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Article:
Isaranuwatchai, Wanrudee, de Oliveira, Claire, Mittmann, Nicole et al. (2019) Impact of smoking on health system costs among cancer patients in a retrospective cohort study in Ontario, Canada. BMJ Open. e026022. ISSN: 2044-6055

https://doi.org/10.1136/bmjopen-2018-026022

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BMJ Open

Impact of smoking on health system costs among cancer patients in a retrospective cohort study in Ontario, Canada

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To cite: Isaranuwatchai W, de Oliveira C, Mittmann N, *et al*. Impact of smoking on health system costs among cancer patients in a retrospective cohort study in Ontario, Canada. *BMJ Open* 2019;**9**:e026022. doi:10.1136/bmjopen-2018-026022

► Prepublication history and additional material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2018-026022).

Received 22 August 2018
Revised 2 April 2019
Accepted 18 April 2019

Check for updates

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ABSTRACT

Objective Smoking is the main modifiable cancer risk factor. The objective of this study was to examine the impact of smoking on health system costs among newly diagnosed adult patients with cancer. Specifically, costs of patients with cancer who were current smokers were compared with those of non-smokers from a publicly funded health system perspective.

Methods This population-based cohort study of patients with cancer used administrative databases to identify smokers and non-smokers (1 April 2014–31 March 2016) and their healthcare costs in the 12–24 months following a cancer diagnosis. The health services included were hospitalisations, emergency room visits, drugs, home care services and physician services (from the time of diagnosis onwards). The difference in cost (ie, incremental cost) between patients with cancer who were smokers and those who were non-smokers was estimated using a generalised linear model (with log link and gamma distribution), and adjusted for age, sex, neighbourhood income, rurality, cancer site, cancer stage, geographical region and comorbidities.

Results This study identified 3606 smokers and 14 911 non-smokers. Smokers were significantly younger (61 vs 65 years), more likely to be male (53%), lived in poorer neighbourhoods, had more advanced cancer stage,and were more likely to die within 1 year of diagnosis, compared with non-smokers. The regression model revealed that, on average, smokers had significantly higher monthly healthcare costs ($5091) than non-smokers ($4847), p<0.05.

Conclusions Smoking status has a significant impact on healthcare costs among patients with cancer. On average, smokers incurred higher healthcare costs than non-smokers. These findings provide a further rationale for efforts to introduce evidence-based smoking cessation programmes as a standard of care for patients with cancer as they have the potential not only to improve patients' outcomes but also to reduce the economic burden of smoking on the healthcare system.

Strengths and limitations of this study

- Findings from this study represent one piece of evidence in support of the integration of smoking cessation programmes into cancer care treatment plans as a standard of practice.
- This study adds to the literature by providing up-to-date and precise healthcare cost estimates of smoking using existing administrative person-level costing approaches.
- A limitation of this study is that it excludes a subset of relevant variables that may have had an influence on health outcomes and cost due to the nature of the study design (eg, type of tumour, amount and duration of smoking).
- This study focused on the cost incurred to the public healthcare payer and, therefore, indirect costs were not considered but could be explored in future research.
- The findings from this study should motivate policy makers to design, implement and fund smoking cessation programmes, which have the potential not only to improve patients' treatment outcomes but also to reduce the economic burden of smoking on the healthcare system.

INTRODUCTION

Cancer care is a substantial component of healthcare expenditures of developed countries.[1–3] In Canada, the economic burden of cancer was estimated to be $7.5 billion in 2012.[4] It is well recognised that smoking is the main modifiable risk factor for cancer,[5] and it is estimated that it contributes to approximately 30% of all cancer deaths.[6 7] Smoking can also harm directly or indirectly almost every organ of the body and is responsible for a number of other chronic diseases that contribute to higher healthcare costs.[5 8–11] Quitting smoking after a diagnosis of cancer has been associated with improved general health, better quality of life, reduced toxicity, greater response to treatment (such as radiation therapy) and decreased risk of disease recurrence and second primary cancers.[12–18] Nevertheless, patients with cancer are just as likely to smoke as the general public, with the

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smoking rate being approximately 20%.[19] Furthermore, smoking cessation programmes are rare in oncology settings.[12 13 20]

Although the impact of smoking on healthcare costs has been examined in the general population, there is very little information on the impact of smoking on the cost of cancer care in patients who are smokers compared with those who are not.

