Treatment Need & Capacity for Radiation Therapy in Minnesota

Report to the Minnesota Legislature

Minnesota Department of Health
March 2013

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MINNESOTA MDH DEPARTMENT OF HEALTH

March 15, 2013

The Honorable Tony Lourey
Chair, Health and Human Services Finance Division
Minnesota Senate
Room 120, State Capitol
75 Rev. Dr. Martin Luther King Jr. Blvd.
Saint Paul, MN 55155-1606

The Honorable Tom Huntley
Chair, Health and Human Services Finance Committee
Minnesota House of Representatives
585 State Office Building
100 Rev. Dr. Martin Luther King Jr. Blvd.
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The Honorable Kathy Sheran
Chair, Health, Human Services and Housing Committee
Minnesota Senate
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The Honorable Tina Liebling
Chair, Health and Human Services Policy Committee
Minnesota House of Representatives
367 State Office Building
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To the Honorable Chairs:

As required by Minnesota Laws, Chapter 217—SF 248, Sec. 2, this report outlines findings from a study about treatment need & capacity for radiation therapy in Minnesota, conducted by the Minnesota Department of Health on the following topics raised by the Legislature during the 2012 session:

1. The volume of current treatment capacity of existing radiation therapy facilities in Minnesota;
2. The present need for radiation therapy services based on population demographics and new cancer cases;
3. The projected need in the next ten years (2022) for radiation therapy services in Minnesota; and
4. Whether the current facilities and equipment can sustain this projected need.

If you have questions or concerns regarding this study, please contact the Stefan Gildemeister, the State Health Economist at 651-201-3554 or stefan.gildemeister@state.mn.us.

Sincerely,

Edward P. Ehlinger, M.D., M.S.P.H
Commissioner
P.O. Box 64975
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Executive Summary

Public debate about radiation therapy in Minnesota is not new; a time-limited moratorium on the construction of new radiation therapy facilities in certain Minnesota counties has been in place since 2007, the same year the Minnesota Legislature directly commissioned a study to analyze existing radiation therapy capacity, present need, and projected changes through 2015 for areas of the state affected by the moratorium.[1] Preceding the moratorium, the 2003 Minnesota Legislature passed legislation that limited the ability to construct radiation therapy facilities in Minnesota to entities that were "owned, operated or controlled" by a Minnesota hospital.[2]

Often the debate on radiation therapy has revolved around two questions: (1) to what extent do limits on radiation therapy capacity in Minnesota pose potential access barriers for cancer patients in need of radiation therapy, and (2) to what extent are restraints on radiation therapy capacity necessary to prevent creating overcapacity of costly technology and undermining the economic viability of hospital-based provision of these services moving forward.

As a result of its deliberations in 2012, the Minnesota Legislature directed the Minnesota Department of Health (MDH) to conduct a study of treatment need and capacity for radiation therapy in Minnesota.[3] Specific issues that the study was required to address include;

- The volume of current treatment capacity of existing radiation therapy facilities in Minnesota;
- The present need for radiation therapy services based on population demographics and new cancer cases;
- The projected need in the next ten years (through 2022) for radiation therapy services in Minnesota; and
- Whether the current facilities and equipment can sustain this projected need.

In conducting the study, MDH and a contractor collected operational statistics from Minnesota radiation therapy facilities, analyzed secondary data on cancer and demographic trends, performed statistical projections of cancer incidence and treatment demand, and simulated potential changes in available radiation therapy capacity over time.

The major findings of this study include:

- Although there are promising trends in the rate of incidence for certain cancers, cancer will remain a significant public health burden in Minnesota and a personal challenge for many patients, family members and caregivers;
- In aggregate, the number of new cancer cases is projected to grow between 2012 and 2022 by about 23.5 percent because of a number of factors, including trends in underlying risk factors

[1] Richard Taylor and Katherine Shrivers, "State of Minnesota Radiation Therapy Centers Analysis," Oncology Solutions, February 2008.

[2] Minnesota Laws, 2003, 1st Special Session, Chapter 14—HF 6, Article 7, Section 42

[3] 2012 Regular Session, MN Laws, Chapter 217—SF 248, Sec. 2

as well as demographic changes;
- Needed radiation therapy treatment volume, which encompasses treatment need for newly diagnosed patients and for patients living with cancer, is projected to grow slightly faster than estimates of incidence, or the number of newly diagnosed patients (23.9 percent compared to 23.5 percent);
- Although capacity for delivering radiation therapy services will grow as well between 2012 and 2022, rates of utilization at existing and planned facilities will increase because the rate of growth in available treatment capacity is lower than that of treatment need (10.3 percent compared to 23.9 percent);
- Without changing current operational practices, rates of utilization of existing capacity will rise for the state overall to 68 percent in 2017 and 75 percent in 2022. Rates of utilization are projected to be highest in the Twin Cities (78 percent and 86 percent in 2017 and 2022, respectively) and in West Central Minnesota (77 percent and 83 percent in 2017 and 2022, respectively).
- Operators of radiation therapy facilities feel there is considerable surge capacity in potentially extending business hours and expanding appointments for treatment beyond the traditional work week.
- If that surge capacity was fully used, projected rates of utilization relative to capacity would be more modest. Under those circumstances, maximum utilization of capacity in the Twin Cities would reach 76 percent by 2022; it would reach 74 percent in West Central Minnesota.

In summary, with current assumptions concerning the projection of cancer incidence, the use of existing capacity, and the prospect that existing radiation therapy facilities may expand available capacity through continued capital investments or expanded hours of operation, it appears that by 2022, projected needed treatment volume is matched by available treatment capacity.

However, considering the substantial uncertainties associated with conducting longer-term projections of demand for radiation therapy capacity and the unknown but potentially considerable effects of implementing Minnesota health reform and the Patient Protection and Affordable Care Act in the state, the Legislature may wish to consider revisiting these estimates well before 2022. This would provide the opportunity to enhance the model presented for this study, as suggested in Appendix A, including the addition of more variables with predictive power to the projection model to improve the models predictive accuracy.

Section 1: Introduction

The 2012 Minnesota Legislature directed the Minnesota Department of Health (MDH) to conduct a study of current and estimated future radiation therapy capacity.[4] Specific issues that the study is required to address include:

- The volume of current treatment capacity of existing radiation therapy facilities in Minnesota;
- The present need for radiation therapy services based on population demographics and new cancer cases;
- The projected need in the next ten years (through 2022) for radiation therapy services; and
- Whether the current facilities and equipment can sustain this projected need.

Public debate about radiation therapy in Minnesota is not new; a time-limited moratorium on the construction of new radiation therapy facilities in certain Minnesota counties has been in place since 2007, the same year the Minnesota Legislature directly commissioned a study to analyze existing radiation therapy capacity, present need, and projected changes through 2015 for the 14 counties that were affected by the moratorium at the time.[5] Preceding the moratorium, the 2003 Minnesota Legislature passed legislation that limited the ability to construct radiation therapy facilities in Minnesota to entities that were "owned, operated or controlled" by a Minnesota hospital.[6]

Debate on radiation therapy has generally revolved around two questions: (1) to what extent do limits on radiation therapy capacity in Minnesota pose potential access barriers for cancer patients in need of radiation therapy, and (2) to what extent are restraints on radiation therapy capacity necessary to prevent creating overcapacity of costly technology and undermining the economic viability of hospital-based provision of these services moving forward. This study is focused on the first concern (patient access) by examining how current and potential future demand for radiation therapy matches up with available capacity. It considers patient access statewide, as well as at the regional level.

In performing this study, MDH issued a Request for Proposals and, after a competitive bid process, engaged WIPFLi LLP, a business consulting firm with Minnesota presence and experience in health care facility planning, to perform key analytic aspects of the study.[7] MDH also convened an advisory group to seek input from clinical experts, academicians, regulators, advocates and cancer epidemiologists on methodological approaches, assumptions and potential future trends.[8]

The study required four main analytic steps: (1) estimating Minnesota population growth and changes in the age distribution; (2) projecting future Minnesota cancer incidence; (3) estimating needed treatment volume for current and future cancer patients receiving care at Minnesota facilities (including out of state residents); and (4) estimating total available radiation therapy capacity.

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[4] 2012 Regular Session, MN Laws, Chapter 217—SF 248, Sec. 2

[5] Richard Taylor and Katherine Shrivers, "State of Minnesota Radiation Therapy Centers Analysis," Oncology Solutions, February 2008.[7] Minnesota Department of Health, Health Economics Program. Health Insurance Premiums and Cost Drivers in Minnesota, 2010

[6] Minnesota Laws, 2003, 1st Special Session, Chapter 14—HF 6, Article 7, Section 42

[7] WIPFLi subcontracted with Professor Chatterjee from the School of Statistics at the University of Minnesota to perform aspects of the statistical modeling.

[8] Members of the advisory group, a list of whom is included in Appendix A, are not responsible for the results of the study or any errors or omissions in it. Members' primary contribution was the provision of insight and expertise to the framing of the study.

The remainder of this report is organized as follows: Section 2 provides background information on cancer burden in Minnesota as well as an overview of existing radiation therapy capacity in the state. Following a presentation of the analytic approach and findings in Section 3, Section 4 summarizes the results and highlights some of the considerable limitations associated with developing long-term projections presented in this report. Additional detail on methodology and data are presented in an Appendix section to the report.

Section 2: Background on Cancer Burden and Radiation Therapy in Minnesota

Cancer is a group of diseases that represents a major public health problem for Minnesota, the nation overall, and many other parts of the world. According to research by the Minnesota Comprehensive Cancer Control Program of the Minnesota Department of Health, nearly half of all Minnesotans will be diagnosed with a potentially serious form of cancer during their lives. Cancer remains Minnesota's leading cause of death, outpacing heart disease, the next leading cause, by nearly 32 percent in 2009. This research also documented disparities in cancer incidence and mortality. American Indians had the highest cancer rates in Minnesota and were 78 percent more likely to die of cancer than non-Hispanic whites. African Americans also had higher likelihood than non-Hispanic whites to develop cancer and die.[9]

Cancer is also a disease group that is characterized by dramatic shifts in incidence[10] over time due to a multitude of factors, including changes in the rates of screening, the emergence of new (potential) treatment options, evolution in treatment preferences by patients and their families, changes in risk factors for cancer, and demographic shifts in the population.

Cancer is not a single disease, nor is the burden equally distributed across age and gender. As shown in Figure 1, the incidence of cancer increases with age, with 80 to 84 year olds exhibiting the highest rate per 100,000 people. Overall, the incidence rate of cancer for men is higher than for women (33 percent), but as shown later, this differs significantly by the body site affected by cancer. As noted earlier, incidence of cancer also differs significantly by race and ethnicity.[11]

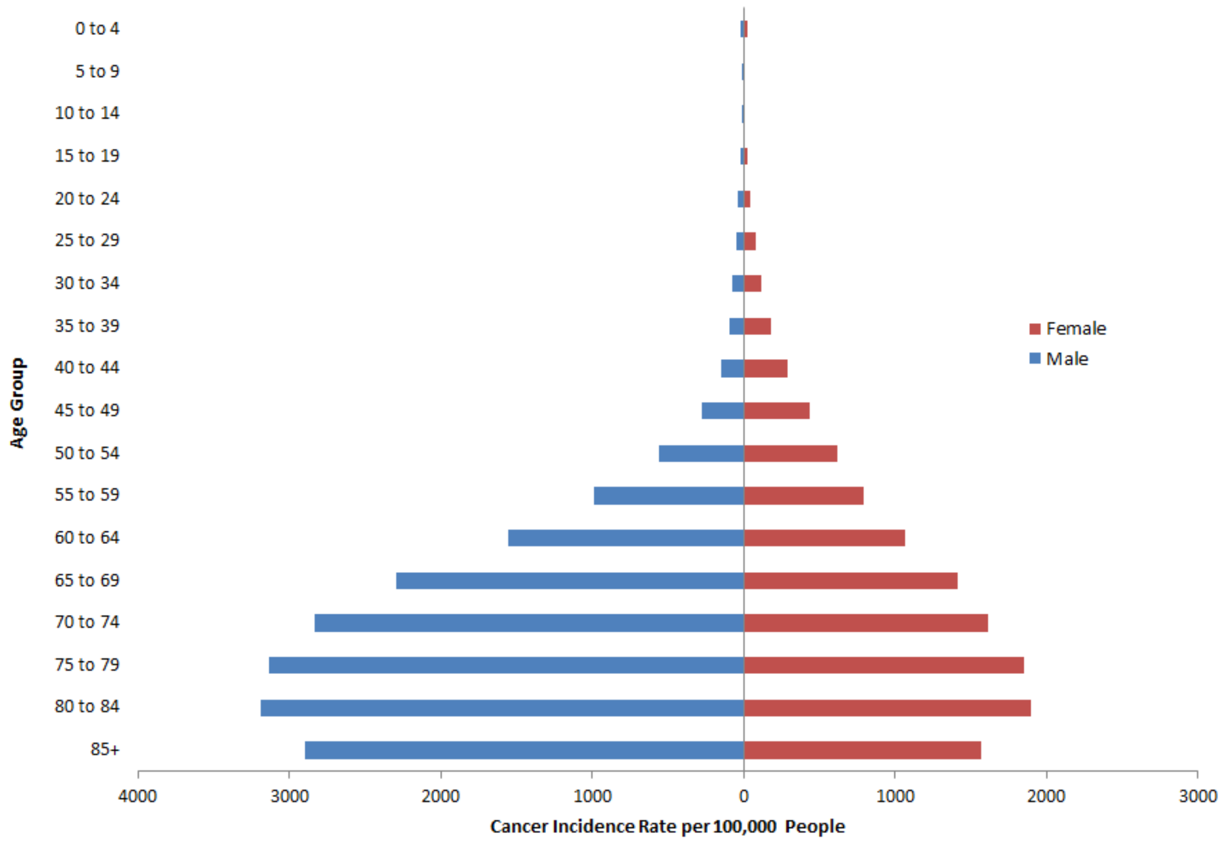
That cancer incidence differs by age is important for this study, because Minnesota as well as the rest of the nation is projected to experience sizeable population shifts towards the elderly, the segment of the population with the highest rates of cancer incidence. Demographic projections indicate that the elderly population in Minnesota will grow at a much faster pace in the next two decades compared to the previous 10 years. Figure 2 illustrates this by indicating that compared to 2010, the ranks of the elderly will grow by nearly 300,000 in 2020 and that this pace will increase through 2030.

