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**Representation of Women in Canadian Radiation Oncology Trainees and Radiation  
Oncologists: Progress or Regress?**

**Running title:** Gender Representation in Radiation Oncology

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**Abstract**

**Purpose:** The study objective was to determine the representation of women in Canadian radiation oncology (RO) trainees and the radiation oncologist workforce over time.

**Methods and Materials:** Gender data for Canadian RO trainees (residents and fellows) and radiation oncologists were collected from the Canadian Post-MD Education Registry (1994-2021) and Canadian Medical Association (1994-2019). Visa trainees were excluded. Gender parity was defined as a 1:1 female-to-male ratio. Descriptive statistics were used to summarize the data.

**Results:** Female trainee proportions varied with two rising trend periods (1994-1998: 38% to 43%,  $p = 0.93$ ; 2002-2014: 35% to 51%,  $p = 0.53$ ) and two regression trend periods (1998-2002: 43% to 35%,  $p = 0.83$ ; 2014-2021: 52% to 35%,  $p = 0.011$ ). Gender parity was observed in RO trainees between 2012-2016. The annual number of RO trainees ranged from 66 to 173 with two near-parallel periods of gender-associated growth (1994-1996; 2002-2008) and regression (1997-2001; 2009-2016) followed by gender divergence (2017-2021) with increasing male and decreasing female trainees. Nearly all Canadian regions, except Ontario, reached 50% or higher female representation in RO trainees during the study period. In the radiation oncologist workforce, female representation increased from 20% (54/271) to 37% (217/582) between 1994-2019, and all regions and age groups demonstrated higher female representation over time. Within radiation oncologist subgroups, age < 35 years old and Quebec region cohorts reached gender parity.

**Conclusion:** Representation of women varied in Canadian RO trainees and has fallen since 2014, whereas female representation generally increased in the radiation oncologist workforce over time. Gender parity was observed in RO trainees, radiation oncologists < 35 years old, and radiation oncologists in Quebec. Recent declining female representation among RO trainees is

worrisome and further study is warranted to identify potential gender-based barriers in attracting women to the specialty.

**Keywords:** Radiation oncology, Workforce, Gender, Disparity, Equity, Trainees

## Introduction

There has been growing interest within the academic literature to understand and address gender disparities and inequities within the radiation oncology (RO) workforce and training programs, particularly in the United States.<sup>1-10</sup> Female representation in RO appears to lag behind other oncology specialties, including hematology oncology and medical oncology.<sup>3,8</sup> In Canada, gender parity was reached by all medical schools in 1995, and 56% of all first-year medical students in 2019 were female.<sup>11</sup> Furthermore, female representation for all Canadian postgraduate medical trainees and licensed physician workforce in 2019 were 53% and 43%, respectively, with trainees reaching and sustaining gender parity since 2006.<sup>12</sup>

Meanwhile, Canada has experienced notable periods of RO workforce planning instability over the last three decades that had the potential to impact medical student perceptions of the specialty.<sup>13</sup> Inadequate government funding for new radiotherapy facilities, equipment, and staff positions meant lengthy radiotherapy wait times for cancer patients and few job opportunities for Canadian RO graduates.<sup>14, 16</sup> Enrollment in training programs fell as a result. A corrective influx of government funding led to new and expanded facilities that improved radiotherapy capacity and restored hiring practices, prompting the Canadian Association of Radiation Oncology in 2001 to reach out to medical students to improve recruitment to the specialty.<sup>17</sup> Trainee numbers rose rapidly in the 2000s, eventually outpacing job demand, and the resulting oversupply led to contraction and stricter regulation of RO trainee positions starting in 2011.<sup>18</sup> Despite these governing efforts, employment difficulties

for recent Canadian RO graduates have occurred.<sup>19,21</sup> These workforce issues may create barriers in attracting women to the specialty in a tight job market due to employment uncertainty, delayed hiring for staff positions, and less desirable location considerations.

