ORIGINAL RESEARCH

Factors contributing to high-cost hospital care for patients with COPD

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Abstract: Chronic obstructive pulmonary disease (COPD) is a leading cause of hospital admission, the fifth leading cause of death in North America, and is estimated to cost $49 billion annually in North America by 2020. The majority of COPD care costs are attributed to hospitalizations; yet, there are limited data to understand the drivers of high costs among hospitalized patients with COPD. In this study, we aimed to determine the patient and hospital-level factors associated with high-cost hospital care, in order to identify potential targets for the reorganization and planning of health services. We conducted a retrospective cohort study at a Canadian academic hospital between September 2010 and 2014, including adult patients with a first-time admission for COPD exacerbation. We calculated total costs, ranked patients by cost quintiles, and collected data on patient characteristics and health service utilization. We used multivariable regression to determine factors associated with highest hospital costs. Among 1,894 patients included in the study, the mean age was 73±12.6 years, median length of stay was 5 (interquartile range 3–9) days, mortality rate was 7.8% (n=147), and 9% (n=170) required intensive care. Hospital spending totaled $19.8 million, with 63% ($12.5 million) spent on 20% of patients. Factors associated with highest costs for COPD care included intensive care unit admission (odds ratio [OR] 32.4; 95% confidence interval [CI] 20.3, 51.7), death in hospital (OR 2.6; 95% CI 1.3, 5.2), discharge to long-term care facility (OR 5.7; 95% CI 3.5, 9.2), and use of the alternate level of care designation during hospitalization (OR 23.5; 95% CI 14.1, 39.2). High hospital costs are driven by two distinct groups: patients who require acute medical treatment for severe illness and patients with functional limitation who require assisted living facilities upon discharge. Improving quality of care and reducing cost in this high-needs population require a strong focus on early recognition and management of functional impairment for patients living with chronic disease.

Keywords: chronic obstructive pulmonary disease, cost analysis, functional limitation, frailty

Abbreviations

ALC, alternate level of care; ANOVA, analysis of variance test; COPD, chronic obstructive pulmonary disease; CI, confidence interval; FEV_1, forced expiratory volume in 1 second; ICD-10, International classification of diseases codes (10th revision); ICU, intensive care unit; LAPS, laboratory-based acute physiology score; LTC, long-term care facility; OR, odds ratio; IQR, interquartile range; pCO_2, arterial partial pressure of carbon dioxide in the blood; SD, standard deviation; TOH, the Ottawa Hospital; TOHDW, the Ottawa Hospital Data Warehouse; Q1, Q2, Q3, Q4, Q5, quintiles.

Introduction

COPD is associated with significant morbidity, mortality, functional decline, and poor quality of life.[1] It is the fifth leading cause of death worldwide[2] and is the number one

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cause for hospital admission and readmission in Canada.[3] It has a substantial economic burden on the health care system and society. In the United States, care for COPD is expected to cost $49 billion annually by 2020.[4,5] Hospitalizations for COPD exacerbations are the largest contributor to total costs.[3,5,6]

Several studies have identified risk factors for hospitalization and readmission among patients with COPD, but the focus has been on disease-specific risk factors, such as the FEV_1, number of previous exacerbations, and use of home oxygen therapy.[7–9] While these factors are important predictors of poor prognosis and hospitalization, they are largely not modifiable with currently available therapies.[10]

Previous studies have also documented a significant degree of medical comorbidity and frailty in COPD patients.[11–13] It is possible that high hospitalization costs among COPD patients may be driven as much by the patient's functional ability than COPD-specific factors alone. In order to explore this potential relationship, it is necessary to have a better understanding of individual patient characteristics and types of hospital services used by COPD patients.

The objective of this retrospective cohort study was to determine acute care costs for patients admitted with COPD exacerbation and to examine the important patient and hospital-level factors associated with high costs. This analysis can be used to better plan and organize health services to meet patient needs. We hypothesize that the sequelae of chronic diseases, including poor functional status and frailty, are major contributors to high hospital costs in this population of hospitalized COPD patients.

