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ORIGINAL ARTICLE

Factors influencing the quality of local management of ductal carcinoma *in situ*: a cohort study

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ABSTRACT

Background

Guidelines recommend radiotherapy (RT) after breast-conserving surgery (BCS) for optimal control of ductal carcinoma *in situ* (DCIS). The aim of the present study was to characterize the rates of RT consideration and administration, and to identify factors influencing those rates in a cohort of women diagnosed between 1998 and 2005 in Quebec.

Methods

Quebec's medical service claims and discharge abstract database were used. Using consultation for RT as an indicator for RT consideration, odds ratios (ORS) and 95% confidence intervals (CIS) were estimated using a generalized estimating equations regression model.

Results

Of 4139 women analyzed (mean age: 58 years), 3435 (83%) received a consultation for RT, and 3057 of them (89%) proceeded with treatment. The rate of RT consideration increased by 7.1% over the study period, with notable differences in the various age groups. Relative to women 50–69 years of age, the ORS for being considered for RT were, respectively, 0.89 (95% CI: 0.71 to 1.12), 0.71 (95% CI: 0.55 to 0.92), and 0.20 (95% CI: 0.14 to 0.31) for women younger than 50, 70–79, and 80 years of age and older. Distance to a designated breast care centre lowered the probability of RT consideration, but the presence of comorbidities did not. A surgeon's volume of BCSS increased the probability of being considered for RT by 7% for every 10 such procedures performed (OR: 1.07; 95% CI: 1.04 to 1.11).

Conclusions

Consideration for RT has increased over time. However, older women (despite being in good health) and those living far from a designated breast care centre or having a low-case-volume surgeon were less likely to be considered for RT.

KEY WORDS

Ductal carcinoma *in situ,* DCIS, radiotherapy, breast-conserving surgery, BCS, guidelines, quality of care

1. INTRODUCTION

The introduction of widespread screening mammography has markedly increased the detection of ductal carcinoma *in situ* (DCIS) in North America, from an incidence of 1.87 per 100,000 between 1973 and 1975 to 32.5 per 100,000 in 2004[1]. Currently, DCIS represents approximately 20% of newly screen-detected breast neoplasms in North America[2,3]. Disease-specific survival for 20 years after a DCIS diagnosis is excellent (98%); however, local recurrences and progression to invasive disease represent an unnecessary risk[4,5]. Local recurrence can be either invasive or noninvasive, but it is currently not possible to reliably predict which lesions will progress and therefore to identify high- and low-risk patients[5–7], thus highlighting the importance of optimizing treatment at initial diagnosis.

Current guidelines for the management of DCIS recommend the use of breast-conserving surgery (BCS) followed by radiotherapy (RT) to minimize the risk of recurrence, invasion,[8,9] and mortality[9]. Compared with BCS alone, treatment using BCS plus RT results in a reduction of local recurrence of DCIS by approximately 50%[10]. However, life expectancy and the presence of comorbidities, combined with tumour histology, are useful in determining the net benefit from RT. A study of 60,000 women 70 years of age and older identified though the U.S. Surveillance, Epidemiology and End Results and Medicare databases showed that women 70–79 years of age without comorbidities stand to benefit the most from RT in terms of preventing recurrence and that

older women with moderate or severe comorbidities benefited the least[11]. Despite the established guidelines and supporting evidence of benefit from RT, observational studies have consistently found that some women with DCIS—particularly those who are older or living in rural areas—receive RT at lower rates[12–15]. This is a concerning situation, because, for healthy elderly women with DCIS, RT appears to confer a substantial benefit that remains meaningful even among low-risk patients[11]. Personal barriers of access to health care because of socioeconomic status or physician adherence to guidelines can both affect the rate of RT use[16,17]. At present, the available information on the characteristics of patients receiving and not receiving RT and on the characteristics of their physicians is limited[18]. To better understand the underutilization of RT, it is necessary to identify new patient-, physician-, and setting-related factors that predict administration of RT.

The Canadian province of Quebec provides universal health care insurance to all its citizens (7.8 million people)[19], offering a unique opportunity to identify factors predictive of access to and use of health care services, confounded to a lesser degree by socioeconomic status[20,21]. The primary objectives of the present study were to characterize the rates of RT consideration and administration in women with DCIS who underwent BCS between January 1, 1998, and December 31, 2005, in Quebec and to identify patient- and surgeon-related factors that predict those rates.

