The impact of routine Edmonton Symptom Assessment System (ESAS) use on overall survival in cancer patients: Results of a population-based retrospective matched cohort analysis

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Abstract

Background: The Edmonton Symptom Assessment System (ESAS) is a validated instrument whose use has been standardized in the Ontario cancer system to measure symptoms among ambulatory cancer patients. The objective was to examine the effect of ESAS exposure on overall survival. We hypothesized, a priori, that patients exposed to ESAS would have higher rates of overall survival than those who were not exposed.

Methods: This was a retrospective matched cohort study of adults diagnosed with cancer between 2007 and 2015. Patients were considered exposed if they were screened with ESAS at least once during the study period. Their first ESAS screening date defined the index date. Each exposed patient was matched randomly to a cancer patient without ESAS using a combination of hard matching (4 variables) and propensity score matching (14 variables). Kaplan-Meier curves and multivariable Cox regression were used to evaluate the impact of ESAS exposure on survival.

Results: There were 128,893 pairs well matched on all baseline characteristics. The probability of survival within the first 5 years was higher among those exposed to ESAS compared to those who were not (81.9% vs. 76.4% at 1 year, 68.3% vs. 66.1% at 3 years, 61.9% vs. 61.4% at 5 years, P-value < .0001). In the multivariable Cox regression model, ESAS was significantly associated with a decreased mortality risk (HR: 0.48, 95% CI: 0.47-0.49).

Conclusions: Our results show that ESAS exposure is associated with improved survival in cancer patients. This provides real world evidence of the impact of routine symptom assessment in cancer care.

Keywords
cohort study, Neoplasms, patient reported outcome measures, propensity score, survival, symptom assessment

Research data are not shared.

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Routine use of patient reported outcomes (PROs) in routine clinical care is a mechanism to improve the person-centred nature of care. Several overviews have demonstrated that using PROs routinely in care can improve identification of symptoms, monitoring symptoms over time, quality of life and communication with the team. Furthermore, emerging results have suggested that routine use of PROs can decrease the use of acute care services such as visits to the emergency department. More enticing are results that their routine use improves survival.

In 2007, Cancer Care Ontario implemented a program of routine symptom screening with the Edmonton Symptom Assessment System (ESAS) for ambulatory oncology patients attending clinics around the province. ESAS assesses 9 common cancer symptoms on a scale of 0 to 10. Most centers have implemented the measure for every visit regardless of cancer type or place in the illness trajectory. Over the past decade, this program has grown and matured. About 60% of eligible patients are screened; 30,000-40,000 symptoms assessments are collected each month; and, over 5 million symptom records have been captured since the beginning of the program. This makes Ontario’s cancer system a unique region to evaluate the impact of symptom screening at a population level.

We used linked administrative healthcare data to create a propensity matched cohort of individuals who have or have not reported symptoms on ESAS and examine the impact of ESAS exposure on overall survival. The methods allow us to better control for measured and unmeasured confounding variables and facilitate a comparison of the two groups using retrospective observational data. We hypothesized that exposure to ESAS would be associated with improved overall survival.

2 | METHODS

2.1 | Study setting and population

To evaluate the effect of ESAS screening on overall survival, a retrospective population-wide exposure-matched study was conducted. We identified all patients with diagnosed with cancer from January, 2007 through December, 2015 from the Ontario Cancer Registry in Ontario, Canada. Patients had to be age 18 or older at the time of diagnosis. Individuals with a previous history of cancer or with multiple cancers were excluded, as were patients with invalid or missing information on demographics. Institutional ethics approval was obtained prior to commencing.

2.2 | Data sources

We linked relevant health administrative databases held at the ICES using unique encoded identifiers to create the cohort. The Ontario Cancer Registry identified all incident cancers in Ontario while the Symptom Management Reporting Database identified patients who used ESAS. The Registered Persons Database provided demographic information on all Ontarians including date of death from any cause and their eligibility to receive care under Ontario Health Insurance Plan (OHIP). The OHIP database recorded all visits to physicians and the Canadian Institute for Health Information’s National Ambulatory Care Reporting System recorded visits to emergency rooms and cancer centers. All hospitalizations or same day surgeries were obtained from the Discharge Abstract and Same Day Surgery databases. All activities during regional cancer center visits were obtained from Activity Level Reporting database.