Materials and methods
Study design, population, and data sources
We conducted a retrospective observational cohort study using linked administrative data sources from the TOH in Ontario, Canada. TOH is a tertiary care, publicly funded health facility with 1,100 beds, servicing a catchment area of 1.1 million people.

We identified all adult patients (≥18 years of age) with a first time (index) hospital admission for COPD exacerbation between September 1, 2010, and September 30, 2014. We used a look-back window of 2 years to ensure there were no previous COPD-related hospitalizations prior to the index visit. COPD exacerbation was defined by the ICD-10 code in the "most responsible diagnosis" field on the hospital discharge abstract (J41–J44), or by a lower respiratory tract infection (J100, J110–J116, J118, J120–J122) and COPD exacerbation listed as a secondary diagnosis. Individuals who were transferred from another facility were excluded.

We collected data from the duration of each index hospitalization using TOHDW. This is a database linking information from the hospital's most important operational systems, including pharmacy, laboratory, radiology, patient booking, case costing, and discharge abstract.

Cost measurement
From the hospital's perspective, total costs are the sum of direct and indirect costs. They were calculated for each index hospitalization using TOH's case-costing system, which links financial, clinical, and patient activity information stored in TOHDW. Direct costs consist of patient care costs, including diagnostic imaging, nursing, and laboratory services. Indirect costs are those associated with administering and providing support to patient care, such as health records, housekeeping, and administrative services. TOH uses a standardized case-costing methodology that was developed by the Ontario Case Costing Initiative and is based on the Canadian Institute for Health Information Management Information Systems guidelines.[14,15] The case-costing system captures both direct and indirect costs for TOH. TOH is a publicly funded hospital, and costs do not represent insurance payments.

We ranked the total hospitalization costs by quintiles to represent the highest (Q5) and lowest (Q1) cost groups. We combined the middle quintiles (Q2–Q4) to represent the mid-range hospitalization costs. Costs are presented in nominal values in Canadian dollars.

Patient and hospitalization characteristics
Data regarding ICU admissions, mortality, length of stay, use of isolation precautions for infection control, 30-day readmission rate, and location of discharge were collected during the index hospitalization. We used the modified Elixhauser comorbidity score to describe the overall comorbidity burden.[16,17] The severity of illness was measured using a validated score for the risk of death at the time of admission to hospital and the LAPS.[18,19]

We determined whether the "Alternate Level of Care" (ALC) designation was used at any point during the hospitalization, as ALC status is known to drive high hospitalization costs.[20] ALC status is assigned to a patient during an acute hospitalization when the acute medical issues have resolved, but the patient cannot safely return to the previous dwelling.[21] Patients with the "ALC" designation receive less frequent and acute nursing care, and remain under ALC status until a suitable discharge location is available.

Analysis

Patient and encounter-level characteristics were described using proportions, means (SDs), and medians (IQR), and were compared across cost quintiles (low Q1, middle Q2–Q4, and high Q5). We used a one-way ANOVA test and Chi-squared tests to compare the differences of means (SD) and proportions, respectively. A subgroup analysis was performed in the highest cost group (Q5) to assess clinical and encounter-level differences based upon ALC status.

Finally, we used a multivariable logistic regression model to identify factors associated with high hospital costs (costs in the Q5 group). Variables for the regression model were selected a priori based upon clinical relevance and the data availability. These variables include age >80 years, Elixhauser score, ICU admission, LAPS, use of home care upon discharge, LTC admission upon discharge, death in hospital, and ALC status during hospitalization.

All data collection and analysis were conducted using SAS, version 9.4. All P-values were considered significant at a level of <0.05. This study was approved by the Ottawa Health Science Network Research Ethics Board, who did not require individual patient consent for this study.

