OR service N2 model*) OR (AB cancer N2 plan* or service N2 plan* or care N2 plan* OR service N2 model*)
S19	(MH "Program Development+/AM/MA/MT/ST/SN/TD/UT")
S18	S13 OR S14 OR S15 OR S16 OR S17
S17	(TI small N2 communit* or remote N2 communit* or rural N2 communit* or isolated N2 communit* or satellite N2 communit*) OR (AB small N2 communit* or remote N2 communit* or rural N2 communit* or isolated N2 communit* or satellite N2 communit*)
S16	(TI distance or travel or geospatial or geo-spatial or geographical) OR (AB distance or travel or geospatial or geo-spatial or geographical)
S15	(TI service W2 delivery or service W2 system? or care W2 delivery or care W2 system? OR service W2 model*) OR (AB service W2 delivery or service W2 system? or care W2 delivery or care W2 system? OR service W2 model*)
S14	(TI access* N2 care or delivery N2 care or utiliz* N2 care or access* N2 service? or delivery N2 service? or utiliz* N2 service?) OR (AB access* N2 care or delivery N2 care or utiliz* N2 care or access* N2 service? or delivery N2 service? or utiliz* N2 service?)
S13	(MH "Health Services Accessibility/AM/MA/MT/ST/SN/TD/UT") OR (MH "Health Care Delivery/AM/MA/MT/ST/SN/TD/UT") OR (MH "Health Care Delivery, Integrated/AM/MA/MT/ST/SN/TD/UT")
S12	S8 OR S9 OR S10 OR S11
S11	(TI health W2 unit? or health W2 servic* or health W2 facilit* or health W2 centre? health W2 center? or community W2 unit? or community W2 servic* or community W2 facilit or community W2 centre? or community W2 center? or homecare W2 unit? or homecare W2 servic* or homecare W2 facilit* or homecare W2 centre? or homecare W2 center?) OR (AB health W2 unit? or health W2 servic* or health W2 facilit* or health W2 centre? health W2 center? or community W2 unit? or community W2 servic* or community W2 facilit or community W2 centre? or community W2 center? or homecare W2 unit? or homecare W2 servic* or homecare W2 facilit* or homecare W2 centre? or homecare W2 center?)
S10	(TI cancer W2 hospital* or cancer W2 unit? or cancer W2 servic* or cancer W2 facilit* or cancer W2 centre? or cancer W2 center? or rural W2 hospital* or rural W2 unit? or rural W2 servic* or rural W2 facilit* or rural W2 centre? or rural W2 center?) OR (AB cancer W2 hospital* or cancer W2 unit? or cancer W2 servic* or cancer W2 facilit* or cancer W2 centre? or cancer W2 center? or rural W2 hospital* or rural W2 unit? or rural W2 servic* or rural W2 facilit* or rural W2 centre? or rural W2 center?)
S9	(MH "Health Services+/AM/MA/MT/ST/SN/TD/UT") OR (MH "Rural Health Services/AM/MA/MT/ST/SN/TD/UT") OR (MH "Home Health Care/AM/MA/MT/ST/SN/TD/UT")
S8	(MH "Health Facilities") OR (MH "Academic Medical Centers/MA/MT/ST/SN/TD/UT") OR (MH "Ambulatory Care Facilities/AM/MA/MT/ST/TD/UT") OR (MH "Pain Clinics/AM/MA/MT/ST/SN/TD/UT") OR (MH "Community Health Centers/AM/MA/MT/SN/ST/TD/UT") OR (MH "Outpatient Service/AM/MA/MT/ST/SN/TD/UT") OR (MH "Home Health Agencies/AM/MA/MT/ST/SN/TD/UT") OR (MH "Oncology Care Units") OR (MH "Hospitals+/AM/MA/MT/ST/SN/TD/UT") OR (MH "Health Facility

#	Query
	Administration") OR (MH "Health Services Administration+/AM/MA/MT/ST/SN/TD/UT")
S7	S4 OR S5 OR S6
S6	patient W2 care or after W2 care or followup W2 care or follow-up W2 care or ambulatory W2 care or long-term W2 care or palliative W2 care or terminal W2 care or hospice W2 care or end-of-life W2 care or continuity W2 care or survivo* W2 care
S5	(MH "Oncologic Nursing+") OR (MH "Radiation Oncology/ES/MA/MT/ST/SN/TD/UT") OR (MH "Oncology/MA/MT/ST/SN/TD/UT") OR (MH "Cancer Survivors/SN")
S4	(MH "Patient Care/AM/ES/MA/MT/ST/SN/TD/UT") OR (MH "Continuity of Patient Care+/AM/MA/MT/ST/SN/TD/UT") OR (MH "Patient Centered Care/AM/MA/MT/ST/SN/TD/UT") OR (MH "Oncologic Care/ES/MT/ST/SN/TD/UT/PF") OR (MH "Palliative Care/ES/MT/ST/SN/TD/UT") OR (MH "Terminal Care/ES/MT/ST/SN/TD/UT") OR (MH "Hospice Care/MT/ES/ST/SN/TD/UT") OR (MH "After Care/ES/MT/ST/SN/TD/UT") OR (MH "Radiotherapy+/ES/MT/ST/SN/TD/UT") OR (MH "Treatment Delay/EP/MT/ST/SN/TD/UT") OR (MH "Long Term Care/ES/MT/ST/SN/TD/UT") OR (MH "Ambulatory Care/ES/MT/ST/SN/TD/UT")
S3	S1 OR S2
S2	(TI cancer* or tumor* or tumour* or neoplas* or malignan* or carcinoma* or lymphoma* or leukemia* or leukaemia* or myeloma*) OR (AB cancer* or tumor* or tumour* or neoplas* or malignan* or carcinoma* or lymphoma* or leukemia* or leukaemia* or myeloma*)
S1	(MH "Neoplasms+/EP/RT/TH/TD")

