Where Do Patients With Cancer in Iowa Receive Radiation Therapy?

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Abstract

Purpose: Multiple studies have shown survival benefits in patients with cancer treated with radiation therapy, but access to treatment facilities has been found to limit its use. This study was undertaken to examine access issues in Iowa and determine a methodology for conducting a similar national analysis.

Patients and Methods: All Iowa residents who received radiation therapy regardless of where they were diagnosed or treated were identified through the Iowa Cancer Registry (ICR). Radiation oncologists were identified through the Iowa Physician Information System (IPIS). Radiation facilities were identified through IPIS and classified using the Commission on Cancer accreditation standard.

Results: Between 2004 and 2010, 113,885 invasive cancers in 106,603 patients, 28.5% of whom received radiation treat-

ment, were entered in ICR. Mean and median travel times were 25.8 and 20.1 minutes, respectively, to the nearest facility but 42.4 and 29.1 minutes, respectively, to the patient's chosen treatment facility. Multivariable analysis predicting travel time showed significant relationships for disease site, age, residence location, and facility category. Residents of small and isolated rural towns traveled nearly 3× longer than urban residents to receive radiation therapy, as did patients using certain categories of facilities.

Conclusion: Half of Iowa patients could reach their nearest facility in 20 minutes, but instead, they traveled 30 minutes on average to receive treatment. The findings identified certain groups of patients with cancer who chose more distant facilities. However, other groups of patients with cancer, namely those residing in rural areas, had less choice, and some had to travel considerably farther to radiation facilities than urban patients.

Introduction

Radiation therapy is a commonly administered treatment for a variety of cancers.¹ Between 2000 and 2010, the National Cancer Data Base (NCDB)² indicated that across all cancer types, 31.1% of patients received radiation therapy, 6.9% as monotherapy and 24.2% in combination with other therapeutic approaches. Multiple studies have shown survival benefits in patients with cancer treated with radiation therapy, especially as an adjuvant to surgery or systemic therapies.¹ NCDB indicates that radiation therapy varies by cancer site, histology, cancer stage, patient age, and treatment facility classification. This prompted us to undertake further analysis of these patterns. Additionally, because most radiation therapy is delivered at specific facilities by radiation oncologists, access to treatment has been investigated³ and found to be a limiting factor in its use. In particular, numerous reports have related longer travel distance with decreased use of radiation therapy for specific cancers.⁴⁻⁹ Use of a statewide comprehensive cancer registry and unique physician tracking system permitted us to examine access issues related to radiation treatment location and travel distance.

Patients and Methods

The Iowa Cancer Registry¹⁰ (ICR) participates in the National Cancer Institute (NCI) SEER¹¹ program, which currently represents 28% of the US population and is widely used to track

cancer incidence, prevalence, and survival. ICR strives to capture all newly diagnosed cancers among Iowa residents, regardless of where they are diagnosed or treated. We accessed data on all newly diagnosed invasive cancers from 2004 to 2010, and ICR provided 303,707 facility records from a total of 113,885 invasive cancer diagnoses in 106,603 distinct Iowa residents. We used SEER codes to identify patients with the 18 most common cancer types, plus a category grouping all other cancer sites. For all cancers, ICR provided information on the derived American Joint Committee on Cancer stage group, which takes tumor size, extension, lymph node status, and metastatic status into consideration.¹² ICR records location of diagnosis and first treatment for all Iowa residents with cancer, regardless of where the facility is located. Facilities were classified using the Commission on Cancer (CoC) of the American College of Surgeons accreditation standard based on facility or organization type, services provided, and cases accessioned.¹³ Physicians in Iowa are tracked continuously through the Iowa Physician Information System (IPIS),¹⁴ which records physicians' self-identified specialty and certification. Practice locations for all physicians identifying radiation oncology as their specialty were provided by IPIS. Patient residence was classified as urban or rural based on the rural-urban commuting area (RUCA) code associated with the patient's zip code at time of diagnosis. RUCA codes¹⁵

are based on census tract population and commuting data. Using the approach described by the Washington, Wyoming, Alaska, Montana, and Idaho Rural Health Research Center,¹⁶ for purposes of drawing conclusions about rural or urban status of local areas, zip codes were assigned to one of four geographic classifications: urban, large rural, small rural, and isolated rural. Distances in miles and minutes were computed from the locations of the centroids^{17,18} of the 920 Iowa zip codes to the locations of the radiation facilities through a commercially available distance function that used the network description of the Iowa road network with its typical speed limits for each road segment. Maps of these distances were created using the location coordinates of each zip code and the spatial interpolation function in the ArcGIS software (Esri, Redlands, CA). Analysis of ICR data for this study was approved by the University of Iowa Institutional Review Board.