2. METHODS

2.1 Setting and Data Sources

The source population consisted of all residents in the province of Quebec covered by the province's public health insurance plan (>99% of the province's population of >7.8 million), which is provided by the Quebec Health Insurance Agency (RAMQ)[22]. A Breast Cancer Database containing available data from 1997 to 2005 (Figure 1) was constructed for this study by anonymous linkage of the following provincial administrative databases:

- The RAMQ registrant database, containing demographic information (name, sex, dates of birth and death, postal code, and material deprivation index[23])
- The RAMQ medical services database, containing records of fee-for-service claims for physician visits
- The Quebec Ministry of Health and Social Services discharge abstract database (MED-ÉCHO), which captures administrative and clinical information on virtually all hospital discharges in the province

The MED-ÉCHO database is the data source for the Quebec Tumour Registry, which was used to verify that all DCIS cancers were new incident cases. Quebec's Material Deprivation Index, provided to RAMQ by the National Institute of Public Health of Quebec, is calculated using census of Canada data. Ethics approval for the study was obtained from the Research Ethics Office at McGill University and the provincial Access to Information Office.

2.2 Design and Study Population

In this historical prospective cohort study, Quebec women who underwent BCS within 6 months of a DCIS diagnosis were selected from the Breast Cancer Database. The DCIS diagnosis date was determined using the date in MED-ÉCHO of the first hospital admission involving a primary diagnosis for DCIS (Table I)[25], identified using the *International Classification of Diseases,* 9th edition, adapted for Quebec (ICD-9-QC)[24]. The use of BCS was ascertained using RAMQ procedure codes (Table II) up to 6 months after the DCIS diagnosis date from the medical services database. Women were entered into the cohort after 1998 to ensure that at least 1 year of medical service history before the BCS was available for the selected patients. Pregnant women (who are ineligible for RT by default) and women who underwent mastectomy, who died, or who became ineligible for medical insurance in the year after diagnosis, were excluded from the study population.

2.3 Assessment of Patient and Surgeon Characteristics

Patient and surgeon characteristics were assessed for the year before the patient underwent BCS. Age at diagnosis was calculated using the patient's date of birth, provided by the registrant database. The residence of each patient was classified as rural or urban depending on whether the second digit of the postal code was or was not 0, in accordance with Canada Post Corporation delivery service[26]. The driving distance between the centroid of each patient's forward sortation area and the nearest designated centre of excellence for breast care in Quebec[27] was calculated in kilometres using Google Maps. The comorbidity profile of each patient was assessed using the Charlson comorbidity index, calculated using the enhanced ICD-9 coding algorithm[28] and the medical services database. The ICD-9 codes for breast cancer were removed from the algorithm index, given that all women in the cohort had breast cancer by default. Visits to the emergency room were determined using the RAMQ establishment code 0X7, corresponding to "emergency department" in the medical services database[24]. Whether a patient had diffuse connective tissue disease (a condition contraindicative for RT)

