CURRENT ONCOLOGY
A Canadian Cancer Research Journal

SHORT COMMUNICATION

COSTING SERIES

Cost-of-illness study for non-small-cell lung cancer using real-world data

S.J. Seung HonBSc,* M. Hurry MSc MSc,† S. Hassan HonBSc,* R.N. Walton MPH,† and W.K. Evans MD‡

ABSTRACT

Background With recent advances in the treatment of non-small-cell lung cancer (NSCLC) and current fiscal constraints within publicly funded health care systems, understanding the real-world economic effect of lung cancer management has become important. The objective of the present study was to determine the costs and resources used in the management of NSCLC cohorts in Ontario.

Methods Patients diagnosed between 1 April 2010 and 31 March 2015 were identified in the Ontario Cancer Registry and linked to provincial administrative databases, capturing resources such as hospitalizations, cancer clinic visits, physician services, and systemic therapies or radiotherapy. A cost-of-illness analysis using a bottom-up approach and the GETCOST macro available at ICES determined the overall total and mean costs in 2017 Canadian dollars. Resource utilization results were analyzed according to the total number of encounters per resource, the number of patients using each resource, and the number of encounters per patient. A separate cost-and-resource analysis was conducted for radiotherapy.

Results The 24,729 NSCLC patients identified included 4542 with stage III unresectable disease and 10,103 with stage IV nonsquamous disease. The overall total cost for all NSCLC patients was $1.9 billion, with inpatient hospitalizations ($635.2 million), cancer clinic visits ($323.7 million), and physician services ($301.4 million) being the top cost contributors. The mean cost per patient was $76,816. The total cost of radiotherapy was $38.5 million.

Conclusions Real-world costs for the management of NSCLC during the 5-year period examined were substantial, despite the fact that median survival was poor and treatment information was limited.

Key Words Lung cancer, costs, resource utilization, administrative data, Ontario

Curr Oncol. 2019 April;26(2):102-107 www.current-oncology.com

INTRODUCTION

Lung cancer is the most commonly diagnosed cancer in Canada, with an estimated 28,600 new cases in 2017; it is also the leading cause of cancer-related death (estimated at 21,000)[1].

Non-small-cell lung cancer (NSCLC) accounts for 80%–85% of lung cancers[2,3]. Approximately 50% of patients are diagnosed with stage IV disease[4], and those patients have a short average survival[1]. The introduction of molecular testing, targeted therapies, and immunotherapy is changing the treatment paradigm for advanced NSCLC and improving patient survival[5–7]. For example, durvalumab has been associated with improvements in both progression-free and overall survival in patients with unresectable stage III disease[5,8]. In the metastatic setting, improved progression-free or overall survival has been observed when patients who are positive for mutations in *EGFR* receive targeted therapies[9,10].

Previously published Canadian studies examining the overall costs of lung cancer have been based largely on simulation models[11–13] or retrospective reviews of patient records[14]. As access to and use of administrative databases increase, large patient cohorts can be analyzed to accurately determine the real-world costs of cancers[15,16]. The objective of the present study was to use administrative data to determine the costs and resource utilization associated with the management of all stages of NSCLC and of stage III unresectable and stage IV nonsquamous NSCLC cohorts in a real-world setting in Ontario. Ethics approval

Correspondence to: Soo Jin Seung, 2075 Bayview Avenue, Room E240, Toronto, Ontario M4N 3M5.
E-mail: soojin.seung@sunnybrook.ca **DOI:** https://doi.org/10.3747/co.26.4555

for the study was obtained from the Research Ethics Board at Sunnybrook Health Sciences Centre.

