Trends in hospital admissions for chronic obstructive pulmonary disease over 16 years in Canada

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) is an ambulatory care–sensitive condition, and the rate of hospital admissions for COPD is an indicator of the quality of outpatient care. We sought to determine long-term trends in hospital admissions for COPD in Canada.

Methods: Using a comprehensive national database of hospital admissions in Canada, we identified those with a main discharge diagnosis of COPD for patients aged 40 years and older between 2002 and 2017. We calculated sex-specific, age-standardized trends in annual rates of hospital admissions for COPD separately for younger (40–64 yr) and older adults (≥ 65 yr). We used spline regression to examine changes in the admissions trends for each sex and age group.

Results: Over 16 years, 1 134 359 hospital admissions were for COPD. Between 2002 and 2017, the total number of admissions increased by 68.8%, from 52 937 to 89 384. The overall crude admission rate increased by 30.0%, from 368 to 479 per 100 000 population, and the sex- and age-standardized admission rate increased by 9.6%, from 437 to 479 per 100 000 population. Age-standardized rates increased by 12.2% among younger females, by 24.4% among younger males and by 29.8% among older females, but decreased by 9.0% among older males. Over the same period, the all-cause sex- and age-standardized admission rate declined by 23.0%.

Interpretation: Hospital admissions for COPD have increased since 2010, even after adjusting for population growth and aging, and despite declining rates of all-cause hospital admissions. The secular increase in COPD admissions indicates that the burden of COPD on Canadian health care systems is increasing.

Chronic obstructive pulmonary disease (COPD) is a chronic and progressive disease that imposes a substantial burden on patients and Canadian health care systems. Despite plateauing rates of smoking, the burden of COPD is projected to increase in Canada because of population growth and aging.[1–3] As the health care system approaches the upper limit of budget expansion, it is increasingly crucial to identify gaps in care that lead to higher utilization.[4] Hospital admissions for COPD may represent one such area for improvement as, in many instances, they could be avoided with proper preventive or early therapeutic interventions.[5,6] For this reason, COPD is considered an ambulatory care–sensitive condition, and trends in COPD admissions are interpreted as an indicator of the quality of outpatient care.[7] Despite this, COPD remains one of the most common reasons for hospital admission in Canada.[8] A Canadian study showed that COPD-specific admissions contribute 57% to the total medical costs of COPD.[3]

Given population growth and aging, COPD-specific hospital admissions are projected to increase significantly in the future.[3] However, population growth and aging contribute to the increasing burden of COPD-specific admissions but do not indicate gaps in care. Secular trends in admissions that account for these factors provide a more informative metric for tracking the quality of outpatient care. Combining secular trends with the projections of population growth and aging enables predictions of the future burden of hospital admissions to inform evidence-based planning.[9]

We sought to document overall and secular trends in COPD admissions in Canada from 2002 to 2017. We also sought to evaluate trends in general admission rates, lengths of stay, in-hospital mortality and readmission rates among patients with COPD.

Methods

Data sources

We obtained data from the Hospital Morbidity Database, Canada's national hospital database managed by the Canadian Institute for Health Information (CIHI), which provides complete geographic coverage of all inpatient admissions.[10] For each record, we had access to dates of admission and discharge, biological sex, age and discharge diagnoses as coded using the *International Classification of Diseases, 9th* (ICD-9) or *10th* (ICD-10) *Revisions*. We defined COPD-specific hospital admissions as those with COPD as the primary (most responsible) diagnosis (ICD-9 codes 491, 492, 493.2 and 496, and ICD-10 codes J41–J44). This definition had a sensitivity of 86% and a positive predictive value of 87% in a chart review study.[11] To avoid including patients with asthma who might have been incorrectly labelled as having COPD, we excluded patients younger than 40 years at admission.

Statistical analysis

We aggregated COPD admissions annually and stratified them by sex and age group (40–64 yr and ≥ 65 yr). We computed crude and direct sex- and age-standardized rates per 100 000 people using the Census-driven population estimates as the denominator with 1-year age groupings, using the 2017 population as the reference for direct standardization.[9] We employed the Byar method for computing 95% confidence intervals (CIs) around rates. By exponentiating the coefficient of the time variable from a negative binomial regression model, we obtained the average annual relative change. To evaluate potentially nonlinear variations in the trends in each sex–age group, we used thin-plate spline regression analysis (9 knots, with the default knot locations determined by the mgcv R package) with the negative binomial model.