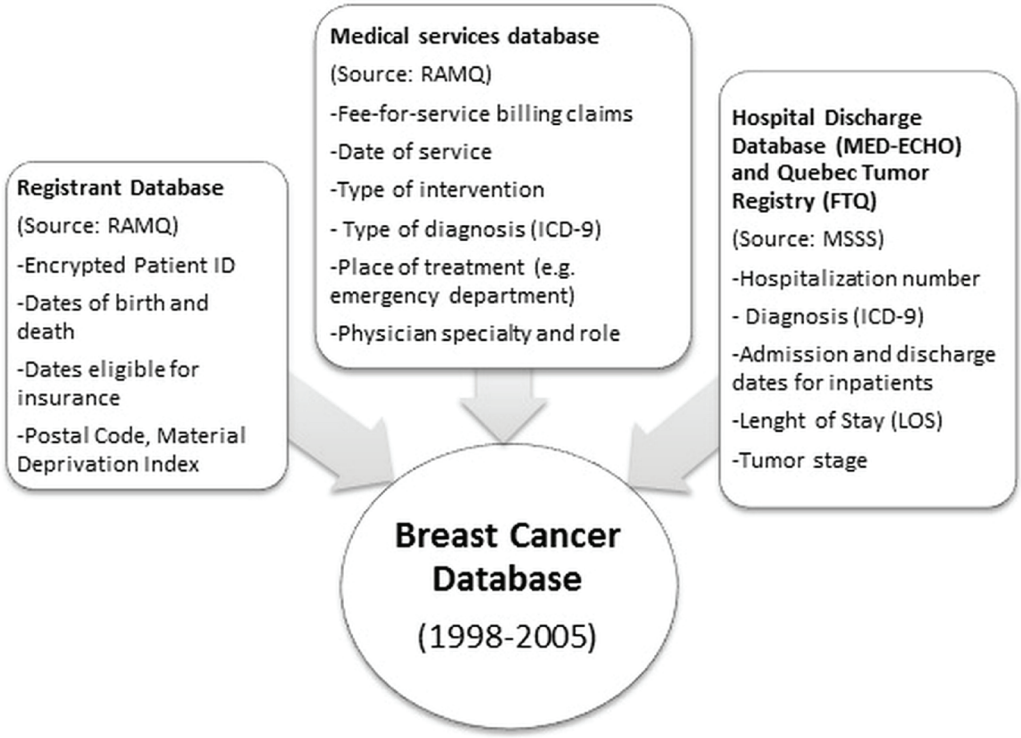

FIGURE 1 Data sources of the Breast Cancer Database. RAMQ = Quebec Health Insurance Agency; ICD-9 = International Classification of Diseases, 9th revision, adapted for Quebec; MSSS = Quebec Department of Health and Social Services.

was assessed using the medical services database and selected ICD-9 codes corresponding to that condition (Table I). Depression was assessed using ICD-9 codes found in the medical services database and tabulated by the Elixhauser comorbidity index[29]. Pregnant women were identified based on whether a pregnancy-related medical procedure appeared in the medical services database (Table II). The number and type of hospitalizations by surgery were determined from the MED-ÉCHO database.

Surgeon and hospital characteristics included the number of BCSS performed before each particular woman's surgery. Using the medical services database, RAMQ procedure codes were checked to determine the number of BCSS (Table II).

2.4 Assessment of Outcome

Consideration for RT was identified by the presence of claims with RAMQ procedure codes corresponding either to consultation with a radiation oncologist (RAMQ physician specialty code of 30)[24] or to treatment in the medical services database up to 1 year after diagnosis, per guideline recommendations[9] (Table II). It was assumed that if a woman had a consultation for RT, she was considered for therapy. In the event that a service claim for consultation with a radiotherapist was not found, it was assumed that a woman who received RT must have had a prior consultation.

TABLE I Disease diagnosis codes from the *International Classification of Diseases,* 9th revision, adapted for Quebec (ICD-9-QC)

Diagnosis	*ICD-9-QC code*	*Description*
DCIS	233.0	Carcinoma *in situ* of breast
Diffuse connective tissue diseases	695.4	Lupus erythematosus
	701.0	Circumscribed scleroderma
	710.0	Systemic lupus erythematosus
	710.1	Systemic sclerosis
	710.2	Sicca syndrome
	710.3	Dermatomyositis
	710.4	Polymyositis
	710.8	Other specified diffuse diseases of connective tissue
	710.9	Unspecified diffuse connective tissue disease

2.5 Data Analysis

Patient and surgeon characteristics are categorized on the basis of their frequency distributions in the cohort. A generalized estimating equation model[30]

TABLE II Procedure codes used by the Quebec Health Insurance Agency (RAMQ)

Procedure	*RAMQ code*	*Description*
Breast conserving surgery (that is, lumpectomy)	01174, 01175, 01201, 01204, 01205,01228, 01229	Partial excision of breast
Pregnancy	00910, 00911, 00921, 00923, 06900, 06902, 06903, 06905, 06906, 06908, 06909, 06912, 06913, 06919, 06923, 06924, 06938, 06939, 06941, 06943, 06945, 06946, 06947, 06948, 06949, 06950, 06951, 06952	Procedures related to the care of pregnant women
Consultation for radiation therapy	09060, 09078, 09080, 09127, 09150, 09152, 09160, 09162, 09164, 09165, 09170, 09171, 09129	Procedures corresponding to consultation between patient and radiation therapist
Treatment with radiation therapy	08520, 08519, 09131, 09133, 09134, 09141, 09143, 09144, 09146, 09172b, 08507, 08508, 08509, 08511, 08553, 08564, 08518	Procedures corresponding to the provision of radiotherapy treatments

with logit link and exchangeable working correlation structure was constructed to assess the association between predictor variables and administration of RT after taking into account the clustering of characteristics among patients treated by the same physician (that is, physician was repeated over patients). The distribution was assumed to be binomial. Univariate analysis assessed the unadjusted associations between each predictor and the outcome. Subsequently, all predictors were included in the generalized estimating equation model. Collinearity between variables was assessed using a Pearson correlation matrix, and as a result, residence was omitted from the model because of its correlation with distance to the hospital (coefficient ≥ 0.5). Selected interaction terms (Material Deprivation Index and distance, Charlson score and distance, Charlson score and emergency room visits, Charlson score and age, surgeon's experience and patient age, surgeon's experience and patient's Charlson score) were introduced into the model one at a time, but none were found to be significant. The working correlation of the final generalized estimating equation model was 0.028. All p values are for two-tailed tests, with statistical significance defined as $p \leq 0.05$. The SAS software application (version 9.2: SAS Institute, Cary, NC, U.S.A.) was used for all analyses. ArcGIS (version 10: ESRI, Redlands, CA, U.S.A.) was used to geo-locate designated centres for excellence in breast care and to map geographic variations in RT consideration (Figure 2).