[9] Minnesota Department of Health, "Cancer in Minnesota, 1988 – 2009," Report to the Minnesota Legislature 2013, December 2012.

[10] Incidence is an epidemiological term that measures the number of new cases (e.g., for cancer) diagnosed during a specific time period. Cancer incidence can also be represented as a rate, measuring new cases for a given period relative to the total number of people in the population.

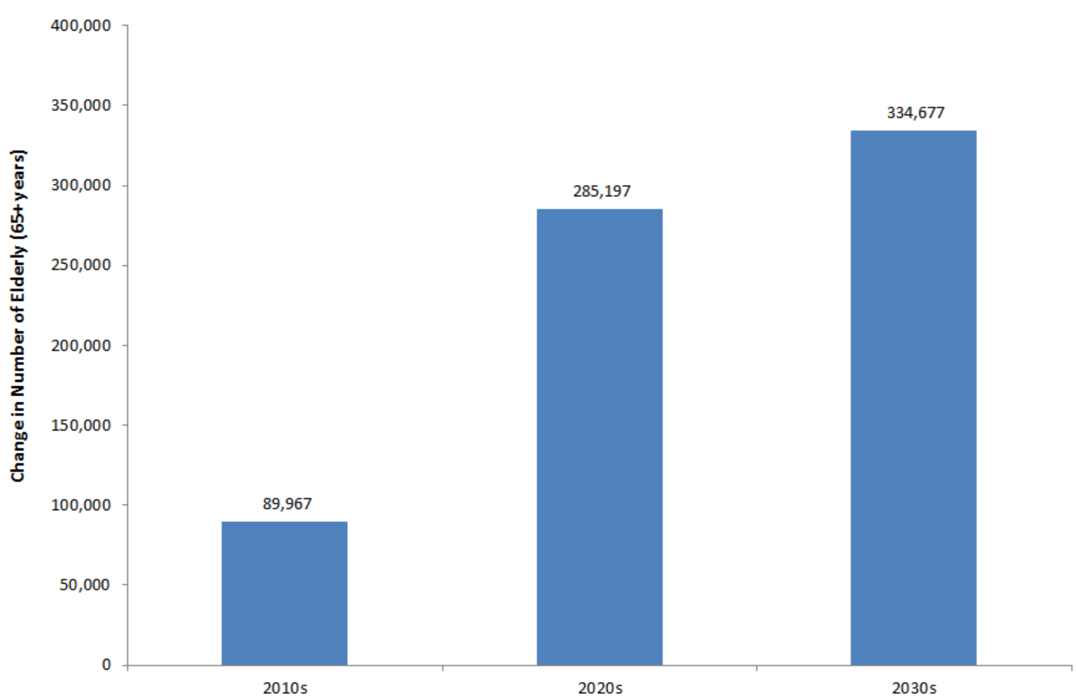
[11] For the purpose of developing projections for this study, incidence by race and ethnicity was not considered, because the number of cases by cancer site, age category and region were not sufficiently large to generate reliable statistical forecasts.

Figure 1: Minnesota Cancer Incidence Rates by Five Year Age Group and Gender, 2005-2009



Source: Minnesota Department of Health analysis of MCSS data

Figure 2: Estimated and Projected Changes in Minnesota Population Age 65+ from 2000-2030

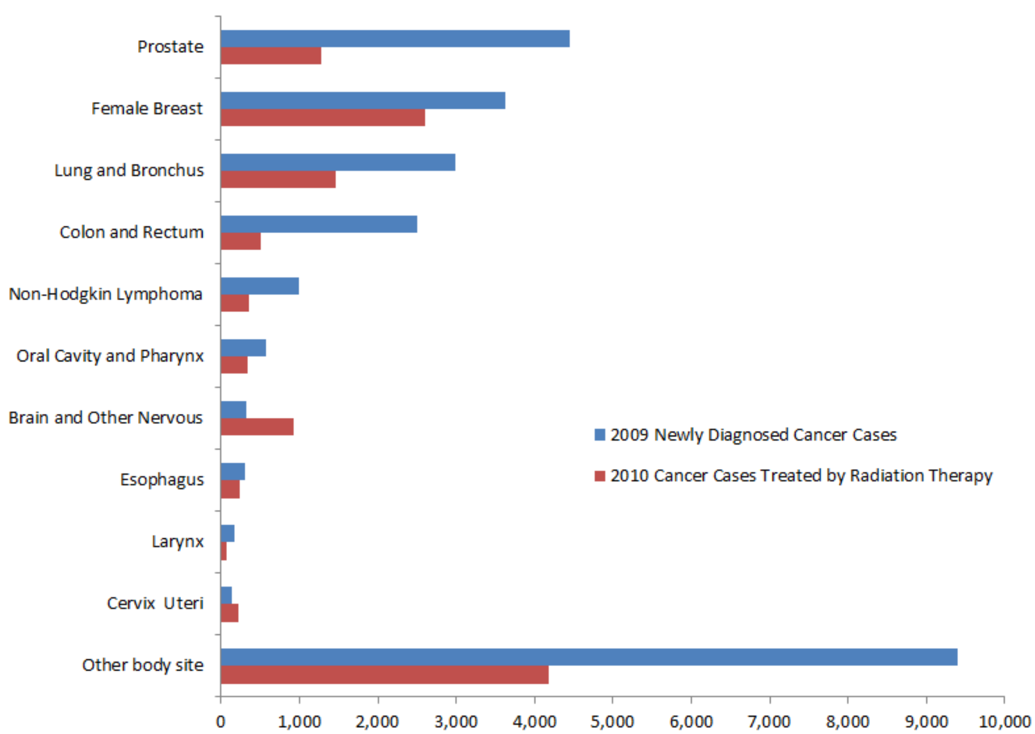


Source: Minnesota Department of Health analysis of data from the Demographer's Office

Lastly, the link between age and cancer incidence also matters for purposes of developing geographic estimates of the number of projected cancer cases because of differences in population size and age distribution across regions. While projected rates of growth of the share of the elderly population does not differ noticeably between regions, the starting point does. For example, the elderly in the Twin Cities in 2010 accounted for about 11 percent of the population, while the elderly in the Southwest and West Central regions accounted for about 18 percent.[12] This means that regional projections of cancer incidence will not just differ because of variation in risk factors and screening rates, they will also differ because of differences in underlying age distribution.

As shown in Figure 3 (and in the more detailed Appendix E), cancer incidence is not evenly distributed across types of cancers. The degree to which patients are treated by radiation therapy, the treatment approach that is the focus of this study, differs by type of cancer.[13] Recognizing this, this study identifies the cancers with the highest number of cases treated by radiation therapy in order to develop site-specific projections, thereby increasing the precision of the analysis. As indicated by Figure 3, although the analysis will have a focus on certain conditions, the projections will consider all cancers treated with radiation therapy.

Figure 3: Number of Newly Diagnosed Cancer Cases in 2009 and Cancer Cases Treated by Radiation Therapy in 2010



Source: MDH Analysis of MCSS data and data collected from Minnesota Radiation Therapy Facilities

[12] See detailed data on demographic projections by age in Appendix C.

[13] Other cancer therapies include chemotherapy, transplantation, certain cancer vaccines, angiogenesis inhibitors, biological therapies and targeted therapies (see for example: www.cancer.gov/cancertopics/treatment/types-of-treatment). Cancer cases that are treated by these and other non-radiation therapies are outside of the scope of this study.

Radiation Therapy in Minnesota

Radiation therapy is the delivery of high-energy radiation to reduce or kill cancer cells.[14] This treatment can be used either alone or in combination with surgery or chemotherapy. The most common form of radiation therapy involves external-beam radiation, where a device called a linear accelerator delivers photon (x-ray) radiation to an affected body area, generally over 25 to 50 treatment sessions.

Advancements in technology have allowed these machines to modify the shape, intensity and angle of focused radiation in order to better target treatment areas. Intensity modulated and image guided technology, as well as complementary volumetric modulated arc technology and tomotherapy have emerged in recent years to concentrate higher doses of radiation on cancer cells while attempting to spare healthy cells. Similarly, other advancements such as stereotactic radiosurgery and stereotactic body radiation therapy have allowed high doses of focused radiation to be delivered over a smaller number of treatment sessions.[15] Recent technological developments have also allowed particle (proton) radiation to be delivered by a proton accelerator.

As part of this study, MDH conducted an inventory of radiation therapy equipment across Minnesota; the inventory documented that in 2012 there were 58 external beam radiation therapy machines operating in 35 radiation therapy facilities across the state.[16] (A list of all existing radiation therapy facilities in Minnesota is available in Appendix F and a map of their location is provided in Appendix G.) As shown in Figure 4, nearly all of the external beam radiation therapy machines in Minnesota are linear accelerators (90 percent). There are also several machines that offer stereotactic radiosurgery including four in the Twin Cities, one in Northeast Minnesota and one in Southeast Minnesota. The only tomotherapy machine is located in the Twin Cities. More than half (33) of all external beam radiation therapy machines are located in the Twin Cities Metro Area.[17]

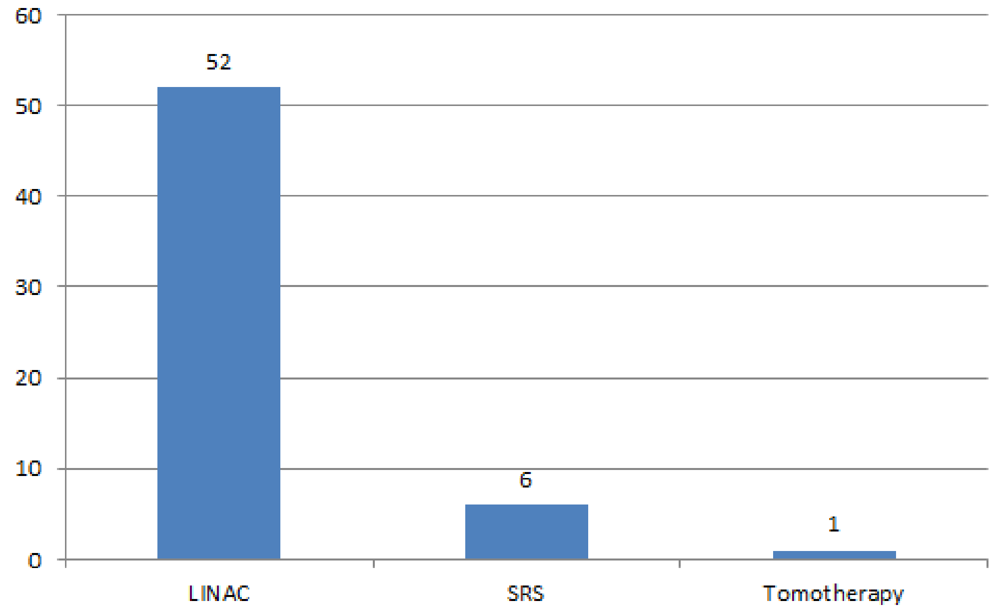
[14]Lawrence TS, Ten Haken RK, Giaccia A. Principles of Radiation Oncology. (2008). In: DeVita VT Jr., Lawrence TS, Rosenberg SA, editors. Cancer: Principles and Practice of Oncology. 8th ed. Philadelphia: Lippincott Williams and Wilkins.