METHODS

Patients diagnosed with NSCLC between 1 April 2010 and 31 March 2015 with disease stage known at diagnosis were identified in the Ontario Cancer Registry. Costing data were obtained up to 31 March 2016 to allow for at least 1 year of follow-up and to 31 March 2017 for resource utilization and survival. The data were analyzed and are presented in three separate cohorts. The main cohort consists of all NSCLC patients defined by relevant diagnosis codes from the International Classification of Diseases, revision 10. Because of new therapies that are likely to be introduced soon, 2 subcohorts were specifically analyzed: unresectable stage III NSCLC (defined by excluding all lung-related surgeries) and stage IV nonsquamous NSCLC (defined by excluding squamous-related diagnosis codes). Each cohort was linked to provincial administrative databases to capture health system resource use such as inpatient hospitalizations, cancer clinic visits, physician visits, radiotherapy, and systemic therapies. Radiotherapy data in the Cancer Care Ontario (CCO) Activity Level Reporting system were not included in the main costing analysis, which used the GETCOST macro; however, a separate analysis using the National Hospital Productivity Improvement Project (NHPIP) treatment codes as a proxy for radiotherapy fractions was conducted to estimate radiotherapy use (both curative and palliative). Use of systemic therapy drugs was captured from CCO's New Drug Funding Program (NDFP) and the Ontario Drug Benefit (ODB) formularies. Based on defined criteria, newer systemic chemotherapies were accessed in the NDFP formulary, and oral therapies, in the ODB formulary. In addition, costs for oral supportive drugs (for example, analgesics, antiemetics) were reported in the ODB. Information about cancer clinic visits was collected separately from other outpatient clinic visits. Physician visits (from OHIP, the Ontario Health Insurance Plan) comprised visits to general practitioners, medical oncologists, radiation oncologists, and all other specialists. All 3 cohorts had inpatient rehabilitation admissions, given that respiratory or exercise rehabilitation (or both) can often be required before and after lung surgery. Same-day surgical procedures might have included treatment-related insertions and removals of blood access ports and chest tubes.

Descriptive statistics are used for baseline characteristics, costing, and resource utilization. Score on the Charlson comorbidity index[17] and Johns Hopkins Aggregated Diagnosis Groups (Baltimore, MD, U.S.A.)[18] describe comorbidities present before the NSCLC diagnosis. A mean score of 0 indicates no comorbidities. The Aggregated Diagnosis Groups are also assigned to a simplified morbidity category called "predicted Resource Utilization Bands" (Johns Hopkins). The five neighbourhood income quintiles reported are based on a conversion of each individual's postal code using Statistics Canada's Postal Code Conversion File.

The cost-of-illness analysis, which calculated the overall total and mean cost per patient in 2017 Canadian dollars, used a macro-based costing methodology called GETCOST that is available at ICES[19]. For total cost, the macro is programmed to determine the costs of short-term episodes (for example, hospital-based encounters) by multiplying the encounter's resource intensity weight by an annual cost per weighted case. Long-term episode costs (for example, complex continuing care) are calculated by weighted days, and costs of visit-based encounters are determined at utilization (a bottom-up approach). As already mentioned, a separate analysis used the number of NHPIP treatment codes as a proxy for radiotherapy fractions. Multiplying the total number of NHPIP treatment codes by a unit cost previously published from a Canadian cancer centre ($137.72 in 1996)[20] and inflated to 2017 dollars ($202.01) using the Consumer Price Index yielded radiotherapy costs for the 3 cohorts. Resource utilization results consisted of the total number of encounters per resource, the numbers of patients using each resource, and the number of encounters per patient (that is, a "per-treated" analysis).

RESULTS

Table I presents the baseline characteristics of the 3 cohorts: all-stage NSCLC (n = 24,729), unresectable stage III (n = 4542), and stage IV nonsquamous (n = 10,103). The median age in all groups was 70 years, and the sex distribution was approximately equal. Although the mean Charlson and Aggregated Diagnosis Groups scores before the NSCLC diagnosis were found to be low, 95% of each cohort had at least moderate resource utilization based on the Resource Utilization Bands. A slightly higher rate of lung cancer was evident in the lowest neighbourhood income quintile, and the mean number of follow-up years after diagnosis was 1.7 for the all-stages NSCLC cohort, but only 0.8 in the stage IV nonsquamous cohort. As expected, mean survival (calculated from date of diagnosis to date of death, if known) was poor for all 3 cohorts.

Table II shows the breakdown of costs for all years for each of the 3 cohorts. The overall total cost for all-stage NSCLC was $1.9 billion; the stage III unresectable and stage IV nonsquamous cohorts respectively accounted for 20.9% and 36.3% of that total. The overall mean cost per NSCLC patient was $76,816 ± $67,789, but it was highest for unresectable stage III patients at $87,393 ± $67,304. Inpatient hospitalizations, cancer clinic visits, and physician visits were the top three cost categories for all 3 cohorts. Oral medications listed on the ODB formulary represented about 7% of the overall total cost for each of the 3 cohorts. Chemotherapies listed on the NDFP formulary accounted for only 3% of the overall total cost for the all-stage NSCLC and stage III unresectable cohorts, but were 6% for the stage IV nonsquamous cohort. Outpatient clinic visits and home care were high cost contributors. Because the overall total cost excluded radiotherapy costs, a separate analysis used NHPIP treatment codes as a proxy for the number of fractions and applied a unit cost per fraction. For the all-stage NSCLC cohort, the total radiotherapy cost was $38.5 million. The unresectable stage III cohort had the highest mean cost, at $3,282 ± $3,319.