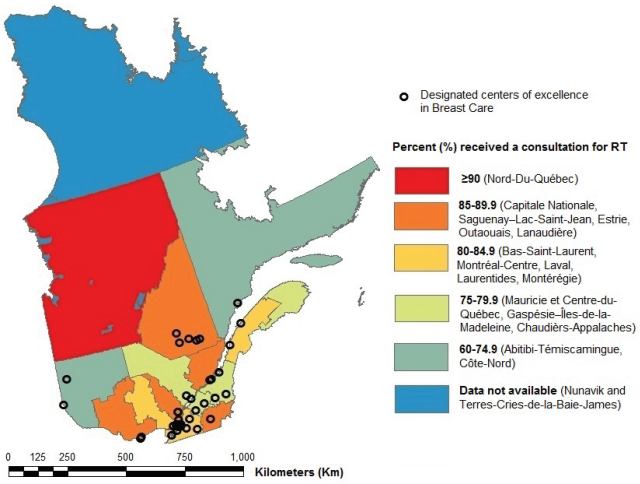

FIGURE 2 Geographic variation in rates of radiotherapy consultation by region.

3. RESULTS

3.1 Patient, Surgeon, and Setting Characteristics

Of the 4998 women diagnosed with DCIS between January 1, 1998, and December 31, 2005, in Quebec, 859 (17.2%) were excluded because they had died (n = 31) or become ineligible for medical insurance (n = 4) within 1 year of diagnosis, had been treated with mastectomy (n = 624) within 1 year of diagnosis, had undergone no breast surgery at all (n = 197), or had been pregnant (n = 3) within 6 months of their diagnosis. The remaining 4139 women constituted the study population. In this group of women, mean age was 58 years (range: 23–93 years), 82% lived in urban areas, 79% did not have major comorbidities (Charlson score: 0), and just 16% were considered severely materially deprived (Table III). In this cohort, fewer than 1% of the women had diffuse connective tissue disease, and 7.6% had depression. About 10% of the women

were hospitalized for reasons unrelated to breast cancer in the year before their diagnosis, and 23% had visited the emergency room.

The nearest centre of excellence for breast care was located less than 20 km away for about 70% of the cohort (Table IV). Only 6.4% of women had to travel more than 100 km to access breast care. A total of 327 surgeons treated the cohort members, with minimum and maximum cluster sizes of 1 and 144 women. Most of the surgeons (60.2%) had performed between 1 and 50 lumpectomies of the breast in the preceding year. The number of DCIS patients treated with lumpectomy increased steadily over the years.

TABLE III Baseline demographic and clinical characteristics of the patients

Characteristic	*Value*
Patients (*n*)	4139
Age (years)	
Mean	58.4±10.2
Range	23–93
Age group [*n* (%)]	
<50 Years	827 (20.0)
50–69 Years	2751 (66.5)
70–79 Years	451 (10.9)
≥80 Years	110 (2.7)
Residence [*n* (%)]	
Urban	3398 (82.1)
Rural	741 (17.9)
Material Deprivation Index[a] [*n* (%)]	
Quintile 1 (most privileged)	990 (23.9)
Quintile 2	820 (19.8)
Quintile 3	798 (19.3)
Quintile 4	734 (17.7)
Quintile 5 (most deprived)	675 (16.3)
Not available[b]	122 (2.9)
CCI score	
None (0)	3261 (78.8)
Low (1–2)	802 (19.4)
Moderate or severe (≥3)	76 (1.8)
Pre-existing conditions[c]	
Has DCTD	22 (0.5)
Has depression	315 (7.6)
Hospitalizations in preceding year	
None	3726 (90.0)
One 1-day hospitalizations	188 (4.5)
Multiple 1-day hospitalizations	22 (0.5)
Hospitalizations longer than 1 day	203 (4.9)
Emergency room visits in preceding year	
Yes	951 (23.0)
No	3188 (77.0)

[a] Calculated using data concerning the percentage of people with no high school degree, the employment-to-population ratio, and the average personal income.
[b] A small subset of the population living in very rural areas.
[c] Conditions contraindicative for radiotherapy in the year preceding the lumpectomy.
CCI = Charlson comorbidity index; DCTD = diffuse connective tissue disease.

3.2 Use of RT in Quebec

Overall, 3435 of the women (83.0%) with DCIS who underwent a lumpectomy between 1998 and 2005 were considered for RT (that is, they had a guideline-appropriate consultation). Of those who had a consultation, 3057 (89.0%) subsequently received treatment. The overall provision of RT consultations in Quebec increased steadily to 85.8% in 2005 from 78.7% in 1998 [Figure 3(A)].