Results

In total, 1,894 patients met the inclusion criteria for an index COPD hospitalization between 2010 and 2014 (Table 1). The mean age (±SD) was 73.4±12.6 years, and one-third of patients were older than 80 years (33.1%, 627 patients). During the index hospitalizations, 7.8% (n=147) died and 9.0% (n=170) were admitted to the intensive care. The median length of stay was 5 (IQR 3–9) days. Over half of the patients (54.9%, n=1,040) used isolation precautions for infection control, while 11.8% (n=201) experienced a readmission to hospital in 30 days after discharge.

Hospital costs

Over a 4-year period, our institution spent $19,776,824 on index hospitalizations, with a median cost per case of $5,121 (IQR $2,853–$10,731) (Table 1). The highest cost quintile (Q5) accounted for 62.9% ($12,449,422) of the total spending, while the lowest cost quintile (Q1) accounted for 3.1% ($609,732).

In the highest cost quintile (Q5), comorbidity scores (Elixhauser score), baseline risk of death on admission, LAPS, and pCO_2 levels were significantly greater when

Table 1 Demographics, characteristics, and costs among patients with index hospitalization for COPD exacerbation between 2010 and 2014

	Total N=1,894	Low cost (Q1, bottom 20%) N=379	Middle cost (Q2–Q4, middle 60%) N=1,136	High cost (Q5, top 20%) N=379	P-value
Age in years, mean ± SD	73.4±12.6	72.2±13.2	73.6±12.4	73.8±12.5	0.126
Age >80 years, n (%)	627 (33.1%)	127 (29.6%)	365 (32.1%)	135 (35.6%)	0.209
Male, n (%)	877 (46.3%)	188 (49.6%)	502 (44.2%)	187 (49.5%)	0.078
Elixhauser score, median (IQR)	8.00 (3.00–13.00)	3.00 (3.00–10.00)	8.00 (3.00–13.00)	8.00 (3.00–15.00)	<0.001
Baseline risk of death at admission, median (IQR)	0.08 (0.04–0.15)	0.05 (0.03–0.12)	0.08 (0.04–0.15)	0.11 (0.06–0.18)	<0.001
pCO_2 (mmHg),[a] mean ± SD	56.38±23.82	46.36±14.35	55.18±22.36	62.62±27.46	<0.001
LAPS score,[b] mean ± SD	39.74±23.80	31.65±20.14	38.69±22.46	50.98±26.87	<0.001
ALC status,[c] n (%)	123 (6.5%)	0 (0.0%)	23 (2.0%)	100 (26.4%)	<0.001
ICU admission, n (%)	170 (9.0%)	≤5 (0.3%)	35 (3.1%)	134 (35.4%)	<0.001
Use of isolation precautions, n (%)	1,040 (54.9%)	164 (43.3%)	635 (55.9%)	241 (63.6%)	<0.001
Length of stay, median (IQR)	5.00 (3.00–9.00)	1.00 (1.00–2.00)	5.00 (3.00–7.00)	17.00 (12.0–28.0)	<0.001
Mortality, n (%)	147 (7.8%)	7 (1.8%)	67 (5.9%)	73 (19.3%)	<0.001
Transferred to long-term care, n (%)	184 (9.7%)	20 (5.3%)	87 (7.7%)	77 (20.3%)	<0.001
Discharged home with support, n (%)	451 (23.8%)	48 (12.7%)	296 (26.1%)	107 (28.2%)	<0.001
30-Day readmission rate,[d] n (%)	201 (11.8%)	34 (9.5%)	130 (12.3%)	37 (12.6%)	0.26
Cost per case, median (IQR)	5,121 (2,853–10,731)	1,716 (1,179–2,101)	5,121 (3,619–7,712)	24,399 (16,896–35,627)	<0.001
Total cost for cases	19,776,824	609,732	6,717,670	12,449,422	<0.001
Total cost (%)	n/a	3.1	34	62.9	n/a

Notes: Costs are given in Canadian dollars. [a]Arterial partial pressure of carbon dioxide (pCO_2 in mmHg). [b]Laboratory-based acute physiology score (LAPS) is a point score based on 14 laboratory tests obtained in the 24 h preceding hospitalization. [c]Alternate level of care (ALC), which is the designation used when a patient is medically stable but cannot be discharged home, and therefore must stay in hospital. [d]Readmission rates exclude the patients who died during index admission (30-day readmissions/eligible patients for readmission).
Abbreviations: COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; IQR, interquartile range; SD, standard deviation; n/a, not applicable.