[15]Detailed information on cancer treatments, including radiation therapy, can be found online at the National Cancer Institute of the National Institutes of Health: www.cancer.gov/cancertopics/treatment/types-of-treatment

[16]Two linear accelerators operated by the Veterans Administration are excluded from this list because treatment by these machines is limited to certain eligible current and former members of the U.S. military.

[17]Several projects plan to add radiation therapy capacity in Minnesota: By 2015, Southeast Minnesota will have added one of fewer than a dozen proton beam treatment centers in the country. Two linear accelerators are in the process of being added elsewhere, one in the Twin Cities, another one in Marshall, MN.

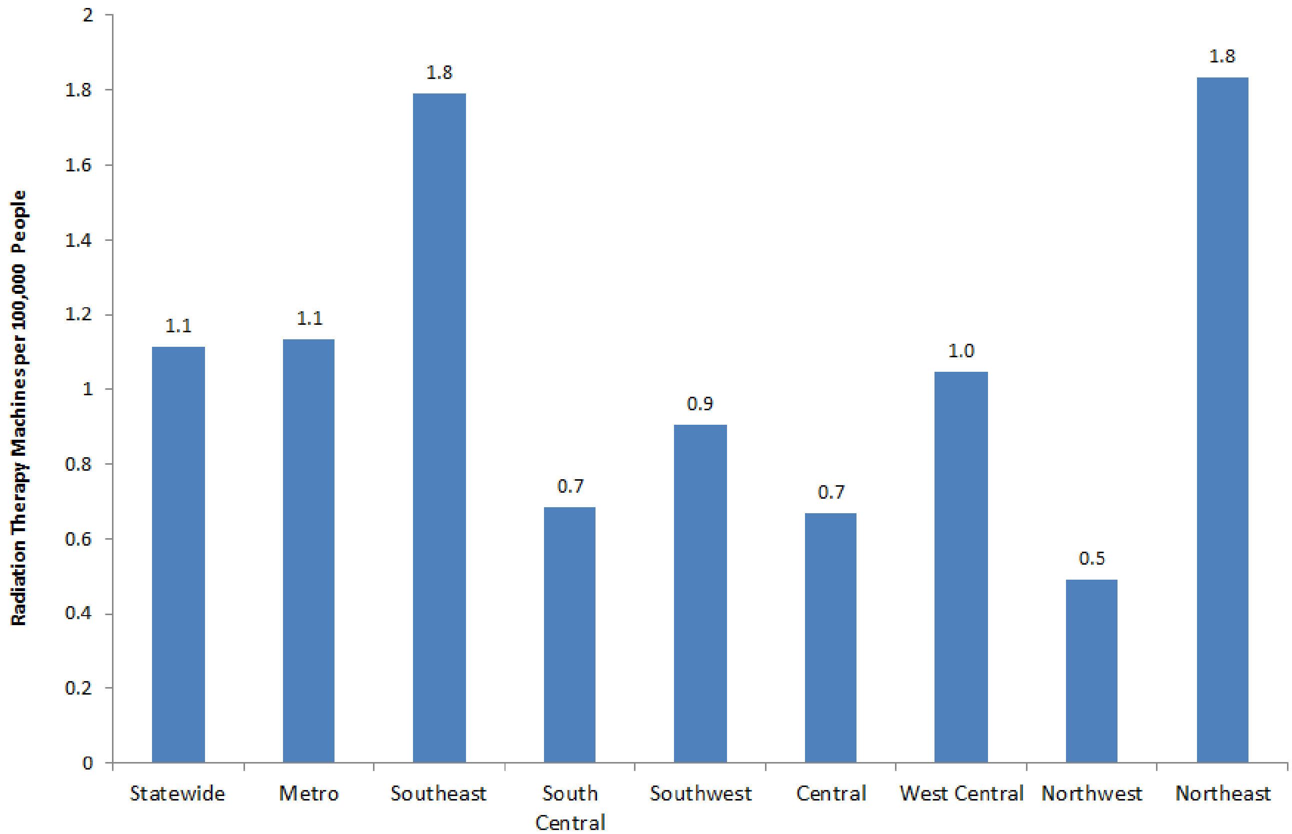
Figure 4: Number of External Beam Radiation Therapy Machines by Type of Machine, 2012



Source: MDH analysis of data collected from radiation therapy facilities for an equipment inventory, 2012
SRS is stereotactic radio surgery and includes Cyber - and Gammaknife technology; LINAC is linear accelerator

Figure 5 illustrates that although most of the radiation therapy machines are in the Twin Cities, other regions of the state have a higher per capita number of radiation therapy machines. In part, this capacity likely exists to respond to treatment needs of patients from outside of Minnesota or other regions of the state who seek care in these areas (the Twin Cities or Southeast Minnesota).

Figure 5: Number of External Beam Radiation Therapy Machines per 100,000 Population, 2012



Source: MDH analysis of administrative data as well as population projections from the Minnesota State Demographic Center

Minnesota's existing radiation therapy facilities are updating and expanding their capacity on an ongoing basis. MDH monitors this trend under its legislative responsibility to review reports on certain planned or actual capital expenditure investments.[18] In aggregate, capital spending on radiation therapy facilities in Minnesota has been substantial in recent years, indicating in part the high fixed costs associated with these investments. Between 2007 and 2011, about $257 million were committed to capital projects at radiation therapy centers throughout the state. Projects ranged from making technology updates to establishing new therapy facilities or new equipment at existing sites. Many of these projects included the introduction of new technology that has the potential to significantly change the number of treatments required. For example, the number of linear accelerators with stereotactic body radiation therapy technology increased from three machines in 2009 to 17 in early 2013. Table 1 presents an overview of the most recent radiation therapy projects still under development or recently implemented in Minnesota.

[18] Under MN Stat. 62J.17, health care providers that make a major capital investment (an expenditure of $1 million), are required to submit a report for review by the Commissioner of Health. In subd. 8 of this statute, the reporting requirement and review are explicitly extended to radiation therapy facilities.

Table 1: Capital Expenditure Commitments Related to Investments in Radiation Therapy Capacity in Minnesota, 2007 to 2011

Radiation Therapy Facility/ Provider Name	Project Description	Location	Spending Commitment	
			Date	Estimated Amount
New River Medical Ctr.	Development of new cancer center	Monticello, MN	5/29/2007	$5.2 mill
Regions Hospital/ HealthPartners	Purchase of multifunction linear accelerator	St. Paul, MN	5/30/2007	$2.2 mill
St. Paul Cancer Ctr./ Minnesota Oncology	Acquisition of linear accelerator from United Hospital	St. Paul, MN	6/1/2007	$1.0 mill
Maplewood Cancer Ctr./ Minnesota Oncology	Replacement of linear accelerator	Maplewood, MN	12/17/2008	$1.7 mill
Abbott Northwestern Hospital/ Allina	Replacement of linear accelerator	Minneapolis, MN	1/6/2009	$3.7 mill
Mercy Radiation Therapy Ctr./ Minneapolis Radiation Oncology	Replacement of linear accelerator	Coon Rapids, MN	7/6/2009	$1.2 mill
Ridges Radiation Oncology/ Minneapolis Radiation Oncology	Replacement of linear accelerator	Burnsville, MN	7/7/2009	$2.2 mill
Ridgeview Radiation Therapy Ctr./ Minneapolis Radiation Oncology	Replacement of linear accelerator	Waconia, MN	7/7/2009	$3.3 mill
Radiation Therapy Ctr. at Fairview Southdale/ Minneapolis Radiation Oncology	Replacement of linear accelerator	Edina, MN	7/13/2009	$2.0 mill
Fairview University Medical Ctr. - Mesabi	Addition of new linear accelerator	Hibbing, MN	7/15/2009	$2.9 mill
Albert Lea Medical Ctr./ Mayo Clinic	Replacement of linear accelerator	Albert Lea, MN	10/22/2009	$2.1 mill
Northfield Radiation Oncology/ Mayo Clinic	Development of cancer center	Northfield, MN	2/19/2010	$11. mill
Rochester Methodist Hospital/ Mayo Clinic	Proton beam therapy project	Rochester, MN	2/19/2010	$201 mill
St. Paul Cancer Ctr./ Minnesota Oncology	Replacement of linear accelerator	St. Paul, MN	4/24/2010	$1.9 mill
University of Minnesota Medical Ctr./ Fairview Health System	Replacement of linear accelerator	Minneapolis, MN	6/3/2010	$3.1 mill
St. Francis Radiation Therapy Ctr./ Minneapolis Radiation Oncology	Replacement of linear accelerator	Shakopee, MN	8/20/2010	$2.5 mill
St. Paul Cancer Ctr./ Minnesota Oncology	Replacement of linear accelerator	St. Paul, MN	10/1/2010	$2.7 mill
Brainerd Radiation Therapy Ctr./ Minneapolis Radiation Oncology	Replacement of linear accelerator	Brainerd, MN	4/6/2011	$3.3 mill
Unity Radiation Therapy Ctr./ Minneapolis Radiation Oncology	Replacement of linear accelerator	Fridley, MN	4/6/2011	$3.1 mill
Avera Marshall Reg. Medical Ctr.	Development of new cancer center	Marshall, MN	12/6/2012	*
Mercy Radiation Therapy Ctr./ Minneapolis Radiation Oncology	Addition of new linear accelerator	Coon Rapids, MN	12/20/2012	*

*Capital expenditure reports for these expenditure commitments are expected as part of 2013 reports to the Department of Health

Section 3: Analysis and Findings

Responding to the questions posed by the legislature requires calculation of both expected treatment volume (how many people will require radiation therapy treatment and at what level of intensity/ duration) and available treatment capacity to determine how well demand for treatment matches supply of available services. Ideally, this analysis would be built "from the bottom up," relying on information about the number of people who are living with cancer, the number of expected new patients who will be diagnosed with cancer, the number/percentage of these patients who require treatment for palliative or curative care, and the intensity of treatment.

Although Minnesota has a powerful data source in the Minnesota Cancer Surveillance System,[19] which tracks nearly all confirmed cancers, including invasive and *in situ* tumors, the system does not include reports at the detail desirable for a bottom-up approach. Instead, the analysis for this study relies on a "top-down" approach, building on actual observed treatment patterns at Minnesota radiation therapy facilities and their relationship to the number of newly diagnosed cancer cases.

Using a top-down approach to developing estimates for comparing future demand for radiation therapy with available treatment capacity in Minnesota, this study aims to address four analytic questions:

1. **How will population demographics change in Minnesota?** Projections of population trends are key to estimating how many individuals in Minnesota may require radiation therapy in the future. Overall population growth, as well as shifts in the age distributions of age groups most likely to require radiation therapy treatment will affect treatment demand.
2. **How will trends in cancer incidence in Minnesota change, given population trends?** In projecting need for particular cancer treatments is important to understand what share of the population may require treatment because of a new cancer diagnosis. The rate of incidence, or the share of the population over a certain time period newly diagnosed with cancer, together with population projections, produces such estimates.
3. **What radiation therapy treatment volume will be needed in Minnesota, given trends in cancer incidence and the rate of patients in survivorship or in surveillance programs?** The needed radiation therapy treatment volume is a function of the number of individuals requiring treatment and the intensity of treatment that is needed. Treatment volume is composed of treatment for people who are newly diagnosed with cancer and require radiation therapy, and patients who were previously diagnosed and may require ongoing or palliative care treatment. Intensity and treatment volume required may differ by type of cancer and the stage of diagnosis.
4. **What treatment capacity is available in Minnesota to serve patients?** In estimating whether there is treatment capacity sufficient to match the potential need for care, we need to understand how many machines are available in Minnesota to deliver radiation therapy, what level of utilization they are capable of operating at (hours per day x days per year), and what potential "surge capacity" exists in the system.

[19] A thorough description of the Minnesota Cancer Surveillance System (MCSS), the data source that it builds on and the information that can be drawn from it can be found in MDH's biennial report to the Legislature: Minnesota Department of Health, "Cancer in Minnesota, 1988-2009," Report to the Minnesota Legislature, 2013, December 2012.