A pan-Canadian RO workforce survey estimated that 35% of practicing radiation oncologists in 2016 were female.<sup>22</sup> Further study confirmed rising female representation among Canadian radiation oncologists reaching 38% in 2018.<sup>23</sup> However, trainee demographics hinted at an emerging trend of declining female representation from gender parity.<sup>23</sup> Given that little is known about female representation trends in the RO community across Canada, a dedicated in-depth analysis focusing on gender-associated data was warranted. The objectives of this study were to evaluate gender demographic trends in Canadian RO trainees and radiation oncologists over time and to propose a narrative that could explain the observed findings.

## Methods

Annual Canadian RO trainee and staff radiation oncologist demographic data were collected from publicly accessible administrative and health information databases: Canadian Post-MD Education Registry (CAPER; 1994-2021) and Canadian Medical Association Physician Data Centre (CMA-PDC; 1994-2019).<sup>12,24</sup> Additional data was obtained from the CMA-PDC including age and jurisdiction classification. Gender and jurisdiction data was available for all practicing radiation oncologists, but a small number of physicians had unknown age information.

Entry into postgraduate medical training programs, including radiation oncology, is coordinated by the Canadian residency matching service (CaRMS), a national independent organization that matches graduating medical students to postgraduate training programs using a fair, transparent, and competitive process. In Canada, the duration of radiation oncology residency training is five years and is comparable to most surgical and medical disciplines. RO trainees were defined as residents and fellows who were Canadian citizens or held valid

Canadian permanent resident documentation. RO trainees in Canada with education visas and requirements to return to their home countries following graduation were excluded from the study. Radiation oncologists were defined as licensed and registered independent RO practitioners within a Canadian jurisdiction, excluding residents, fellows, and radiation oncologists  $\leq$  80 years old.

RO trainees and radiation oncologists located in the thirteen RO training programs and ten Canadian provinces, respectively, were grouped into five distinct groups for regional analysis: West Coast, Prairies, Ontario, Quebec, and Atlantic Canada (see Supplementary Table 1). The official region of Central Canada consists of the provinces of Quebec and Ontario, but these jurisdictions were evaluated separately given that they are the two most populated Canadian provinces and account for 50% of the population in 2021.<sup>25</sup> The Canadian Territories (Yukon, Northwest Territories, and Nunavut) were excluded from analysis since these jurisdictions do not have RO training programs, radiation oncologists, or cancer centers with radiotherapy services.

Gender parity was defined as a 1:1 female-to-male ratio. Descriptive statistics were used to summarize the data. Female representation was defined as the proportion of trainees or radiation oncologists who were female in a given year. The chi square test was used to compare annual totals of male and female RO trainees during rising and declining female representation trend periods. A p value  $<$  0.05 was considered statistically significant.

## Results

### *Radiation oncology trainees*

Female representation in trainees varied over the study period with two rising trend periods (38% (39/103) in 1994 to 43% (40/93) in 1998; and 35% (28/80) in 2002 to 52% (69/134) in 2014) and two regression trend periods (43% in 1998 to 35% (28/80) in 2002; and 52% in 2014 to 35% (46/133) in 2021) (Figure 1A). These corresponding periods were compared to annual male and female trainee numbers over the same time intervals that showed the gender-associated divergence observed in 2014-2021 correlated with the decline in female representation (Figures 1A and 1B;  $p = 0.011$ ). Annual RO trainee numbers by gender varied over time with totals ranging from nadirs of 41 male and 25 female trainees in 2001 to peaks of 97 male trainees in 2008 and 84 female trainees in 2010 (Figure 1B). RO trainee growth and regression trends by gender were largely in parallel until 2014, when gender-based divergence in annual headcounts was observed with increasing male and decreasing female trainees.

Regional analyses of trainee female representation showed that nearly all regions reached 50% or higher between 1994 and 2021 except for Ontario (Figure 2). The prevalence of female representation at or above 50% was: Quebec, 24 out of 28 annual data points (86%); West Coast, 14 (50%); Atlantic Canada, 11 (39%); Prairies, 2 (7%); and Ontario, 0 (0%). Atlantic Canada and the West Coast showed the widest variation in female representation over this interval due to few trainees with only one training program in each of these regions. The corresponding breakdown of trainee numbers by gender and region are presented in Supplementary Figure 1.