We conducted a series of secondary analyses. We further subdivided the younger and older adult groups (40–54 yr, 55–64 yr,

Table 1: Annual number and crude rate per 100 000 population of COPD hospital admissions by calendar year, overall and within sex and age subgroups

	Overall			Younger adult (40–64 yr)			Older adult (≥ 65 yr)		
Variable	**Both**	**Female**	**Male**	**Both**	**Female**	**Male**	**Both**	**Female**	**Male**
16-year study period									
No. of admissions	1 134 359	566 550	567 809	240 611	127 514	113 097	893 748	439 036	454 712
Crude rate per 100 000 (95% CI)	425 (424 to 426)	410 (409 to 411)	441 (440 to 442)	127 (127 to 128)	135 (134 to 135)	120 (119 to 121)	1147 (1144 to 1149)	1014 (1011 to 1017)	1313 (1309 to 1317)
2002									
No. of admissions	52 937	25 254	27 683	10 381	5664	4717	42 556	19 590	22 966
Crude rate per 100 000 (95% CI)	368 (365 to 372)	337 (333 to 341)	403 (398 to 407)	100 (98 to 102)	109 (106 to 111)	91 (89 to 94)	1067 (1057 to 1077)	862 (850 to 874)	1337 (1320 to 1355)
2017									
No. of admissions	89 384	45 939	43 445	19 061	9853	9208	70 323	36 086	34 237
Crude rate per 100 000 (95% CI)	479 (476 to 482)	477 (472 to 481)	482 (477 to 486)	152 (150 to 154)	156 (153 to 159)	148 (145 to 151)	1146 (1138 to 1155)	1084 (1073 to 1096)	1220 (1207 to 1233)
Absolute change from 2000 to 2017									
No. of admissions	36 447	20 685	15 762	8680	4189	4491	27 767	16 496	11 271
Crude rate per 100 000 (95% CI)	111 (106 to 116)	139 (134 to 146)	79 (73 to 85)	52 (49 to 55)	48 (43 to 51)	57 (53 to 61)	80 (66 to 93)	222 (205 to 239)	−118 (−139 to −95)
Relative change, %									
No. of admissions	68.8	81.9	56.9	83.6	74.0	95.2	65.2	84.2	49.1
Crude rate per 100 000 (95% CI)	30.0 (28.5 to 31.8)	41.4 (39.5 to 43.6)	19.7 (18.1 to 21.2)	52.2 (48.4 to 55.6)	43.8 (39.3 to 46.9)	62.2 (56.3 to 68.9)	7.5 (6.1 to 8.7)	25.8 (23.5 to 28.0)	−8.8 (−10.3 to −7.2)
Average annual relative change,* %									
Crude rate per 100 000 (95% CI)	1.2 (0.8 to 1.7)	1.8 (1.4 to 2.2)	0.6 (0.1 to 1.1)	2.4 (2.1 to 2.7)	2.2 (1.8 to 2.6)	2.7 (2.4 to 3.1)	−0.2 (−0.7 to 0.3)	0.8 (0.4 to 1.3)	−1.3 (−1.8 to −0.8)

Note: CI = confidence interval, COPD = chronic obstructive pulmonary disease.
*Obtained from a negative binomial regression model by exponentiating the coefficient of the time variable.

65–74 yr, 75–84 yr, ≥ 85 yr) and used pairwise hypothesis testing with the Bonferroni adjustment to see if the trends were different within each age group. Next, we determined whether trends in COPD-specific hospital admissions paralleled trends in all-cause hospital admissions, reflecting health system–wide factors not specific to COPD. Because all-cause admissions were reported in fiscal years, we recalculated COPD-specific admissions for April–March, inclusive, for this analysis. Further, we tested whether changes in admission rates could be attributed to a threshold effect by evaluating trends in the average length of stay among patients admitted to hospital with COPD and in-hospital mortality in each sex–age group. For example, a temporal trend of admitting less severe cases could result in increased admissions but a shorter average length of stay. A similar threshold phenomenon could exist at the time of discharge; for instance, a trend toward discharging patients earlier may increase the risk of readmissions. To investigate the threshold effect, we evaluated trends in the proportion of patients with no readmissions in the same year and trends in the sex- and age-standardized rate of readmissions within the same year. For this analysis, we excluded the 2% of COPD admissions that had missing anonymized patient identifiers. Lastly, we investigated whether the frequency of the 8 most common comorbidities among patients admitted to hospital for COPD (determined over the entire study period) changed from 2002 to 2017. Discharge diagnostic codes used to classify comorbidities are shown in Appendix 1, Supplementary Table A1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.221051/tab-related-content.

We used R statistical software to conduct all analyses. Unless otherwise stated, all rates are presented per 100 000 population.