Business Source Complete

Interface - EBSCOhost Research Databases

Search Mode – Boolean/Phrase

Search date: 25.06.2014

Limits: 2009-current, English

Results: 108 De-duped: 108

#	Query
S13	S1 AND S11 AND S12
S12	S2 OR S5 OR S10
S11	(TI cancer N2 plan* or service N2 plan* or care N2 plan* OR service N2 model*) OR (AB cancer N2 plan* or service N2 plan* or care N2 plan* OR service N2 model*)
S10	S6 OR S7 OR S8 OR S9
S9	(TI small N2 communit* or remote N2 communit* or rural N2 communit* or isolated N2 communit* or satellite N2 communit*) OR (AB small N2 communit* or remote N2 communit* or rural N2 communit* or isolated N2 communit* or satellite N2 communit*)
S8	(TI distance or travel or geospatial or geo-spatial or geographical) OR (AB distance or travel or geospatial or geo-spatial or geographical)
S7	(TI service W2 delivery or service W2 system? or care W2 delivery or care W2 system? OR service W2 model*) OR (AB service W2 delivery or service W2 system? or care W2 delivery or care W2 system? OR service W2 model*)
S6	(TI access* N2 care or delivery N2 care or utiliz* N2 care or access* N2 service? or delivery N2 service? or utiliz* N2 service?) OR (AB access* N2 care or delivery N2 care or utiliz* N2 care or access* N2 service? or)

#	Query
	delivery N2 service? or utiliz* N2 service?)
S5	S3 OR S4
S4	(TI health W2 unit? or health W2 servic* or health W2 facilit* or health W2 centre? health W2 center? or community W2 unit? or community W2 servic* or community W2 facilit or community W2 centre? or community W2 center? or homecare W2 unit? or homecare W2 servic* or homecare W2 facilit* or homecare W2 centre? or homecare W2 center?) OR (AB health W2 unit? or health W2 servic* or health W2 facilit* or health W2 centre? health W2 center? or community W2 unit? or community W2 servic* or community W2 facilit or community W2 centre? or community W2 center? or homecare W2 unit? or homecare W2 servic* or homecare W2 facilit* or homecare W2 centre? or homecare W2 center?)
S3	(TI cancer W2 hospital* or cancer W2 unit? or cancer W2 servic* or cancer W2 facilit* or cancer W2 centre? or cancer W2 center? or rural W2 hospital* or rural W2 unit? or rural W2 servic* or rural W2 facilit* or rural W2 centre? or rural W2 center?) OR (AB cancer W2 hospital* or cancer W2 unit? or cancer W2 servic* or cancer W2 facilit* or cancer W2 centre? or cancer W2 center? or rural W2 hospital* or rural W2 unit? or rural W2 servic* or rural W2 facilit* or rural W2 centre? or rural W2 center?)
S2	patient W2 care or after W2 care or followup W2 care or follow-up W2 care or ambulatory W2 care or long-term W2 care or palliative W2 care or terminal W2 care or hospice W2 care or end-of-life W2 care or continuity W2 care or survivo* W2 care
S1	(TI cancer* or tumor* or tumour* or neoplas* or malignan* or carcinoma* or lymphoma* or leukemia* or leukaemia* or myeloma*) OR (AB cancer* or tumor* or tumour* or neoplas* or malignan* or carcinoma* or lymphoma* or leukemia* or leukaemia* or myeloma*)