Table 2 Costs by hospital discharge location after index hospitalization for COPD between 2010 and 2014

	Died in hospital N=147	Discharged home N=1,029	Discharged home with support services[a] N=451	Transferred to long-term care facility N=184	Transferred to acute care N=57
Total cohort (%)	7.8	54.3	23.8	9.7	3
Cost per case, median (IQR)	12,895 (7,001–28,934)	3,759 (2,296–6,462)	6,582 (3,882–12,574)	10,177 (4,983–22,382)	13,267 (8,184–22,326)
Total cost	3,558,586	6,256,907	5,261,468	3,365,399	1,156,548
Total cost (%)	18.0	31.6	26.6	17.0	5.8

Notes: All costs are in Canadian dollars. [a]Support services refer to home care, which could include any of physiotherapy, occupational therapy, personal care, and palliative care at home.
Abbreviations: COPD, chronic obstructive pulmonary disease; IQR, interquartile range.

compared to the other quintiles (Table 1). There was also a nonsignificant trend toward more octogenarians in Q5 versus Q1 (35.6% in Q5 vs 29.6% in Q1, P=0.21). Mortality, ICU admission, use of isolation precautions, and length of stay were all significantly greater in Q5 compared to other quintiles ($P<0.001$).

Discharge location

The majority of patients (54.3%, n=1,029) were discharged home after their hospitalization, while 9.7% (n=184) of patients were transferred to LTC facilities upon discharge. The proportion of LTC transfers were significantly higher in Q5 compared to Q1 (20.3% in Q5 vs 5.3% in Q1, $P<0.001$; Table 1). Overall, 23.8% (n=451) of patients were discharged home with support services, such as physiotherapy, occupational therapy, personal care support, and palliative care.

Table 2 shows the disproportionate share of the total hospital costs across the type of discharge location after

hospitalization. Only 7.8% of patients died during the index hospitalization for COPD, accounting for 18% of the total budget. Similarly, 9.7% of patients who were discharged to LTC accounted for 17% of the total budget.

ALC status

Overall, 6.5% (n=123) of patients were assigned the ALC designation during their hospitalization. However, 81% of these patients (n=100) fell into the top cost quintile (Q5). The remaining 23 patients were distributed as follows: 19 patients in Q4, 3 patients in Q3, and 1 patient in Q2 (Table 1).

ALC patients in the top cost quintile (Q5) were older than non-ALC patients, with a mean age of 78.3 years versus 72.2 years ($P<0.001$), and consisted of more octogenarians (52% vs 30%, $P<0.001$) (Table 3). In this cost quintile, the baseline risk of death at the time of admission was significantly higher for patients in the ALC group compared to those in the non-ALC group (16% vs 11%, P=0.002). Despite

Table 3 Characteristics by ALC status during index hospitalization for COPD exacerbation in the top cost quintile (Q5, n=379 patients), 2010–2014