Ethics approval

Ethics approval was granted by the University of British Columbia's Clinical Research Ethics Board (H18-01026).

Results

Over the 16-year study period, 1 134 359 admissions were for COPD, of which 240 611 (21.2%) were for younger adults (< 65 yr). The average age at admission was 74 (interquartile range 66–82) years. More than half of admissions were for female patients (n = 127 514, 53.0%) in the younger group and slightly more than half of admissions were for male patients (n = 454 712, 50.9%) in the older group. In the first year of the study (2002), the total number of admissions was 10 381 for the younger group and 42 556 for the older group (Table 1). In the last year of the study (2017), the corresponding numbers were 19 061 and 70 323, representing a relative increase in admissions of 83.6% and 65.3%, respectively. More detailed results are presented in Appendix 1, Supplementary Table A2.

Trends in rates

Trends in crude and sex- and age-standardized admissions rates (per 100 000 population) between 2002 and 2017 are depicted in Figure 1. The overall crude rate increased from 368 (95% CI 365 to 372) in 2002 to 479 (95% CI 476 to 482) in 2017. The overall sex- and age-standardized rate of hospital admissions per 100 000 population increased from 437 (95% CI 434 to 440) in the first year to 479 (95% CI 476 to 482) in the last year of the study.

Age-standardized rates increased over the study period in all sex and age groups except older males, among whom the rate was 1341 (95% CI 1324 to 1359) in 2002 and 1220 (95% CI 1207 to 1233) in 2017 (Figure 2). For the younger group, the age-standardized rate of COPD admissions increased from 139 (95% CI 135 to 143) among females and 119 (95% CI 115 to 122) among males in 2002, to 156 (95% CI 153 to 159) among females and 148 (95% CI 145 to 151) among males in 2017. For both males and females in the younger group, the rates increased from 2002 to 2005, subsequently decreased at a modest pace until 2010, and rose again. These patterns were similar to those observed among older females (835, 95% CI 823 to 847, in 2002 to 1084, 95% CI 1073 to 1096, in 2017). However, among older males, the rate nearly plateaued from 2011 to 2014 and declined afterward.

Secondary analyses

By age subgroup, the model-based average annual relative changes in the sex- and age-standardized rate of COPD hospital admissions were 2.4% per year (95% CI 1.7% to 3.1%) for patients aged 40–54 years, 0.7% per year (95% CI 0.3% to 1.2%) for those aged 55–64 years, –0.9% per year (95% CI –1.3% to –0.5%) for those aged 65–74 years, –0.0% per year (95% CI –0.5% to 0.5%) for those aged 75–84 years and 1.3% per year (95% CI 0.6% to 2.0%) for those aged 85 years and older. Most differences between age subgroups were statistically significant (Appendix 1, Supplementary Figure A1).

Sex- and age-standardized rates of all-cause admissions decreased by a model-based relative annual average of –0.8% per year from the baseline rate (95% CI –1.1% to –0.5%) between 2002 and 2016 in fiscal years (corresponding to a relative decline of 23.0% over the study period). In contrast, sex- and age-standardized admission rates for COPD increased by a model-based relative annual average of 1.3% per year (95% CI 0.6% to 1.9%), corresponding to a relative increase of 9.2% over the same period in fiscal years (Figure 3).

In-hospital mortality from COPD admission declined in each sex and age group over the study period. The relative change in in-hospital deaths between 2002 and 2017 was –8.3% (from a rate of 2.4 to 2.2 per 100 COPD admissions) for younger females, –7.4% (from 2.7 to 2.5 per 100 COPD admissions) for younger males, –6.3% (from 6.8 to 6.4 per 100 COPD admissions) for older females, and –9.9% (from 8.1 to 7.3 per 100 COPD admissions) for older males (Figure 4). In-hospital mortality was higher among males in both age groups. Among younger adults, in-hospital mortality stayed nearly constant or increased for the first 5 years of the study period and then declined after 2007. Among older adults, in-hospital mortality increased until 2007 and then declined until the end of the study period.

The average age-standardized length of stay for COPD-specific hospital admissions declined for all sex and age groups from 2002 to 2017. Lengths of stay declined by 20.3% (7.9 d to 6.3 d) among younger females, 16.2% (7.4 d to 6.2 d) among younger males, 16.7% (10.2 d to 8.5 d) among older females and 14.9% (9.4 d to 8.0 d) among older males (Appendix 1, Supplementary Figure A2).