Four resource types (capitation, dialysis, laboratory, and non-physician costs) were not included in the results because they accounted for less than 2% of the overall cost.

In Table III, factors that were found to be resource-intensive were physician visits (general practitioners,

TABLE I Baseline characteristics of the study cohorts

Characteristic	Non-small-cell lung cancer cohort		
	All	Stage III unresectable	Stage IV nonsquamous
Patients *(n)*	24,729	4,542	10,103
Age (years)			
Median	70	70	69
IQR	62–77	63–77	61–77
Sex [*n* (%)]			
Women	12,000 (48.5)	2,081 (45.8)	4,976 (49.3)
Men	12,727 (51.5)	2,460 (54.2)	5,127 (50.7)
Stage at diagnosis [*n* (%)]			
I	5,120 (20.7)	NA	NA
II	2,307 (9.3)		
III	5,143 (20.8)		
IV	12,159 (49.2)		
Mean score on the CCI	0.7±1.3	1.0±1.5	0.9±1.5
Mean ADG score	8.1±3.7	7.9±3.6	7.5±3.6
Predicted RUB [*n* (%)]			
Non-users	303 (1.2)	42 (0.9)	182 (1.8)
Healthy users	223 (0.9)	40 (0.9)	131 (1.3)
Low utilization	721 (2.9)	119 (2.6)	425 (4.2)
Moderate utilization	8,933 (36.1)	1,663 (36.6)	4,215 (41.7)
High utilization	7,793 (31.5)	1,468 (32.3)	2,931 (29.0)
Very high utilization	6,756 (27.3)	1,210 (26.6)	2,219 (22.0)
Income quintile [*n* (%)]			
1 (lowest)	5,683 (23.1)	1,102 (24.4)	2,207 (22.0)
2	5,367 (21.8)	989 (21.9)	2,175 (21.6)
3	4,816 (19.6)	869 (19.2)	1,985 (19.7)
4	4,640 (18.8)	864 (19.1)	1,938 (19.3)
5 (highest)	4,111 (16.7)	699 (15.5)	1,749 (17.4)
Mean follow-up (years)	1.7	1.6	0.8
Deaths [*n* (%)]	18,840 (76.2)	3,746 (82.5)	9,538 (94.4)
Overall survival (years)			
Median	1.0	1.1	0.4
IQR	0.3–3.7	0.5–2.6	0.2–1.0

IQR = interquartile range; CCI = Charlson comorbidity index; ADG = Johns Hopkins (Baltimore, MD, U.S.A.) Aggregated Diagnosis Group system; RUB = Johns Hopkins Resource Utilization Band.

medical or radiation oncologists), with minor differences between the stage III and stage IV cohorts. Inpatient hospitalizations averaged only 2 per patient, at an estimated mean cost of $25,686 ± $36,641 for all-stage NSCLC patients. Cancer clinic visits occurred most frequently, at 30.1, for patients with unresectable stage III disease. The stage IV nonsquamous and all-stages NSCLC cohorts averaged 16.4 visits and 19.8 visits per patient respectively. Each patient in the all-stages NSCLC cohort had an average of 121 claims for oral medications from the ODB formulary. Patients in the stage IV nonsquamous cohort had half that number of claims (n = 63). In the stage IV nonsquamous cohort, 293 patients received targeted therapies (afatinib, erlotinib, gefitinib) as first-line treatment and were therefore assumed to be positive for *EGFR* mutation. The mean number of NDFP-funded chemotherapy drugs per patient was 8 for all 3 cohorts, and the mean number of NHPIP treatment codes used for radiotherapy was highest (16.3) for the patients with unresectable stage III disease.