The study objective was to compare the health system costs of patients with cancer who were current smokers with those of non-smokers between 2014 and 2016, from the perspective of a public healthcare payer, using administrative databases in Ontario, Canada. We hypothesised that smoking would be associated with higher overall health system costs as a result of the need to manage more frequent and severe toxicities of treatment, more frequent disease recurrence and more non-cancer-related morbidities. Understanding the cost burden of smokers with cancer may help drive policy change by providing an economic argument for investing in cessation resources and programmes for patients with cancer who smoke.

MATERIALS AND METHODS

This study was a secondary data analysis using existing administrative databases at Cancer Care Ontario (CCO) and the Institute for Clinical Evaluative Sciences (ICES), both located in Toronto, Ontario, Canada.

Study population and setting

The study population consisted of newly diagnosed adult patients with cancer, aged ≥18 years, who received ambulatory care from one of the 14 Regional Cancer Centres (RCCs) in Ontario, Canada, between 1 April 2014 and 31 March 2015. The Ontario Cancer Registry (OCR) was used to identify our study population. We excluded patients with (1) an invalid health card (ie, who were not eligible for public healthcare insurance); (2) an invalid death date (ie, where death date was on or before the date of diagnosis); (3) missing data on smoking status; (4) a cancer stage of zero; (5) missing data on neighbourhood-level income, geographical location or rurality of residence; (6) lost healthcare coverage during the follow-up time; or (7) multiple cancers. Each patient was followed until death or the end of the observation period (31 March 2016), whichever came first. Online S1 appendix provides a flow diagram of the number of patients excluded from the analysis.

Study population subgroups (smokers and non-smokers)

The study population of patients with cancer was divided into those who were identified as smokers and non-smokers. Patients with cancer who were either currently smoking at the time of diagnosis or who had smoked in the previous 6 months of their first ambulatory care visit were identified as *smokers*, whereas all others were identified as *non-smokers*. Information on *smoking status* was obtained from the *CCO Smoking Cessation Dataset* (CCOSCD), which is part of the Activity Level Reporting (ALR) database housed at CCO. The CCOSCD collects information on the self-reported smoking status of newly diagnosed ambulatory patients with cancer, whether the current smoker has been advised to quit, and whether the patient has been referred for smoking cessation counselling and/or pharmacotherapy.[21] Each RCC submits the data on these metrics on a monthly basis to CCO as part of CCO's Smoking Cessation Programme. Online S2 appendix describes the data elements in the data set and their definitions.

Data sources and variables

A number of databases were used to obtain healthcare utilisation data: the ALR database, the New Drug Funding Programme database, the Ontario Drug Benefit claims database, the Discharge Abstract Database obtained from the Canadian Institute for Health Information (CIHI), the National Ambulatory Care Reporting System obtained from CIHI, the Ontario Health Insurance Programme claims database, the Home Care Database, the Continuing Care Reporting System and the National Rehabilitation Reporting System. Table 1 provides a brief description of each database.

Healthcare costs

The outcome of interest for the study was total and disaggregated healthcare costs from the perspective of the Ontario Ministry of Health and Long-Term Care from the time of diagnosis. Patients in Ontario receive publicly funded healthcare, which covers costs for health services (eg, hospitalisation) including the costs of most drugs for patients over the age of 65 years or who are on social assistance. Healthcare costs included costs associated with hospitalisations, same-day surgeries, emergency room (ER) visits, outpatient prescription drugs, rehabilitation, complex continuing care, home care services, physician services, and laboratory and diagnostic tests. Cost estimates were derived using an existing costing algorithm at ICES. For example, hospitalisations and ER visit costs were estimated by multiplying a resource intensity weight (measure of utilisation) with an average cost per hospital stay or ER visit (unit cost).[22] Physician visit costs were obtained from the Ontario Schedule of Benefits for Physician Services.[23] Additional details on the methods to estimate cost can be found elsewhere.[4 22 24] Costs were adjusted to 2016 Canadian dollars ($C) using the health component of the Consumer Price Index in healthcare category ($C1=approximately US$0.78).[25]