### *Radiation oncologists*

Female representation in Canadian radiation oncologists from 1994 to 2019 is presented in Figure 3A. Gender parity was not reached in radiation oncologists during the study period with female representation rising from 20% (54/271) in 1994 and peaking at 38% (213/567) in

2018. The number of male radiation oncologists consistently exceeded female radiation oncologists throughout the study period, with predominantly steady or stepwise growth observed in both genders over time, except for a substantial 20% drop in male radiation oncologists from 210 to 169 that occurred between 1997 and 1998 (Figure 3B).

Regional breakdown by gender of Canadian radiation oncologists from 1994 to 2019 are shown in Figure 4A-E. All regions exhibited steady or stepwise growth in the number of male and female radiation oncologists over the study period, except for Quebec, which experienced a 66% decline in male staff from 67 in 1994 to 23 in 1998 before slowly rising to mid-60 levels again in 2015-2019. Overall, most of the declining numbers of male radiation oncologists observed nationally in the late 1990s were due to male workforce departures in Quebec (Figure 4D). Female representation levels and trends in the radiation oncologist workforce differed across Canadian regions with the highest levels predominantly seen in Quebec and Atlantic Canada over the study period (Figure 4F). All regions demonstrated a steadily increasing trend in female representation over time, except for a fluctuating trend observed in Ontario. Radiation oncologists in Ontario went from having the highest female representation of all regions in 1994 at 22% to the lowest in Canada from 2014 onwards at 28-30%. Quebec was the only region to reach gender parity.

Radiation oncologist workforce demographics by gender and age cohorts are shown in Figure 5A-E. Gender parity was observed in the age < 35 years cohort within the study period (Figure 5A), but not in older age cohorts. Declining numbers of male radiation oncologists were observed in the age 54-64 cohort from 1994 to 1998 (Figures 5D and 5E, respectively), suggesting workforce departures due to career retirements. Specifically, male radiation oncologists aged 65 years decreased by 90% from 71 in 1994 to 7 in 1998. Female representation was age-dependent with lower proportions of female staff associated with increasing age cohorts (Figure 5F). The proportions of female radiation oncologists by age

cohort in 2019 were 62% (13/21) for age < 35, 44% (83/189) for age 35-44, 34% (50/148) for age 45-54, 30% (36/121) for age 55-64, and 25% (15/60) for age ≥ 65. The data demonstrated higher female representation over time. Between 1-20 and 1-23 radiation oncologists in the female and male staff workforce, respectively, had unknown age in annual assessments (Supplementary Figure 2), and were not included in this analysis. The absolute difference in female representation between the workforce with known gender with age and the entire workforce with known gender varied between 0.7% and -0.9% over the study period with a median value of -0.3%.

## Discussion

We conducted a retrospective review of gender demographic trends in Canadian RO trainees and radiation oncologists using large data repositories of over two decades in duration. We observed transient periods where female representation in RO trainees reached or exceeded gender parity followed by substantial regression in female representation starting in 2014 to the lowest level during the study period in 2021. Regional analysis of RO trainees revealed nearly all regions, except Ontario, had reached gender parity at some point during the study period. Although gender parity was not observed in the radiation oncologist workforce, representation of women increased over time and subgroup analysis revealed that > 50% of the Quebec staff workforce and radiation oncologists age < 35 years were women in 2019. Higher rates of female representation were observed in Quebec RO trainees and radiation oncologists in general, suggesting a strong regional correlation.