3.1 Estimating Population Changes

As noted in Section 2, the incidence of cancer differs substantially by age and region (as well as type of cancer). As such, population estimates and projections for this study were analyzed at a level of granularity that allowed sufficient precision for developing age-adjusted projections of cancer incidence. Considering the types of cancer with the highest number of patients that require radiation therapy (see also Figure 3) and their underlying age distribution, this study analyzed demographic trends by age, gender, and region for the period of 1988 through 2022. Historical estimates were derived from the U.S. Census Bureau for the years 1988 to 2009; projected population estimates for the years 2010 to 2022 came from the Minnesota Office of the State Demographer.

The analysis of demographic trends found:

- The overall population of Minnesota is expected to grow by about 460,000 people between 2012 and 2022, or 8.5 percent.
- As shown in Appendix D, the rate of growth for this period is uneven across the state. Population growth between 2012 and 2022 is projected to range between 2.2 percent in the Northeast to 13.9 percent in Central Minnesota.
- Rates of growth also differ by age, as was shown earlier. Minnesota's elderly population is predicted to see the most rapid growth of all age groups for the period. Population growth for Minnesotans between 60 and 69 through 2022 is projected to be more than four times that of the population overall (36.9 percent vs. 8.5 percent); the share of the population older than 70 years is expected to grow at more than five times the statewide rate.
- While the rate of growth for age groups differs across regions of the state, the fact that the elderly account for the largest share of population growth in Minnesota over the next ten years is consistent across all Minnesota regions.

In conclusion, population groups in Minnesota that historically saw the largest rates in cancer incidence will experience significant growth across the projection period relevant for this study. Factors such as patient preference, the capability of the medical care system, and changes in risk factors will shape how this population growth will affect growth in the number of newly diagnosed cases. The next section presents a range of projections of cancer incidence derived based on historical patterns.

3.2 Projecting Future Cancer Incidence

Cancer incidence measures the number of newly diagnosed cancer cases over a given time period. This study asks: given the projected population trends, how many Minnesotans might be diagnosed with cancer every year between 2012 and 2022?

To ensure that projections are sufficiently precise, MDH estimated overall incidence of cancer by major cancer sites (e.g., prostate and lung/bronchus) that are characterized by high rates of first-course radiation therapy treatment and region in the state. (In estimating cancer incidence, all cancers were considered; however, cancers with lower rates of radiation treatment were projected as a group.)

Including estimating statewide cancer incidence, this granular approach required estimating models for 117 cells (13 cancer site categories by nine levels of geography).

Recognizing the substantial uncertainties associated with projecting demand for specific health care services, a topic that is discussed in greater detail in Appendix A, cancer incidence was projected using two scenarios:

1. Assuming static rates of cancer incidence: population projections are multiplied by a static rate of actual cancer incidence per 100,000 people in 2012 for each major cancer site, age group and region, using the most recently available information from the MCSS;[20] and
2. Projecting cancer incidence on the basis of changing rates of incidence: new cancer cases are projected using historical data and demographic trends (for purposes of age-adjusting), by employing statistical models used in time series analyses. These models (vector autoregression, or VAR) are designed to best capture linear and non-linear trends, as well as cyclical behaviors of the historical observed data, to predict future incidence.[21] For the regional analysis the VAR models were reinforced using Bayesian techniques to create robust estimates for areas and time periods with greater relative volatilities in the trend. Bayes' small area methods were also used to generate prediction confidence bounds to illustrate how the degree of uncertainty increases with the length of the prediction time horizon.

Results from simulation and modeling conducted for this study show that the number of new cancer cases between 2012 and 2022 are projected to increase by between 7.2 percent (under the scenario with static rates of incidence) and 23.5 percent (under the scenario with projected incidence rates). As shown in Figure 6, the increase in the number of new cases differs by cancer site, particularly when using projections of incidence. Cancer of the esophagus is projected to see the most significant percent increase (50.7 percent), rising from an estimated 365 cases in 2012 to a projected 550 in 2022. In contrast, cancers of the colon & rectum are projected to fall over the 10-year period by 7.9 percent, from 2,456 new cases in 2012 to 2,263 in 2022.

Detailed data on the number of new cancer cases and the rate of incidence by cancer site and geography in Appendix E demonstrate that there is some potentially encouraging news from these projections for certain cancers. For instance, although the number of new cancer cases is increasing for most cancers, the rate of incidence, or the likelihood that certain populations at risk will develop cancer, is projected to stay stable or decline for seven types of cancer that collectively account for 34 percent of all new cancer cases.[22] However, for most of these cancers, population trends (increase in the number of Minnesotans and the aging of the population) will still lead to an increase in the actual number of cases of cancer diagnosed each year despite declining rates of incidence. Comparing estimated new cancer cases between the two methods used in developing Figure 6 — holding rates of incidence constant (assuming only population factors matter) or projecting actual growth in the incidencerate — show that population plays an important, but secondary role in the growth of new cancer cases; population factors account only for 30.5 percent of growth in incidence.

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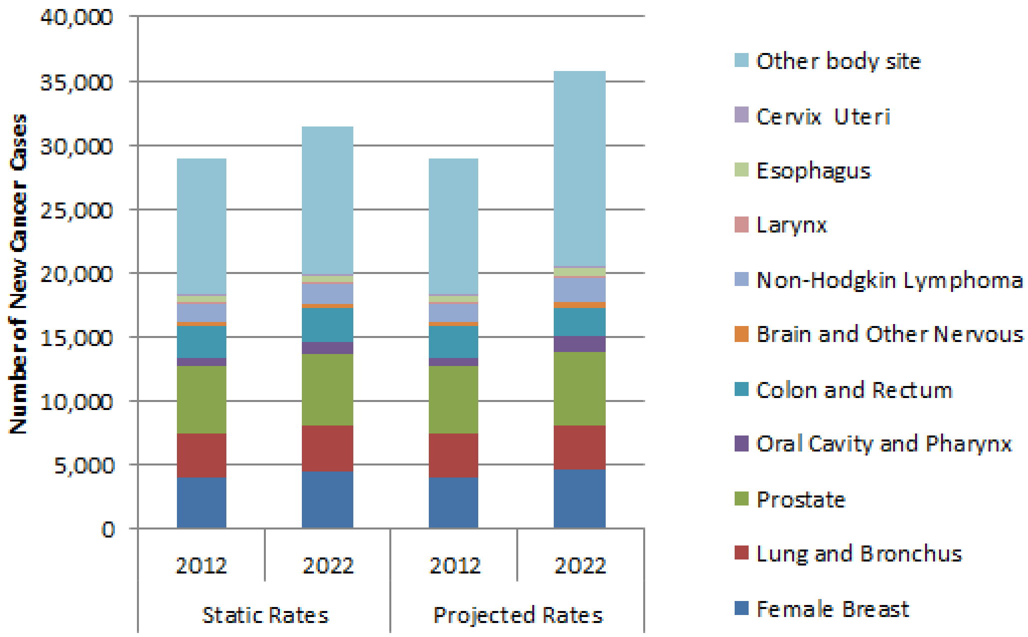
[20] Static incidence rates are computed based on statistical analysis of actual historical rates that correct for random year-to-year fluctuation.

[21] Vector autoregressive modeling techniques were selected for this study because of how well their statistical properties were matched to the challenges of generating projections of a volatile time series such as cancer incidence. In addition, recent research demonstrated that this technique produces superior results for developing estimates at the state-level and for the most common cancers, one reason why the American Cancer Society has used this technique in their latest national projection estimates. (see: Liz Zhu, Linda W. Pickle and Deepa Naishadham et.al., "Predicting U.S. and State-Level Cancer Counts for the Current Calendar Year, Part II: Evaluation of Spatiotemporal Projection Methods for Incidence," Cancer, Feb. 2012). Additional methodological detail is included in the Methods Appendix.

[22] Cancer sites with stable or declining rates of incidence included lung/bronchus (men), prostrate, oral cavity and pharynx (non HPV-related), colon & rectum, brain & other nervous system, larynx, and cervix utiri.

Figure 6: Estimates for New Cancer Cases in Minnesota Under Varying Assumptions, 2012 and 2022



Source: MDH and WIPFLi analysis of estimated current treatment volume and cancer projections.

In summary, it is clear from the projections in this study that cancer will remain a significant public health burden that comes with great individual suffering and loss. How the increase in the number of new cancer cases translates into demand for radiation therapy treatment is addressed next.

3.3 Estimating Needed Radiation Therapy Treatment Volume

As noted earlier, to estimate needed treatment volume, this study cannot rely on granular data about treatment need by new cancer patients and patients who are in survivorship or a surveillance plan. Instead, this study develops a proxy for the two aspects of treatment volume (length and intensity of treatment for differing patients) by analyzing the volume of total actual radiation therapy treatment provided in an index year (2010) by region and cancer site in relationship to the number of new cancer cases, an index year (2009).[23] Importantly for Minnesota, the use of this ratio in the equation below enables accounting for the fact that some Minnesota cancer patients will seek care outside of Minnesota or travel to other regions of the state and that non-Minnesota patients, as discussed in the context of Figure 5, will seek care in the state and contribute to utilization rates of available equipment.

[23]Ideally both metrics would be from the same time period, however because of the differences in data sources – the numerator is derived data collected by MDH in 2012, the denominator originates with the MCSS – this was not possible.

Equation 1: Estimation of Needed Treatment Volume

$$Estimated\ Treatment\ Volume_{Year\ x} = New\ Cancer\ Cases_{Year\ x}\ x\ \frac{Radiation\ Therapy\ Treatment\ Volume_{2010}}{New\ Cancer\ Cases_{2009}}$$

Table 2 illustrates the calculation of the ratio and its application to estimating needed treatment volume. Using a regional example, the current ratio of the actual total treatment volume to the number of new cancer cases for the Twin Cities Metro Area is 10.5. Assuming a level of incidence in 2012 of 14,956 cancer cases, needed treatment in 2012 is estimated to be 156,423 treatments (14,956 times 10.5).[24] As mentioned earlier, high ratios likely indicate in-migration of cancer patients from outside the region (e.g., the Twin Cities and Southeast Minnesota), while a low ratio indicates possible outmigration of patients (e.g., patients from Northwest Minnesota being treated in North Dakota).

Table 2: Projecting Treatment Demand - Ratio of Cancer Treatment with Radiation Therapy to Number of New Cancer Cases

	Radiation Therapy Volume (2010)	Number of New Cancer Cases (2009)	Ratio of Volume to New Cases	Number of New Cancer Cases (2012)	Est. Needed Treatment Volume (2012)
	A	B	A / B	C	C x A / B
Statewide*	260,943	26,579	–	28,942	284,161
Twin Cities Metro	143,271	13,699	10.5	14,956	156,423
Southeast	43,256	2,579	16.8	2,798	46,938
South Central	7,704	1,505	5.1	1,621	8,300
Southwest	9,244	1,227	7.5	1,320	9,946
Central	25,606	3,645	7.0	4,005	28,132
West Central	10,403	1,018	10.2	1,110	11,346
Northwest	2,801	1,085	2.6	1,175	3,031
Northeast	18,658	1,821	10.2	1,956	20,044

Source: MDH analysis of radiation therapy treatment volume (data collected from radiation facilities in 2010), actual cancer cases (developed from the MCSS for 2009), and projected cancer cases (2012).
*Estimated statewide volume is the sum of the Minnesota regions.

Absent other available data, this study makes four simplifying assumptions for estimating needed treatment volume:

1. The share of newly diagnosed cancer patients in a given year who require radiation treatment does not change significantly over the period considered for this study.
2. The ratio of 2010/2009 radiation therapy treatment volume to newly diagnosed cancer cases remains stable over the projection window as well.

[24] It is important to remember, the ratio presented here does not measure the number of treatments per each newly diagnosed cancer patient. It is a factor that is developed based on volume of radiation treatment for all cancer patients and includes of care for patients in survivorship or in surveillance plans.

3. Section 3.2 described two approaches to projecting future cancer incidence. For this analysis, we assume that projected rates of incidence are likely to provide a more realistic picture of incidence patterns than holding historical rates constant, so all estimates from hereon are based on this approach.
4. The net effect of cancer patients coming from outside of Minnesota for treatment in the state, or leaving for treatment elsewhere remains unchanged over time.

While generally reasonable assumptions, there are a range of inherently unpredictable factors that could affect needed treatment volume, including the availability of new treatment options, cultural changes affecting the use of radiation therapy, and technological advancements that could affect how much or how intense a treatment cancer patients might require.