Other variables

Due to potential differences between smokers and non-smokers, we controlled for patient characteristics by adjusting for a number of variables such as age at diagnosis, sex, cancer site, cancer stage (where available), geographical location of residence (ie, rurality and Local Health Integration Network (LHIN)), neighbourhood income quintile and comorbidity (measured

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Table 1 Administrative databases used in the analysis

Database	Description
OCR	The Ontario Cancer Registry is the largest population-based cancer registry in Canada. The OCR contains over 300 fields, including primary site of cancer, county of residence at diagnosis and health insurance number.
ALR	The Ontario Activity Level Reporting provides a set of data elements from selected Ontario Cancer Centres that cannot be obtained from other providers. This information is used to support management decision-making process.
NDFP	The New Drug Funding Programme data are used for reimbursement decisions and to support cancer system planning for systemic therapy. To be eligible for reimbursement through the NDFP, hospitals must submit eligibility/enrolment data and treatment data in compliance with monthly billing deadlines. For treatment reimbursement, each patient must be enrolled in the NDFP by providing eligibility/enrolment data that include patient-specific demographic information and answers to a series of medical questions.
ODB	The Ontario Drug Benefit Formulary lists prescription drugs that are covered for patients over 65 years and selected other groups (eg, those that require income supports).
CIHI DAD	Hospitalisation and comorbidity data are in the Discharge Abstract Database from the Canadian Institute for Health Information.
CIHI NACRS	Emergency room visits and same-day surgery data were obtained from the National Ambulatory Care Reporting System.
OHIP	Ontario Health Insurance Programme reports outpatient physician visits based on fee-for-service claims.
HCD	Home Care Database captures all home care services in Ontario.
CCRS	The Continuing Care Reporting System reports utilisation of continuing care.
NRS	National Rehabilitation Reporting System captures rehabilitation utilisation.

by the Adjusted Clinical Groups or ACG), all of which were obtained from the previously mentioned databases. In Ontario, publicly funded healthcare services are administered on a regional basis by the LHINs, which serve as the regional health authority. Each of the 14 LHINs is responsible for a distinct geographical location.[26] The ACG system is a patient case-mix adjustment system used to measure health status by grouping diagnoses into clinical groups. The goal of this system is to assign each patient a single value, which represents the patient's comorbidity through his/her expected or actual use of health services, where a higher number refers to a greater number of comorbidities (0–4, 5–6, 7–9 and 10+).[27] In this study, this value was assigned at the time of the cancer diagnosis. Cancer sites or groupings were reported on as follows: bladder; bronchus and lung; breast; colorectal; corpus uteri; head and neck; prostate; melanoma; and 'other'. Other included cancers of the anus and anal canal, brain, oesophagus, haematopoietic system, liver, ovary, pancreas, renal, stomach, testis and thyroid. The four most common types of cancer were lung, breast, colorectal and prostate cancer. The extent of cancer was reported in one of three groups: stage 1–2; stage 3–4; and unknown stage. Cancer stage data in Ontario were available predominantly for the four most common types of cancer (eg, lung, breast, prostate and colorectal); therefore, it was necessary to create a separate category for unknown cancer stage.

ANALYSIS

The raw costs for non-smokers and smokers were reported descriptively. To adjust for different follow-up times, as some patients (particularly smokers) have a greater chance of dying than non-smokers, we estimated person-month costs.[28]

The output of the economic analysis was the incremental cost (reported in 2016 CAD) between patients with cancer who smoked and those who did not. We analysed our dependent variable (monthly healthcare costs) using regression models to estimate the difference in expected healthcare cost between the two groups using recycled predictive methods,[28–30] as described in the following equation:

$$Cost_i = \beta_0 + \beta_1(smoking\ status)_i + \beta_2(age)_i + \beta_3(sex)_i + \beta_4(income\ quintile)_i + \beta_5(rurality)_i + \beta_6(cancer\ stage)_i + \beta_7(cancer\ type)_i + \beta_8(LHIN)_i + \varepsilon_i,$$

where $cost_i$ represents a monthly cost of patient I; β_x refers to a coefficient estimate of each variable, X, such as smoking status, age and sex; and ε represents the error term. The smoking status variable was the primary independent variable, and the regression model was adjusted for potential confounding variables, such as age, sex, income, rurality, cancer stage, cancer site, geographical region (LHIN) and comorbidity. To accommodate for the skewness of cost data, a generalised linear model with log link and gamma family was used to estimate the incremental cost between smokers and non-smokers.[28 31] We also conducted a modified Park test to ensure that our selected model was the best fit.[28 31] Collinearity was also explored using a variance inflation factor, and we found no evidence of collinearity. Online S3 appendix reports a completed Strengthening the Reporting of Observational Studies in Epidemiology statement, a checklist of items that should be included in reports of cohort studies.