2.3 | Exposure and matching

Exposed patients were those completing at least one ESAS assessment during the study, while unexposed patients had never used ESAS. Every cancer centre had a system in place to capture patients’ symptoms via a touch screen kiosk, hence the ability to capture symptoms at every visit exists as a matter of routine; however, the strength of the implementation would affect the proportion of patients who actually complete ESAS. Examples of reasons for non-exposure would include patients being roomed immediately after check in, patient preference, absent volunteers (in an implementation that relies on volunteers), poor staff engagement or staff turnover.

The index date for the exposed patients was the first ESAS assessment date after the cancer diagnosis. For each patient exposed to ESAS, we aimed to find 1 unexposed patient via both hard and propensity score matching. Patients were hard matched on year of birth (+2 years), date of cancer diagnosis (+1 year), cancer type and sex. Logistic regression was used to calculate the propensity score of completing an ESAS assessment. The model included patient characteristics (age, sex, neighborhood income quintile, urban/rural residence, region), cancer characteristics (type, stage, year of diagnosis), treatments within 6 months of diagnosis (chemotherapy, radiation and surgery), various measures of comorbid conditions in the past 2 years (total Charlson score, total Aggregated Diagnosis Groups score and Resource Utilization Bands score from John Hopkins Adjusted Clinical Groups System), and number of visits to the emergency department in the 2 years prior to cancer diagnosis. Exposed and unexposed patients were matched on a caliper width of 0.2 standard deviations of the log odds of the estimated propensity score.

Upon completion of matching, a dummy index date were assigned to each unexposed patient such that the gap time (in days) between their diagnosis date and dummy index date was the same as the gap time between the corresponding
exposed patient’s diagnosis date and first ESAS date (Figure 1). Patients were followed from their index date until death, diagnosis of a new cancer, 5-year observation mark, or the end of study at December 31, 2015, whichever came first. The 5-year time point is often used for the evaluation of survival.

### 2.4 Phase of care (defined in order to be incorporated as a time-varying covariate)

The study period between index date and end of observation for each patient was segmented into one of three cancer management-related phases: initial, continuing, or palliative care. For patients diagnosed with stage I-III cancer, the initial phase included first 12 months after diagnosis. The palliative care phase started when a patient (a) was initially diagnosed with stage IV or subsequently found to have metastases; (b) initiated chemotherapy or radiation after 12 months of cancer diagnosis; (c) re-started chemotherapy or radiation after 3-month interval (d) started chemotherapy or radiation with a palliative intent; or (e) received palliative care services. The continuing phase which includes ongoing surveillance and routine follow up care was assigned to the time between initial and palliative care phases. Not all patients were assigned to every phase of care. For example, a patient who was diagnosed with a stage IV cancer would have only been assigned to the palliative care phase. For each patient, as we move along their observation timeline, it is important to note that this phase of care definition did not require looking forward or ahead into time to determine one’s current phase of care status; it’s definition only depended on the occurrences of events up to the given point in time, which thus makes it a suitable time-varying covariate.19

### 2.5 Statistical analysis

Baseline characteristics of matched exposed and unexposed patients were compared using standardized differences. A difference larger than 10% was felt to represent meaningful imbalance in the given characteristic between the exposed and unexposed group.20 Kaplan-Meier method and log-rank test were used to compare the unadjusted probabilities of survival between the two groups. Multivariable Cox proportional hazards model was used to evaluate the impact of ESAS assessment on survival. A robust sandwich variance estimator was used in the model to account for correlation within matched pairs. Since the matching process balanced many baseline factors between the exposed and unexposed, the multivariable model only adjusted for the following additional measures: number of visits to a radiation or medical oncologist between cancer diagnosis and index date was incorporated as a fixed covariate measured at index; number of visits to a family physician or radiation/medical oncologist between the index date and end of follow-up was captured as counter time-varying covariate; and experiencing surgery after diagnosis was captured as a binary time-varying covariate that turned “on” once surgery was received.