We attempt to simulate the effect of a technological advancement that seems to be taking root in the community. Evidence from the literature, feedback from the advisory group that MDH convened for this study, and data from operators of radiation therapy equipment indicates that operators are in the process of making technical modifications to existing equipment that will allow for delivery of stereotactic body radiation therapy (SBRT). Because of the specifically designed targeting system, SBRT treatment can more precisely locate and treat tumors with higher-dose radiation treatment, but for shorter durations. For cancers eligible for this treatment (at this point primarily lung cancer and potentially prostate cancer),[25] SBRT can reduce the number of treatments from 25 to 50 blocks over a five to 10 week period, to one to five treatments within a few days.[26]

To illustrate the potential effect of broader adoption of this technology on needed treatment volume, we performed a sensitivity analysis that simulates SBRT technology adoption of radiation equipment reaching about 75 percent of machines; we assumed treatment rate for indicated cancers of 15 percent, recognizing that only a small share of patients can benefit from this service and that adoption of SBRT, primarily in rural areas and on older machines, will likely occur at lower rates.

As shown in Table 3 through a simulation of treatment changes to one linear accelerator, the estimated downward effect from SBRT adoption on treatment volume is projected to be negligible (a reduction from a simulated 15,625 treatment hours at one facility to 15,531, or less than 1 percent). As the simulation shows, the reduction in the number of needed treatments per patient (from an average of 25 treatments to about 5) is largely offset by the increase in the length of each individual treatment (from a traditional 15 minutes block to one requiring about an hour). Nevertheless, the potential reductions in treatment burden for some patients may be substantial enough to justify considering greater adoption of this technology.

[25] See an AHRQ meta-analysis of research on this topic: Tipton et al., "Stereotactic Body Radiation Therapy" Technical Brief No. 6. AHRQ Publication No. 10 (11)-EHC058-EF. Rockville, MD: Agency for Healthcare Research and Quality. Available at www.effectivehealthcare.ahrq.gov/reports/final.cfm

[26] Anecdotal evidence from conversations with Minnesota operators of radiation therapy facilities suggests that by 2012, at minimum seven cancer centers have adopted SRBT technology.

Table 3: Effect of Greater Adoption of SBRT Technology on Estimated Treatment Time

Treatment Options	Number of Patients	Estimated Per Person Treatments	Estimated Per Person Treatment Time (Minutes)	Total Estimated Treatment Time (Hours)
1. NO SBRT TREATMENT AVAILABLE				
Total Patients Receiving Radiation Therapy (no SBRT treatment option)	**2,500**	**25**	**15**	**15,625**
2. SBRT TREATMENT AVAILABLE				
Patients Eligible for SBRT Treatment Not Receiving SBRT	425	25	15	2,656
Patients Receiving SBRT Treatment (15% of eligible)	75	5	60	375
Total Patients Not Eligible and Not Receiving SBRT Treatment	2,000	25	15	12,500
Total Patients Receiving Radiation Therapy (SBRT treatment option incl)	**2,500**	**-**	**-**	**15,531**

Source: MDH analysis of treatment volume data.

3.4 Projecting Radiation Therapy Capacity in Minnesota

To determine available radiation therapy capacity, we use operational statistics and machine inventory data collected by MDH in 2012 from each of the existing 35 radiation therapy facilities in the state,[27] sorted into four major machine types: traditional linear accelerators (LINAC), stereotactic radiosurgery (SRS), tomotherapy (Tomo) and proton therapy (Proton). We added to the machine inventory data for known planned additions of machines at existing sites, as well as the establishment of a new radiation therapy facility in Southwest Minnesota. This includes:

- One linear accelerator for the Twin Cities Metro region at Mercy Radiation Therapy Center;
- Four proton therapy machines in the Southeastern region at the Mayo Clinic in Rochester; and
- One additional linear accelerator in the Southwestern region at Avera Marshall Medical Center.

With regard to questions concerning operational details of radiation therapy equipment, evidence from interviews with operators of radiation therapy facilities indicates that these facilities are generally open 253 days per year, leaving them closed for weekends and seven holidays. Because of the need for maintenance and general downtime, this study used 250 days of operation in estimating available treatment capacity. In addition, radiation therapy facilities and clinician members of the Advisory Group also indicated that as treatment demand requires, facilities extend their hours of operation beyond a usual eight hour day or add weekend hours. As such, for the purpose of this study, we estimate available radiation therapy capacity in two scenarios:

1. Using operator-reported maximum annual treatment capacity based on eight-hour workdays and 250 days of operation per year; and

[27] Excluded from this analysis was the radiation therapy equipment used by the Veterans Administration in the state because this capacity is not available for treatment of the general population.

2. Adding potential "surge capacity" to operator-reported maximum annual treatment capacity equal to extending operating hours from eight to nine hours per day.[28]

The estimated maximum treatment per machine, calculated as an average by machine type and region for a given calendar year, was derived from reported number of treatments per hour.

Given the data and the indicated assumptions, this study finds that treatment capacity at existing radiation therapy facilities in Minnesota in 2012 amounted to 424,250 treatments statewide. Taking into consideration growth in capacity through planned expansions or upgrades, treatment capacity is projected to grow by 10 percent, or 43,500 units, by 2017 and stay unchanged through 2022. Building into this projection of treatment capacity a conservative estimate for potential surge capacity (increasing operating hours from eight to nine hours per day, without adding additional days of operation), we estimated that treatment capacity in 2022 could potentially increase by another 13 percent, or approximately 60,808 additional radiation treatments.

Table 4: Radiation Therapy Treatment Capacity at Existing Facilities, Actual & Projected Treatment Volume

	Reported Maximum Available Capacity*		Max. w/ Estimated Potential Surge Capacity‡
	2012	2017/2022	2022
Statewide	424,250	467,750	528,558
Twin Cities Metro	218,750	227,000	256,510
Southeast	68,500	95,500	107,915
South Central	15,000	15,000	16,950
Southwest	19,250	27,500	31,075
Central	42,750	42,750	48,308
West Central	16,000	16,000	18,080
Northwest	8,000	8,000	9,040
Northeast	36,000	36,000	40,680

Source: Source: MDH analysis of data collected from Minnesota radiation therapy facilities in December of 2012.
*Maximum available capacity was reported on a daily basis, assuming an annual operational schedule of 253 days per year less an average of three days for maintenance.
‡Maximum available surge capacity assumes an addition of an extra hour per day.

[28] The estimate of available capacity or potential "surge capacity" does not take into consideration staffing needs that may or may not be available to operate the additional treatment capacity.

3.5 Comparison of Available Radiation Treatment Capacity and Treatment Need in Minnesota

Analyses in this Section of the report projected needed treatment volume for cancer patients requiring radiation therapy treatment and estimated how much treatment capacity is currently available in existing radiation therapy facilities or will be added over the next couple of years. Table 5 brings these two analytic steps together by comparing existing and likely future demand for radiation therapy capacity with needed treatment volume.

As shown in the table, existing radiation therapy treatment capacity in Minnesota in 2012 was utilized at about 67 percent of estimated available operating capacity. Usage of available capacity differed by region of the state, with the Twin Cities and West Central Minnesota utilizing 72 and 71 percent of available capacity, respectively; the Northwest used about 38 percent of available radiation therapy capacity.

Usage relative to available capacity statewide is projected to increase slightly by 2017, from 67 percent to 68 percent. This modest increase is due to growth in needed treatment volume (associated with growth in cancer incidence) somewhat offsetting the planned expansion of capacity described in section 3.4. Nevertheless, usage relative to capacity in the two regions with the highest rates of utilization, the Twin Cities and West Central Minnesota, is projected to increase to 78 percent and 77 percent, respectively. If we consider the potential availability of surge capacity, as indicated in part by current practice capacity utilization in the Twin Cities and West Central Minnesota is projected to top out at 69 percent and 68 percent, respectively as shown in Table 6. (Because of its neglible impact, SBRT adoption was not further considered).

Growth in treatment demand by 2022, resulting from demographic trends and an increase in rates of incidence, is projected to occur assuming no further growth treatment capacity. Consequently, rates of utilization compared to available capacity are projected to increase relative to 2017. Without considering available surge capacity, capacity utilization statewide is projected to increase to 75 percent by 2022; it is projected to reach 86 percent in the Twin Cities and 83 percent in West Central Minnesota, the two regions with the highest rates of utilization. Again, as shown in Table 6, when we assume facilities would increase their hours of operation to meet capacity demand, projected utilization relative to available capacity declines. Under this scenario, rates of utilization of available radiation therapy capacity for the Twin Cities and West Central Minnesota are projected to reach 77 percent and 74 percent, respectively.

Table 5: Current and Projected Treatment Demand and Capacity for Radiation Therapy

	2012			2017			2022		
	Available Capacity	Projected Needed Treatment Volume	Projected Capacity Use	Available Capacity	Projected Needed Treatment Volume	Projected Capacity Use	Available Capacity	Projected Needed Treatment Volume	Projected Capacity Use
Statewide	424,250	284,161	67%	467,750	318,006	68%	467,750	352,067	75%
Twin Cities Metrc	218,750	156,423	72%	227,000	176,510	78%	227,000	196,140	86%
Southeast	68,500	46,938	69%	95,500	52,564	55%	95,500	58,521	61%
South Central	15,000	8,300	55%	15,000	9,039	60%	15,000	9,780	65%
Southwest	19,250	9,946	52%	27,500	10,528	38%	27,500	11,090	40%
Central	42,750	28,132	66%	42,750	32,039	75%	42,750	36,263	85%
West Central	16,000	11,346	71%	16,000	12,351	77%	16,000	13,327	83%
Northwest	8,000	3,031	38%	8,000	3,301	41%	8,000	3,557	44%
Northeast	36,000	20,044	56%	36,000	21,674	60%	36,000	23,388	65%

Source: Analysis of future cancer incidence projections prepared for MDH using data from MCSS along with data collected from Minnesota radiation therapy centers in December of 2012.

Table 6: Current and Projected Treatment Demand and Capacity for Radiation Therapy with Simulation of Surge Capacity

	2012			2017			2022		
	Available Capacity	Projected Needed Treatment Volume	Projected Capacity Use	Available Capacity	Projected Needed Treatment Volume	Projected Capacity Use	Available Capacity	Projected Needed Treatment Volume	Projected Capacity Use
Statewide	479,403	284,161	59%	528,558	318,006	60%	528,558	352,067	67%
Twin Cities Metrc	247,188	156,423	63%	256,510	176,510	69%	256,510	196,140	76%
Southeast	77,405	46,938	61%	107,915	52,564	49%	107,915	58,521	54%
South Central	16,950	8,300	49%	16,950	9,039	53%	16,950	9,780	58%
Southwest	21,753	9,946	46%	31,075	10,528	34%	31,075	11,090	36%
Central	48,308	28,132	58%	48,308	32,039	66%	48,308	36,263	75%
West Central	18,080	11,346	63%	18,080	12,351	68%	18,080	13,327	74%
Northwest	9,040	3,031	34%	9,040	3,301	37%	9,040	3,557	39%
Northeast	40,680	20,044	49%	40,680	21,674	53%	40,680	23,388	57%

Source: Analysis of future cancer incidence projections prepared for MDH using data from MCSS along with data collected from Minnesota radiation therapy centers in December of 2012.

Section 4: Conclusions and Limitations

The objective of this study was to compare how well current and future demand for radiation therapy treatment is matched with treatment capacity in existing and planned radiation therapy facilities in Minnesota. MDH and its contractor collected operational statistics from Minnesota facilities providing radiation therapy, analyzed secondary data on cancer and demographic trends, performed statistical projections of cancer incidence and treatment demand, and simulated potential changes in available radiation therapy capacity over time.

In conducting the research for this study, MDH and its contractor used the most recently available data; considered evidence from the literature, to the extent it was available; developed reasonably cautious assumptions that would not bias the outcome of the research; and conducted, where possible, sensitivity analyses to consider the effect of alternative assumptions. Nevertheless, in considering the findings from this study, policy makers should be aware of the considerable uncertainties associated with projections in general, and projections of demand for cancer care, in particular. These limitations and uncertainties are described in more detail in the methods discussion in Appendix A to this report.

The major findings of this study include:

- Although there are promising trends in the rate of incidence for certain cancers, cancer will remain a significant public health burden in Minnesota and a personal challenge for many patients, family members and caregivers;
- In aggregate, the number of new cancer cases is projected to grow between 2012 and 2022 by about 23.5 percent because of a number of factors, including trends in underlying risk factors as well as demographic changes;
- Needed radiation therapy treatment volume, which encompasses treatment need for newly diagnosed patients and for patients living with cancer, is projected to grow slightly faster than estimates of incidence (23.9 percent compared to 23.5 percent);
- Although capacity for delivering radiation therapy services will grow as well between 2012 and 2022, rates of utilization at existing and planned facilities will increase because the rate of growth in available treatment capacity is lower than that of treatment need (10.3 percent compared to 23.9 percent);
- Without changing current operational practices, rates of utilization of existing capacity will rise for the state overall (to 68 percent in 2017 and 75 percent in 2022). Rates of utilization are projected to be highest in the Twin Cities (78 percent and 86 percent in 2017 and 2022, respectively) and in West Central Minnesota (77 percent and 83 percent in 2017 and 2022, respectively).
- Operators of radiation therapy facilities feel there is considerable surge capacity in potentially extending business hours and expanding appointments for treatment beyond the traditional work week.
- Projected rates of utilization of available capacity would be more modest if promises of available surge capacity were fulfilled. Under those circumstances, maximum utilization of capacity in the Twin Cities would reach 76 percent by 2022; it would reach 74 percent in West Central Minnesota.