Canada has experienced a cyclical history of perceived employment difficulties post-residency with RO trainees expressing high levels of job market concerns, delayed workforce entry with graduates pursuing fellowships and advanced degrees, and high emigration rates outside Canada for staff positions.<sup>19,26,30</sup> Perceptions of a difficult job market were highest in the mid-to-late 2010s.<sup>19,26,30</sup> Female representation fell after both of

these periods and the gender composition of RO trainees. The transient decline in the proportion of female RO trainees recovered rapidly that led to more Canadian RO trainee numbers rebounded in the years that followed, along with higher proportions of women in training programs, to help fill the unmet need for more radiation oncologists.<sup>14</sup>

In 2011, workforce oversupply concerns within the specialty led to a reduction in RO trainee positions.<sup>18</sup> A protracted job market recovery has continued for more than a decade. Declining numbers of female RO trainees in the face of rising male RO trainees from 2014 to 2021, despite contraction efforts in RO residency positions to manage workforce oversupply concerns, suggest that prolonged employment uncertainties after residency training may influence the career choices of female medical students more than their male counterparts.

The recent decline in female representation among Canadian RO trainees is concerning and likely multifactorial. A 2019 survey of Canadian medical students interested in oncology reported the most important career selection considerations for oncology disciplines were ease of employment, practice location, and partner/family preference.<sup>31</sup> Similarly, a qualitative study of 4th year medical students in one Canadian province found several major influences on career selection, including ease of postgraduate recruitment, teacher/family influences, and training duration.<sup>32</sup> Most Canadian RO graduates (71-77%) pursue fellowship training after their 5-year residency training.<sup>21</sup> Women in medicine may be disproportionately discouraged from pursuing RO as a career due to a perceived desire to avoid extending training for maternity leave(s) or delay their reproductive plans.<sup>33</sup> Furthermore, decreased flexibility for preferred practice locations in regionalized Canadian cancer centers may contribute to gender-based barriers and

disproportionately influence female medical students away from the specialty toward more location-friendly career options in the context of family planning.

Improvements in the representation of women in the Canadian radiation oncologist workforce have largely been driven by regional and age-related differences, particularly in Quebec, which was the only region to reach gender parity. There were at least two factors that contributed to higher female representation in Quebec. The first factor was a documented mass retirement event of predominantly male radiation oncologists 65 years old or older from Quebec <sup>34, 36</sup> several provincial governments, including Quebec, Nova Scotia, and New Brunswick, endorsed voluntary retirement programs and buyouts to help manage a perceived physician oversupply across Canada. As a result, female representation in Quebec radiation oncologists jumped from 18% (12/67) in 1996 to 38% (14/37) in 1998 following the expedited loss of retiring male colleagues.

The second factor involved the reactive expansion of Quebec RO programs with more trainee positions to rectify a workforce shortage situation that developed following these retirements. During this expansion period, female trainees consistently outnumbered male trainees to substantially increase the number of female radiation oncologists entering the workforce. Female representation in Quebec medical schools achieved gender parity for the first time in 1988, before other Canadian medical schools, and also peaked in 2006, suggesting that the gender composition of RO trainees in Quebec mirrored the female-predominant enrollment trends in Quebec medical schools.<sup>11</sup> This recruitment pattern, with the vast majority of trainees favoring residency training in the same jurisdiction as their medical student training, is supported by recent Canadian residency match data. In 2021, 91% (771/848) of matched medical student graduates who trained in Quebec matched to a residency training program located in Quebec.<sup>37</sup>

Higher female representation in Quebec RO trainees appears to be directly associated with the higher representation of women in the Quebec radiation oncologist workforce.

Trends for the representation of women observed in Canadian RO trainees and radiation oncologists were comparable to other international RO workforce demographics. The proportion of RO trainees in the United States (US) in 2019 who were women was 30% compared to 33% in 2010.<sup>38</sup> Meanwhile, female representation in RO trainees in Australia and New Zealand (ANZ) increased from 44% in 2014 to 51% in 2018.<sup>39,40</sup> The proportion of women in the Canadian radiation oncologist workforce at 37% in 2019 falls behind Australia (43% women in 2019), but was higher than in the US (27% women in 2019).<sup>38,41</sup> Despite less women than men in the specialty in these comparators, female representation in the US and ANZ radiation oncologist workforces have risen. The estimated annual growth rate of female representation over the last decade in Canadian radiation oncologists was 0.5% per year, similar to ANZ at 0.5% per year, but higher than in the United States at 0.3% per year.<sup>38,40</sup> While the 2014 ESTRO Health Economics in Radiation Oncology (HERO) study reported radiation oncologist headcounts and full time equivalents for 24 European countries, gender demographics were not captured.<sup>42</sup>