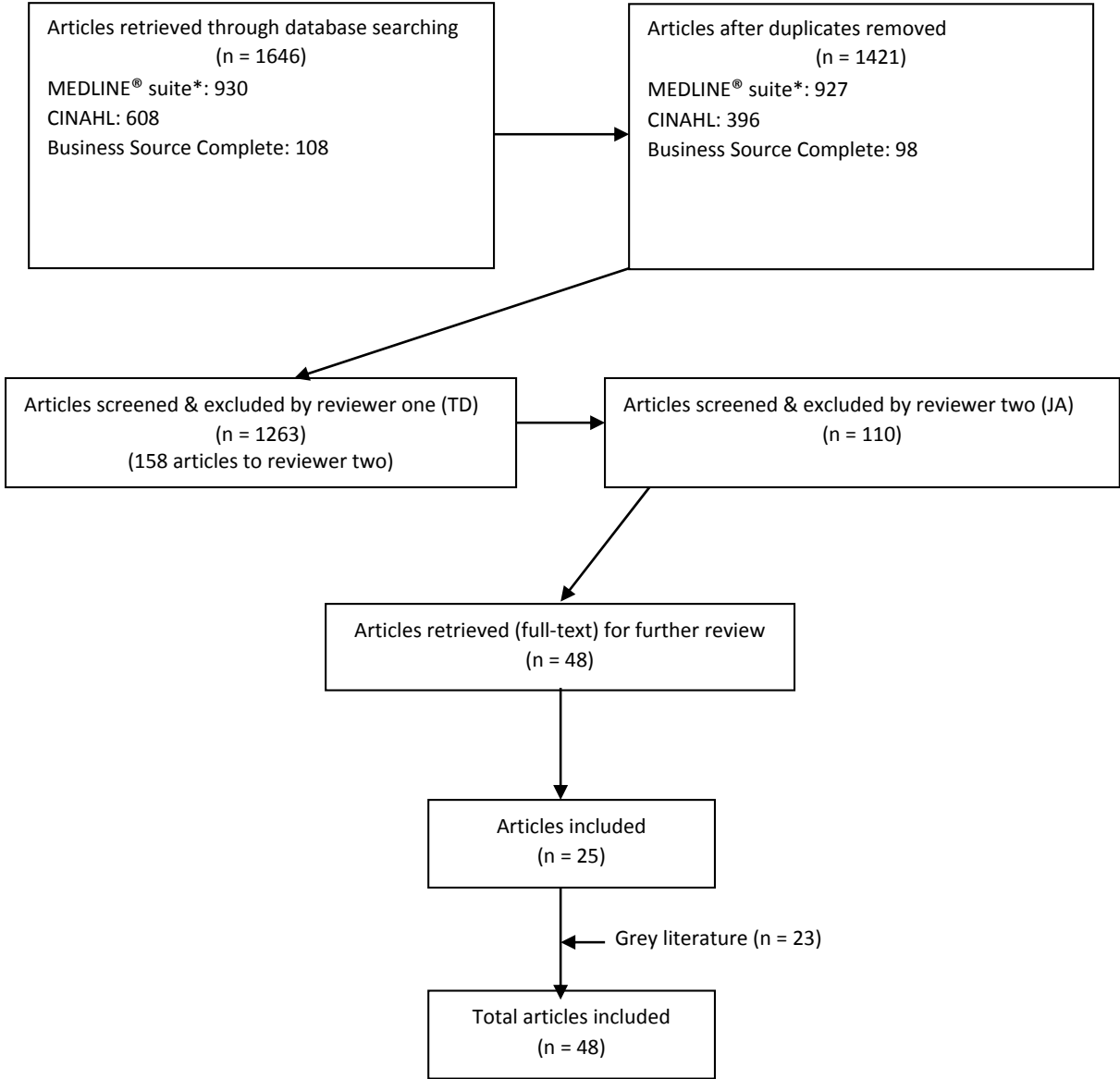
Grey Literature Search

Table: Summary Grey Literature Websites Searched

Website	URL
American Society for Radiation Oncology (ASTRO)	https://www.astro.org/
Australian Government Department of Health	http://www.health.gov.au/
Canadian Association of Medical Physicists – Organisation canadienne des physiciens médicaux (COMP-OCMP)	https://www.medphys.ca/
Canadian Association of Medical Radiation Technologists (CAMRT)	http://www.camrt.ca/
Canadian Association of Radiation Oncology – Association canadienne de radio-oncologie (CARO-ACRO)	http://www.caro-acro.ca/
<i>Canadian Partnership Against Cancer</i> (CPAC)	http://www.partnershipagaincancer.ca/
Canadian Partnership for Quality Radiotherapy – Partenariat canadien pour la qualité en radiothérapie (CPQR - PCQR)	http://www.cpqr.ca/
Cancerview.ca	http://www.cancerview.ca
European Partnership for Action Against Cancer (EPAAC)	http://www.epaac.eu/
European Society for Radiology & Oncology (ESTRO)	http://www.estro.org/
Royal Australian and New Zealand College of Radiologists (RANZCR)	http://www.ranzcr.edu.au/

Appendix 2: Article Flow Chart

Article Flow Chart – Radiation Therapy (RT) Service Delivery Literature Review



*MEDLINE® suite: MEDLINE® and MEDLINE® In-Process & Other Non-Indexed Citations

Appendix E: NL Demographic Detail

Appendix E1: Service Area & Population Projections Detail

Source: Newfoundland/Labrador Department of Finance Economic Research and Analysis Division Population Projections updated April 2014

Current and projection population of the four Health Regions:

NL RHA	2014	2026	Change 2014 to 2016
Central	93,750	86,684	-7.5%
Eastern	316,930	322,702	1.8%
Labrador/Grenfell	37,836	38,246	1.1%
Western	78,157	75,245	-3.7%
Total	526,673	522,877	-0.7%

2014 population distribution by Health Region

	2014 population proportion by RHA
Central Health	18%
Eastern Health	60%
Labrador/Grenfell Health	7%
Western Health	15%

Proportion of Population Aged 70 Years and Over

	70+ Age Group as Percentage of Total Population	
	2014	2026
Central	14%	23%
Eastern	10%	17%
Labrador Grenfell	7%	12%
Western	13%	22%
All	11%	18%

Central Health

Year	Age	0-19	20 – 49	50 - 69	70+	Total
2014	Male	8908	15244	16023	6049	46224
	Female	8393	15851	16202	7080	47526
	TOTAL	17301	31095	32225	13129	93750
2026	Male	7252	10280	15021	9202	41755
	Female	6758	11584	15596	10991	44929
	TOTAL	14010	21864	30617	20193	86684

Age Group	Percentage of Total Population		Population Percentage Change
	2014	2026	2014 to 2026
0-19	18%	16%	-19%
20-49	33%	25%	-30%
50-69	34%	35%	-5%
70+	14%	23%	54%
TOTAL	100%	100%	-8%

Eastern Health

Year	Age	0-19	20 - 49	50 - 69	70+	Total
2014	Male	32443	63364	45531	14159	155497
	Female	30973	64838	47056	18566	161433
	TOTAL	63416	128202	92587	32725	316930
2026	Male	31590	55597	44521	24285	155993
	Female	30792	58056	47084	30777	166709
	TOTAL	62382	113653	91605	55062	322702

Age Group	Percentage of Total Population		Population Percentage Change
	2014	2026	2014 to 2026
0-19	20%	19%	-2%
20-49	40%	35%	-11%
50-69	29%	28%	-1%
70+	10%	17%	68%
TOTAL	100%	100%	2%

Labrador Grenfell Health

Year	Age	0-19	20 - 49	50 - 69	70+	Total
2014	Male	4621	8187	5083	1350	19241
	Female	4271	7996	4907	1421	18595
	TOTAL	8892	16183	9990	2771	37836
2026	Male	4536	7264	5558	2079	19437
	Female	4131	6928	5407	2343	18809
	TOTAL	8667	14192	10965	4422	38246

Age Group	Percentage of Total Population		Population Percentage Change
	2014	2026	2014 to 2026

Age Group	Percentage of Total Population		Population Percentage Change 2014 to 2026
	2014	2026	
0-19	24%	23%	-3%
20-49	43%	37%	-12%
50-69	26%	29%	10%
70+	7%	12%	60%
TOTAL	100%	100%	1%

Western Health

Year	Age	0-19	20 - 49	50 - 69	70+	Total
2014	Male	7368	12791	13356	4684	38199
	Female	7202	13806	13265	5685	39958
	TOTAL	14570	26597	26621	10369	78157
2026	Male	6654	9987	12135	7402	36178
	Female	6597	11190	12366	8914	39067
	TOTAL	13251	21177	24501	16316	75245

Age Group	Percentage of Total Population		Population Percentage Change 2014 to 2026
	2014	2026	
0-19	19%	18%	-9%
20-49	34%	28%	-20%
50-69	34%	33%	-8%
70+	13%	22%	57%
TOTAL	100%	100%	-4%

Appendix E2: Newfoundland/Labrador Population Percentage Distribution & Change by Age Groups

All Regional Health Authorities

	0-19	20 - 49	50 - 69	70+	Total
2012	106684	209675	156069	54694	526841
2026	97401	170886	157688	95993	522877