Patient and public involvement

There was no involvement of patients during the study period but there are knowledge translation activities with various knowledge users.

RESULTS

There were 3606 smokers and 14911 non-smokers in our study cohort (see table 2). Patients with cancer who smoked were significantly younger (61 vs 65 years), more

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Table 2 Demographic characteristics of study population between smokers and non-smokers

Variable*	Non-smokers	Smokers
n	14911	3606
Mean age in years (SD)	65.1 (13.6)	60.6 (12.1)
Male	6681 (44.8%)	1907 (52.9%)
Age groups in years, n (%)		
18–44	1116 (7.5%)	310 (8.6%)
45–54	1973 (13.2%)	661 (18.3%)
55–64	3443 (23.1%)	1217 (33.7%)
65–74	4525 (30.3%)	1035 (28.7%)
75+	3854 (25.8%)	383 (10.6%)
Income quintile, n (%)		
1 (lowest)	2387 (16.0%)	887 (24.5%)
2	2597 (17.4%)	818 (22.7%)
3	3065 (20.6%)	691 (19.2%)
4	3351 (22.5%)	649 (18.0%)
5 (highest)	3511 (23.5%)	561 (15.6%)
Living in rural areas, n (%)	2267 (15.2%)	662 (18.4%)
Death within 1 year, n (%)	2211 (14.8%)	850 (23.6%)
Mean time from diagnosis to death (SD)	255.2 days (163.3)	236.8 days (159.6)
Comorbidity (ACG), n (%)		
0–4	3589 (24.1%)	1092 (30.3%)
5–6	3295 (22.1%)	838 (23.2%)
7–9	4533 (30.4%)	985 (27.3%)
10+	3494 (23.4%)	691 (19.2%)
Cancer stage, n (%)		
1–2	6378 (42.8%)	1289 (35.7%)
3–4	3958 (26.5%)	1392 (38.6%)
Unknown	4575 (30.7%)	925 (25.7%)
Cancer types, n (%)		
Lung	1673 (11.2%)	1017 (28.2%)
Breast	3088 (20.7%)	497 (13.8%)
Head and neck	614 (4.1%)	292 (8.1%)
Prostate	1694 (11.4%)	290 (8.0%)
Colorectal	1460 (9.8%)	268 (7.4%)
Melanoma	563 (3.8%)	81 (2.2%)
Corpus uteri	701 (4.7%)	64 (1.8%)
Bladder	196 (1.3%)	43 (1.2%)
Other	4922 (33.0%)	1054 (29.3%)

*The two groups were significantly different across all variables (p<0.05).
ACG, Adjusted Clinical Groups; n, sample size.

likely to be male (53% vs 45%), live in lower income neighbourhoods (25% of smokers compared with 16% of non-smokers were in the lowest income quintile) and more likely to live in rural areas (18% vs 15%) compared with patients with cancer who were non-smokers. Cancer stage data were available for approximately 70% of patients over the study period. Of those with available cancer stage data, smokers were more likely to have advanced cancer stages than non-smokers. Almost 40% of smokers were in stage 3–4 compared with approximately 27% of non-smokers. Roughly 25% of smokers died within 1 year of diagnosis compared with 15% of non-smokers who died over the same follow-up period. Approximately 30% of smokers were in the lowest comorbidity level (0–4) compared with 24% of non-smokers. Only 19% of smokers were in the highest comorbidity level (10+) compared with 23% of non-smokers. Among all cancer types studied, lung cancer was the most common type of cancer among smokers followed by breast cancer. For non-smokers, the most common cancer type was breast cancer followed by prostate cancer and lung cancer (table 2); all three were identified as common types of cancer.