Variable	ALC N=100	No ALC N=279	P-value
Cost per case, median (IQR)	29,422.78 (21,420.02–41,649.00)	22,166.20 (16,050.95–32,374.37)	<0.001
Total cost	3,762,454.71	8,686,967.41	n/a
ICU admission, n (%)	9 (9.0%)	125 (44.8%)	<0.001
ICU days, mean ± SD	1.12±4.22	4.37±8.29	<0.001
Length of stay, mean ± SD	40.85±31.98	16.95±10.27	<0.001
Mortality, n (%)	11 (11.0%)	62 (22.2%)	<0.001
Discharged home, n (%)	7 (7.0%)	84 (30.1%)	<0.001
Discharged with support services, n (%)	35 (35.0%)	72 (25.8%)	<0.001
Transferred to long-term care, n (%)	43 (43.0%)	34 (12.2%)	<0.001
Baseline risk of death at admission, median (IQR)	0.16 (0.09–0.21)	0.11 (0.06–0.18)	0.002
Elixhauser score, median (IQR)	8.00 (3.00–15.00)	8.00 (3.00–15.00)	0.902
Respiratory therapist cost per case, median (IQR)	141.93 (0.00–1,597.41)	1,706.98 (304.84–3,720.97)	<0.001
Total nursing cost per case, median (IQR)	15,241.73 (10,731.20–23,165.68)	20,619.69 (14,550.81–29,217.27)	<0.001
Allied health professional cost per case, median (IQR)	2,396.46 (1,341.16–4,588.22)	871.73 (208.12–2,018.54)	<0.001
Age in years, mean ± SD	78.31±10.75	72.21±12.72	<0.001
Age >80 years, n (%)	52 (52.0%)	83 (29.7%)	<0.001

Note: All costs are in Canadian dollars.
Abbreviations: ALC, alternate level of care; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; IQR, interquartile range; SD, standard deviation.
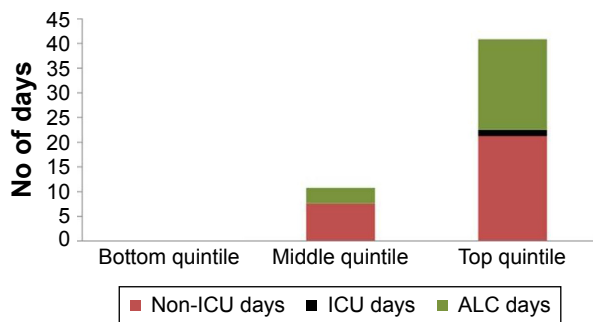
Figure 1 Relative contribution of hospital days spent under ALC status, acute care, and in ICU, to the mean total length of stay in hospital among middle (Q2–Q4) and top (Q5) cost quintiles.
Abbreviations: ALC, alternate level of care; ICU, intensive care unit.

this, only a small proportion of ALC patients required ICU admission (9.0%, 9/100), and they had a lower mortality rate ($P<0.001$) compared with non-ALC patients. The overall length of stay was significantly higher in the ALC patient group (mean 41 days vs 17 days; $P<0.001$). Figure 1 demonstrates the contribution of ALC days to the total length of stay among cost quintiles.

ALC patients had a significantly higher median cost per case ($29,423 vs $22,166, $P<0.001$), which appeared driven by use of allied health professional services. Allied health service costs were significantly higher in the ALC group compared to the non-ALC patient group ($2,397 vs $872), $P<0.001$ (Table 3).

Factors associated with highest costs

Multivariable logistic regression demonstrated that discharge location (LTC or home care) and ALC designation during hospitalization were significantly associated with high costs during hospital stay (Table 4). Furthermore, hospitalization in which ICU admission or death occurred

Table 4 Adjusted odds ratios for factors contributing to high-cost hospitalizations (Q5) for patients hospitalized with COPD between 2010 and 2014

Variable	Adjusted odds ratio for high cost (95% CI)
Age >80 years[a]	0.89 (0.64–1.25)
Elixhauser score[a]	1.04 (1.02–1.06)
ICU admission	32.4 (20.3–51.7)
LAPS	1 (0.99–1.01)
Home care on discharge	3.2 (2.2–4.7)
Long-term care after discharge	5.7 (3.5–9.2)
Death in hospital	2.6 (1.3–5.2)
ALC status during hospital stay	23.5 (14.1–39.2)

Notes: [a]Continuous variables in the regression model. The other variables were treated as categorical variables.
Abbreviations: ALC, alternate level of care; CI, confidence interval; COPD, chronic obstructive pulmonary disease; LAPS, laboratory-based acute physiology score; ICU, intensive care unit.

was also significantly associated with high costs. Age >80 years and comorbidity scores were not significantly associated with high costs. The model demonstrated strong discrimination (c-statistic =0.871).