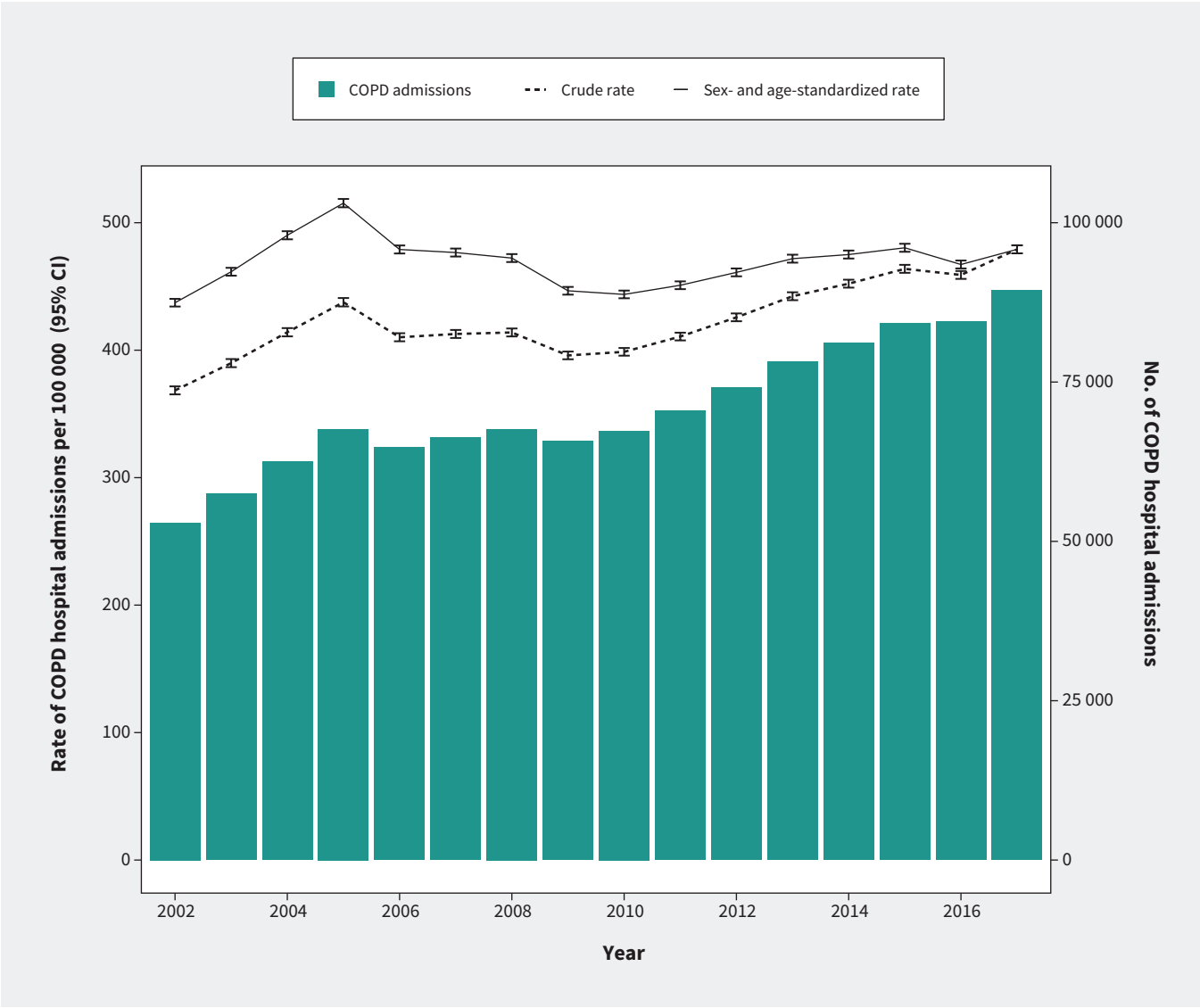

Figure 1: Annual number and crude and sex- and age-standardized rates per 100 000 population of hospital admissions for chronic obstructive pulmonary disease (COPD), by calendar year. Note: CI = confidence interval.

The proportion of patients with no readmissions for COPD within the same calendar year remained relatively constant at 78.0% (Appendix 1, Supplementary Table A3). However, the sex- and age-standardized rate of readmissions increased by 15.4% (from 181 to 209 per 100 000 population) over the study period (Appendix 1, Supplementary Figure A3). Of the 8 most common comorbidities among patients admitted to hospital for COPD, 5 increased in proportion from 2002 to 2017, with relative changes of 660.7% (from 0.6% to 4.2%) for acute kidney failure, 166.1% (from 0.8% to 2.1%) for bronchopneumonia, 57.7% (from 10.7% to 16.9%) for pneumonia, 42.2% (from 3.8% to 5.4%) for other lung diseases and 41.8% (from 3.9% to 5.5%) for fluid-, electrolyte- and acid-based disorders. In contrast, the proportion decreased by 79.8% (from 4.4% to 0.9%) for cardiac dysrhythmias, 44.4% (from 5.0% to 2.8%) for diabetes mellitus and 23.3% (from 8.7% to 6.7%) for heart failure (Appendix 1, Supplementary Figure A4).