Online S4 appendix reports the unadjusted monthly healthcare costs between the study groups. Generally, smokers incurred higher healthcare costs than non-smokers for hospitalisations, physician services, ER visits, home care services and complex continuing care. Focusing on specific types of healthcare costs, smokers had approximately 30% higher hospitalisation costs, 43% higher ER visit costs, 23% higher physician visit costs and 30% higher home care costs than non-smokers. Overall, total monthly healthcare costs were higher among smokers ($5649 ± $7169) than non-smokers ($4704 ± $6737).

From the adjusted regression model (controlling for age, sex, income, rurality, stage, disease site, geographical region and comorbidity), on average, smokers had significantly higher monthly healthcare costs ($5091) than non-smokers ($4847). Smokers incurred $244 (±113; 95% CI $242, $245 and IQR $145, $328) more in healthcare cost per month, or $2928 more per year than non-smokers, p=0.0047.

DISCUSSION

Understanding the impact of smoking on the healthcare costs of patients with cancer may strengthen the rationale for decision makers to further invest in smoking cessation programmes. It is generally understood that smoking can lead to worse clinical outcomes, but there is a paucity of literature on the impact of smoking on healthcare costs among patients with cancer. The findings from this analysis are aligned with the limited available literature. Specifically, we found that patients with cancer who were smokers were younger and more commonly males compared with patients with cancer who were not smokers, which is in line with the literature.[10 32] Additionally, smokers had, on average, almost 20% higher total monthly healthcare costs than non-smokers. When focusing mainly on hospitalisations, the incremental cost due to smoking was approximately 30% higher than non-smokers, in contrast to an increase of up to 50% in incremental hospitalisation costs among smokers reported in the literature.[9 33] Our findings suggest that patients with cancer who are smokers are responsible for a greater economic burden than non-smokers.

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Evidence on the importance of smoking cessation for patients with cancer has strengthened in recent years. Several cancer care institutions in the USA have emerged as leaders in this field by incorporating smoking cessation programmes into practice.[34] Ontario is the first jurisdiction in North America to implement a systematic smoking cessation programme in all of its RCCs. Under the leadership of CCO, the provincial agency responsible for improving the quality of cancer services in Ontario, a smoking cessation programme provides support for new ambulatory patients with cancer by screening patients for tobacco use, advising on the benefits of quitting and offering referrals to smoking cessation resources. Understanding the impact of smoking on the healthcare costs incurred by patients with cancer may further strengthen the rationale for the programme and encourage policy makers (eg, public healthcare payer) to invest in smoking cessation programmes. The findings from this study may also be beneficial to other cancer agencies and not-for-profit organisations (eg, American Cancer Society, Worldwide Cancer Research and Canadian Partnership Against Cancer) engaged in developing smoking cessation policies and implementing smoking cessation programmes. In addition, this study may help to inform the general public about the burden of smoking among patients with cancer and motivate hospital and health system administrators about the incremental economic impact of failing to help patients with cancer quit smoking. The findings from this study represent a further piece of evidence in support of the integration of smoking cessation programmes into cancer care treatment plans (in settings similar to the study setting) and will hopefully stimulate further research into the optimal implementation of smoking cessation programmes in order to improve cancer care outcomes and reduce morbidity, mortality and cost.

This study has strengths and limitations, which should be highlighted. The medical literature has called for more up-to-date and precise healthcare cost estimates of smoking.[9 35] Existing Canadian literature has used cost estimates for smokers from the 1990s and/or employed high-level costing approaches, instead of using patient-level cost estimates. These prior estimates might not accurately reflect the true healthcare cost difference between smokers and non-smokers.[9 35–37] This study represents a first step in systematically collecting these data and linking them to data on system-level resources. Furthermore, using existing data from administration databases, we were able to conduct the analysis with adjustment of potential confounders to increase the validity of the findings.