Age Group	% of total population		% change 2012 - 2026
	2012	2026	
0-19 yrs	20%	19%	-9%
20-49 yrs	40%	33%	-18%
50-69 yrs	30%	30%	1%
70+ yrs	10%	18%	76%
0-49 yrs	60%	51%	-15%
50+ yrs	40%	49%	20%
TOTAL			-1%

Central Health

	0-19	20 - 49	50 - 69	70+	Total
2012	18072	33135	31509	12363	95079
2026	14101	21864	30617	20193	86684

Age Group	% of total population		% change 2012 - 2026
	2012	2026	
0-19 yrs	19%	16%	-22%
20-49 yrs	35%	25%	-34%
50-69 yrs	33%	35%	-3%
70+ yrs	13%	23%	63%
0-49 yrs	54%	41%	-30%
50+ yrs	46%	59%	16%
TOTAL			-9%

Eastern Health

	0-19	20 - 49	50 - 69	70+	Total
2012	64062	131628	89315	30355	315360
2026	61382	113653	91605	55062	322702

Age Group	% of total population		% change 2012 - 2026
	2012	2026	
0-19 yrs	20%	19%	-4%
20-49 yrs	42%	35%	-14%
50-69 yrs	28%	28%	3%
70+ yrs	10%	17%	81%
0-49 yrs	62%	54%	-11%
50+ yrs	38%	45%	23%
TOTAL			2%

Labrador Grenfell Health

	0-19	20 - 49	50 - 69	70+	Total
2012	8982	16279	9565	2548	37374
2026	8667	14192	10965	4422	38246

Age Group	% of total population		% change 2012 - 2026
	2012	2026	
0-19 yrs	24%	23%	-4%
20-49 yrs	44%	37%	-13%
50-69 yrs	26%	29%	15%
70+ yrs	7%	12%	74%
0-49 yrs	68%	60%	-10%
50+ yrs	32%	40%	27%
TOTAL			2%

Western Health					
	0-19	20 - 49	50 - 69	70+	Total
2012	15568	28633	25680	9428	79020
2026	13251	21177	24501	16316	75245

Age Group	% of total population		% change 2012 - 2026
	2012	2026	
0-19 yrs	20%	18%	-15%
20-49 yrs	36%	28%	-26%
50-69 yrs	32%	33%	-5%
70+ yrs	12%	22%	73%
0-49 yrs	56%	46%	-22%
50+ yrs	44%	54%	16%
TOTAL			-5%

Appendix E3: Travel Distances to Corner Brook

NL RHA	Communities potentially in CCW service area	% assumed to attend CCW ¹	Driving distance from Corner Brook
Central	Green Bay	80%	180-218 km
	Exploits	50%	280-353 km
	Lewis Port	50%	301-379 km
	Baie Verte	80%	211-237 km
	Grand Falls Windsor	60%	235-267 km
	Proportion of population of identified communities assumed to attend CCW	~ 60%	
	Proportion of Central Health population assumed to attend CCW	30%	
Labrador Grenfell	Northern Peninsula	66%	285-485 km
	Labrador South	33%	396-556 incl ferry ²
	Proportion of population of identified communities assumed to attend CCW	~ 60%	
	Proportion of Labrador Grenfell population assumed to attend CCW	20%	

Notes:

1. Proportion of community population assumed to attend CCW was based on driving distance, since those at greater driving distance from Corner Brook are considered more likely to choose to travel to St. John's.
2. Excludes Labrador South communities over 600 km distance including Cartwright, Charlottetown, Port Hope Simpson, St Lewis, and Pinsent's Arm

Appendix E4: Travel Distances within NL

Community to:	Gander		Port aux Basques		St. Anthony		St. John's		Airport	Airport name/ Code	Nearest Airport
	km	time	km	time	km	time	km	time	Yes or No		
Argentia	282	3:31	854	10:41	1000	12:55	130	1:37	No		St. John's YYT - 98.2km
Badger	124	1:33	448	5:36	594	8:42	454	5:41	No		Botwood - 43.5km
Baie Verte	272	3:24	425	5:19	571	8:54	602	7:31	No		Deer Lake YDF - 134.1km
Bishop's Falls	80	1:00	492	6:09	638	9:08	410	5:07	No		Gander YQX - 68.5km
Bonavista	233	3:07	805	10:04	951	13:04	296	3:44	No		Gander YQX
Botwood	93	1:10	513	6:25	659	9:28	423	5:17	No		Gander YQX - 61km
Branch	331	4:08	903	11:17	1049	13:29	145	1:58	No		St. John's YYT - 122km
Buchans	198	2:29	522	6:31	668	9:56	528	6:36	No		Deer Lake YDF - 58km
Burgeo	566	7:05	305	4:03	676	10:31	896	11:12	No		Stephenville YJT - 124km
Cape St. Mary's	342	4:17	913	11:25	1059	13:34	171	2:08	No		St. John's YYT - 140km
Carbonear	300	3:45	872	10:54	1018	13:14	101	1:22	No		St. John's YYT - 37km
Carmanville	64	1:04	632	7:54	778	10:58	394	4:55	No		Gander YQX - 55km
Clarenville	161	2:00	717	8:58	863	11:25	186	2:20	No		Gander YQX - 97km
Conche	658	8:13	633	7:55	140	2:04	986	12:19	No		St. Anthony YAY - 58km
Corner Brook	357	4:28	219	2:44	467	7:27	687	8:35	No		Deer Lake YDF - 50km
Deer Lake	307	3:50	265	3:19	417	6:56	637	7:58	Yes	Deer Lake Regional - YDF	
Ferryland	354	4:25	926	11:35	1072	13:44	75	0:56	No		St. John's YYT - 66km
Gambo	46	0:34	618	7:43	764	10:26	294	3:41	No		Gander YQX - 31km
Gander	0	0:00	572	7:09	718	9:56	330	4:07	Yes	Gander Int'l - YQX	
Glovertown	72	0:53	634	7:55	780	10:35	273	3:25	No		Gander YQX - 48km
Goobies	190	2:22	745	9:19	891	11:40	157	1:58	No		St. John's YYT - ?
Grand Bank	371	5:02	919	11:29	1065	14:58	355	4:54	No		Gander YQX - 224km
Grand Falls - Windsor	95	1:11	477	5:58	623	8:59	425	5:19	No		Gander YQX - 80km
Harbour Breton	280	4:10	702	8:47	848	12:37	610	7:37	No		Gander YQX - 187km
Hawke's Bay	514	6:32	477	6:10	204	3:24	844	10:33	No		St. Anthony YAY - 116km
Hermitage	274	4:04	697	8:43	843	12:31	604	7:33	No		Gander YQX - 185km
Keels	206	2:40	778	9:43	924	12:37	269	3:22	No		Gander YQX - 93km
La Scie	316	3:57	470	5:53	616	9:38	646	8:04	No		Gander YQX - 135km
Lewisporte	60	0:45	541	6:46	687	9:44	390	4:53	No		Gander YQX - 50km
Marystown	315	4:06	864	10:48	1010	14:02	299	3:59	No		St. John's YYT - 188km
Old Perlican	350	4:23	922	11:31	1068	14:05	153	2:14	No		St. John's YYT - 55km
Placentia	278	3:29	850	10:37	996	12:50	126	1:35	No		St. John's YYT - 101km
Port aux Basques	572	7:09	0	0:00	681	9:34	902	11:17	No		Stephenville YJT - 117km
Port au Choix	536	6:57	500	6:35	203	3:26	866	10:49	No		St. Anthony YAY - 117km
Rocky Harbour	372	4:39	335	4:11	347	5:47	702	8:47	No		Deer Lake YDF - 58km