Discussion

Our study highlights two COPD patient populations that contributed to high costs during hospitalization. First, patients with acute severe illness who require ICU admission and those who die in the hospital setting are significant contributors to expensive care. Second, patients who are not able to cope well at home, such as those requiring ALC designation in hospital and assisted living arrangements upon discharge, also contribute to high costs. Interestingly, the ALC-designated patients and those requiring ICU admission appear to be distinct populations with little overlap. This suggests that early recognition and intervention for the frail and functionally limited population may have a significant impact on hospital costs.

The ALC designation during hospitalization is a surrogate measure for functional status, as it is used when a patient cannot return to their previous dwelling because more support is required.[22] We found that the top cost quintile had significantly more ALC-designated patients, and they incurred higher allied health professional costs than the non-ALC patients ($2,000 per case vs $900 per case in non-ALC patients). Interestingly, 78% of ALC-designated patients in the top cost quintile were discharged to either LTC facilities or home with home care services. Our findings are echoed in other studies that found that ALC patients awaiting LTC placement have more functional impairments and complex health needs, which result in long lengths of hospital stay.[22,23] If hospital costs are to be saved in this group of patients, early identification of patients with chronic disease and poor functional status in the community setting could help initiate early introduction of support services and arrangement for assisted living facilities.

Our study also found that patients in the highest cost quintile had a higher mortality rate compared to those in the lower cost quintiles. Given that one in three patients in the top cost quintile were >80 years, had a high baseline risk of death on admission (11%), a larger degree of physiologic derangement (LAPS), and need for ICU, the high mortality rates are not unexpected. Our results are consistent with other work, demonstrating that high end-of-life care costs are largely driven by the hospitalization cost in the last 4 months of life.[24,25] In Ontario, Canada, $4.7 billion was spent on health care at the end of life in 1 year, representing 10% of the total health care budget.[24]

In this study, we did not examine the appropriateness of hospitalization and ICU admission at the end of life or the causes of death in hospital; however, previous work has suggested that a proportion of hospitalizations and intensive care at the end of life are potentially avoidable.[26,27] Kronman et al showed that more primary care visits in the 12 months prior to death were associated with lower costs, less in-hospital death, fewer preventable hospitalizations, and fewer hospital days at the end of life.[26] One might presume that this could be due to better discussion of advanced directives and goals of care. Finally, Zhang et al demonstrated that early discussions on goals of care with patients reduced the high health care costs at the end of life in the cancer population.[28] These data suggest that the high health care spending due to hospitalization at the end of life can be reduced, while improving the quality of patient care for patients with chronic disease.

Finally, a large focus has been placed on readmissions as the cause for increased cost because the current perception is that hospital readmissions are a marker for poor quality of care.[29] While the readmission rate was higher in our highest cost group (12.6% vs 9.5%, after exclusion of deaths), previous literature has cautioned using readmission rates as an indicator for quality of care, as it is estimated that only 25% of readmissions are avoidable.[30,31] These results underscore the need for additional work to understand whether early identification of the frail patient with chronic disease, better community-based health services for frail patients, and emphasis on advanced care planning will have a favorable impact on health care costs and improved quality of care for patients with COPD.

Based on our review of the literature, to date, this has been the first cohort study that captures indirect and direct hospital costs using a case-costing system in a population of patients admitted for acute exacerbations of COPD. The identification of discharge locations, ALC status, and cost of allied health professional assessment in hospital are helpful surrogates for a patient's functional status and have not been previously evaluated in this population.