In terms of limitations, data on smoking status were limited to one assessment during the initial consultation period (28 days) for new ambulatory patients with cancer. Therefore, it is possible that patients may have changed their smoking status after their cancer diagnosis but data on change in smoking status were not captured. Our analysis followed the intent-to-treat principle and was applied to both study groups (ie, smokers at the time of diagnosis or who had quit in the last 6 months remained smokers throughout the analysis and vice versa). If some 'smokers' quit smoking, their medical outcomes or tolerance to treatment may have been better than that of persistent smokers (presumably with less resource utilisation and less cost). Consequently, this analysis may have provided a lower bound of the incremental cost. Individuals who had quit prior to 6 months would likely still have more health complications and resource utilisation than life-long non-smokers. Classification of these patients as non-smokers may again lead to the possibility of an underestimation of the difference in cost between smokers and non-smokers. The data available on smoking status limited our ability to analyse former smokers and recent quitters as separate groups.

Our analysis was also limited by the available follow-up data. As the follow-up period was relatively short, it is possible that significant differences might be observed with a longer period of follow-up. It is also possible that, given the nature of the study design, relevant variables were not collected. For example, cancer stage data were available for the common types of cancer (ie, lung, breast, colorectal and prostate cancer), but not for some other tumour types, such as head and neck cancer. In addition to the common cancer types, our study included other tumour types (eg, brain, liver) but their smaller numbers did not allow us to examine them separately. This could be a future area of research. Patients with multiple cancers were excluded from the study to distinguish the impact of smoking on a single tumour type. In addition, there were no data available on the amount or duration of smoking, which would likely have an influence on health outcomes and cost. Smoking has been shown to increase both direct and indirect costs.[9 36 37] However, because our study used administrative data, indirect costs were not explored. Future clinical trials could consider prospectively documenting the specific clinical and financial benefits of smoking cessation as part of clinical care to evaluate the smoking cessation programmes. Finally, the cost to implement a smoking cessation programme was not included in this analysis and may cancel out some of the economic benefits of helping smokers to stop smoking.

In conclusion, the smoking status of patient with cancer has a significant impact on health system costs. On average, smokers incurred higher healthcare costs than non-smokers. These findings provide an additional reason for the introduction of evidence-based smoking cessation programmes for patients with cancer. The findings from this study should motivate policy makers to fund, design and implement smoking cessation programmes, which have the potential not only to improve patients' treatment outcomes but also to reduce the economic burden of smoking on the healthcare system.

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Acknowledgements We would like to acknowledge the assistance of Refik Saskin and Lisa Ellison from the Institute for Clinical Evaluative Sciences (ICES), and Stephanie Young, Mohammad Hoque, Elisa Candido, Julie Klein-Geltink, Brooke Filsinger, the Cancer Care Ontario (CCO) Research Office, and the Data Disclosure Committee from CCO including Ashna Jinah and Dr Deena from St. Michael's Hospital for preparation of submission. This study made use of de-identified data from the ICES Data Repository, which is managed by the ICES with support from its funders and partners: Canada's Strategy for Patient-Oriented Research (SPOR), the Ontario SPOR Support Unit, the Canadian Institutes of Health Research and the Government of Ontario. The opinions, results and conclusions reported are those of the authors. No endorsement by ICES or any of its funders or partners is intended or should be inferred. Parts of this material are based on data and/or information compiled and provided by Canadian Institute for Health Information (CIHI). However, the analyses, conclusions, opinions and statements expressed in the material are those of the author(s) and not necessarily those of CIHI. Parts of this material are based on data and information provided by CCO. The opinions, results, view and conclusions reported in this paper are those of the authors only.

Contributors All authors made important contributions to this work. WI, CdO, NM, WKBE, AP, RT and KC contributed to this study's conception and design. WI, NM, AP and RT were responsible for data collection and assembly. All authors (WI, CdO, NM, WKBE, AP, RT, KC) were involved in data analysis and interpretation. WI, CdO, NM and WKBE drafted the paper, and all authors critically reviewed and suggested amendments prior to submission. The corresponding author attests that all listed authors meet authorship criteria and that others not meeting the criteria have been omitted.

Funding This work was funded by the Canadian Centre for Applied Research in Cancer Control (ARCC). ARCC receives core funding from the Canadian Cancer Society Research Institute (Grant No: 2015-703549).

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Research ethics approval was obtained from St. Michael's Hospital, Toronto, Ontario, Canada.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement This study made use of de-identified data from the Institute for Clinical Evaluative Sciences and Cancer Care Ontario who have the right and control over the data used.

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