Community to:	Gander		Port aux Basques		St. Anthony		St. John's		Airport	Airport name/ Code	Nearest Airport
	km	time	km	time	km	time	km	time	Yes or No		
Roddickton	640	8:00	615	7:41	123	1:50	968	12:06	No		St. Anthony YAY - 58km
Sandyville	274	4:04	697	8:43	843	12:31	604	7:33	No		Gander YQX - 187km
Springdale	199	2:29	394	4:55	540	8:14	529	6:37	Yes		
St. Anthony	718	9:56	681	9:34	0	0:00	1048	13:16	Yes	St. Anthony YAY	
St. John's	330	4:06	902	11:17	1048	13:16	0	0:00	Yes	St. John's Int'l YYT	
Stephenville	435	5:26	165	2:04	545	8:25	765	9:34	Yes	Stephenville Int'l YJT	
Trepassey	371	4:38	943	11:47	1089	14:31	147	1:51	No		St. John's YYT - 109km
Trinity East	193	2:27	765	9:34	911	12:23	256	3:12	No		St. John's YYT -95km
Twillingate	113	1:53	626	7:49	772	11:08	443	5:32	No		Gander YQX - 80km

Appendix F: NL Cancer Incidence

Appendix F1: Cancer Incidence in Newfoundland: 2008 - 2012

Source: Clinical Epidemiologist, Cancer Care Program, Eastern Health, June 2014

In order to provide some context for the distribution of cancer incidence by Regional Health Authority (RHA), the entire provincial population was examined first. According to Statistics Canada census data for 2006 (accessed from Community Accounts, Economic and Statistics Branch, Dept. of Finance), there were 505,470 people residing in the province in 2006. Of these, 7.3% (n = 36,755) were residing in the Labrador-Grenfell RHA, 18.9% (n = 95,460) were residing in the Central RHA, 58.1% (n = 293,795) were residing in the Eastern RHA and 15.7% (n = 79,460) were residing in the Western RHA.

Provincial-Level Incidence

Between the years 2008 and 2012 inclusive there were 15,760 cancer cases registered in NL. This does not include non-melanoma skin cancers or those with cancer aged between 0 – 17 years. All 'out of province' cases were also removed along with all carcinoma in situ cases, except breast cancer cases. These exclusions are frequently employed when reporting cancer incidence data.

The gender breakdown is displayed in table 1. This result is expected, as generally, there are slightly more men than women diagnosed with cancer each year.

Table 1. Gender Breakdown for Cancers Diagnosed in NL (2008-2012)

Gender	Frequency	Percent
Female	7272	46.1
Male	8488	53.9
Total	15760	100.0

Age distribution at diagnosis is displayed in table 2. It can be seen that the number of cancer cases increases as age increases, which is typical in any population. The number of cases begins to decrease again in the oldest age groups because there are less people alive at these ages.

Table 2. Age Group at Diagnosis for Cancers Diagnosed in NL (2008-2012)

Age Group	Frequency	Percent
15-19	13	.1
20-24	47	.3
25-29	83	.5
30-34	132	.8
35-39	233	1.5
40-44	454	2.9
45-49	767	4.9
50-54	1288	8.2
55-59	1775	11.3
60-64	2379	15.1
65-69	2499	15.9
70-74	2127	13.5
75-79	1815	11.5
80-84	1235	7.8

Age Group	Frequency	Percent
85+	913	5.8
Total	15760	100.0

In table 3 it is observed that there has not been a great deal of fluctuation in the number of cases diagnosed over the five year period from 2008 to 2012. The most recent year of data reported has the lowest number of cases.

Table 3. Frequency of Cancers Diagnosed in NL by Year of Diagnosis (2008-2012)

Diagnosis Year	Frequency	Percent
2008	3126	19.8
2009	3109	19.7
2010	3157	20.0
2011	3276	20.8
2012	3092	19.6
Total	15760	100.0

Tumour group breakdowns were carried out for various cancers as evidenced in table 4. The four main cancer types diagnosed were breast, colon/rectum, prostate and lung. These comprised over half of all cancers diagnosed each year (57.4%). Other cancers that were seen in relatively high numbers included lymphoma, melanoma, kidney, uterine, bladder, pancreas, stomach and thyroid. Some cancers occurred to a lesser extent, with several sites being grouped under 'Other Cancer' due to small numbers.

Table 4. Cancer Incidence by Tumour Group for NL (2008-2012)

Site	Frequency	Percent
Breast	1956	12.4
Colon	2023	12.8
Rectum	650	4.1
Prostate	2329	14.8
Lung	2090	13.3
Brain	216	1.4
Bladder	335	2.1
Cervix Uteri	145	.9
Corpus Uteri	465	3.0
Esophagus	115	.7
Kidney	594	3.8
Leukemia	296	1.9
Lymphoma	694	4.4
Sarcoma	172	1.1
Melanoma	469	3.0
Multiple myeloma	171	1.1
Ovary	181	1.1
Pancreas	295	1.9
Stomach	327	2.1
Thyroid	436	2.8
Other Cancer	1801	11.4
Total	15760	100.0

The following two tables provide a further breakdown of the data on a provincial level. They include cancer site by gender and cancer site by year of diagnosis.