In summary, with current assumptions concerning the projection of cancer incidence, the use of existing capacity, and the prospect that existing radiation therapy facilities may expand available capacity through capital investments or expanded hours of operation, it appears that by 2022, projected needed treatment volume is matched by available treatment capacity.
Considering the uncertainties associated with conducting longer-term projections of demand for radiation

therapy capacity and the unknown but potentially considerable effects of implementing Minnesota health reform and the Patient Protection and Affordable Care Act in the state, the Legislature may wish to consider revisiting these estimates well before 2022. This would provide the opportunity to enhance the model presented for this study, as suggested in Appendix A, including by adding additional variables with predictive power to the projection model.

Appendix A: Methods

As indicated earlier, in conducting this study, MDH and its contractor collected operational statistics from Minnesota facilities providing radiation therapy, used secondary data on cancer and demographic trends, performed statistical projections of cancer incidence and treatment demand, and simulated a range of potential changes in available radiation therapy capacity over time. Throughout the analysis, MDH made a series of assumption concerning the choice of data, the analytical approach, methodological decision, and what sensitivity analyses to pursue.

This section is intended provide additional detail on those assumptions and methodological decisions, so that the user of this information may evaluate the uncertainties associated with the findings presented in this report.

A.1 Uncertainties Associated with Projecting Cancer Incidence

All projections, independent of the metric that is the focus, rely on the existence of historical data that contains measurable relationships between variables from which to derive a “signal” for estimating future trends. Many cancers, however, exhibit extremely volatile patterns over time that are affected by factors such as changes in practice pattern, trends in screening, pace of technological advancement, changes in risk factors, and changes in patient preference.

Much of this is exemplified by the figure in Appendix H, representing statistical model fit of historical and projected rates of incidence for prostate cancer. Rates of incidence were affected by the availability of screening techniques for prostate cancer, the recommendation that men of certain ages be screened for prostate cancer, and the recent more cautious approach towards preventive testing for prostate cancer. Recognizing the challenges associated with projecting cancer incidence, including the increase in the uncertainty associated with projections when the timeframe for projection is longer, most national and government organizations that estimate the burden of cancer limit their projection horizon to four years, rather than the ten years required for this study.

In addition, the accuracy of projections, particularly in the long run, will be affected by potential changes to historical patterns that currently are either inherently unknowable or not possible to predict with any accuracy and that were therefore not built into the model:

- Changes in the capabilities of technology might reduce the treatment burden, as is the case with SBRT treatment. New technologies, however, may also increase the treatment burden if it enables treatment of patients who are currently considered not good candidates for radiation therapy treatment.
- Changes in practice pattern may affect whether cancer patients are recommended for radiation therapy or alternative therapies.

- Changes in screening methods, as currently considered by the U.S. Preventive Task Force for lung cancer, may affect incidence rates.
- Changes in patient preferences with regard to treatment alternatives, particularly for advanced cases, may affect needed treatment volume.
- Changes in environmental risk factors for cancer, such as for example the rate of smoking, may affect the rate of cancer incidence and the need for treatment.
- Changes in population demographics may affect rates of incidence and rates of morality, which in turn may affect treatment demand.
- Lastly, shifts in the direction of incidence rates (e.g., female lung cancer incidence rates increase but are expected to decline) or the scale of the trend (e.g., male lung and colorectal cancer incidence rates are expected to decline more rapidly),

One potentially important factor that may affect the accuracy of projections of incidence of cancer, the need for radiation therapy, or available capacity concerns are the potential uncertainties associated with the implementation of health reform in Minnesota and of the Patient Protection and Affordable Care Act (ACA) over the next couple of years.[29]

Although the impact is not well enough understood to incorporate into a model or to simulate quantitatively with any precision as part of a sensitivity analysis, there are several potential pathways of this effect:

- Key among the objectives of the ACA is the intent to increase access to insurance by establishing a requirement of insurance coverage and lowering the barriers to affordable access to health insurance coverage. Mechanisms such as making available insurance subsidies, creating standards for health insurance products and establishing insurance exchanges on which to comparison-shop for health insurance products are expected to reduce the rate of uninsurance in Minnesota.[30] With greater insurance coverage, more patients may be diagnosed earlier with cancer, leading to a greater need for radiation therapy treatment for some or less need for treatment for others, because of availability of alternative services.
- The ACA's regulation of insurance premiums, the removal of pre-existing condition exclusions, the elimination of annual and lifetime limits, and the availability of cost-sharing subsidies for some individuals may have similar effects whose direction are not easily predicted.
- The increased transparency in provider quality may lead to greater rates of screening and increased need for treatment. For instance, screening rates of colorectal cancer were collected for the first time in 2011 and are intended for public reporting under Minnesota's Statewide Quality Reporting and Measurement initiative, with the goal of achieving statewide improvement in screening rates over time.[31] At the same time, a greater focus on comparative effectiveness research may re-balance the use of treatment alternatives leading to potential changes in the use of radiation therapy.

[29] The Patient Protection and Affordable Care Act (Pub.L. No. 111-149, 124.Stat 119) amended by the Health Care Education and Reconciliation Act, (Pub.L. No. 111-152, 124.Stat 1029 is generally referred to in abbreviated form as the Affordable Care Act.

[30] Gruber J. and Gorman B., "Analysis of Implementation of the Affordable Care Act, Health Insurance Exchange, and Basic Health Plan on Minnesota," Report to the Department of Minnesota Management and Budget, March 2013.

[31] See: http://www.health.state.mn.us/healthreform/measurement/index.html

- Lastly, the focus of health reform on increasing efficiency in the delivery system and stemming the growth in health care costs may also impact the need for treatment and use of treatment capacity. The development of Accountable Care Organizations under the ACA, as well as other shared savings arrangements, with their greater focus on care coordination, care effectiveness, population health management, safety and effectiveness, will likely affect cancer treatment patterns in still difficult to predict ways.[32] Certainly, what has been clear is that the delivery system is working on placing patient preferences more at the center of care. Whether this means that, as is the case with prostate cancer, more men chose against more intensive treatment and regular screening,[33,34] or whether cancer patients prefer therapies with a wider spread of outcomes (coined "hopeful gamble") is an empirical question that ought to be monitored over the period of implementing health reform.[35]

A.2 Assumptions and Their Likely Effect

In order to project future demand for radiation therapy, this study made a number of assumptions given the paucity of available data and empirical evidence. Each assumption, while reasonable and conservative in that it attempts to avoid creating artificially low estimates of treatment demand, will potentially affect the outcome of the projections. Being aware of these assumptions and their potential effect is important in considering projection results:

- Population projections were taken from reputable sources. However, for the historical analysis and the projection the study had to rely on estimation results from different sources. This may have introduced additional noise into the analysis.
- The analysis did not consider cancer rates at the level of race and ethnicity (it considered age and region), primarily because the number of cases by race and ethnicity, cancer site and region were too small to be used in statistical models. To the extent that population growth for American Indians and African Americans in the projection window will substantially outpace that of the population in general, projected treatment need might have been slightly understated.
- The projection of treatment need is based on a static ratio of treatment demand in 2010 to new cancer cases in 2009. While we believe the ratio will stay nearly stable, if the relationship between care required for new cancer cases and care for patients in survivorship or surveillance programs differs over time, projections of treatment need could be understated or overstated.
- We used an average treatment maximum by machine type based on data reported by operators of radiation therapy treatment. This assumes certain downtimes, estimated on average to be three days out of an operational maximum of 253 days per year. While there is some variation around reported treatment volume and maintenance downtime, reported totals track relatively well across reporters.

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[32] Ferris L, Farber M, Guidi TU et al., "Impact of Health Care Reform on the Cancer Patient: A View from Cancer Executives," The Cancer Journal, 16(6), November/December 2010.

[33] Howard DH, Tangka FK, Guy, GP et al., "Prostate Cancer Screening in Men Ages 75 and Older Fell by 8 Percentage Points After Task Force Recommendation, Health Affairs, 32(8), March 2013

[34] Cutler D, "Where are the Health Care Entrepreneurs? The Failure of Organizational Innovation in Health Care," Working Paper 16030, National Bureau of Economic Research

[35] Lakdawalla DN, Romley JR, Sanchez Y, et al., "How Cancer Patients Value Hope and the Implications for Cost-Effectiveness Assessments of High-Cost Cancer Therapies, Health Affairs, 31(4), April 2012.

- The analysis assumes that supply of radiation therapy services is fixed by the number of machines currently available or known to be planned. Evidence from Table 1 suggests that radiation therapy facilities are making ongoing upgrades to existing equipment, as well as adding new capacity. In addition, where state law has allowed it, new facilities are being planned (e.g., Avera Marshall Regional Center, MN). The assumption of fixed supply likely results in overestimation of capacity usage, shown in Table 1.
- Lastly, our projections include the addition of proton beam therapy capacity planned for Rochester, MN by the Mayo Clinic System. In estimating regional rates of capacity utilization, this study built on evidence from the literature in estimating potential future available treatment volume. The study was not able to consider the extent to which available future treatment volume would be met in part by greater inflow of non-Minnesota patients and patients from other areas of the state. For 2017 and 2022, this may somewhat understate capacity utilization in the Southeast area and overstate capacity utilization elsewhere.

A.3 Vector-Autoregression Analysis to Project Cancer Incidence

A multivariate time series method, vector auto-regression (VAR), was used for projecting the number of new Minnesota cancer cases. Data used in the model included MCSS data from 1988 to 2009 with variables for cancer type, cancer count, age group, region of residence, and year of diagnosis. In addition, historical population data was included from the U.S. Census Bureau for the years 1988 to 2009, and population projection data was included, which form the basis for computing age-adjusted incidence, where drawn from the Minnesota State Demographic Center for the years 2010 through 2022. Population variables included gender, age group, region of residence, and year. The R software package was used for obtaining forecast counts.

Age-adjustment

Cancer incidence data from MCSS was age-adjusted into rates per 100,000 to control for differences in age distribution between populations. This adjustment was a weighted average of age-specific rates, with the proportion of individuals in the four corresponding population age groups (0 to 49, 50 to 59, 60 to 69 and 70 and older) functioning as the weights.

Future Cancer Incidence Model Design

Cancer incidence was estimated using a multivariate time-series VAR model consistent with the following specifications:

$$X_t \in \mathbb{R}^d$$

$$X_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} + \cdots \phi_p X_{t-p} + e_t$$

Where $\phi_1, \dots, \phi_p$ are *d* x *d* matrices, and $\{e_t\}$ is a white-noise stochastic process

This model uses spectral analysis commonly used by scientists and economists who use time series data that can be non-linear and non-stationary.[36] Age-adjusted cancer rates were modeled as an exponential family time series after a logistic transformation, whose parameters were in turn modeled as random variables in the model. This allowed for the possibility that the noise process could be heteroscedastic (or be based on variables that are not independent and normally distributed), and thus not necessarily a pure white-noise process.

The VAR analysis performed on a number of sets of data that is cancer-site-specific , using a non-stochastic polynomial time trend, and the above autoregression model for temporal dependence. The length of the lag-period, i.e. p in the expression above, depends on the data. The Yule-Walker method was used for "moment estimation" and external bootstrap method[37] was used to obtain the possible pathways in which different cancer rates could have evolved, or will evolve in the future. These pathways were then used to construct point-wise 95 percent confidence intervals.

Regional Analysis

Age-adjusted cancer counts were projected at both the statewide level as well as the regional level to recognize variation between regions of the state and to incorporate underlying demographic differences between regions. Forecasting at the sub state-level required using small-area methods[38] to account for high volatility and improve prediction quality. The Fay-Haerriot small area model was adapted to the time-series data after computing two following volatility factors annually: (1) volatility within the region itself and (2) the volatility across regions. This allowed each regional forecast for each cancer type to "borrow strength" from the statewide forecast. The amount of "borrowed strength", depends on the relative volatilities; regions with greater volatility for any cancer type in and given year were reinforced based on the region's statistical dependence to the state as a whole. This step is based on conditional inference methodology using empirical Bayesian techniques, and results in an intermediate step where the projected rates for a region reflect the data from that region as an independent unit, and also as a component within the state. As a last step, the different regional projections were benchmarked for consistency with the state-wide projections.