Results

ICR provided data on 113,885 cancers, of which 32,417 (28.5%) were treated with radiation therapy. Of these, the treatment facility where radiation treatment occurred was identified in 29,463 (90.9%). We limited analysis to external-beam radiation therapy, because it is the dominant form of radiation therapy (86.9% or 25,611 cases of cancer in Iowa), and it must be delivered in registered radiation treatment facilities, so the access points are known.

Efforts to identify all radiation therapy facilities in the United States by Ballas et al¹⁹ found 22 facilities in Iowa, in agreement with data available to us through IPIS¹⁴ and verified by the Iowa Department of Public Health. ICR indicated that 10.8% of cancers were treated in neighboring states, but the vast majority of Iowa residents (89.2%) had their cancers treated in the 22 Iowa facilities.

Facilities providing radiation therapy were classified using CoC accreditation standards,¹³ and facilities where Iowa residents received radiation therapy fell into the seven categories listed in Table 1. In five of these categories, all facilities were accredited by CoC; the remaining facilities were either hospital-based or freestanding centers that were not accredited. The majority (57.9%) of external-beam radiation therapy for Iowa residents was delivered at Comprehensive Community Cancer Program facilities, 15.3% was delivered at NCI-designated Comprehensive Cancer Centers, 9.8% was delivered at Community Cancer Program facilities, all of which were CoC accredited,¹³ and 12.7% was delivered at non-CoC-accredited hospital-based facilities. Only a small number of Iowa residents received radiation therapy at Academic Comprehensive Cancer Program facilities (2.5%), Integrated Network Cancer Program facilities (0.5%), and Free Standing Radiation Treatment facilities (1.4%), because most such facilities used by Iowa residents were out of state.

Access to radiation treatment was examined by identifying the home residence at time of cancer diagnosis of all patients receiving radiation treatment, the location where they received treatment (ie, chosen facility), and the location of the closest radiation treatment facility (ie, nearest available facility). Of

patients with cancer receiving radiation treatment, 60.1% (15,404 patients) bypassed the closest radiation treatment facility and incurred an average additional travel-to-treatment time of 27.9 minutes. The mean travel time was 42.4 minutes, and the median travel time was 29.1 minutes, to the chosen facility. In contrast, the travel time to the nearest available facility was statistically significantly shorter (mean, 25.8 minutes; median, 20.1 minutes; $t = 76.05$; $P < .001$).

The map in Figure 1A shows the travel times that residents of different areas of Iowa drove to receive radiation therapy at their chosen facility. As can be seen in Figure 1A, there are isolated pockets of the state where patients with cancer typically drove more than 2 hours to receive radiation therapy. The map in Figure 1B shows the travel times that residents of different areas of Iowa drove to the nearest available radiation therapy facility.

As shown in these maps, most of the state was within 1 hour of a radiation treatment facility, but several regions near the northern and southern state borders required long travel even to the nearest facility. Most radiation treatment facilities are in urban areas, and the largest cities had multiple radiation treatment facilities. A comparison of the maps in Figures 1A and 1B shows clearly that many Iowa residents chose to travel to more distant facilities for radiation therapy rather than using the nearest facility.

To explore the considerable variability in travel times, analyses were conducted to examine patient and facility characteristics associated with travel time to the actual radiation therapy facility where patients received treatment. As shown in Table 1, nonparametric analysis of variance showed significant relationships between travel time and disease site, stage, age, residence location, and facility category. In multivariable analyses, cancer stage was no longer significant. No significant differences were found across the 7-year data period, indicating that patterns in driving distance were stable across time.