Table 5. Cancer Site by Gender for NL (2008-2012)

Cancer Site	Gender		Total
	Female	Male	
Breast	1942	14	1956
Colon	921	1102	2023
Rectum	227	423	650
Prostate	0	2329	2329
Lung	799	1291	2090
Brain	86	130	216
Bladder	74	261	335
Cervix Uteri	145	0	145
Corpus Uteri	465	0	465
Esophagus	33	82	115
Kidney	244	350	594
Leukemia	115	181	296
Lymphoma	337	357	694
Sarcoma	113	59	172
Melanoma	217	252	469
Multiple myeloma	80	91	171
Ovary	181	0	181
Pancreas	142	153	295
Stomach	125	202	327
Thyroid	314	122	436
Other Cancer	713	1088	1801
Total	7273	8487	15760

Table 6. Cancer Site by Year of Diagnosis for NL (2008-2012)

Cancer Site	Diagnosis Year					Total
	2008	2009	2010	2011	2012	
Breast	436	357	366	398	399	1956
Colon	406	363	387	431	436	2023
Rectum	128	132	131	126	133	650
Prostate	469	504	490	465	401	2329
Lung	392	452	432	411	403	2090
Brain	49	39	48	33	47	216
Bladder	67	79	78	60	51	335
Cervix Uteri	28	29	39	29	20	145
Corpus Uteri	79	74	92	108	112	465
Esophagus	20	24	16	30	25	115
Kidney	112	134	113	128	107	594
Leukemia	78	64	56	50	48	296
Lymphoma	113	148	148	149	136	694

Cancer Site	Diagnosis Year					Total
	2008	2009	2010	2011	2012	
Sarcoma	29	29	41	32	41	172
Melanoma	91	87	82	111	98	469
Multiple myeloma	28	30	36	42	35	171
Ovary	39	30	38	40	34	181
Pancreas	67	58	59	61	50	295
Stomach	62	76	67	56	66	327
Thyroid	60	55	62	122	137	436
Other Cancer	373	345	376	394	313	1801
Total	3126	3109	3157	3276	3092	15760

RHA-Level Incidence

Table 7 shows the counts and percentages of cancer diagnoses by RHA for 2008-2012. It can be seen that the percentage of cases occurring in each RHA is reflective of the percentage of the total provincial population that resides in each area. There is no area for which the percentage of cases occurring is discordant. Almost 60% of cases are found in the Eastern RHA, followed by 20% in the Central RHA, and then a 15.7% and 7.3% in Western and Labrador-Grenfell respectively.

Table 7. Cancer Incidence by Regional Health Authority

RHA	Frequency	Percent	Provincial %
Central	3225	20.5	18.9
Eastern	9105	57.8	58.1
Labrador	736	4.7	7.3
Western	2694	17.1	15.7
Total	15760	100.0	100.0

For all RHAs there were more men than women diagnosed between 2008 and 2012.

Table 8. Cancer Incidence by Gender and RHA (2008-2012)

RHA	Gender		Total
	Female	Male	
Central	1451 (45%)	1774 (55%)	3225
Eastern	4374 (48%)	4731 (52%)	9105
Labrador	312 (42%)	424 (58%)	736
Western	1136 (42%)	1558 (58%)	2694
Total	7273	8487	15760

The number of cases diagnosed in each RHA remained relatively stable over the five year period. This is also true when broken down by gender.

Table 9. Cancer Incidence by Regional Health Authority and Diagnosis Year (2008-2012)

RHA	Diagnosis Year					Total
	2008	2009	2010	2011	2012	
Central	635	598	687	653	652	3225
Eastern	1832	1812	1751	1916	1794	9105
Labrador	125	148	169	159	135	736

RHA	Diagnosis Year					Total
	2008	2009	2010	2011	2012	
Western	534	551	550	548	511	2694
Total	3126	3109	3157	3276	3092	15760

Table 10. Cancer Incidence by Regional Health Authority, Gender and Diagnosis Year (2008-2012)

Gender			Diagnosis Year					Total
			2008	2009	2010	2011	2012	
Female	RHA	Central	292	233	276	336	314	1451
		Eastern	892	820	838	912	912	4374
		Labrador	53	63	83	57	56	312
		Western	221	223	237	219	236	1136
	Total	1458	1339	1434	1524	1518	7273	
Male	RHA	Central	343	365	411	317	338	1774
		Eastern	940	992	913	1004	882	4731
		Labrador	72	85	86	102	79	424
		Western	313	328	313	329	275	1558
	Total	1668	1770	1723	1752	1574	8487	

The following four tables represent tumour group by RHA and year of diagnosis. Some cancer sites were removed for certain RHAs due to small counts in each cell.

Table 11a. Tumour Group by Diagnosis Year for Eastern Health

RHA		Diagnosis Year					Total
		2008	2009	2010	2011	2012	
Eastern	Breast	260	217	214	233	232	1156
	Colon	252	221	193	258	255	1179
	Rectum	75	76	77	64	75	367
	Prostate	235	265	257	239	191	1187
	Lung	261	270	234	236	225	1226
	Brain	22	28	25	15	30	120
	Bladder	40	43	43	35	30	191
	Cervix Uteri	15	13	25	16	14	83
	Corpus Uteri	45	42	53	66	66	272
	Esophagus	10	11	9	22	17	69
	Kidney	66	80	65	68	69	348
	Leukemia	43	40	30	23	28	164
	Lymphoma	71	82	86	94	86	419
	Sarcoma	15	17	27	15	22	96
	Melanoma	62	47	48	81	64	302
	Multiple myeloma	17	19	22	26	19	103
	Ovary	25	15	24	27	22	113
	Pancreas	31	38	31	31	35	166
	Stomach	37	42	33	32	33	177

RHA		Diagnosis Year					Total
		2008	2009	2010	2011	2012	
	Thyroid	37	41	41	88	98	305
	Other Cancer	213	205	214	247	183	1062
	Total	1832	1812	1751	1916	1794	9105