The provision of RT consultations was highest for the 50–69 age group (84.8%) and lowest for the 80 or older age group (55.4%). The overall RT consultation

TABLE IV Baseline characteristics of physician and setting

Characteristic	*Value*
Distance to designated centre for excellence in breast care (km)	
Mean	31.0±61.6
Range	0.5–352
Distance group [*n* (%)]	
<20 km	2883 (69.7)
20–49 km	676 (16.3)
50–99 km	316 (7.6)
≥100 km	264 (6.4)
Surgeons (*n*)	327
Lumpectomies performed [*n* (%)]	
Mean	57.5±53.6
Range	0–297
Surgical volume in preceding year [*n* (%)]	
0 (zero)	18 (0.4)
1–50	2492 (60.2)
51–100	801 (19.4)
>100	828 (20.0)
Year of diagnosis [*n* (%)]	
1998	390 (9.4)
1999	478 (11.5)
2000	490 (11.8)
2001	485 (11.7)
2002	544 (13.1)
2003	541 (13.1)
2004	579 (14.0)
2005	632 (15.3)

rate improved over the years, rising to 85.8% from 78.7% between 1998 and 2005, but notable differences were evident in the various age groups. The most remarkable change was seen in the 80 or older and 70–79 age groups, in which the RT consultation rate rose to 75% from 22.2% and to 78.8% from 68.8% respectively. For women less than 50 years of age, the improvement was only modest, increasing to just 82.5% from 79.0% [Figure 3(B)]. Most of the designated centres of excellence in breast care were located in the southern and more urbanized part of the province.

3.3 Factors Associated with the Use of RT

Tables V and VI describe results of the statistical analysis of factors associated with consideration of postoperative RT. Relative to the largest age group (50–69 years), ORs for the younger than 50, 70–79, and 80 or older age groups were 0.89 (95% CI: 0.71 to 1.12), 0.71 (95% CI: 0.55 to 0.92), and 0.20 (95% CI: 0.14 to 0.31) respectively. Relative to women living within 20 km of a designated centre for excellence in breast care, those living more than 100 km away had a significantly lower OR of being considered for RT: 0.59 (95% CI: 0.42 to 0.81). Material deprivation, comorbidities, emergency room visits, and hospitalizations in the preceding year did not significantly predict consideration for RT. The lack of association between having comorbidities and use of RT persisted in secondary analysis, appearing only in women 70 years of age and older (13.6% of the cohort). The surgeon's volume of BCSS in the preceding year significantly predicted RT consideration. The chance of having a consultation for RT showed a 7% increase for every 10 additional lumpectomies performed in the preceding year by the treating surgeon ($p < 0.0001$). Year of diagnosis also significantly predicted consideration for RT, with women diagnosed after 2002 being more likely than those diagnosed in 1998 to receive a consultation (OR: 1.45; 95% CI: 1.01 to 2.08).

4. DISCUSSION

In the present study, we characterized the rate of guideline-recommended RT consideration by assessing consultation after BCS for patients with DCIS in Quebec. We also identified a number of factors associated with RT consideration. Overall, we found that 83.0% of eligible women were considered (had a consultation) for RT, of which only 11% subsequently did not receive treatment. Patients who were 70 or more years of age, who lived farther than 100 km from a designated breast care centre, who had a surgeon whose lumpectomy numbers were low, or who had been diagnosed earlier during the study period were less likely to receive a consultation and thus RT.

We know that, in the United States, the rate of RT use varies significantly by hospital and geographic