Interpretation

Our study used quality-controlled national population-based data from Canada with complete coverage of inpatient hospital admissions to report trends in admissions for COPD from 2002 to 2017. We have created a Web app that allows rates of COPD-specific hospital admissions to be explored by province and territory (https://resp.core.ubc.ca/ipress/copdHospitalizationCanada).

Considering the number of admissions, the crude rates and the sex- and age-standardized rates together shows interesting patterns. Over 16 years, the number of COPD admissions increased by more than two-thirds, the crude admission rate increased by around 30% and the sex- and age-standardized rate increased by around 10%. The attenuation of trends in admissions from frequencies to crude rates demonstrates the influence of population growth; further attenuation between crude and age-standardized rates reflects the impact of population aging.

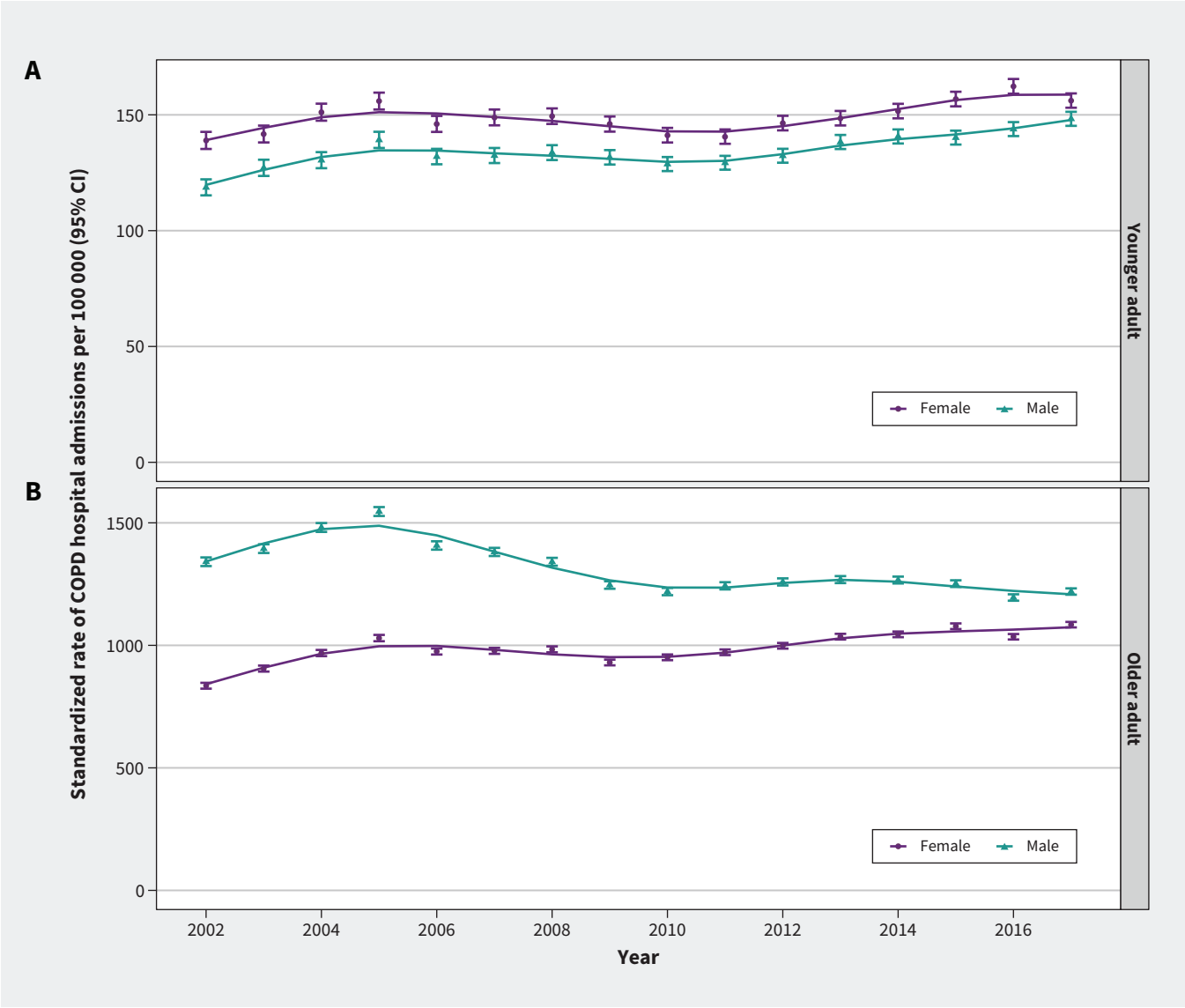

Figure 2: Spline regressions for age-standardized rates per 100 000 population of hospital admissions for chronic obstructive pulmonary disease (COPD), by calendar year, among (A) younger adults aged 40–64 years and (B) older adults aged 65 years and older. Note that scales for the y-axis are different for each age group. Note: CI = confidence interval.

However, after adjusting for these factors, we still observed a secular increase that cannot be attributed to population demographics. Importantly, sex- and age-standardized rates of COPD admissions increased in excess of sex- and age-standardized rates of all-cause admissions over the same period, which rejects the hypothesis that our observations were driven by rising admissions across all disease areas, and despite the continual reduction in smoking rates in Canada.[12] Our findings may indicate an increasing gap in care for COPD compared with other conditions. Alternatively, higher survival rates among patients admitted with severe exacerbations of COPD could result in repeat admissions for such patients. This hypothesis may be supported by the observed decline in lengths of stay and in-hospital mortality. However, the observed increase in the rate of readmissions within the same year could reflect premature discharge of patients with COPD rather than better in-hospital care.[13]

We observed the secular increase in COPD admissions after adjustment for population growth and aging in all demographic groups except males aged 65 years and older. Similarly, Orozco-Beltran and colleagues[14] determined that age-standardized rates of admission for COPD in Spain decreased from 1998 to 2010 among both males and females but started rising, modestly among males and sharply among females until 2018, especially among patients aged 85 years and older. A similar study in Germany reported increasing rates of COPD-specific admissions (2005–2011), with males aged 75–84 years having the highest age-standardized rate of 39.4 hospital admissions per 100 000 population, and females having the greatest average annual increases.[15] Improved survival among patients with COPD could increase the prevalence of severe disease and ultimately increase the rate of hospital admissions. Changes in the rates of pneumonia and influenza, the most common causes of COPD