Opportunities to Improve Predication Quality

There are three distinct opportunities to strengthen the prediction model and improve prediction quality:

1. **Inclusion of covariates:** The VAR model is capable of including covariates such as changes in cancer screening guidelines, diagnostic imaging advancement, changes in mortality, and many other demographic factors that could be taken into account. In predicting future cancer incidence

[36] Detailed information on VAR can be found in: Reinsel GC, Elements of Multivariate Time Series Analysis, Springer, New York, 2003 or Hamiltion JD Time series analysis, Princeton University Press, Princeton, USA, 1994.

[37] Wu CFJ "Jackknife, bootstrap and other resampling methods in regression analysis (with discussion)," The Annals of Statistics; 14:1295, 1986. Mammen E, "When does bootstrap work? Asymptotic results and simulations," Lecture Notes in Statistics, Volume 77, Springer - Verlag, New York.

[38] Rao JNK, Small Area Estimation, Wiley, New York, 2003. Pfeffermann D and Tiller R, "Bootstrap approximation to prediction MSE for state-space models with estimated parameters," Journal of Time Series Analysis, 26:893-916, 2005. Chatterjee S, Lahiri P and Li H, "Parametric bootstrap approximation to the distribution of EBLUP, and related prediction intervals in linear mixed models," The Annals of Statistics; 36:1221-1245, 2008.

using the VAR model Zhu et al.[39] used 30 ecologic covariates including: measures of income, education, housing, racial distribution, foreign birth, language isolation, urban/rural status, land area, availability of physicians and hospitals, health insurance coverage and rates of cigarette smoking, obesity, vigorous activity, and cancer screening, and rates of mortality due to the same type of cancer. Addition of some or all of these variables should be considered in future iterations of this work.

2. **Refinements to bootstrap approach:** As indicated, this analysis used a bootstrap approach to address the length of temporal dependence. Refinement of this approach and exclusion of multivariate quantiles used to get confidence bands for the entire cancer projection pathways could produce greater robustness of estimates.
3. **Modeling dependencies between variables in concert:** The VAR model used in this study is constructed so that the data for any given region, in any given year, in any cancer type, for any age group, is dependent on data from other regions (spatial and small area dependence), other years (temporal dependence), other age groups (VAR type dependence) and possible other types of cancer as well. (The latter is especially important for the 70+ age category, where we may expect the data to be affected by competing risks of different kinds of cancers and other health factors.) Modeling the dependencies in a future analysis together, perhaps with including some of the potential ecological covariates should lead to greater precision and accuracy of estimates.

Appendix B: Radiation Therapy Facility Capacity Study Advisory Group Members

Name	Job Title	Organization	Expertize
Katie Dusenbery, MD	Assistant Professor of Radiation Oncology	UMN Twin Cities Department of Radiation Oncology	Medical doctor - oncologist
Yolanda Garces, MD	Consultant, Assistant Professor of Radiation Oncology	Mayo Clinic Department of Radiation Oncology	Medical doctor - oncologist
Jane Korn, MD	Medical Director	MDH - Health Promotion and Chronic Disease Division	Public health physician
Susan McClanahan	Radiation Specialist 3	MDH - Environmental Health Radiation Control	Registration and inspection of radiation therapy facilities and equipment
Carin Perkins, PhD	Epidemiologist	MDH - Minnesota Cancer Surveillance System	Public health
Matt Schafer	State Government Relations Director	American Cancer Society	Cancer patient advocacy

[39] Op. Cit. Zhu L Pickle LW, Ghosh K, et al. (2012).

Appendix C: Data Collection Template

MINNESOTA MDH DEPARTMENT OF HEALTH

Please fill in fiscal year 2010 data by machine and cancer site

	Machine 1		Machine 2		Machine 3		Total (all Machines)	
	Cancer Cases Treated	Treatment Count	Cancer Cases Treated	Treatment Count	Cancer Cases Treated	Treatment Count	Cancer Cases Treated	Treatment Count
Female Breast								
Lung and Bronchus								
Prostate								
Oral Cavity and Pharynx								
Colon and Rectum								
Brain and Other Nervous								
Non-Hodgkin Lymphoma								
Larynx								
Esophagus								
Cervix Uteri								
Other body site								
***Total All Sites**								

*Please at a minimum provide the aggregrate volume by machine type (blue highlighted cells)

Operating Statistics by Machine	Machine 1	Machine 2	Machine 3	Total (all Machines)
Number of Days Open Per Week				
Number of Hours Open Per Day				
Maximum Daily Treatment Capacity				

Radiation therapy facilities received, independent of whether they are hospital-based or not received the data request on xxxxx, 2012. MDH staff worked with facilities on validating the information throughout the study and collect data on future planned facilities and equipment.

Appendix D: Demographic Projections by Age & Region

Age Group	Number of People			Distribution by Age		
	2012	2017	2022	2012	2017	2022
Statewide						
0 to 49	3,588,151	3,612,966	3,690,836	66.5%	64.2%	63.0%
50 to 59	767,059	766,104	696,198	14.2%	13.6%	11.9%
60 to 69	534,627	654,366	732,019	9.9%	11.6%	12.5%
70+	507,472	597,899	739,344	9.4%	10.6%	12.6%
All Ages	5,397,309	5,631,334	5,858,398	100.0%	100.0%	100.0%
Twin Cities Metro*						
0 to 49	2,007,210	2,034,570	2,085,222	69.0%	66.5%	65.3%
50 to 59	409,185	414,138	379,919	14.1%	13.5%	11.9%
60 to 69	268,136	332,497	373,483	9.2%	10.9%	11.7%
70+	226,381	277,832	355,525	7.8%	9.1%	11.1%
All Ages	2,910,911	3,059,038	3,194,149	100.0%	100.0%	100.0%
Southeast						
0 to 49	325,466	327,577	335,804	64.8%	62.6%	61.6%
50 to 59	71,398	70,013	62,158	14.2%	13.4%	11.4%
60 to 69	50,808	62,148	69,584	10.1%	11.9%	12.8%
70+	54,927	63,507	77,288	10.9%	12.1%	14.2%
All Ages	502,600	523,245	544,834	100.0%	100.0%	100.0%
South Central						
0 to 49	187,596	184,541	184,811	64.0%	61.9%	61.0%
50 to 59	41,220	39,488	34,719	14.1%	13.3%	11.5%
60 to 69	30,499	36,588	39,799	10.4%	12.3%	13.1%
70+	33,679	37,279	43,879	11.5%	12.5%	14.5%
All Ages	292,994	297,896	303,209	100.0%	100.0%	100.0%
Southwest						
0 to 49	133,268	128,855	126,507	60.2%	58.8%	58.3%
50 to 59	32,611	29,805	25,075	14.7%	13.6%	11.6%
60 to 69	24,532	28,719	30,512	11.1%	13.1%	14.1%
70+	30,899	31,726	34,997	14.0%	14.5%	16.1%
All Ages	221,310	219,105	217,091	100.0%	100.0%	100.0%
Central						
0 to 49	500,703	509,102	526,950	67.0%	63.8%	61.9%
50 to 59	103,201	110,991	107,066	13.8%	13.9%	12.6%
60 to 69	73,347	91,337	108,768	9.8%	11.4%	12.8%
70+	70,574	86,388	108,857	9.4%	10.8%	12.8%
All Ages	747,825	797,819	851,641	100.0%	100.0%	100.0%
West Central						
0 to 49	116,356	115,697	116,974	60.9%	59.2%	58.4%
50 to 59	27,448	25,860	22,182	14.4%	13.2%	11.1%
60 to 69	22,040	26,267	28,785	11.5%	13.4%	14.4%
70+	25,122	27,771	32,274	13.2%	14.2%	16.1%
All Ages	190,966	195,596	200,215	100.0%	100.0%	100.0%
Northwest						
0 to 49	124,859	123,925	125,010	61.3%	59.4%	58.7%
50 to 59	30,034	28,680	24,997	14.8%	13.8%	11.7%
60 to 69	23,868	28,099	30,404	11.7%	13.5%	14.3%
70+	24,849	27,830	32,695	12.2%	13.3%	15.3%
All Ages	203,610	208,535	213,106	100.0%	100.0%	100.0%
Northeast						
0 to 49	192,692	188,698	189,557	58.9%	57.2%	56.7%
50 to 59	51,962	47,129	40,083	15.9%	14.3%	12.0%
60 to 69	41,398	48,710	50,683	12.7%	14.8%	15.2%
70+	41,040	45,565	53,829	12.5%	13.8%	16.1%
All Ages	327,093	330,101	334,152	100.0%	100.0%	100.0%

Appendix E: Estimated Number of New Cases and Incidence Rates by Cancer Type, Year and Region (2012, 2017, and 2022)

	New Cases			Rates Per 100,000		
	2012	2017	2022	2012	2017	2022
All Cancers	0					
Statewide	28,942	32,337	35,752	536.2	574.2	610.3
Metro	14,956	16,877	18,754	513.8	551.7	587.1
Southeast	2,798	3,134	3,489	556.8	598.9	640.4
South Central	1,621	1,766	1,910	553.4	592.7	630.0
Southwest	1,320	1,397	1,472	596.3	637.6	677.9
Central	4,005	4,561	5,163	535.6	571.7	606.2
West Central	1,110	1,208	1,304	581.3	617.8	651.2
Northwest	1,175	1,279	1,378	576.9	613.3	646.7
Northeast	1,956	2,116	2,283	598.1	640.9	683.2
Female Breast	2012	2017	2022	2012	2017	2022
Statewide	4,095	4,445	4,659	150.5	156.1	156.6
Metro	2,222	2,449	2,588	149.8	156.0	156.6
Southeast	387	416	436	152.7	157.7	158.2
South Central	212	223	228	144.4	148.7	149.1
Southwest	184	188	187	167.0	173.2	173.8
Central	516	567	609	139.7	144.1	144.5
West Central	148	156	159	155.5	161.1	161.6
Northwest	157	167	171	155.5	162.4	163.1
Northeast	269	279	282	166.1	172.6	173.2
Prostate	2012	2017	2022	2012	2017	2022
Statewide	5,302	5,435	5,681	198.1	195.2	197.1
Metro	2,621	2,696	2,817	183.6	181.0	182.8
Southeast	514	528	553	206.3	203.8	205.6
South Central	312	313	320	213.9	211.3	213.1
Southwest	260	255	256	234.5	230.8	233.3
Central	772	812	874	203.9	201.1	203.1
West Central	226	230	239	236.1	232.3	235.0
Northwest	232	236	245	226.6	223.4	225.7
Northeast	364	365	376	220.3	216.9	219.3
Male Lung	2012	2017	2022	2012	2017	2022
Statewide	1,668	1,672	1,538	62.3	60.0	53.3
Metro	773	778	712	54.1	52.3	46.2
Southeast	173	173	160	69.3	66.8	59.5
South Central	95	93	84	65.3	62.9	55.8
Southwest	81	77	68	72.7	69.6	62.0
Central	255	263	249	67.3	65.0	57.9
West Central	72	72	66	75.2	72.3	64.8
Northwest	80	79	73	78.1	75.0	67.4
Northeast	139	137	125	84.3	81.2	73.1
Female Lung	2012	2017	2022	2012	2017	2022
Statewide	1,613	1,778	1,931	59.3	62.5	64.9
Metro	858	951	1,035	57.8	60.6	62.6
Southeast	148	163	178	58.6	61.9	64.4
South Central	88	95	101	59.6	63.4	66.3
Southwest	65	68	70	58.9	62.6	65.3
Central	227	258	289	61.5	65.5	68.5
West Central	57	62	66	60.1	63.9	66.7
Northwest	62	67	71	61.3	65.1	68.0
Northeast	108	115	121	66.8	71.0	74.2
Oral Cavity & Pharynx, HPV Associated	2012	2017	2022	2012	2017	2022
Statewide	299	468	712	5.5	8.3	12.2
Metro	168	259	386	5.8	8.5	12.1
Southeast	27	43	65	5.4	8.2	12.0
South Central	15	22	30	5.0	7.4	10.0
Southwest	11	17	25	4.9	7.7	11.5
Central	42	70	117	5.6	8.8	13.8
West Central	9	13	18	4.6	6.8	9.0
Northwest	10	16	26	4.9	7.9	12.2
Northeast	17	28	44	5.3	8.4	13.1
Oral Cavity & Pharynx, Non-HPV Associated	2012	2017	2022	2012	2017	2022
Statewide	440	466	497	8.2	8.3	8.5
Metro	222	236	252	7.6	7.7	7.9
Southeast	45	47	51	8.9	9.0	9.3
South Central	24	25	26	8.3	8.4	8.7
Southwest	19	20	20	8.8	8.9	9.2
Central	62	67	74	8.3	8.5	8.7
West Central	17	18	19	9.0	9.2	9.5
Northwest	19	20	21	9.5	9.7	10.0
Northeast	32	33	34	9.7	9.9	10.2