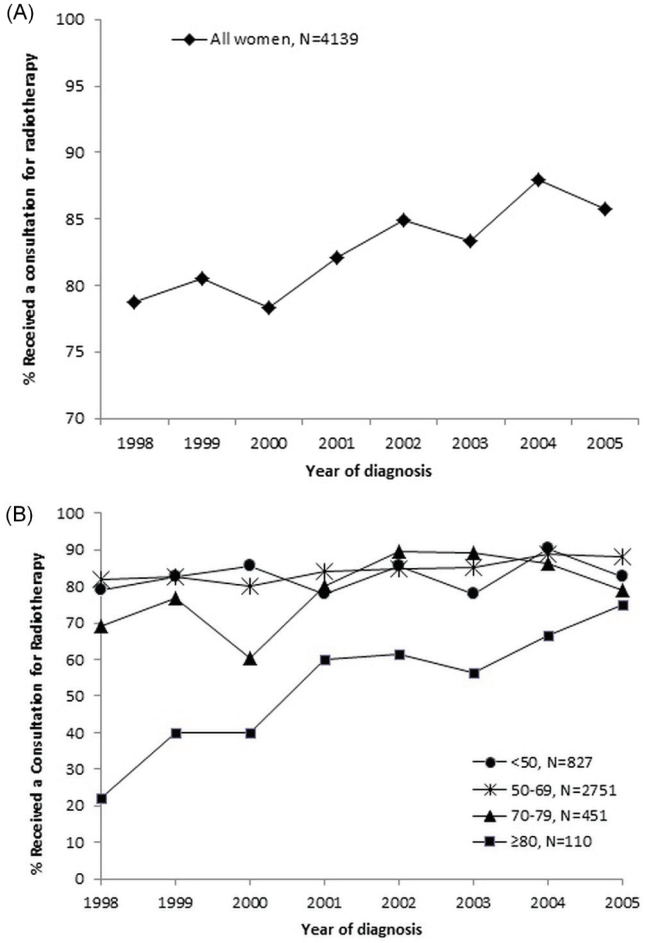

FIGURE 3 (A) Radiotherapy consultations by year in Quebec, 1998–2005. (B) Radiotherapy consultation by age group in Quebec, 1998–2005.

region. An analysis of Medicaid-insured patients in North Carolina showed that 81% received guideline-recommended RT during the years 2003–2007[31]. The rate of RT use in Quebec was similar or slightly higher. It did not vary widely for heavily urbanized areas, but it was lower for the more rural regions of the province, except Nord-du-Quebec. The higher observed rate of RT use in that region could be a result of random error stemming from the very small number of cases ($n = 7$) available for that region or from the fact that all cases from that region are handled by a single centre, which might result in more efficient patient tracking and execution of routine practices. We further observed a significant increase in the use of RT after BCS after 2002. That improvement may reflect an increase in the awareness of the benefits of RT invoked by the 20-year outcomes published that same year by Nakamura *et al.*[5] concerning treatment of DCIS using BCS combined with RT.

Across the literature, patient age has consistently been reported as a risk factor for inappropriate RT omission[16]. Despite clear improvement in RT use

TABLE V Patient-related demographic and clinical factors affecting use of radiotherapy (RT)

Factor	*Considered for RT (%)*	*Pts (n)*	*Unadjusted model*[a]				*Adjusted model*[b]			
			OR	*95% CL*		p *Value*	*OR*	*95% CL*		p *Value*
Age										
<50 Years	82.71	827	0.86	0.71	1.05	0.141	0.89	0.71	1.12	0.330
50–69 Years	84.81	2751	1.00	Referent			1.00	Referent		
70–79 Years	79.82	451	0.73	0.58	0.91	0.006	0.71	0.55	0.92	0.010
≥80 Years	55.45	110	0.24	0.16	0.35	<0.0001	0.20	0.14	0.31	<0.0001
Material Deprivation Index										
Quintile 1 (most privileged)	83.84	990	1.02	0.82	1.27	0.884	0.97	0.75	1.27	0.834
Quintile 2	84.88	820	1.19	0.95	1.50	0.136	1.19	0.91	1.56	0.201
Quintile 3	82.08	798	1.00	Referent			1.00	Referent		
Quintile 4	82.97	734	1.10	0.87	1.40	0.409	1.16	0.89	1.51	0.270
Quintile 5 (most deprived)	80.15	675	0.95	0.74	1.21	0.671	1.05	0.79	1.40	0.720
Not available[c]	87.70	122	1.37	0.88	2.12	0.160	1.65	0.92	2.94	0.093
CCI score										
None (0)	83.10	3261	1.00	Referent			1.00	Referent		
Low (1–2)	82.79	802	0.97	0.81	1.16	0.726	1.05	0.85	1.30	0.653
Moderate or severe (≥3)	84.21	76	1.05	0.63	1.75	0.839	1.24	0.67	2.26	0.493
Pre-existing conditions										
With DCTD	95.45	22	3.57	0.86	14.80	0.080	3.60	0.49	26.65	0.210
Without DCTD	83.00	4117	1.00	Referent			1.00	Referent		
With depression	80.95	315	0.85	0.66	1.09	0.207	0.89	0.66	1.20	0.440
Without depression	83.24	3824	1.00	Referent			1.00	Referent		
Hospitalizations in preceding year										
None	83.52	3726	1.00	Referent			1.00	Referent		
One 1-day hospitalization	79.26	188	0.81	0.60	1.11	0.191	0.86	0.60	1.22	0.390
Multiple 1-day hospitalizations	72.73	22	0.57	0.24	1.37	0.211	0.79	0.31	1.98	0.610
Hospitalizations longer than 1 day	79.31	203	0.80	0.59	1.10	0.166	0.88	0.61	1.27	0.494
Emergency room visits in preceding year										
Yes	80.76	951	0.86	0.73	1.01	0.061	0.91	0.75	1.10	0.318
No	83.75	3188	1.00	Referent			1.00	Referent		

[a] Unadjusted associations were assessed in a bivariate analysis between outcome and characteristics, using a generalized estimating equation (GEE) model to account for clustering of characteristics in patients treated by the same physician.