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**FIGURE 1** Creation of matched pairs and definition of index date
Phase of care was defined and included as a 3-level categorical time-dependent covariate. The category a patient belonged to depended on the phase of care they were in at that specific point in time.

In a separate multivariable Cox model, we also incorporated an interaction between ESAS exposure and phase of care to assess the variation in the impact of ESAS on survival during each phase of care. Indicators for chemotherapy and radiation were not included in the model as they were part of phase of care definition.

All statistical analyses were done in SAS 14.2 (SAS Institute, Inc, Cary, NC).

3 | RESULTS

3.1 | Baseline Characteristics

Of 508,073 patients who were diagnosed with a cancer, 213,887 had at least one ESAS assessment during the study period. We successfully matched 128,893 (60.3%) patients with ESAS exposure to 128,893 patients without ESAS exposure. Before matching, several differences were present between exposed and unexposed patients: exposed patients were more likely to be younger, women, living in areas of higher income quintile, diagnosed with breast, gynecological, or hematologic cancer, not missing cancer stage, in early stages of cancer, having fewer comorbid conditions, having less healthcare services in the past and more cancer treatments. After matching, baseline characteristics of the matched patients were similar between the two groups (Table 1). The median follow up was 1.4 years. The median time spent in the initial, continuing or palliative phase for the group without ESAS was 0.5 years (IQR 0.2-0.8), 1.8 (0.8-3.8), and 0.3 (0.09-1.0), respectively. For those with ESAS the median time spent in the initial, continuing or palliative phase was 0.6 years (0.3-0.8), 1.6 (0.7-3.7) and 0.8 (0.3-1.7), respectively. During the study period, those exposed had a median of 3 (IQR 2-8) ESAS assessments. Seventy-five percent of patients had more than one ESAS. 98.5% completed all nine symptoms.

3.2 | Overall survival

The probability of survival within the first five years was higher among those exposed to ESAS compared to those who were not (81.9% vs. 76.4% at 1 year, 68.3% vs. 66.1% at 3 years, 61.9% vs. 61.4% at 5 years, P-value < .0001, Figure 2).

In the multivariable Cox regression model, ESAS assessment was significantly associated with a decreased mortality risk (HR: 0.48, 95% CI: 0.47-0.49, Table 2). As expected, in the base model, initial or palliative phase of care are associated with a higher hazard of death when compared to continuing phase.

We added an interaction term between ESAS assessment and phase of care in a separate model to evaluate whether the impact of ESAS on mortality varied between different phases of care. A statistically significant association between ESAS assessment and reduced mortality was seen across all phases and the reduction in risk was highest in the initial phase (HR: 0.33 95% CI: 0.31-0.36), followed by the palliative phase (HR: 0.48 95% CI: 0.47-0.49) followed by the continuing phase (HR: 0.67 95% CI: 0.63-0.71) (Figure 3). Addition of this interaction term did not change the estimated coefficients of the other covariates in the model. Surgery within 6 months of diagnosis and an increased number of clinic visits to radiation or medical oncologists between diagnosis and index date were associated with a reduced mortality risk whereas an increased number of clinic visits to a family physician, radiation or medical oncologist after index was associated with an increased mortality risk. In a separate model as a sensitivity analysis, we examined the effect of exposure to ESAS on overall survival without limiting the follow up to 5 years and the main effect was unchanged.

The R-square value for the univariable model is 0.0019, for the multivariable model is 0.4261 and for the multivariable model with the interaction is 0.4265. The R-square value improves substantially with the main multivariable model and a small amount more with the addition of the interaction term.