Achieving gender balance may still require several decades as more female trainees enter the workforce and predominantly older male radiation oncologists retire.<sup>43</sup> The recent decline in the number and proportion of female Canadian RO trainees may slow, or potentially reverse, advancements in the representation of women in the Canadian RO workforce. Strategic efforts to attract female medical students to RO as a potential career option in regions with lower female-to-male ratios in RO trainees and radiation oncologists, namely in Ontario and the Prairies, will be required to reduce the variability in gender distribution of the workforce across Canada. Fewer women than men in the pool of Ontario trainees likely contributed to the widening gender gap observed in the Ontario RO workforce (Supplemental Figure 1C and Figure 4C).

Increasing female representation in RO provides better alignment with cancer patients given that 48% of the estimated new cancer diagnoses in 2021 were in Canadian women.<sup>44</sup> Furthermore, studies within the field of family medicine and internal medicine have shown that health care provided by female physicians leads to improved patient outcomes and higher quality of care.<sup>45,46</sup> Workplace diversity that includes and supports racial and ethnic minority women leads to improved collective intelligence, innovations in research and quality improvement, and diverse mentors from different backgrounds to cultivate and enrich future generations of trainees entering the RO workforce.<sup>33,47</sup>

Addressing gender-based barriers and inequity in medicine requires a multipronged approach at personal, systemic, and leadership levels.<sup>1,3,48</sup> Recommendations to improve gender inequity include addressing unconscious bias in recruitment, employing a diverse recruitment committee, mitigating gender-based discrimination and harassment, deliberate sponsorship of women, and fostering equal access to mentorship programs, networking, and research opportunities.<sup>1,3,47,49</sup> Strategies to counteract workforce oversupply and undersupply cycles may also help attract more medical students, including women, to the discipline. For example, anticipatory recruitment funding directly tied to the number and distribution of trainee positions based on 5-year windowing of robust cancer incidence growth and radiotherapy utilization projections may provide more employment security to current and future RO trainees. Other approaches include encouraging more gender-based messaging of the specialty to medical students via career information sessions in medical schools and on social media, and promoting testimonial experiences from women in RO.<sup>49</sup> Future work towards understanding gender-associated issues in training programs should first start with quantifying and characterizing the nature of gender-based experiences in Canadian RO trainees using quantitative and qualitative survey methods, emulating efforts that reported gender inequities in US RO trainees.<sup>33,50</sup>

Several limitations are acknowledged in our study. The data was collected by third-party organizations and therefore the quality or accuracy of the data could not be assessed. Total trainee numbers varied between 66 and 173 per year where lower denominators may accentuate differences in derived gender proportions from year-to-year. Similarly, regional analyses based on Canadian geography did not contain equally sized sub-groups, so lower denominators in gender proportion calculations increase the possibility of observed differences due to chance. Furthermore, radiation oncologist data from the CMA-PDC for 2020 and 2021 were not available for analysis. While gender and regional demographics from the CMA-PDC were complete with no unknown gender or region classification, a small proportion of the radiation oncologist workforce had unknown age. However, a negative median absolute difference in the comparison between the proportion of female radiation oncologists with known age and the entire workforce favors an underestimation of female representation by age subgroup analysis and suggests that the magnitude of unknown age data was marginal. Despite these limitations, our study demonstrates the value of leveraging large data repositories to evaluate trends in gender demographics of Canadian RO trainees and radiation oncologists over time.