[b] Multivariate logistic regression using a GEE model with an exchangeable working correlation (value: 0.028) to account for clustering of patients within physicians assessed associations between outcome and characteristics while adjusting for age, Material Deprivation Index, Charlson comorbidity index, pre-existing conditions, hospitalizations, emergency room visits, distance to breast centre, volume of lumpectomies by the surgeon, and year of diagnosis.

[c] A small subset of the population living in very rural areas.

Pts = patients; OR = odds ratio; CL = confidence limits; CCI = Charlson comorbidity index; DCTD = diffuse connective tissue disease.

between 1998 and 2005 in the two oldest age groups, our findings show that RT consideration is still significantly lower in those age groups than in the 50–69 age group. When we limited the analysis to women 70 years of age and older (13.6% of cohort), no association was evident between comorbidities and consultation for RT, indicating that RT may have been inappropriately omitted for many women in excellent health based solely on their age. According to a study assessing the effectiveness of RT in seniors, women 70–79 years of age with minimal comorbidity were most likely to benefit from RT; patients 80

TABLE VI Physician and setting-related demographic and clinical factors affecting the use of radiotherapy (RT)

Factor	*Considered for RT (%)*	*Pts (n)*	*Unadjusted model*[a]				*Adjusted Model*[b]			
			OR	*95% CL*		p *Value*	*OR*	*95% CL*		p *Value*
Distance to breast centre										
<20 km	83.91	2883	1.00	Referent			1.00	Referent		
20–49 km	85.06	676	1.10	0.88	1.37	0.410	1.10	0.84	1.43	0.501
50–99 km	80.06	316	0.80	0.60	1.08	0.146	0.77	0.56	1.05	0.098
≥100 km	72.35	264	0.60	0.44	0.82	0.001	0.59	0.42	0.81	0.002
Surgeon's case volume in preceding year										
Per 10 additional lumpectomies			1.08	1.05	1.12	<0.0001	1.07	1.04	1.11	<0.0001
Year of diagnosis										
1998	78.72	390	1.00	Referent			1.00	Referent		
1999	80.54	478	1.12	0.80	1.56	0.506	1.08	0.77	1.51	0.657
2000	78.37	490	0.98	0.71	1.35	0.900	0.89	0.63	1.26	0.518
2001	82.06	485	1.24	0.88	1.73	0.215	1.19	0.84	1.69	0.336
2002	84.93	544	1.52	1.09	2.13	0.015	1.45	1.01	2.08	0.045
2003	83.36	541	1.35	0.97	1.89	0.073	1.31	0.92	1.87	0.140
2004	87.91	579	1.97	1.39	2.78	0.000	1.89	1.33	2.70	0.000
2005	85.76	632	1.63	1.17	2.26	0.004	1.56	1.12	2.16	0.008

[a] Unadjusted associations were assessed by bivariate analysis between outcome and characteristics using generalized estimating equation (GEE) model to account for clustering of characteristics in patients treated by the same physician.

[b] Multivariate logistic regression using a GEE model with an exchangeable working correlation (value: 0.028) to account for clustering of patients within physicians was used to assess associations between outcome and characteristics while adjusting for age, Material Deprivation Index, Charlson comorbidity index, pre-existing conditions, hospitalizations, emergency room visits, distance to breast centres, volume of lumpectomies by the surgeon, and year of diagnosis.

OR = odds ratio; CL = confidence limits; DCTD = diffuse connective tissue disease.

years of age and older with substantial comorbidity were the least likely to benefit[32]. Contrary to the common belief that elderly patients do not tolerate RT well, many laboratory and clinical studies show that elderly patients in excellent health tolerate RT very well[33]. Experts encourage clinicians to weigh the benefits of RT after BCS against the potential risks for each woman within the context of her life expectancy[34,35]. However, it should also be noted that, in Quebec, a woman 70 years of age or older in excellent health has a life expectancy of more than 16 years, and a woman 80 or older, more than 10 years[36], which may leave enough time for local recurrence and subsequent breast cancer morbidity and mortality[37]. Older women in excellent health not only benefit from a reduction in local recurrence, but possibly even from a reduction in future breast cancer diagnoses, morbidity, and mortality. Healthy and fit seniors should therefore be considered for RT. For women 80 years of age and older, a thoughtful consideration of life expectancy, comorbidities (possibly in a comprehensive geriatric assessment), and local recurrence risk could aid in the decision concerning optimal treatment for DCIS[35].