4 | DISCUSSION

We used administrative health care data to create a matched cohort of cancer patients who were and were not exposed to ESAS. We observed that those exposed to ESAS lived longer than those who were not. We further observed that the association between ESAS exposure and survival was strongest in the initial phase and in the palliative phase. This finding provides further real world evidence of the impact of routine use of PROs in clinical care. Prior work has demonstrated those exposed to ESAS are less likely to go to the emergency department or be hospitalized and are more likely to be referred to palliative care.21,22

Our results are consistent with randomized studies that have evaluated overall survival as an endpoint. Namely, Basch et al7 found that routine symptom monitoring in cancer patients with solid tumors on chemotherapy had a hazard of 0.83 (95% CI 0.70-0.99) compared to those who did not have routine symptom monitoring. Denis et al8 evaluated the impact of routine symptom monitoring from home in patients with lung cancer using an algorithmic approach to recall patients based on predefined criteria for symptom
### TABLE 1  Patient characteristics by exposure status (N = 128,893 pairs)

| Variable                          | Value              | ESAS = No (N = 128,893) | ESAS = Yes (N = 128,893) | Standardized difference |
|-----------------------------------|--------------------|-------------------------|--------------------------|-------------------------|
| Age at cancer diagnosis           | Mean ± SD          | 64.28 ± 12.97           | 64.35 ± 12.97            | 0.01                    |
| Sex                               | Female             | 61,549 (47.8%)          | 61,549 (47.8%)           | Matched Variable        |
|                                   | Male               | 67,344 (52.2%)          | 67,344 (52.2%)           |                         |
| Cancer type                       | Brain              | 1439 (1.1%)             | 1439 (1.1%)              | Matched Variable        |
|                                   | Breast             | 18,642 (14.5%)          | 18,642 (14.5%)           |                         |
|                                   | Colorectal         | 14,240 (11.0%)          | 14,240 (11.0%)           |                         |
|                                   | Gynaecological     | 9657 (7.5%)             | 9657 (7.5%)              |                         |
|                                   | Head and Neck      | 3822 (3.0%)             | 3822 (3.0%)              |                         |
|                                   | Hematology         | 17,213 (13.4%)          | 17,213 (13.4%)           |                         |
|                                   | Lung               | 16,537 (12.8%)          | 16,537 (12.8%)           |                         |
|                                   | Melanoma           | 4568 (3.5%)             | 4568 (3.5%)              |                         |
|                                   | Non-melanoma       | 340 (0.3%)              | 340 (0.3%)               |                         |
|                                   | Prostate           | 22,418 (17.4%)          | 22,418 (17.4%)           |                         |
|                                   | Thyroid            | 2215 (1.7%)             | 2215 (1.7%)              |                         |
|                                   | Other Gastrointestinal | 9626 (7.5%)       | 9626 (7.5%)              |                         |
|                                   | Other Genitourinary| 5743 (4.5%)             | 5743 (4.5%)              |                         |
|                                   | Other              | 1650 (1.3%)             | 1650 (1.3%)              |                         |
|                                   | Unknown primary    | 783 (0.6%)              | 783 (0.6%)               |                         |
| Cancer stage                      | 0                  | 381 (0.3%)              | 316 (0.2%)               | 0.01                    |
|                                   | I                  | 29,923 (23.2%)          | 27,164 (21.1%)           | 0.05                    |
|                                   | II                 | 29,854 (23.2%)          | 28,640 (22.2%)           | 0.02                    |
|                                   | III                | 16,612 (12.9%)          | 17,040 (13.2%)           | 0.01                    |
|                                   | IV                 | 16,417 (12.7%)          | 20,349 (15.8%)           | 0.09                    |
|                                   | Unknown            | 35,706 (27.7%)          | 35,384 (27.5%)           | 0.01                    |
| Neighbourhood Income Quintile    | Lowest             | 22,936 (17.8%)          | 23,220 (18.0%)           | 0.01                    |
|                                   | Next to lowest     | 25,542 (19.8%)          | 25,631 (19.9%)           | 0                       |
|                                   | Middle             | 25,416 (19.7%)          | 25,521 (19.8%)           | 0                       |
|                                   | Next to highest    | 27,191 (21.1%)          | 27,042 (21.0%)           | 0                       |
|                                   | Highest            | 27,808 (21.6%)          | 27,479 (21.3%)           | 0.01                    |
| Number of inpatient admission in 2 years prior to diagnosis | 0 | 107,487 (83.4%) | 107,224 (83.2%) | 0.01 |
|                                   | 1                  | 15,609 (12.1%)          | 15,843 (12.3%)           | 0.01                    |
|                                   | 2                  | 3811 (3.0%)             | 3847 (3.0%)              | 0                       |
|                                   | 3+                 | 1986 (1.5%)             | 1979 (1.5%)              | 0                       |
| Number of unplanned visits to emergency department in 2 years prior to diagnosis | 0 | 64,944 (50.4%) | 64,776 (50.3%) | 0 |
|                                   | 1                  | 30,685 (23.8%)          | 30,072 (23.3%)           | 0.01                    |
|                                   | 2                  | 14,643 (11.4%)          | 14,694 (11.4%)           | 0                       |
|                                   | 3+                 | 18,621 (14.4%)          | 19,351 (15.0%)           | 0.02                    |