DISCUSSION AND CONCLUSIONS

This cost analysis of an all-stage NSCLC cohort found that, in a 5-year period, the total cost of care was $1.9 billion, at

TABLE II Cost results

Cost type	Summary measure	Cost, 2017 Canadian dollars, all years		
		All NSCLC (*n*=24,729)	Stage III unresectable (*n*=4,542)	Stage IV nonsquamous (*n*=10,103)
Overall total[a]	Total	1,899,571,969	396,939,652	689,980,195
	Mean per patient	76,816±67,789	87,393±67,304	68,295±58,026
Cancer clinic visits	Total	323,705,991	107,512,095	116,622,466
	Mean per patient	13,090±18,855	23,671±23,775	11,543±17,749
Chemotherapy (NDFP)	Total	61,505,575	10,770,008	41,604,143
	Mean per patient	2,487±11,130	2,371±10,673	4,118±14,235
Complex continuing care	Total	67,325,154	12,533,873	28,597,180
	Mean per patient	2,723±15,352	2,760±14,091	2,831±12,803
Emergency department visits	Total	41,248,095	8,371,551	14,818,783
	Mean per patient	1,668±1,793	1,843±1,903	1,467±1,329
Homecare services	Total	102,209,907	21,049,530	46,081,212
	Mean per patient	4,133±7,937	4,634±8,552	4,561±7,834
Inpatient admissions	Total	635,178,635	108,447,485	230,972,458
	Mean per patient	25,686±36,641	23,877±33,863	22,862±24,699
Long-term care admissions	Total	27,531,680	4,797,990	3,768,451
	Mean per patient	1,113±10,264	1,056±9,601	373±5,049
Mental health admissions	Total	4,631,966	976,528	382,312
	Mean per patient	187±4,783	215±6,854	38±1,674
Oral medications (ODB)	Total	137,147,742	25,164,723	46,214,247
	Mean per patient	5,546±12,483	5,540±11,683	4,574±11,830
Outpatient clinic visits	Total	123,842,902	25,683,802	42,354,018
	Mean per patient	5,008±4,799	5,655±5,110	4,192±4,327
Physician visits (OHIP)	Total	301,438,705	56,890,288	103,193,961
	Mean per patient	12,190±9,090	12,525±8,950	10,214±8,123
Radiotherapy costs	Total	38,458,866	14,907,328	12,835,311
	Mean per patient	1,555±2,368	3,282±3,319	1,270±1,721
Inpatient rehabilitation admissions	Total	19,901,416	3,563,132	5,559,027
	Mean per patient	805±4,623	784±4,543	550±3,860
Same-day surgery admissions	Total	27,341,937	6,685,664	5,384,093
	Mean per patient	1,106±1,700	1,472±1,762	533±1,003

[a] Excludes radiotherapy costs because different methods were used.
NSCLC = non-small-cell lung cancer; NDFP = New Drug Funding Program; ODB = Ontario Drug Benefit; OHIP = Ontario Health Insurance Plan.

a mean cost of $76,816 ± $67,789 per patient. The mean cost was higher for the stage III unresectable cohort ($87,393 ± $67,304) than for the stage IV nonsquamous cohort ($68,295 ± $58,026), possibly reflecting the longer survival of those patients. Another Canadian study using administrative data reported that the mean 5-year net cost per patient for lung cancer was approximately $30,000 (2009 Canadian dollars) or $34,132 in 2017 dollars[16]. However, unlike our study, the latter study used a case–control design to ensure that the costs incurred were attributable to lung cancer. Our resource utilization results were similar for all 3 cohorts, with the exception of cancer clinic visits and oral medications (ODB), for which utilization was lower in the stage IV nonsquamous cohort.

The strengths of our study include the large cohort size, known stage distribution[a], and representation of all adults diagnosed with NSCLC living in both rural and urban areas. One limitation was whether the reported costs and resources were attributable to NSCLC, thus possibly resulting

[a] The Canadian Partnership Against Cancer's National Staging Initiative has resulted in the consistent and reliable collection of staging information by 9 provinces (including Ontario) for Canadians diagnosed with breast, colorectal, lung, and prostate cancers.