The significant differences in travel time across patient residence indicate that residents of small and isolated rural towns traveled nearly 3× longer than urban residents to receive radiation therapy (as shown in Fig 1A), largely because they did not have radiation therapy facilities as close to their homes as did urban patients (as shown in Fig 1B). The significant differences across facility category shed light on factors related to patients traveling to facilities other than the nearest available one. This relationship is demonstrated more clearly in Figure 2, which shows the patterns of travel times by graphing the proportion of patients who traveled to each category of facility and the considerable variability across categories. The curves show much longer travel times to certain categories of facilities, notably of 1 hour or more on average to receive treatment at NCI-designated Comprehensive Cancer Centers. For some categories of facilities, most facilities used by Iowa residents are located out of state (shown in dotted lines), and these categories had longer travel times. In contrast, patients who received treatment at Community Cancer Programs, Community Comprehensive Cancer Programs, and non-CoC-accredited hospital-based radiation facilities (shown in solid lines) did so relatively close to

Table 1. Factors Related to Driving Time to Chosen Radiation Treatment Facility for 25,611 Patient Cases of Newly Diagnosed Cancers Between 2004 and 2010

Variable	No.*	Driving Time (minutes)		P†	P‡
		Mean	Median		
Year				NS	NS
2004	3,081	43.7	30.1		
2005	3,398	42.6	28.7		
2006	3,600	42.5	28.6		
2007	3,853	41.9	29.2		
2008	3,829	41.9	29.2		
2009	3,978	42.1	29.1		
2010	3,872	42.9	30.0		
Disease site§				< .001	< .001
Breast	6,317	33.5	22.5		
Other male genital	189	36.3	24.4		
Lung	6,019	40.4	27.3		
Prostate	3,344	38.8	29.2		
Rectal	1,334	44.6	30.9		
Lymphoma	946	44.2	32.3		
Myeloma	322	45.4	32.8		
Colon	128	46.2	33.5		
Urinary system	461	47.9	35.4		
Other digestive	1,710	51.6	35.7		
Skin	219	53.8	38.3		
Other respiratory	847	49.4	38.5		
Other	391	53.6	38.5		
Oral cavity/pharynx	1,346	53.6	40.9		
Female genital	725	51.0	42.5		
Endocrine	99	57.1	42.5		
Brain/CNS	923	60.1	44.9		
Soft tissue	222	60.1	47.4		
Leukemia	69	87.3	93.4		
Stage				< .001	NS
I	5,795	36.2	23.9		
II	6,553	39.4	27.5		
III	4,822	43.9	30.4		
IV	5,539	46.3	33.3		
Unknown	2,902	52.2	39.9		
Age group, years				< .001	< .001
< 18	179	83.0	81.1		
18-65	13,031	44.3	29.9		
> 65	12,401	39.9	28.5		
Sex				< .001	.03
Male	12,938	45.5	33.6		
Female	12,671	39.4	25.1		
Residence				< .001	< .001
Urban	13,604	24.6	17.1		
Large rural city/town	3,800	49.7	43.2		
Small rural town	4,212	65.7	54.9		
Isolated small rural town	3,995	71.8	59.9		

Continued on next column

Table 1. (Continued)

Variable	No.*	Driving Time (minutes)		P†	P‡
		Mean	Median		
Facility category				< .001	< .001
Community Cancer Program	2501	26.5	19.8		
Comprehensive Community Cancer Program	14,838	31.7	22.0		
Hospital-based radiation treatment facility¶	3248	37.4	30.5		
Integrated Network Cancer Program	114	53.4	39.8		
Freestanding radiation treatment facility¶	346	42.7	39.9		
Academic Comprehensive Cancer Program	636	55.4	50.7		
NCI-designated Comprehensive Cancer Center Program	3928	95.0	87.0		

Abbreviations: CoC, Commission on Cancer; NCI, National Cancer Institute; NS, not significant.

* Missing values were minimal: -2 for sex, -1 for residence.

† P value for bivariable analysis of variance.

‡ P value for multivariable analysis of covariance including all variables.

§ Disease site ordered by driving time from shortest to longest median time in minutes.

|| Facilities accredited by American College of Surgeons CoC.

¶ Facilities not accredited by American College of Surgeons CoC.

home. Rural residents were significantly more likely to be treated at NCI-designated program or other community cancer program facilities and were significantly less likely to be seen at Academic Comprehensive Cancer Program or Community Cancer Program facilities ($P < .001$).