**Conclusion**

Our findings reveal layers of success, past difficulties, and new challenges in the representation of women within the RO community in Canada to inform stakeholders, develop strategic initiatives to improve gender balance, and promote gender equity and equality. Gender parity was transiently observed in RO trainees during the study period. Within the radiation oncologist workforce, gender parity was observed in those age < 35 years and in Quebec. The narrowing gender gap in Canadian radiation oncologists provides much optimism in light of more male-predominant retirements to come, but the recent decline in female representation among trainees in the specialty is concerning. Further study is required to explore potential gender-based barriers so that appropriate interventions can be developed to mitigate the potential retrenchment of women in RO.

**Declaration of interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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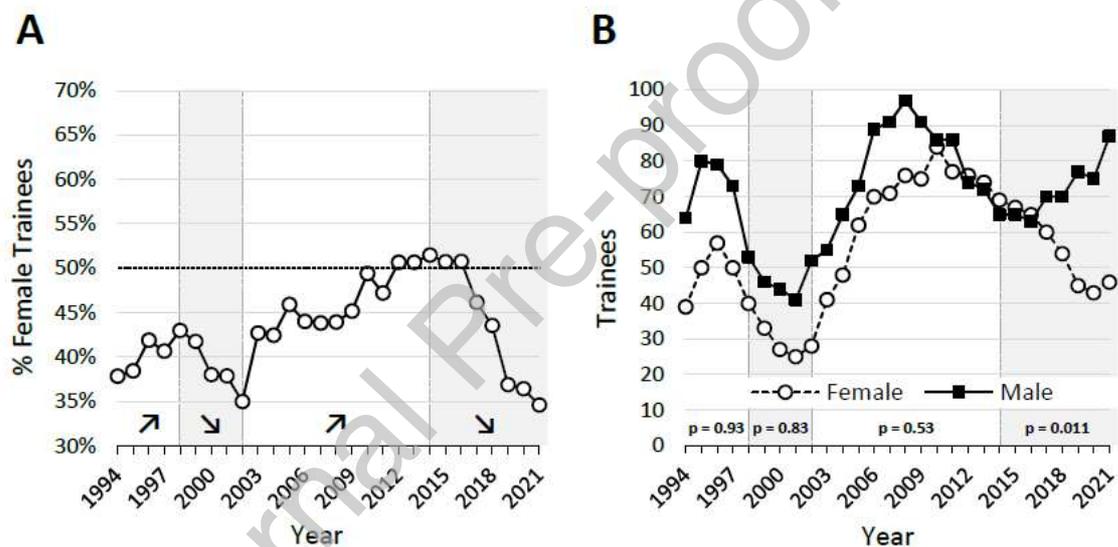
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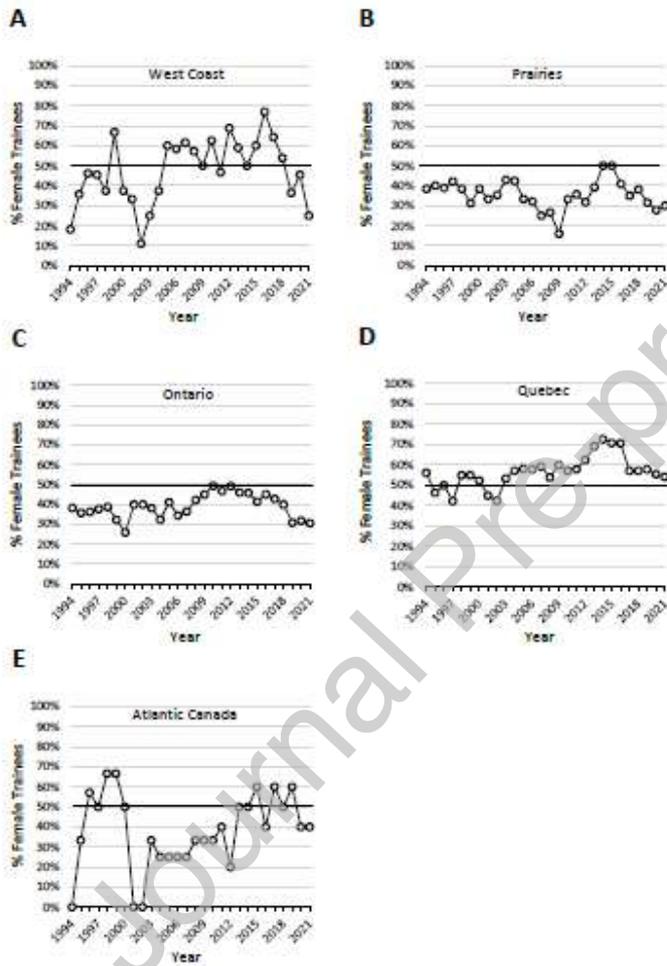