TABLE III Resource results

Resource type	All NSCLC (*n*=24,729)			Stage III unresectable (*n*=4,542)			Stage IV nonsquamous (*n*=10,103)		
	Encounters (all years)	Pts (*n*)	Encounters per pt[a] (*n*)	Encounters (all years)	Pts (*n*)	Encounters per pt[a] (*n*)	Encounters (all years)	Pts (*n*)	Encounters per pt[a] (*n*)
Cancer clinic visits	352,226	17,816	19.8	115,373	3,830	30.1	125,053	7,612	16.4
Chemotherapies (NDFP)	55,740	6,607	8.4	9,978	1,311	7.6	27,804	3,207	8.7
Complex continuing care	6,996	3,541	2.0	1,261	611	2.1	3,382	1,843	1.8
Emergency department visits	88,663	21,899	4.0	17,846	4,112	4.3	29,398	9,024	3.3
Homecare services	1,101,176	18,319	60.1	226,110	3,534	64.0	463,383	8,127	57.0
Inpatient admissions	53,542	22,325	2.4	9,738	3,922	2.5	19,900	9,064	2.2
Long-term care admissions	5,331	774	6.9	926	139	6.7	857	185	4.6
Mental health admissions	215	131	1.6	36	22	1.6	26	20	1.3
Oral medications (ODB)	2,707,976	22,327	121.3	492,571	4,215	116.9	545,737	8,714*	62.6
Outpatient clinic visits	343,659	24,158	14.2	71,080	4,448	16.0	116,401	9,793	11.9
Primary care physician visits (OHIP)	1,379,774	24,483	56.4	262,578	4,490	58.5	494,060	9,987	49.5
Other specialist physician visits (OHIP)	3,417,541	24,713	138.3	638,180	4,541	140.5	1,074,628	10,091	106.5
Medical oncologist visits (OHIP)	294,100	14,034	21.0	70,716	3,067	23.1	143,987	6,187	23.3
Radiation oncologist visits (OHIP)	160,840	18,457	8.7	44,248	4,124	10.7	59,726	7,985	7.5
Radiotherapy encounters (NHPIP codes)	190,381	24,729	7.7	73,795	4,542	16.3	63,538	10,103	6.3
Inpatient rehabilitation admissions	1,125	963	1.2	190	169	1.1	298	272	1.1
Same-day surgery admissions	22,725	12,407	1.8	5,081	2,917	1.7	4,657	3,426	1.4

[b] The encounters for all years divided by the patients who used the resource.

NSCLC = non-small-cell lung cancer; Pt[s] = patient[s]; NDFP = New Drug Funding Program; ODB = Ontario Drug Benefit; OHIP = Ontario Health Insurance Plan; NHPIP = National Hospital Productivity Improvement Program.

in an overestimation, given that the resources and costs could not be allocated to a specific diagnosis (that is, lung cancer). On the other hand, because the GETCOST macro from ICES does not calculate Activity Level Reporting costs, systemic therapy costs have been underestimated. A separate analysis to estimate Activity Level Reporting radiotherapy costs was conducted, however. Another limitation is the 31 March 2016 cut-off date for the costing analysis, because the use of new drugs (immuno-oncology and targeted therapy agents) would not be captured in this cost-of-illness study.

In conclusion, although the 3 cohorts all experienced poor survival, total management costs were large. The uptake of new and effective systemic therapies will result in new practice patterns and affect both resource utilization and costs.

ACKNOWLEDGMENTS

The Ontario Institute for Cancer Research (OICR) is funded by the Government of Ontario through the Ministry of Economic Development, Job Creation and Trade. The Canadian Centre for Applied Research in Cancer Control (ARCC) receives core funding from the Canadian Cancer Society (grant no. 2015-703549). Both OICR and ARCC are proud to support the publication of this costing series.

This study was funded by an unrestricted research grant from AstraZeneca Canada Inc. The study made use of de-identified data from the ICES Data Repository, which is managed by 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 here 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 information compiled and provided by the Canadian Institute for Health Information (CIHI). However, the analyses, conclusions, opinions, and statements expressed herein are those of the authors and not necessarily those of CIHI. Parts of this material are based on data and information provided by CCO. The opinions, results, views, and conclusions reported in this paper are those of the authors and do not necessarily reflect those of CCO. No endorsement by CCO is intended or should be inferred. This work was presented as a poster at ISPOR Europe 2018; Barcelona, Spain; 10–14 November 2018.

CONFLICT OF INTEREST DISCLOSURES

We have read and understood *Current Oncology*'s policy on disclosing conflicts of interest, and we declare the following interests: SJS and SH declare consultancies through the HOPE Research Centre, a group that consults to the pharmaceutical industry; MH and RW are employees of AstraZeneca Canada; WKE reports personal fees from AstraZeneca during the conduct of the study.

AUTHOR AFFILIATIONS

*HOPE Research Centre, Sunnybrook Research Institute, Toronto, ON; †AstraZeneca Canada, Mississauga, ON; ‡McMaster University, Hamilton, ON.