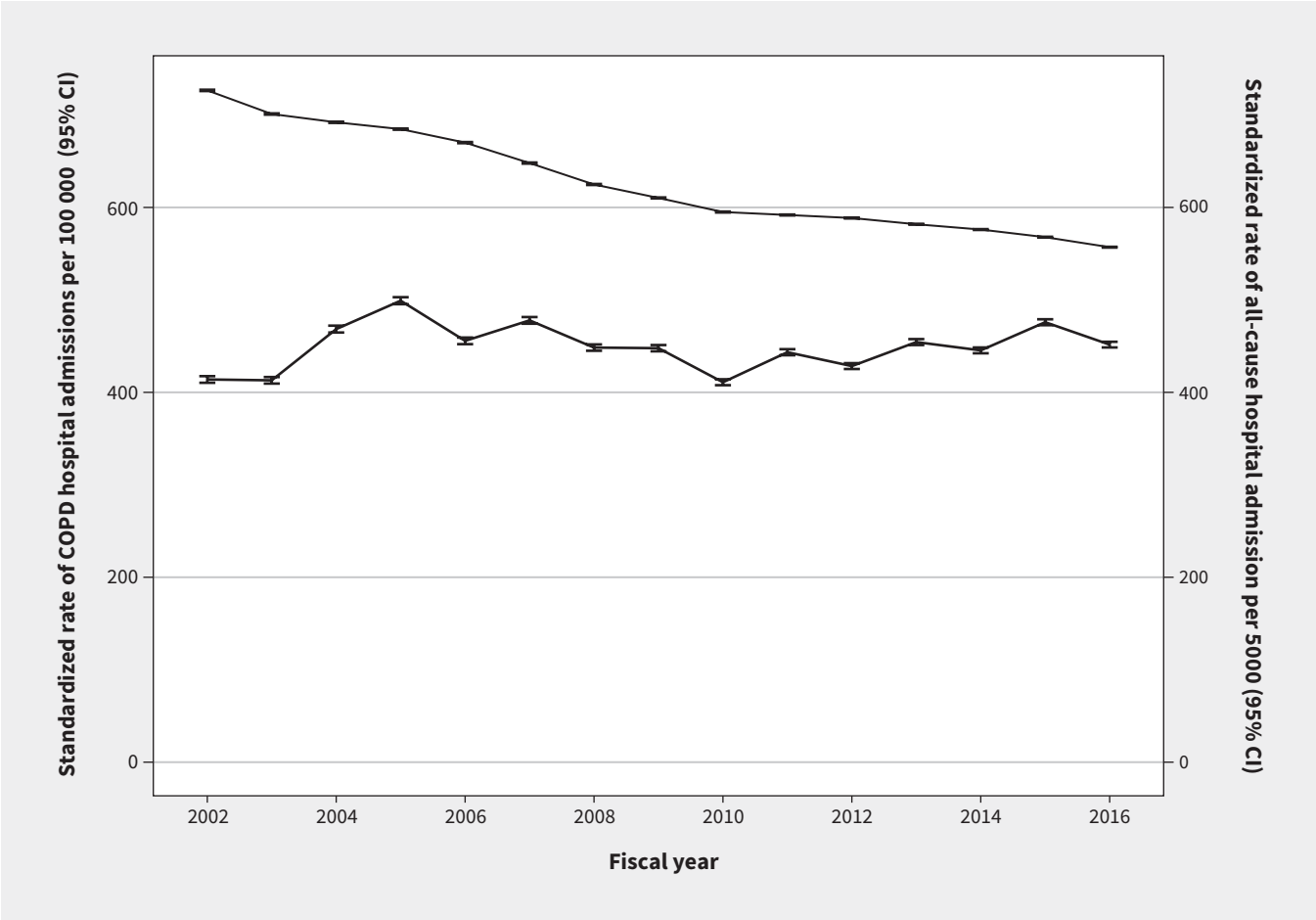

Figure 3: Sex-and age-standardized rates of hospital admissions for chronic obstructive pulmonary disease (COPD) per 100 000 population and all-cause hospital admissions per 5000 population per fiscal year. Note: CI = confidence interval.

exacerbations, could also be contributing to increased admission rates for COPD.[16] The mortality rate for influenza and pneumonia has increased since 2010 in Canada, which is in line with the secular increase in COPD admissions after 2010 observed in our study, and with the increased prevalence of pneumonia at admission.[17] In addition, the number of comorbid conditions among patients with COPD is increasing, which is associated with a greater risk of hospital admission.[18]

Many other factors may have influenced the observed trends in admissions. Evidence-based clinical practice and treatment of COPD have undergone major changes over the study period, including the introduction of therapeutic recommendations based on the Global Initiative for Chronic Obstructive Lung Disease severity grades in 2001.[19] Decreasing hospital admissions for COPD in other countries has been attributed to this new paradigm of COPD management.[20,21] However, trends in use of medication are often not aligned with evidence-based guidelines, and overuse of inhaled corticosteroids, which increase the risk of pneumonia, has been documented among patients with COPD.[22] We observed an increase in sex- and age-adjusted rates of COPD admission, particularly after 2010, which was concomitant with an observed decrease in length of stay and in-hospital mortality, and a slight increase in readmissions. These findings may be attributed to a decrease in the threshold for severity of COPD exacerbation leading to admission, better in-hospital management of exacerbations or a combination of both.

Historically, COPD has been regarded as a condition that mainly affects male smokers. Several recent studies have questioned this narrative by documenting the growing burden of COPD among females and nonsmokers.[23–25] We observed a sharper increase in rates of hospital admission among older females, compared with all other groups. This may be owing to differences in the prevalence of smoking.[26] The observed gap between males and females can be explained by historical trends in smoking prevalence in Canada, which peaked later among females (1974) than among males (1965).[27] The burden of hospital admissions for COPD can be expected to follow a similar pattern with a delay. The lagged effect of smoking may explain the declining rates of COPD among older males and continued increase in rates among older females. Sex and gender differences in COPD diagnosis and treatment in clinical practice may also explain these observations.[28–30] The role of extrinsic factors such as changes in population exposure to air pollution or indoor toxic inhalants should also be considered.[31,32]