Colon and Rectum	2012	2017	2022	2012	2017	2022
Statewide	2,456	2,434	2,263	45.5	43.2	38.6
Metro	1,141	1,148	1,084	39.2	37.5	33.9
Southeast	255	252	232	50.8	48.1	42.6
South Central	155	149	135	53.0	50.1	44.4
Southwest	144	135	119	64.9	61.6	55.0
Central	334	338	318	44.7	42.3	37.4
West Central	110	106	96	57.6	54.3	47.9
Northwest	119	116	105	58.4	55.5	49.5
Northeast	198	190	174	60.5	57.7	51.9
Brain and Other Nervous System	2012	2017	2022	2012	2017	2022
Statewide	365	387	412	6.8	6.9	7.0
Metro	196	208	220	6.7	6.8	6.9
Southeast	35	37	40	7.0	7.1	7.4
South Central	20	21	22	6.7	6.9	7.1
Southwest	14	14	15	6.5	6.6	6.8
Central	52	57	62	7.0	7.1	7.3
West Central	12	13	14	6.4	6.6	6.9
Northwest	13	14	15	6.4	6.6	6.9
Northeast	23	23	24	6.9	7.0	7.3
Non-Hodgkin Lymphoma	2012	2017	2022	2012	2017	2022
Statewide	1,367	1,615	1,918	25.3	28.7	32.7
Metro	724	857	1,015	24.9	28.0	31.8
Southeast	131	154	183	26.0	29.4	33.6
South Central	76	89	106	26.0	29.9	35.0
Southwest	60	68	78	27.1	31.0	35.9
Central	187	224	271	25.0	28.1	31.8
West Central	48	55	64	25.1	28.2	31.9
Northwest	53	63	76	26.0	30.2	35.7
Northeast	89	104	125	27.1	31.5	37.3
Larynx	2012	2017	2022	2012	2017	2022
Statewide	192	202	214	3.6	3.6	3.7
Metro	100	106	112	3.4	3.5	3.5
Southeast	19	20	21	3.7	3.8	3.9
South Central	9	10	10	3.2	3.2	3.3
Southwest	7	7	7	3.3	3.3	3.4
Central	30	32	35	4.0	4.0	4.1
West Central	6	6	7	3.2	3.3	3.4
Northwest	7	7	8	3.5	3.5	3.7
Northeast	14	14	14	4.2	4.2	4.3
Esophagus	2012	2017	2022	2012	2017	2022
Statewide	365	449	550	6.8	8.0	9.4
Metro	181	216	256	6.2	7.1	8.0
Southeast	38	48	61	7.5	9.3	11.3
South Central	21	27	34	7.2	9.0	11.1
Southwest	15	18	22	7.0	8.4	10.1
Central	54	69	88	7.2	8.7	10.3
West Central	14	18	22	7.2	9.0	11.1
Northwest	15	20	26	7.5	9.6	12.2
Northeast	26	32	40	8.0	9.8	12.0
Cervix Uteri	2012	2017	2022	2012	2017	2022
Statewide	149	138	139	5.5	4.8	4.7
Metro	87	82	83	5.9	5.2	5.0
Southeast	13	12	12	5.2	4.6	4.4
South Central	8	7	7	5.2	4.7	4.5
Southwest	6	5	5	5.1	4.6	4.4
Central	19	17	18	5.2	4.4	4.2
West Central	4	3	3	3.9	3.2	3.1
Northwest	4	3	3	4.0	3.3	3.2
Northeast	9	8	8	5.4	4.8	4.7
All Other Cancer	2012	2017	2022	2012	2017	2022
Statewide	10,630	12,848	15,241	196.9	228.2	260.2
Metro	5,664	6,891	8,193	194.6	225.3	256.5
Southeast	1,013	1,239	1,496	201.6	236.8	274.5
South Central	586	692	807	199.9	232.4	266.2
Southwest	453	525	600	204.7	239.4	276.3
Central	1,455	1,787	2,159	194.5	224.0	253.5
West Central	387	457	531	202.7	233.6	265.3
Northwest	402	470	538	197.6	225.2	252.4
Northeast	669	787	917	204.6	238.5	274.3

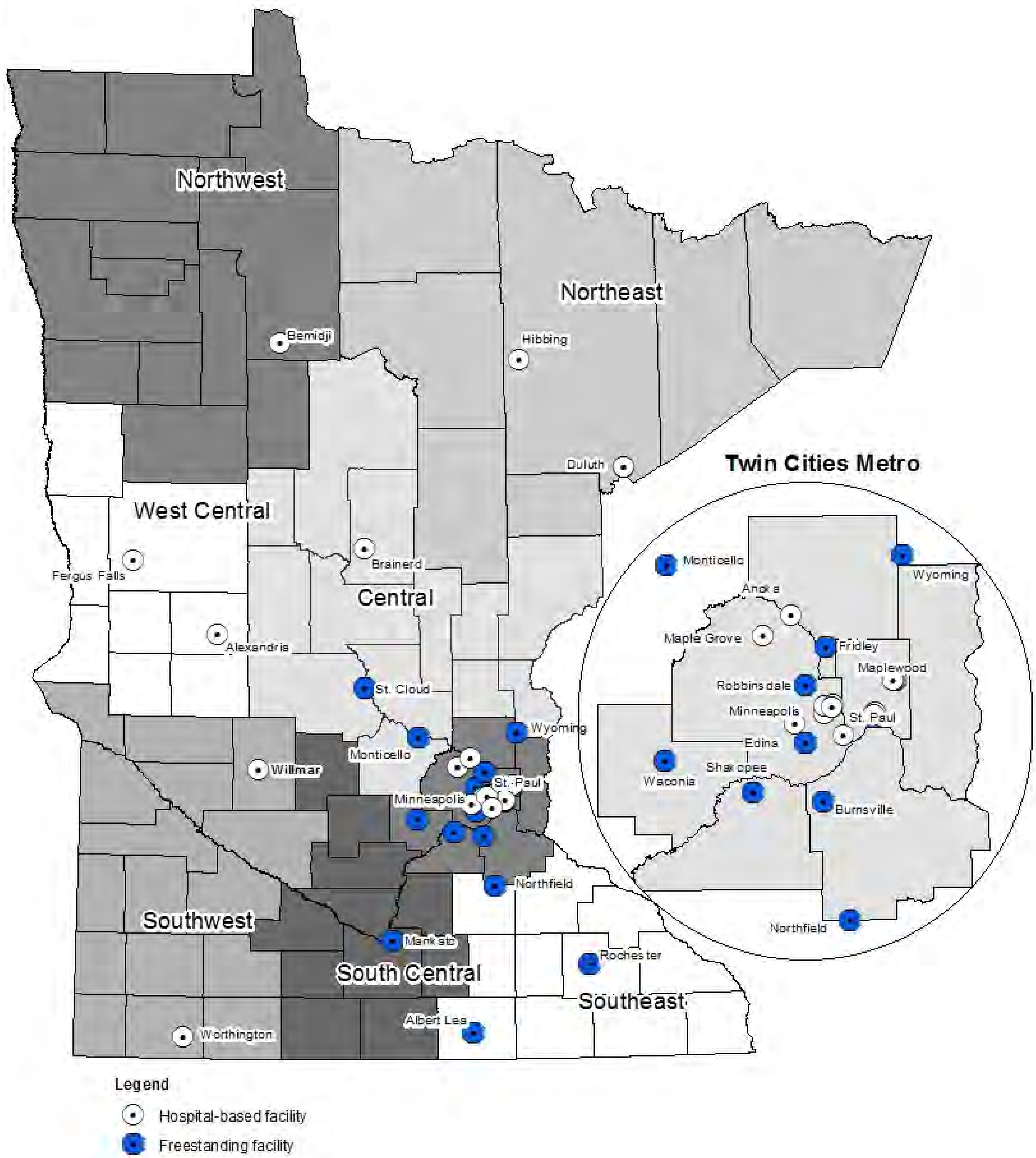
Source: New cancer incidence projections were prepared for MDH using data from MCSS (1988-2009) and population data from the Minnesota State Demographic Center (December 2012). Rates are per 100,000 and are age adjusted to demographic

Appendix F: Overview of Minnesota Radiation Therapy Facilities, 2011 and Geographic Location

Facility Name	Number of Machines	Cancer Cases	Treatments	Treatments per Case
All Radiation Therapy Facilities	**58**	**12,748**	**260,943**	**21.2**
Twin Cities Metro Area	**30**	**6,765**	**143,271**	**21.2**
Abbott Northwestern Hosp./Allina Health	3	664	13,360	20.1
Fairview Maple Grove Cancer Center	1	105	2,569	24.5
Radiation Therapy Center at Fairview Southdale/Minneapolis Radiation Oncology (MRO)	2	480	12,162	25.3
HCMC -Radiology	1	168	3,530	21.0
Maplewood Cancer Center/ Minnesota Oncology	2	856	15,086	17.6
Mercy Radiation Therapy Center/MRO	1	308	7,721	25.1
North Radiation Therapy Center/MRO	2	393	10,116	25.7
Park Nicollet Radiation Oncology*	3	680	16,556	24.3
Regions Hospital-Radiation Therapy/HealthPartners	2	340	7,419	21.8
Ridges Radiation Oncology/MRO	1	285	7,692	27.0
Ridgeview Radiation Therapy Center/MRO	1	284	7,754	27.3
St. Francis Radiation Therapy/MRO	1	109	2,849	26.1
St. John's Radiation Oncology/HealthEast	1	279	5,952	21.3
St. Joseph's Radiation Oncology/HealthEast*	1	156	565	3.6
St. Paul Cancer Center/Minnesota Oncology-Allina	2	459	8,958	19.5
University of Minnesota Medical Ctr. /Fairview*	4	932	14,344	15.4
Unity Radiation Therapy Center/MRO	2	267	6,638	24.9
Southeast	**10**	**2,813**	**43,256**	**15.4**
Mayo Clinic-Northfield Cancer Ctr. (not open in 2010)	2	NA	NA	NA
Mayo Clinic-Radiation Oncology Ctr. Albert Lea	1	150	4,744	31.6
Rochester Mayo Clinic (includes St. Mary's Hospital)*	7	2,663	38,512	14.5
South Central	**2**	**419**	**7,704**	**18.4**
Mayo Cancer Center-Mankato	2	419	7,704	18.4
Southwest	**2**	**338**	**9,244**	**27.3**
Rice Regional Cancer Center	1	244	6,675	27.4
Sanford Medical Center-Worthington	1	94	2,569	27.3
Central	**5**	**1,043**	**25,606**	**24.6**
Brainerd Radiation Therapy Center	1	267	7,718	28.9
Coborn Cancer Center	2	476	9,943	20.9
Monticello Cancer Center	1	94	2,274	24.2
U of M Physicians-Wyoming	1	206	5,671	27.5
West Central	**2**	**414**	**10,403**	**25.1**
CentraCare-Douglas Co. Hosp. Radiation Therapy	1	207	5,555	26.8
Lake Region Cancer Center	1	207	4,848	23.4
Northwest	**1**	**141**	**2,801**	**19.9**
Sanford Medical Center-Bemidji	1	141	2,801	19.9
Northeast	**6**	**815**	**18,658**	**26.6**
EssentiaHealth Cancer Center - Duluth*	3	474	8,338	17.6
Fairview Range Cancer Services	2	195	4,861	24.9
St. Luke's Hospital	1	146	5,459	37.4

Source: Source: MDH administrative data and 2010 data collected from radiation therapy centers in December of 2012.
*Includes stereotactic radiosurgery or tomotherapy

Appendix G: Location of Minnesota Radiation Therapy Facilities by Regions of the State, 2012



Source: WIPFLi and MDH analysis of Radiation Therapy Facility Data and MDH SCHSAC Regions.
Light circles are facilities that are part of a hospital and dark circles are freestanding facilities.

Appendix H: Projections of Rates of Incidence for Prostate Cancer

Source: Projection of rates of incidence for prostate cancer by Professor Chatterjee of the School of Statistics at the University of Minnesota, using age-adjusted incidence from MCSS data; data through 2009 are actual, data from 2010 forward are projected.

Notes:

- The solid line represent rates of prostate cancer incidence from the Minnesota Cancer Surveillance System
- The dashed line represents projected estimates between 2009 and 2022.
- The dotted red lines represent error bounds associated with the statistical fit of the model to historical and projected rates.

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