Discussion

The first aim of our analysis was to identify all patients with cancer who received radiation therapy. In ICR, analyses indicated that 28.5% of cancers in Iowa were treated with radiation therapy as part of the first course of treatment, with 5.1% treated with radiation therapy as monotherapy and 23.3% in combination with surgery, chemotherapy, hormone, or other therapy. Between 2000 and 2010, NCDB indicated that 31.1% of patients received radiation therapy, 6.9% as monotherapy and 24.2% in combination with other therapeutic approaches. Although the percentage of Iowa residents receiving radiation therapy was slightly lower than the US average, examination of the percentages of patients receiving each form of combination therapy showed similar patterns between ICR and NCDB. Thus, the rate of use of radiation therapy identified in ICR seems generalizable to the nation.

The second aim of our analysis was to identify where patients with cancer received radiation therapy. An important question was whether access to external-beam radiotherapy treatment facilities changed over time. The American College of Radiology identified 1,542 radiation therapy facilities in the United States in 1994.²⁰ Ballas et al¹⁹ identified 2,246 radiation

Figure 1. Distances traveled to (A) chosen radiation treatment facility and (B) nearest available radiation treatment facility for 25,611 patient cases of newly diagnosed cancers between 2004 and 2010.

Figure 2. Travel time to chosen radiation treatment facility by category of facility for 25,611 patient cases of newly diagnosed cancers between 2004 and 2010. CoC, Commission on Cancer; NCI, National Cancer Institute.

therapy facilities in the United States in 2004. These figures suggest an increase of 46% nationally in the decade from 1994 to 2004. Our data in Iowa indicate that the number of facilities held steady from 2004 to 2010. Moreover, analysis of the mean and median distances traveled by patients with cancer to receive radiation therapy showed no significant differences across years. However, over the 7 years of data, the number of patients receiving radiation therapy increased by 5.6%. Thus, hypotheses that access to radiation therapy improved in recent years were not supported by the data on number of facilities or changes in markets affecting travel time. Iowa is a Certificate of Need state and uses a combination of metrics including use and travel time.²¹ Meeting this combination of metrics to justify a new facility would be challenging, as reflected in the stability in number of facilities over recent years.

The third aim of our analysis was to examine characteristics of the radiation therapy facilities where patients with cancer received treatment. Data from the American College of Radiology 1994 survey indicated that 75.3% of radiation treatment facilities were hospital based, 22.1% were free standing, and 2.6% were federal.²⁰ The American Society for Radiation On-

cology Workforce Committee surveyed member radiation oncologists in 2002²² and found that 76% worked in private practice, 17% worked in academic settings, and 7% worked in other settings. Findings from our analysis seem generally consistent with these earlier data.

The fourth and ultimate aim of our analysis was to examine the issue of access to radiation therapy facilities. One indicator of access is the number of patients treated per facility and per provider. Ballas et al¹⁹ reported that the US average was 1.59 facilities per 1,000 patient cases of cancer and that Iowa had 1.38 facilities per 1,000 patient cases of cancer. Data from 1994²⁰ indicated that the ratio of radiation oncologists (full-time equivalents) to facilities was 1.80 nationally. Data from IPIS indicated that the corresponding ratio in Iowa was 1.73 from 2004 to 2010. Data from 1994²⁰ indicated that of US radiation treatment facilities, 13.9% treated fewer than 200 new patients per year, 51.4% treated 200 to 600 new patients per year, and 31.3% treated more than 600 new patients per year. ICR data indicated that the corresponding percentages for Iowa radiation treatment facilities were 18%, 27%, and 55%, respectively, from 2004 to 2010. Thus, these data suggest that access in Iowa related to the number of facilities and radiation oncologists is slightly lower than the national average, and correspondingly, many Iowa facilities have higher caseloads than the national average.