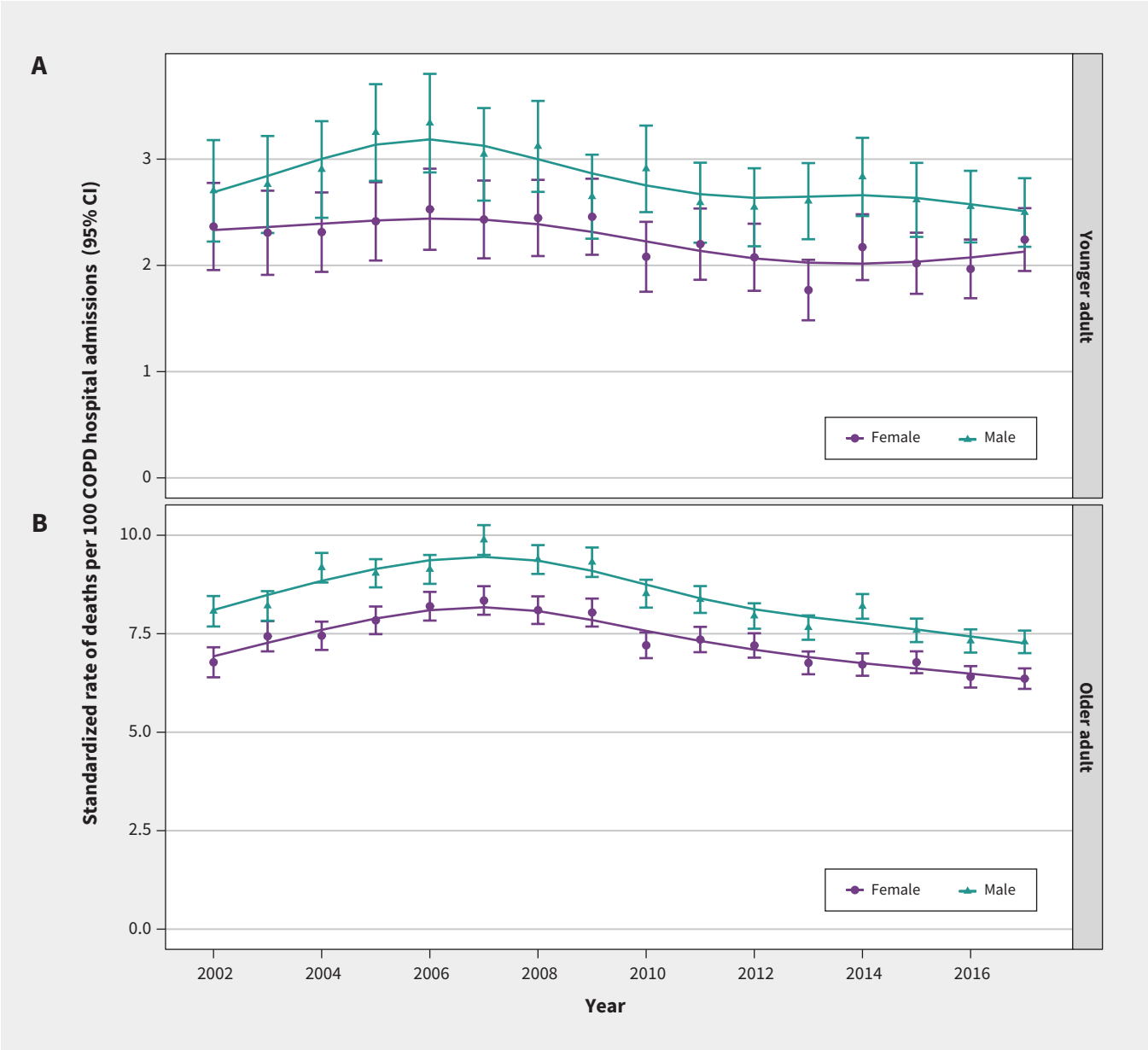

Figure 4: In-hospital mortality per 100 hospital admissions for chronic obstructive pulmonary disease (COPD) by calendar year, among (A) younger adults aged 40–64 years and (B) older adults aged 65 years and older. Note that scales for the y-axis are different by age group. Solid lines indicate the curves fitted by spline regression, and points indicate the observed values. Note: CI = confidence interval.

Limitations

Although our study was affected by the adaptation of ICD-10 from ICD-9 that occurred at different time points from 2001 to 2006, its effect on our measurement of admissions was likely negligible as the implementation of ICD-10 did not substantially change coding practices across Canada.[33] Similarly, hospital admissions are less sensitive to changes in diagnostic criteria than other measures of COPD burden, including physician visits and prescription records.[34] We were unable to assess trends in patient characteristics — such as race, socioeconomic status and smoking status — and their impact on the risk of admission, as these data were unavailable. In addition, we were unable to evaluate trends in COPD admissions for more recent years as a result of lags in data availability because of quality assurance procedures, and a recent change in the content of the data sets that CIHI provides for research, which would affect our ability to compare the results with more recent trends.[35]

Conclusion

The number of hospital admissions for COPD has rapidly increased since 2010 in Canada. Even after adjusting for population growth and aging, COPD admission rates have risen since 2010 in all groups except among older males. This is in contrast to declining all-cause admission rates over this period. Our findings call into question whether progress is being made in improving COPD care and outcomes.

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