We found that, compared with surgeons having a lower volume of BCSS, surgeons having a higher volume were significantly more likely to comply with guidelines and to provide a consultation for RT (7% increase for every 10 additional lumpectomies). We observed a similar relationship between high-volume centres and treatment outcomes (data not shown). Other studies have also observed a positive relationship between surgeon volume and improved treatment outcomes[38]. However, the direction of the causal relationship is not clear[38–40]. Does volume affect quality? Or do better surgeons and larger hospitals attract more patients?

Birkmeyer *et al.*[41] observed that high-volume hospitals have better outcomes in large part because patients at those hospitals are more likely to be treated by high-volume surgeons, and that standards based on surgeon volume and hospital volume would be more useful in directing patients to the providers who are likely to achieve the best outcomes. Improving the quality of surgical care delivered by low-volume surgeons requires a deeper understanding of the underlying mechanisms of the observed associations between volume and outcomes. Birkmeyer *et al.*[41] proposed that the key mechanism could simply be "practice"—clinical judgment and technical skill that are achieved only by surgeons who perform a specific procedure with sufficient frequency. If that hypothesis is true and if a threshold frequency can be characterized, hospitals might have to consider

a system of redistribution of cases among a smaller number of surgeons to ensure certain practice-based competency levels.

Women who lived farther then 100 km from a hospital offering RT services (6.4% of our total cohort) had a significantly lower probability of being considered for RT after lumpectomy. A recent population-based study of RT use in Ontario using administrative databases also observed that living farther away from a RT centre was significantly associated with a reduced probability of RT being administered[42]. That finding raises an issue of appropriateness of care, because some of the women could be left with an unnecessarily high risk of experiencing a local recurrence. A rapidly emerging concept in the provision of health services (at least for consultation) is telemedicine, which could aid in reaching out to patients living in remote areas. The American Telemedicine Association defines telemedicine as "the use of medical information exchanged from one site to another via electronic communications to improve patients' health status"[43]. The results of a recent systematic literature review on the benefits of telemedicine revealed predominantly positive results, with a clear trend toward better results for "behavioural" endpoints (for example, adherence to medication or diet, and self-efficacy) than for medical outcomes (for example, blood pressure or mortality), quality of life, and economic outcomes (for example, costs or hospitalization)[44]. Thus, telemedicine could aid in providing RT consultations to eligible patients who would not otherwise receive them because of distance barriers.

Our study has some important limitations. No information was available on the provider's reasoning or on tumour factors such as size of margins, histology grade, and presence of comedo necrosis, all of which might influence treatment decision-making and recommendations[45,46]. The lack of prior data did not allow us to control for patients with childhood Hodgkin lymphoma, a contraindication to RT because of prior RT. However, given the low incidence rate of that disease in the Canadian population (3 per 100,000)[47], control for that variable in the present study would have excluded 1 patient at the most. In addition, data for the most northern regions of the province (Nunavik, Terres-Cries-de-la-Baie-James, and Nord-du-Québec) were either unavailable or limited in terms of the number of cases, which compromised regional estimates for RT use in those areas. The Charlson comorbidity index might underestimate the true patient comorbidity profile because the coding algorithm flags only diagnoses arising from comorbidities severe enough to result in the use of medical services. Thus, less morbid conditions or missing diagnoses are not captured. Nevertheless, Charlson score is the best proxy for this variable. Procedures that physicians failed to bill for and procedures performed at private clinics (an exception in Quebec) were missing.

The strengths of our study lie in the fact that the entire population of women undergoing a lumpectomy for DCIS in Quebec was captured and that the data are robust. Physicians are paid on a fee-for-service basis, and completeness and accuracy of reporting have monetary incentives attached[48].

5. CONCLUSIONS

We found that 83.0% of women with DCIS who underwent a BCS in Quebec from 1998 to 2005 were considered for guideline-recommended RT. Use of RT has increased significantly since 2002. Women 70 years of age and older and those who lived farther than 100 km from a designated centre for breast care were significantly less likely to be considered for RT, regardless of their health status. A 7% probability increase for providing RT was associated with every 10 additional lumpectomies performed by the surgeon. Emerging tools such as comprehensive geriatric assessments and telemedicine might be considered in an effort to ensure that elderly women in good health and those living far from hospitals receive RT. Further investigation is required to better understand the relationship between surgeon volume and compliance with guidelines of care.

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7. CONFLICT OF INTEREST DISCLOSURES

The authors have no financial conflicts of interest to declare.

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