REFERENCES

1. Canadian Cancer Society. Lung cancer statistics [Web page]. Toronto, ON; Canadian Cancer Society; 2018. [Available at: http://www.cancer.ca/en/cancer-information/cancer-type/lung/statistics/?region=on; cited 18 September 2018]
2. Aupérin A, Le Péchoux C, Rolland E, *et al.* Meta-analysis of concomitant versus sequential radiochemotherapy in locally advanced non-small-cell lung cancer. *J Clin Oncol* 2010;28:2181–90.
3. Canadian Cancer Survivor Network. Prognosis and survival statistics [Web page]. Ottawa, ON: Canadian Cancer Survivor Network; 2018. [Available at: http://survivornet.ca/cancer-type/lung-cancer/diagnosis-and-lung-cancer/prognosis-and-survival-statistics; cited 18 September 2018]
4. Canadian Cancer Statistics Advisory Committee. *Canadian Cancer Statistics 2018.* Toronto, ON: Canadian Cancer Society; 2018. [Available online at: http://www.cancer.ca/Canadian-Cancer-Statistics-2018-EN; cited 18 September 2018]
5. Antonia SJ, Villegas A, Daniel D, *et al.* on behalf of the PACIFIC investigators. Durvalumab after chemoradiotherapy in stage III non-small-cell lung cancer. *N Engl J Med* 2017;377:1919–29.
6. Davies J, Patel M, Gridelli C, de Marinis F, Waterkamp D, McCusker ME. Real-world treatment patterns for patients receiving second-line and third-line treatment for advanced non-small cell lung cancer: a systematic review of recently published studies. *PLoS One* 2017;12:e0175679.
7. Wu YL, Zhou C, Hu CP, *et al.* Afatinib versus cisplatin plus gemcitabine for first-line treatment of Asian patients with advanced non-small-cell lung cancer harbouring *EGFR* mutations (LUX-Lung 6): an open-label, randomised phase 3 trial. *Lancet Oncol* 2014;15:213–22.
8. Antonia SJ, Villegas A, Daniel D, *et al.* Overall survival with durvalumab versus placebo after chemoradiotherapy in stage III NSCLC: updated results from PACIFIC [abstract PL02.01]. *J Thorac Oncol* 2018;13(suppl):S184.
9. Mok TS, Cheng Y, Zhou X, *et al.* Improvement in overall survival in a randomized study that compared dacomitinib with gefitinib in patients with advanced non-small-cell lung cancer and *EGFR*-activating mutations. *J Clin Oncol* 2018;36:2244–50.
10. Soria JC, Ohe Y, Vansteenkiste J, *et al.* on behalf of the FLAURA investigators. Osimertinib in untreated *EGFR*-mutated advanced non-small-cell lung cancer. *N Engl J Med* 2018;378:113–25.
11. Jaakkimainen L, Goodwin PJ, Pater J, Warde P, Murray N, Rapp E. Counting the costs of chemotherapy in a National Cancer Institute of Canada randomized trial in nonsmall-cell lung cancer. *J Clin Oncol* 1990;8:1301–9.
12. Evans WK, Will BP, Berthelot JM, Wolfson MC. Estimating the cost of lung cancer diagnosis and treatment in Canada: the POHEM model. *Can J Oncol* 1995;5:408–19.
13. Earle CC, Evans WK. Cost-effectiveness of paclitaxel plus cisplatin in advanced non-small-cell lung cancer. *Br J Cancer* 1999;80:815–20.
14. Demeter SJ, Jacobs P, Chmielowiec C, *et al.* The cost of lung cancer in Alberta. *Can Respir J* 2007;14:81–6.
15. de Oliveira C, Bremner KE, Pataky R, *et al.* Trends in use and cost of initial cancer treatment in Ontario: a population-based descriptive study. *CMAJ Open* 2013;1:E151–8.
16. de Oliveira C, Pataky R, Bremner KE, *et al.* Phase-specific and lifetime costs of cancer care in Ontario, Canada. *BMC Cancer* 2016;16:809.
17. Quan H, Li B, Couris CM, *et al.* Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *Am J Epidemiol* 2011;173:676–82.
18. Austin PC, van Walraven C, Wodchis WP, Newman A, Anderson GM. Using the Johns Hopkins Aggregated Diagnosis Groups (ADGS) to predict mortality in a general adult population cohort in Ontario, Canada. *Med Care* 2011;49:932–9.
19. Wodchis WP, Bushmeneva K, Nikitovic M, McKillop I. *Guidelines on Person Level Costing Using Administrative Databases in Ontario.* Vol. 1. Working Paper Series. Toronto, ON: Health System Performance Research Network; 2013.
20. Earle C, Coyle D, Smith A, Agboola O, Evans WK. The cost of radiotherapy at an Ontario regional cancer centre: a re-evaluation. *Crit Rev Oncol Hematol* 1999;32:87–93.