(Continues)
severity and worsening. They reported improved overall survival with weekly symptom monitoring compared with three monthly clinic visits and more frequent diagnostic imaging (HR 0.59, 95% CI: 0.37-0.96). Both of these studies asked questions about symptoms commonly experienced by cancer patients and have overlapping items with ESAS, such as pain, appetite, shortness of breath, fatigue, nausea, or depression. This manuscript adds to the existing literature because it evaluates the impact of symptom screening in the real world context. In randomized studies where eligibility criteria are strict and interventions tightly defined, results may have limited generalizability. These limitations do not exist with population based data where the particulars of how symptom screening happens are not controlled.

| Variable | Value | ESAS = No (N = 128,893) | ESAS = Yes (N = 128,893) | Standardized difference |
|----------|-------|------------------------|------------------------|------------------------|
| Charlson score (comorbidities in 2 years prior to diagnosis) | 0 | 113,986 (88.4%) | 113,580 (88.1%) | 0.01 |
| | 1 | 7459 (5.8%) | 7405 (5.7%) | 0 |
| | 2 | 4072 (3.2%) | 4349 (3.4%) | 0.01 |
| | 3+ | 3376 (2.6%) | 3559 (2.8%) | 0.01 |
| Surgery within 6 months after diagnosis | No | 60,068 (46.6%) | 64,089 (49.7%) | 0.06 |
| | Yes | 68,825 (53.4%) | 64,804 (50.3%) | 0.06 |
| Chemotherapy within 6 months after diagnosis | No | 95,780 (74.3%) | 94,538 (73.3%) | 0.02 |
| | Yes | 33,113 (25.7%) | 34,355 (26.7%) | 0.02 |
| Radiation within 6 months after diagnosis | No | 99,235 (77.0%) | 98,293 (76.3%) | 0.02 |
| | Yes | 29,658 (23.0%) | 30,600 (23.7%) | 0.02 |
| Number of years between cancer diagnosis and index date | Mean ± SD | 1.1 (1.6) | 1.1 (1.6) | Matched Variable |
| | Median (IQR) | 0.3 (0.1-1.5) | 0.3 (0.1-1.5) |

**TABLE 1** (Continued)

**FIGURE 2** Cumulative incidence function of death for patients exposed and unexposed to ESAS

| Year | 0 | 1 | 2 | 3 | 4 | 5 |
|------|---|---|---|---|---|---|
| ESAS=No | 128,893 | 71,666 | 44,888 | 31,416 | 23,322 | 15,669 |
| ESAS=Yes | 128,893 | 81,776 | 46,773 | 36,023 | 26,340 | 17,622 |
We observed the strongest association between ESAS exposure and survival when it occurred in the first year after diagnosis (when most receive treatment) or after the cancer recurred. This suggests that the impact is largest when patients are sicker. This is consistent with the two randomized trials\textsuperscript{7,8} that identified survival benefit, which also targeted sicker or metastatic patients. The possible mechanisms leading to benefit include earlier symptom identification or more comprehensive symptom identification whose management directly benefits the patient; alternatively, improvements in symptom management may also have allowed patients to stay on chemotherapy longer. In other work (submitted) we demonstrate a small increase in palliative care referrals for those exposed to ESAS. Early palliative care has also been shown to improve survival.\textsuperscript{23}