Table 11b. Tumour Group by Diagnosis Year for Central Health

RHA		Diagnosis Year					Total
		2008	2009	2010	2011	2012	
Central	Breast	103	71	70	93	92	429
	Colon	91	76	101	85	102	455
	Rectum	25	24	28	30	37	144
	Prostate	107	87	115	93	82	484
	Lung	56	88	86	80	86	396
	Bladder	14	24	20	15	10	83
	Corpus Uteri	19	10	23	20	25	97
	Kidney	25	26	20	27	20	118
	Leukemia	11	14	13	18	8	64
	Lymphoma	16	27	31	19	27	120
	Melanoma	15	26	19	12	22	94
	Pancreas	16	9	10	15	6	56
	Stomach	11	19	17	12	19	78
	Other Cancer	76	61	82	76	61	356

Table 11c. Tumour Group by Diagnosis Year for Western Health

RHA			Diagnosis Year					Total
			2008	2009	2010	2011	2012	
Western	Numeric	Breast	59	52	55	59	57	282
	Site	Colon	48	55	75	69	61	308
		Rectum	24	23	15	25	15	102
		Prostate	102	137	97	104	97	537
		Lung	68	68	92	80	81	389
		Bladder	11	9	10	8	9	47
		Corpus Uteri	14	17	12	17	19	79
		Kidney	15	19	19	23	13	89
		Leukemia	21	6	9	7	10	53
		Lymphoma	17	28	26	29	17	117
		Melanoma	14	13	12	14	12	65
		Ovary	6	6	6	9	8	35
		Pancreas	15	9	15	11	6	56
		Stomach	11	11	11	7	10	50
		Thyroid	10	8	8	10	11	47

RHA		Diagnosis Year					Total
		2008	2009	2010	2011	2012	
	Other Cancer	64	58	62	50	55	289

Table 11d. Tumour Group by Diagnosis Year for Labrador-Grenfell Health

RHA		Diagnosis Year					Total
		2008	2009	2010	2011	2012	
Labrador-Grenfell	Breast	14	17	27	13	18	89
	Colon	15	11	18	19	18	81
	Prostate	25	15	21	29	31	121
	Lung	7	26	20	15	11	79
	Kidney	6	9	9	10	5	39
	Lymphoma	9	11	5	7	6	38
	Other Cancer	20	21	18	21	14	94
				159	135	736	

Appendix F2: Cancer Incidence Projection Methodology

The methodology utilized to project future cancer incidence is outlined in this Appendix.

1. Time periods

- Baseline incidence used the average of cases from 2010 to 2012, as follows:

Health Region	Cases				Average Annual Cases
	2010	2011	2012	TOTAL	2010-2012
Central	687	653	652	1992	664
Eastern	1751	1916	1794	5461	1,820
Labrador	169	159	135	463	154
Western	550	548	511	1609	537
TOTAL	3157	3276	3092	9525	3,175

Source: Clinical Epidemiologist, Cancer Care Program, Eastern Health, June 2014

- Projection time period: Data were projected to 2026

2. Age Standardized Cancer Incidence Rates

Source: Research and Evaluation Department Newfoundland and Labrador Centre for Health Information, June 2014, from Provincial Cancer Registry, 1990-2012; Population Projections file, accessed May 30, 2014.

The projection methodology assumed that NL's Age Standardized Cancer Incidence Rate (ASIR) will continue to increase over the next ten to fifteen years before impact is seen from current prevention and screening programs. In contrast to Canadian ASIR that declined in aggregate between 2001 and 2010, NL's rates are expected to increase due to key lifestyle factors impacting cancer.

For the purpose of assessing the impact of ASIR on cancer projections, the ASIR developed by Newfoundland & Labrador Centre for Health Information (NLCHI) were used, as follows:

	1990-92	1993-97	1998-2002	2003-07	2008-12	2013-17	2018-22	2023-26
Age-standardized incidence rate (per 100,000)	339.6	362.6	369.2	409.5	438.9	468.3	486.8	495.0

Source: Research and Evaluation Department Newfoundland and Labrador Centre for Health Information, June 2014, from Provincial Cancer Registry, 1990-2012; Population Projections file, accessed May 30, 2014.

Between 2008-2012 and 2023-2026, there is a 12.8% increase in the ASIR, or approximately 0.9% annually for the next approximately 14 years. For purposes of the incidence projection calculation, 13% increase in ASIR overall was used.

3. Population Age Impact on Incidence

Canadian Cancer Statistics 2014 found that on average those aged 50+ years account for 89% of cancer cases and those 0-49 years of age account for 11%. Percentage changes in these two age groups between 2012 and 2026 were applied to estimate increased cancer incidence arising from the changes in the NL population age distribution by region. See Appendix C2: Newfoundland/Labrador Population Percentage Distribution & Change by Age Groups

Cancer Incidence Projection Resulting from Methodology

	Average cancer cases (2010-12)	Add 13 % growth for cancer incidence	Total cases average plus 13% growth)	baseline (2010-12 plus projected pop. growth in this age group to 2026	Projected increase in 89% of cases (aged 50+) based on projected pop. decrease in this age group to 2026	Projected decrease in 11% of cases (aged 0-49) based on projected pop. decrease in this age group to 2026	Total projected cases to 2026 based on cancer incidence & population change
Central	664	86	750	107	-19	838	
Eastern	1820	237	2057	421	-22	2456	
Labrador	154	20	174	42	-2	215	
Western	537	70	606	86	-12	681	
TOTAL	3175	413	3588	656	-55	4190	