Another indicator of access is the travel time patients must spend getting to treatment facilities. Previous examination of the supply of radiation oncologists in the United States found geographic maldistribution with an undersupply in rural areas.³ Longer travel times by rural residents to receive radiation therapy have been noted in several studies for specific cancers.⁴⁻⁹ Half of Iowa patients could reach the nearest facility in 20 minutes but instead drove 30 minutes on average to the actual facility where they received treatment. This difference between the nearest available facility and the chosen facility makes definitive pronouncements about the adequacy of access challenging. Although rural Iowa patients must travel greater distances than their urban counterparts, those distances may compare favorably with travel times for similar services in other states that have a concentration of radiation therapy services at fewer

sites than Iowa. We previously examined access in terms of nontreatment issues and showed that the 12.3% of patients with invasive cancer in Iowa who did not receive a first course of treatment had the same distance relationship to oncology providers as other patients with cancer who were treated.²³ If poor geographic access to radiation services were an impediment to treatment, we would expect that patients who chose not to be treated would be located at distances farther from the place of usual treatment than those who sought treatment. This was not the case. Thus, access, as measured by travel time, suggests an adequate number and distribution of facilities in Iowa to provide reasonable access in terms of travel to radiation therapy. This conclusion is in contrast with others' projections based on the distribution of radiation oncologists.³

A strength of our study was the use of a comprehensive cancer registry, which permitted all cancer types to be explored across a recent timeframe. Another strength was the use of a unique database of all providers and facilities, which permitted the location of actual treatment and selected treatment options to be examined. The population distribution in Iowa is 53.4% urban and 46.6% rural,¹⁸ using RUCA codes to define rural and urban populations,¹⁵ which facilitated examination of this important variable. However, the findings presented here must be qualified in terms of several study limitations. In particular, because of confidentiality safeguards in ICR, the location of providers where treatment was delivered cannot be divulged using registry data. More importantly, data on the exact timing of treatment were not available, which precluded examination of treatment delay as an indicator of access. Also, data were not available at the patient level on socioeconomic variables, which precluded exploration of poverty and insurance coverage, variables that have been linked to treatment choice and travel distance in earlier studies.^{3,6,7,9} Data were available on racial/ethnic group, but the population of Iowa is predominantly non-Hispanic white, limiting the analysis options for this variable, which has also proven of interest in earlier studies.^{3,4,6-9}

In summary, data indicate that approximately one quarter of Iowa residents who received radiation therapy did so at facilities more than 1 hour away from their homes. For example, 10% of cancers were treated in neighboring states. Analyses identified several factors related to long travel time. In particular, pediatric patients traveled much farther on average than older patients. They were treated at 15 different institutions, but two thirds of these patients traveled to one of the two children's hospitals in Iowa, and one quarter traveled to hospitals out of state, bypassing much closer radiation therapy facilities. Another group of patients with long travel times were those treated at NCI-designated Comprehensive Cancer Centers. Iowa residents who received radiation therapy at one of these centers tended to travel farther, because one of these centers is located in eastern Iowa, but others are spread throughout the US Midwest. Across disease sites, the average travel time ranged from 33 to 60 minutes, with the relatively few patients with leukemia who received radiation therapy traveling 90 minutes on average. In general, travel times were lowest for the most prevalent cancer

sites (ie, breast and prostate cancers) and higher for less prevalent cancer sites.

These anomalies in terms of travel time suggest that certain patient groups bypass local treatment options to receive treatment at more distant, probably specialized, facilities. It is likely that patient and provider choices determine whether treatment occurs at nonlocal facilities in these situations. A number of factors affect these choices. Foremost is that radiation therapy facilities are geographically fixed. Second, there are some cancers that can be appropriately treated with different modalities. Examples include early breast, localized prostate, and some head and neck cancers. Third, more diseases are being treated with the simultaneous administration of both chemotherapy and radiation therapy, including curative treatments for esophageal, lung, rectal, and head and neck cancers. Access to radiation therapy, which is administered 5 days per week for up to 6 weeks, is critically important to delivering the highest quality cancer care. The perceptions of radiation therapy access by the physician and patient will shape treatment selection and ultimately the cost, outcome, and late effects of the treatment. The travel time discrepancies related to patient place of residence reflect an access issue for rural residents that has been explored in previous studies. In particular, a number of studies have related longer travel distance, as is common in rural areas, with decreased use of radiation therapy for specific cancers.⁴⁻⁹ For some patients, this may present an insurmountable barrier of time, cost, or both. Any barrier to radiation therapy access creates a group of patients who are receiving inferior care. Thus, clinical decision making would be substantially affected if radiation therapy were not available.