For patients who are well and attending routine surveillance visits the routine use of ESAS was associated with smaller survival improvement. There may be less opportunity to improve outcome for patients in the follow up or surveillance phase of care. Their symptom burden based on ESAS may be less and as such the impact of symptom management may be minimal. Measures that focus on long term toxicities specific to cancer type or treatment and that focus on survivorship issues may have more of an impact in this group. The quality of life or other end points may also be more relevant for this group.

The strengths of this paper are the comprehensive nature of the data used. We were able to create a matched cohort of 128,893 pairs of patients. We hard matched on 4 variables and then matched further on a propensity score created with 14 variables. We included common oncologic prognostic variables such as age, sex, cancer type, and stage. This would be the highest quality comparison of two groups that could be made with observational data. To the extent possible, extensive matching methods have mitigated biases inherent to observational data. The very small differences that existed (eg stage or surgery) favored the unexposed group.

However, limitations include that the data may be missing important clinical prognostic information which may be different between the two groups. As ESAS measurement is considered routine in Ontario, there may be other unmeasured confounders between patients who do and do not avail themselves of it. The direction of this bias is difficult to estimate. For example, patients with multiple symptoms might be keen to report their symptoms and very likely to go to the kiosk; alternatively, they might feel too unwell to go to the kiosk and report their symptoms. We note that the direction of the estimate of ESAS association with survival remained consistent between univariable (HR 0.85) and multivariable (HR 0.48) analyses, implying the message is the same even after adjusting for obvious confounders. ESAS completion may be associated with other factors such as increased health literacy or ability to self-manage.
symptoms. Finally, the algorithm to assign phases of care has not been validated with a chart review. It is possible for example, that patients receiving curative intent therapy also received palliative care services for symptom management. Our algorithm would incorrectly label that phase of care as palliative. This limitation would not have any impact on the finding of the main model, and is unlikely to occur frequently enough to change the direction of the interaction findings.

This paper provides real world evidence of the impact of routine patient reported outcome use in clinic. Improvements in survival are seen, in particular for patients in the first year after diagnosis or after recurrence. This adds to the body of evidence to support the important role of routine standardized symptom assessment. Future studies should include survival as an endpoint to further develop this evidence base. Generic measures that include common symptoms seem to be adequate for this outcome. Disease specific measures and other outcomes may be more relevant for patients who are well and in the surveillance part of their journey.

PRIOR PRESENTATION
This work was presented in abstract form at the 2019 annual American Society for Clinical Oncology (ASCO) meeting.

ETHICS
Institutional ethics approval was obtained prior to commencing.

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CONFLICT OF INTEREST
LB has received an honorarium from Genentech. DH reports personal fees from CareVive Technology Company. All other authors have nothing to disclose.

AUTHOR CONTRIBUTIONS
LB, RS, HS, NM, DH, and CE contributed to concept/design. LB, RS, HS, NM, DH, and CE contributed to funding. LB and RS contributed to draft manuscript. All authors contributed to analysis and interpretation and approved the final manuscript. LB is the Guarantor of the study.