Appendix G: Canadian Sites Visited/Reviewed

Element	Brandon, MB (Western Manitoba Cancer Centre)	Sault Ste. Marie, ON (Algoma District Cancer Program)	Lethbridge, AB (Jack Ady Cancer Centre)
Years Open	3 year (2011)	3 years (2011)	4 years (June 2010)
Service Pop size	~165,000	~127,000	~250,000
Affiliation & Road Distance	Winnipeg Tertiary Cancer Centre at the Health Sciences campus; ~2.5-3.5 hours	North East Ontario Cancer Centre, Sudbury = 3-4 Hrs	Tom Baker Cancer Centre (tertiary), Calgary= 2.5 hrs
Configuration & Host Hospital	Standalone addition to Brandon General Hospital; fully integrated CC	Incorporated into new hospital; share OPU clinics with rest of CC, which is staffed by local hospital	Combined new & renovated space in Lethbridge Regional Hospital: fully integrated CC; Phase 2 extra space scheduled in next yr.
Governance	Local Manager & Oncologist Lead report to CancerCare Manitoba (CCMB); Manager also reports to local health region for other budget and onsite matters	Local Manager & Oncologist lead reports to NECC Sudbury	Alberta Health Services = AB sole health authority; AB CC responsible for cancer care provincially reporting to AHS; Local coordinator of Regional CC sites reports to AB CC Community Oncology division & liaises closely with host hospital
Set Policy & Practice Guidelines	Cancer Care Manitoba	Cancer Care Ontario + some Regional CC adjustment for local aspects.	CancerControl Alberta with some local adjustments to reflect local aspects
RT Vaults	1 + planned space for 2nd when needed for linac replacement	1 + planned building for future expansion for 2nd when needed for future demand	2 planned & built
Linac: # & type	1- Varian iX	1- Varian iX	2- Varian iX
Tx Planning & Clinical Data	On site-integrated with main tertiary site	On site-integrated with main tertiary site	On site-integrated with main tertiary site
Data Storage	Tertiary CC site	Regional CC site	Tertiary CC site (TBCC)
Clinical Scope	4 large tumour group + palliative	All disease sites except sarcoma, some head & neck, SABR	Prostate, Breast, Lung, Rectum, Other Pelvic and Palliative
Initial Consults & RT Treatments	About 80% done	About 85%+ done locally due to rotating sub-specialist ROs	About 70-80% done locally. Phasing of some tumor groups delayed by MO staffing
Working Hours	8 hours/day	Currently 8 hrs/day flex to 10 hrs/day on demand; will increase to 10 hrs/day when workload increases;	8 hours/day
RO Staffing & On-call	1 FTE onsite; plus 0.33 FTE traveling to BCC each week for clinics;	Rotating staff travel to SSM for 2 days/week; rest are managed remotely; consults & follow-up completed by tele-medicine in Sudbury;	2 FTE RO's;
Telehealth	Heavily used; patients consults & team sessions	Heavily used; patients & team sessions	Moderately used; patients & team sessions; teaching;
Other RT Onsite Staff	Medical Physicist/ RT Safety Officer; RT Therapists/Dosimetrists; nurses; Nuclear Electronics Technologist; Physics Associate;	RT Supervisor; Medical Physicist (however investigating having MP travel from Sudbury versus permanently onsite); RT Therapists /Dosimetrists; nurses; Electronics	Medical Physicist/ RT Safety Officer (2FTE); RT Therapists/Dosimetrists (10FTE & 2PartTime); Nurses (2FTE); RT Equipment Service Specialist (RTESS-1FTE); Physicist Assistant (0.5FTE);

Element	Brandon, MB (Western Manitoba Cancer Centre)	Sault Ste. Marie, ON (Algoma District Cancer Program)	Lethbridge, AB (Jack Ady Cancer Centre)
		Technician; Medical Physics Assistant (<i>who is also RSO with CNSC training and cross trained with Electronics Tech</i>); dedicated IT staff;	
CT Sim Service	Yes-in local CC	Use host hospital's CT	Yes-in local CC
Unplanned Linac Downtime	Total of ~35 hours over 3 years; no patients transferred to Winnipeg;	Policy that 4 fractions must be treated within a 7 day time span. Will treat on weekend and/or holiday, or be transferred to Sudbury if needed (this is written in employee's contracts). Additional site specific protocols followed. Have treated on weekend and holiday but no patients have been transferred to Sudbury.	Total downtime for 2 machines in 2014 was 98.4 hours;
Patient Response to Down Time	Prefer to wait until fixed	No negative responses to being treated on the weekend to make up for downtime. If linac is to be fixed the same day, patient's prefer to go home and come back at a later appointment time (rebook for the same day)	Prefer to wait until fixed
Airport Service	1/day; Brandon-Winnipeg	In SSM- infrequent flights to Sudbury	In Lethbridge- 2-3 flights/day to Calgary/Edmonton
Weather	6-7 months unpredictable winter weather	6-7 months unpredictable winter weather	6-7 months unpredictable winter weather

Appendix H: Selected RT Education Facilities

Program	Professional Organization	School(s)	Contact Info
Radiation Therapy Program – Degree Program	Canadian Association of Medical Radiation Technologists (CAMRT) http://www.camrt.ca/certification/canadian/educationprogramsradiationtherapy/	Michener Institute/ Laurentian U. Program	935 Ramsay Lake Rd, Sudbury, ON, P3E 2C6 Phone: 706-675-1151 ext. 2220 www.laurentian.ca
Medical Radiation Sciences (RT) – Degree Program	Canadian Association of Medical Radiation Technologists (CAMRT) http://www.camrt.ca/certification/canadian/educationprogramsradiationtherapy/	Michener Institute/ University of Toronto	222 Saint Patrick St., Toronto ON, M5T 1V4 Phone: 416-596-3101 ext. 3903 www.michener.ca
Medical Oncology	Royal College of Physicians and Surgeons of Canada http://www.royalcollege.ca/portal/page/portal/rc/credentials/accreditation/arps/specialty/med-oncology	Memorial University of Newfoundland, St. John's	300 Prince Philip Drive, St. John's NL, A1B 3V6
Radiation Oncology	Royal College of Physicians and Surgeons of Canada http://www.royalcollege.ca/portal/page/portal/rc/credentials/accreditation/arps/specialty/rad_oncology	Dalhousie University, Halifax, NS	Nova Scotia Cancer Centre QEII Health Sciences Centre, VGHS 1276 South Park Street Halifax NS B3H 2Y9 david.bowes@cdha.nshealth.ca
Medical Physics - Degree	Canadian College of Physicists in Medicine (CCPM)	Dalhousie University, Halifax, NS	
Radiation Therapy Equipment Service Specialist/ Electronics Engineering (Biomedical) - Diploma		College of the North Atlantic, St. John's, NL - http://www.cna.nl.ca/programs-courses/show-program-details.aspx?program=49	St. John's, NL Phone: 1-888-982-2268