## Figure Legends

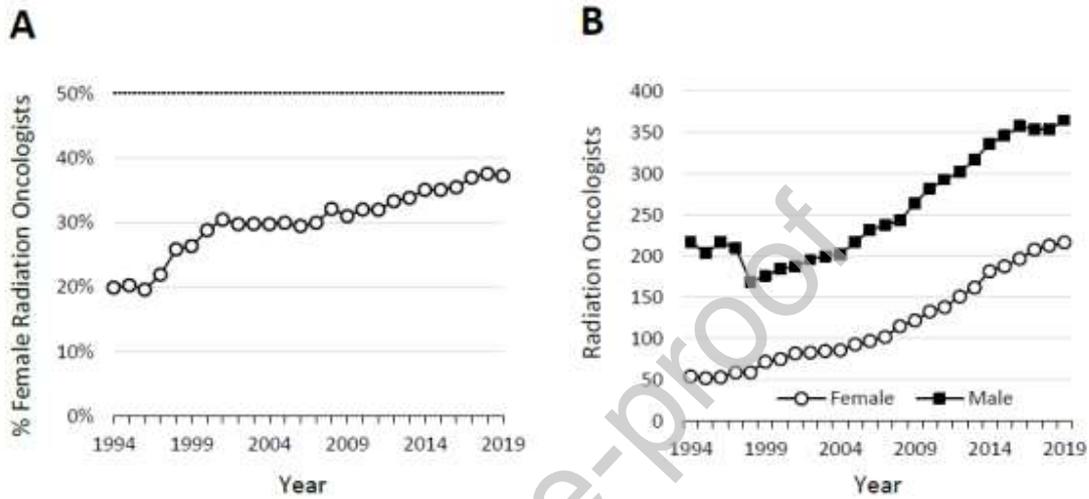
**Figure 1. Female representation in Canadian radiation oncology trainees from 1994 to 2021.** (A) Proportion of female CC/PR trainees in Canada. Periods corresponding to rising and falling female representation trends are indicated by  $\nearrow$  by  $\searrow$  symbols. (B) Number of CC/PR trainees by gender. Chi square tests with indicated p values were performed on data corresponding to the rising and falling female representation periods shown in Figure 1A. CC/PR = Canadian citizens or permanent residents.



**Figure 2. Female representation in Canadian radiation oncology trainees by region from 1994 to 2021.** Proportion of female CC/PR trainees in the West Coast (A), Prairies (B), Ontario (C), Quebec (D) and Atlantic Canada (E). CC/PR = Canadian citizens or permanent residents.