The main limitation of this study lies in the accuracy of COPD diagnosis on the medical record and the subsequent ICD-10 coding for COPD in our administrative database. We were not able to reference the coded diagnosis against actual pulmonary function testing values. Furthermore, it is possible that our cohort contained some patients who did not have a first-time COPD-related hospitalization. We used a 2-year look-back window at our institution to ensure no previous COPD-related hospitalizations, however, patients may have been hospitalized elsewhere for COPD exacerbation during this period. It is possible that this phenomenon affected the

breakdown of costs. Regarding costs, we did not adjust for inflation between the years included in this study. However, with a low inflation rate in Canada, it is unlikely that the lack of adjustment for inflation would have significantly impacted the cumulative costs. Finally, this study was conducted at a single, academic, publicly funded hospital in Canada, which may affect the external validity of our findings.

In summary, findings from this study lend support to our hypothesis that the sequelae of chronic disease, including poor functional status and frailty, are major contributors to high hospital costs in this population of hospitalized COPD patients. Focusing on interventions that identify frail patients with declining functional ability in the community setting may reduce costs for the health system. Specifically, functional assessments at home, better and earlier discussions of advanced care directives, and reorganization of hospital care based on frailty and functional status may improve the quality of care and reduce costs for patients with COPD and other chronic medical diseases.

Acknowledgment

Author contributions

SM had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors contributed to the concept and study design. JM performed the initial data extraction and analysis from TOHDW. JM and SM conducted additional analysis. SM, JM, PER, DK, KT, and AJF reviewed the analysis and contributed to critical review of the manuscript. All authors contributed toward data analysis, drafting and critically revising the paper and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

References

1. O'Donnell DE, Aaron S, Bourbeau J, et al; Canadian Thoracic Society. Canadian Thoracic Society recommendations for management of chronic obstructive pulmonary disease–2003. *Can Respir J*. 2003;10(Suppl A): 11A–65A.
2. World Health Organization. Chronic respiratory diseases. Burden of COPD. Available from: http://www.who.int/respiratory/copd/burden/en/. Accessed April 22, 2016.
3. Canadian Thoracic Society. The human and economic burden of COPD: a leading cause of hospital admission in Canada. 2010. Available from: http://www.respiratoryguidelines.ca/sites/all/files/CTS_COPD_report.pdf. Accessed April 22, 2016.