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References

- Bernier J, Hall EJ, Giaccia A: Radiation oncology: A century of achievements. *Nat Rev Cancer* 4:737-747, 2004
- American College of Surgeons: National Cancer Data Base. http://cromwell.facs.org/BMarks/BMPub/Ver10/bm_reports.cfm
- Aneja S, Smith BD, Gross CP, et al: Geographic analysis of the radiation oncology workforce. *Int J Radiat Oncol Biol Phys* 82:1723-1729, 2011
- Athas WF, Adams-Cameron M, Hunt WC, et al: Travel distance to radiation therapy and receipt of radiotherapy following breast-conserving surgery. *J Natl Cancer Inst* 92:269-271, 2000
- Celaya MO, Rees JR, Gibson JJ, et al: Travel distance and season of diagnosis affect treatment choices for women with early-stage breast cancer in a predominantly rural population (United States). *Cancer Causes Control* 17:851-856, 2006
- Nattinger AB, Kneusel RT, Hoffmann FG, et al: Relationship of distance from a radiotherapy facility and initial breast cancer treatment. *J Natl Cancer Inst* 93:1344-1346, 2001
- Punglia RS, Weeks JC, Neville BA, et al: Effect of distance to radiation treatment facility on use of radiation therapy after mastectomy in elderly women. *Int J Radiation Oncology Biol Phys* 66:56-63, 2006
- Schroen AT, Brenin DR, Kelly MD, et al: Impact of patient distance to radiation therapy on mastectomy use in early-stage breast cancer patients. *J Clin Oncol* 23:7074-7080, 2005
- Voti L, Richardson LC, Reis IM, et al: Treatment of local breast carcinoma in Florida: The role of the distance to radiation therapy facilities. *Cancer* 106:201-207, 2006
- State Health Registry of Iowa: Iowa Cancer Registry. www.public-health.uiowa.edu/shri/index.html
- National Cancer Institute: Surveillance, Epidemiology and End Results: SEER overview. <http://seer.cancer.gov/about/overview.html>
- Collaborative Stage Data Collection System Coding Instructions. www.cancerstaging.org/cstage/manuals/csmanual-p1s1.pdf
- American College of Surgeons: Cancer programs: Categories of accreditation. <http://www.facs.org/cancer/coc/categories3.html>
- University of Iowa Carver College of Medicine: Office of Statewide Clinical Education Programs. www.medicine.uiowa.edu/oscep/
- US Department of Agriculture Economic Research Service: Rural-urban community area codes. <http://www.ers.usda.gov/briefing/RuralUrban/RuralUrbanCommunitingAreas/>
- Francis R, Lowe T, Rushton G, et al: A synthesis of aggregation methods for multi-facility location problems: Strategies for containing error. *Geogr Anal* 31:67-87, 1999
- Beyer KM, Saftlas AF, Wallis AB, et al: A probabilistic sampling method (PSM) for estimating geographic distance to health services when only the region of residence is known. *Int J Health Geogr* 10:4, 2011
- Washington, Wyoming, Alaska, Montana, and Idaho Rural Health Research Center: Rural-urban commuting area codes data: Code definitions—Version 2.0. <http://depts.washington.edu/uwruca/ruca-codes.php>
- Ballas LK, Elkin EB, Schrag D, et al: Radiation therapy facilities in the United States. *Int J Radiat Oncol Biol Phys* 66:1204-1211, 2006
- Owen JB, Coia LR, Hanks GE: The structure of radiation oncology in the United States in 1994. *Int J Radiat Oncol Biol Phys* 39:179-185, 1997
- Iowa Department of Public Health: Certificate of Need State Health Facilities Council: Standard for radiation therapy—Administrative code 641-202.3. http://idph.state.ia.us/adper/cert_of_need.asp
- ASTRO Workforce Committee: 2002 Radiation Oncology Workforce Study: American Society for Therapeutic Radiology and Oncology. *Int J Radiat Oncol Biol Phys* 56:309-318, 2003
- Ward MM, Ullrich F, Matthews K, et al: Who does not receive treatment for cancer? *J Oncol Pract* 9:20-26, 2013

Appendix

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