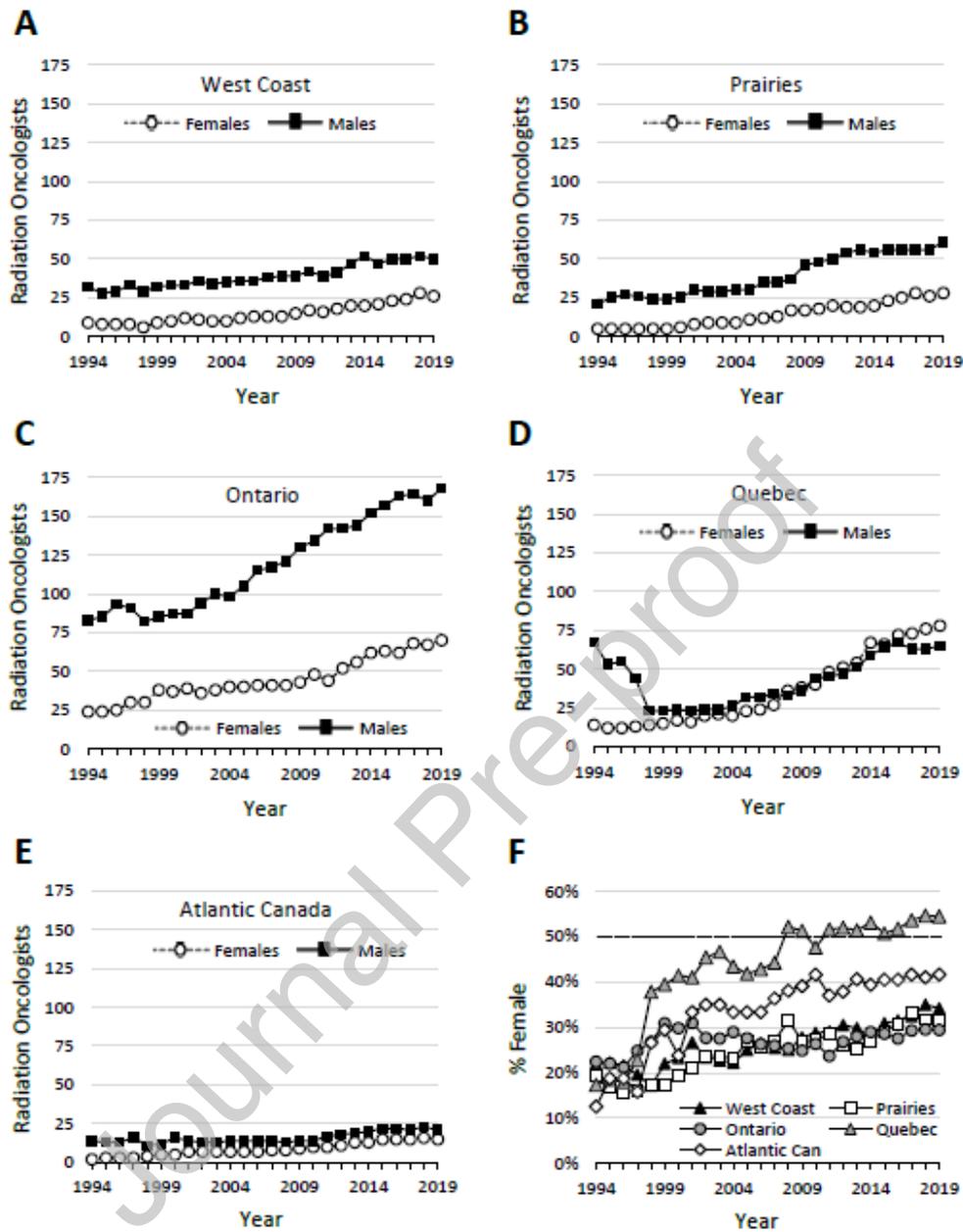


**Figure 3. Female representation in Canadian radiation oncologists from 1994 to 2019.** (A) Proportion of female radiation oncologists in Canada. (B) Number of radiation oncologists by gender.



**Figure 4. Female representation in Canadian radiation oncologists by region from 1994 to 2019.** Number of male and female radiation oncologists in the West Coast (A), Prairies (B), Ontario (C), Quebec (D) and Atlantic Canada (E). (F) Proportion of female radiation oncologists by Canadian region.

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**Figure 5. Female representation in Canadian radiation oncologists by age cohort from 1994 to 2019. (A) Age < 35, (B) Age 35-44, (C) Age 45-54. (D) Age 55-64**

Proportion of female radiation oncologists by age cohort.