4. Mannino DM. Counting costs in COPD: what do the numbers mean? *Chest*. 2015;147(1):3–5.
5. Ford ES, Murphy LB, Khavjou O, Giles WH, Holt JB, Croft JB. Total and state-specific medical and absenteeism costs of COPD among adults aged ≥18 years in the United States for 2010 and projections through 2020. *Chest*. 2015;147(1):31–45.
6. Khakban A, Sin DD, FitzGerald JM, et al. Ten-year trends in direct costs of COPD: a population-based study. *Chest*. 2015;148(3):640–646.
7. Müllerova H, Maselli DJ, Locantore N, et al; ECLIPSE Investigators. Hospitalized exacerbations of COPD: risk factors and outcomes in the ECLIPSE cohort. *Chest*. 2015;147(4):999–1007.
8. Bahadori K, FitzGerald JM. Risk factors of hospitalization and readmission of patients with COPD exacerbation–systematic review. *Int J Chron Obstruct Pulmon Dis*. 2007;2(3):241–251.
9. Garcia-Aymerich J, Farrero E, Félez MA, Izquierdo J, Marrades RM, Antó JM; Estudi del Factors de Risc d'Agudització de la MPOC investigators. Risk factors of readmission to hospital for a COPD exacerbation: a prospective study. *Thorax*. 2003;58(2):100–105.
10. Aaron SD. Management and prevention of exacerbations of COPD. *BMJ*. 2014;349:g5237.
11. Gershon AS, Mecredy GC, Guan J, Victor JC, Goldstein R, To T. Quantifying comorbidity in individuals with COPD: a population study. *Eur Respir J*. 2015;45(1):51–59.
12. Valenza MC, Torres-Sánchez I, Cabrera-Martos I, Rodríguez-Torres J, González-Jiménez E, Muñoz-Casaubon T. Physical activity as a predictor of absence of frailty in subjects with stable COPD and COPD exacerbation. *Respir Care*. 2016;61(2):212–219.
13. Echave-Sustaeta JM, Comeche Casanova L, Cosio BG, Soler-Cataluña JJ, Garcia-Lujan R, Ribera X. Comorbidity in chronic obstructive pulmonary disease. Related to disease severity? *Int J Chron Obstruct Pulmon Dis*. 2014;9:1307–1314.
14. Canadian Institute for Health Information. Canadian patient cost database technical document: MIS patient costing methodology. 2011. Available from: http://www.cihi.ca/CIHI-ext-portal/pdf/internet/MIS_PATIENT_COST_METH_EN. Accessed on April 22, 2016.
15. Ontario case costing guide, version 9.0. Toronto: Data Standards Unit, Health Data Branch, Ministry of Health and Long-Term Care; 2014. Available upon request (info@occp.com).
16. van Walraven C, Austin PC, Jennings A, Quan H, Forster AJ. A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. *Med Care*. 2009;47(6):626–633.
17. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36(1):8–27.
18. van Walraven C, Escobar GJ, Greene JD, Forster AJ. The Kaiser Permanente inpatient risk adjustment methodology was valid in an external patient population. *J Clin Epidemiol*. 2010;63(7):798–803.
19. Escobar GJ, Greene JD, Scheirer P, Gardner MN, Draper D, Kipnis P. Risk-adjusting hospital inpatient mortality using automated inpatient, outpatient, and laboratory databases. *Med Care*. 2008;46(3):232–239.
20. Ronksley PE, McKay JA, Kobewka DM, Mulpuru S, Forster AJ. Patterns of health care use in a high-cost inpatient population in Ottawa, Ontario: a retrospective observational study. *CMAJ Open*. 2015;3(1):E111–E118.
21. Ontario Ministry of Health and Long Term Care. ALC Provincial Definition. Available from: http://www.health.gov.on.ca/en/pro/programs/waittimes/edrs/alc_definition.aspx. Accessed April 22, 2016.
22. Costa AP, Hirdes JP. Clinical characteristics and service needs of alternate-level-of-care patients waiting for long-term care in Ontario hospitals. *Healthc Policy*. 2010;6(1):32–46.
23. Costa AP, Poss JW, Peirce T, Hirdes JP. Acute care inpatients with long-term delayed-discharge: evidence from a Canadian health region. *BMC Health Serv Res*. 2012;12:172.
24. Tanuseputro P, Wodchis WP, Fowler R, et al. The health care cost of dying: a population-based retrospective cohort study of the last year of life in Ontario, Canada. *PLoS One*. 2015;10(3):e0121759.
25. Lubitz JD, Riley GF. Trends in Medicare payments in the last year of life. *N Engl J Med*. 1993;328(15):1092–1096.
26. Kronman AC, Ash AS, Freund KM, Hanchate A, Emanuel EJ. Can primary care visits reduce hospital utilization among Medicare beneficiaries at the end of life? *J Gen Intern Med*. 2008;23(9):1330–1335.
27. Wennberg JE, Fisher ES, Stukel TA, Skinner JS, Sharp SM, Bronner KK. Use of hospitals, physician visits, and hospice care during last six months of life among cohorts loyal to highly respected hospitals in the United States. *BMJ*. 2004;328(7440):607.
28. Zhang B, Wright AA, Huskamp HA, et al. Health care costs in the last week of life: associations with end-of-life conversations. *Arch Intern Med*. 2009;169(5):480–488.
29. Steiner M. Hospital admission and readmission for acute exacerbation of COPD. A tough nut to crack. *Thorax*. 2015;70(12):1108–1109.
30. van Walraven C, Bennett C, Jennings A, Austin PC, Forster AJ. Proportion of hospital readmissions deemed avoidable: a systematic review. *CMAJ*. 2011;183(7):E391–E402.
31. van Walraven C. The utility of unplanned early hospital readmissions as a health care quality indicator. *JAMA Intern Med*. 2015;175(11):1812–1814.