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REFERENCES
1. Chen J, Ou L, Hollis SJ. A systematic review of the impact of routine collection of patient reported outcome measures on patients, providers and health organisations in an oncologic setting. BMC Health Serv Res. 2013;13:211.
2. Kotronoulas G, Kearney N, Maguire R, et al. What is the value of the routine use of patient-reported outcome measures toward improvement of patient outcomes, processes of care, and health service outcomes in cancer care? A systematic review of controlled trials. J Clin Oncol. 2014;32(14):1480-1501.
3. Yang LY, Manhas DS, Howard AF, Olson RA. Patient-reported outcome use in oncology: A systematic review of the impact on patient-clinician communication. Support Care Cancer. 2018;26(1):41-60.
4. Howell D, Molloy S, Wilkinson K, et al. Patient-reported outcomes in routine cancer clinical practice: A scoping review of use, impact on health outcomes, and implementation factors. Ann Oncol. 2015;26(9):1846-1858.
5. Barbera L, Sutradhar R, Howell D, et al. Does routine symptom screening with ESAS decrease ED visits in breast cancer patients undergoing adjuvant chemotherapy? Support Care Cancer. 2015;23(10):3025-3032.
6. Basch E, Deal AM, Kris MG, et al. Symptom monitoring with patient-reported outcomes during routine cancer treatment: a randomized controlled trial. J Clin Oncol. 2016;34(6):557-565.
7. Basch E, Deal AM, Dueck AC, et al. Overall survival results of a trial assessing patient-reported outcomes for symptom monitoring during routine cancer treatment. JAMA. 2017;318(2):197-198.
8. Denis F, Basch E, Septans A-L, et al. Two-year survival comparing web-based symptom monitoring vs routine surveillance following treatment for lung cancer. JAMA. 2019;321(3):306-307.
9. Bruera E, Kuehn N, Miller MJ, Selmsper P, Macmillan K. The edmonton symptom assessment system (ESAS): A simple method for the assessment of palliative care patients. J Palliat Care. 1991;7(2):6-9.
10. Barbera L, Lee F, Sutradhar R. Use of patient-reported outcomes in regional cancer centres over time: a retrospective study. CMAJ Open. 2019;7(1):E10-E108.
11. Cancer CO. Cancer system quality index. http://www.csqi.on.ca/by_patient_journey/treatment/symptom_assessment_and_management/. Updated. 2017.
12. Robles SC, Marrett LD, Clarke EA, Risch HA. An application of capture-recapture methods to the estimation of completeness of cancer registration. J Clin Epidemiol. 1988;41(5):495-501.
13. Clarke EA, Marrett LD, Kreiger N. Cancer registration in ontario: A computer approach. In: Jensen OM, Parkin DM, MacLennan R, Muir CS, Skeet RG, eds. Lyon: IARC Pub; 1991:246-257.
14. Iron K, Zagorski BM, Sykora K, Manuel DG. Living and dying in ontario: An opportunity for improved health information. ICES Investigative Report. 2008.
15. Canadian Institute for, Health Information. CIHI data quality study of Ontario emergency department visits for fiscal year. 2007:2004–2005.

16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373-383.

17. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992;45(6):613-619.

18. Weiner JP. The Johns Hopkins ACG case-mix system version 6.0 release notes (systems documentation). 2003.

19. Therneau TM, Crowson S, Atkinson E. Using time dependent covariates and time dependent coefficients in the cox model. *Mayo Clinic Report*. 2018;1:1-27.

20. Normand SLT, Landrum MB, Guadagnoli E, et al. Validating recommendations for coronary angiography following an acute myocardial infarction in the elderly: a matched analysis using propensity scores. *J Clin Epi*. 2001;54(4):387-398.

21. Barbera L, Sutradhar R, Seow H, et al. Impact of standardized Edmonton Symptom Assessment System use on emergency department visits and hospitalization: Results of a population-based retrospective matched cohort analysis. *JCO Oncol Pract*. 2020 May 28 JOP1900660. doi: 10.1200/JOP.19.00660. Online ahead of print.

22. Barbera LC, Sutradhar R, Earle C, et al. The impact of routine ESAS use on receiving palliative care services: results of a population-based retrospective matched cohort analysis. *J Clin Oncol*. 2018;36(suppl30):abst 191.

23. Temel JS, Greer JA, Muzikansky A, et al. Early palliative care for patients with metastatic non-small-cell lung cancer. *N Engl J Med*. 2010;363(8):733-742.

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