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Income inequalities in the risk of potentially avoidable hospitalisation and readmission for chronic obstructive pulmonary disease: a population data linkage analysis

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Abstract

Introduction

Hospitalizations for ambulatory care sensitive conditions, of which chronic obstructive pulmonary disease (COPD) is among the most common, represent an indirect measure of the healthcare system to manage chronic disease. Research has pointed to disparities in various COPD-related outcomes between persons of lower versus higher income; however, few studies have examined the influence of patients' social context on potentially avoidable COPD admissions.

Objective

The research explores the use of linked population census and administrative health data to assess the influence of income inequalities on the risk of hospitalization and rehospitalization for COPD among Canadian adults.

Methods

This analysis utilizes data from the 2006 Census linked longitudinally to the 2006/07-2008/09 Discharge Abstract Database. Multiple logistic regressions were conducted to assess the independent influence of income inequality on the risks of hospitalization and of six-month readmission due to COPD among the population aged 30-69, controlling for age, sex, education and other sociodemographic characteristics.

Results

Compared with adults in the most affluent income quintile, the adjusted odds of COPD hospitalization were significantly greater in the 4th highest income quintile (OR: 1.38; 95%CI: 1.30–1.47), and peaked for those in the least affluent quintile (OR: 2.92; 95%CI: 2.77–3.09). Among individuals who had been hospitalized at least once for COPD in the study period, and compared with the most affluent group, the adjusted odds of readmission were highest in the least affluent group (OR: 1.39; 95%CI: 1.22–1.58).

Conclusions

Despite Canada's system of universal coverage for physician and hospital care, a clear income gradient in the risk of being hospitalized and, to some extent, rehospitalized for COPD, is found. Income inequalities may be contributing to excess hospitalizations, reinforcing the importance of integrating social and economic issues in primary care to meet the ambulatory needs of this population.

Keywords

Chronic obstructive pulmonary disease; hospitalization; hospital readmission; socioeconomic factors; healthcare disparities; census; national hospital discharge survey; data linkage

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Highlights

- Analysis of population census data linked longitudinally with hospital records shows persistent income inequalities in potentially avoidable hospitalizations for COPD among Canadians aged 30–69.
- Canadians in the least affluent income groups are more likely to be hospitalized for COPD and to be readmitted following discharge compared with the most affluent group, after adjusting for other sociodemographic factors, and this despite Canada's system of publicly-funded universal coverage for physician and hospital services.
- Targeted investments in social capital to reduce the influence of lower income on the risk of COPD hospitalization may help achieve more equitable health outcomes and enhance health system sustainability.

Introduction

Hospitalizations for chronic obstructive pulmonary disease (COPD) are widely considered to be potentially avoidable through effective management in primary care [1–3]. Differences across population groups in the risk of admission (and readmission) for COPD and other ambulatory care sensitive conditions (ACSCs) provide an indirect measure of the capacity of the healthcare system to manage chronic conditions, and help outline inequalities related to access for primary care services for early diagnosis and prevention of acute exacerbation [3, 4]. There is strong evidence to support the notion that large income differences at the societal level have negative effects on health, and specifically that socioeconomic status is inversely associated with COPD outcomes even in high-income countries [5, 6]. In the Canadian context, although primary care physician services are universally accessible based on medical need rather than ability to pay through the stipulation of the Canada Health Act, and thus should be resistant to income inequalities, the equality of accessing primary care services may be amenable to improvements if there exists differential levels of access based on income. The effects of these unequal health outcomes for persons with COPD are experienced as reduced levels of breathing capabilities, decreased ability for the individual to leave home, and increased difficulty with activities of daily living, all of which may contribute to acute needs requiring hospitalizations if primary care services are not available, accessible and acceptable [2, 7].

Prevalence estimates of COPD in Canada vary depending on the information source. Survey data based on self-reports of physician-diagnosed COPD suggest a prevalence rate of 4.1% (95% confidence interval [CI]: 3.8–4.3%) among Canadian adults in 2018 [8]. However, comparisons from those who had a measured airflow obstruction consistent with COPD indicate the disease is under-reported and under-diagnosed, with a “true” prevalence closer to 14.1% (95% CI: 11.6–17.0%) among those aged 35–79 years [9]. A study using linked survey and hospitalization data found that Canadians aged 12–74 admitted for any one of seven ACSCs represent 0.4% of the population, with COPD accounting for one-quarter (26%) of

such potentially avoidable hospitalizations [3]. Increases in the burden of COPD over time have been attributed to a lack of improvement in smoking rates and increased hospitalization rates in the lowest income group [10]. Studies have also pointed to persistent and increasing income-related disparities in COPD mortality [11].

Understanding inequities in health outcomes for persons with COPD can help inform the development of medical and non-medical interventions for this at-risk population. Hospitalizations for COPD are commonly hypothesized to serve as a proxy for inadequate primary care access, quality and coordination, notably given that effective pharmacological treatment can be delivered in primary care, which should lower the risk of acute-care admissions [12, 13]. Having follow-up in primary and community-based care after discharge is presumed to reduce readmission risks; however, there is little robust empirical evidence explaining why hospitalization and rehospitalization rates vary across population groups [14]. Patient sociodemographic characteristics have been found to play a role in COPD admissions and readmissions in Canada, although the literature is inconclusive, with variances in observed outcomes reflecting differences across studies in target population, methodological approach and clinical need [2, 14]. Some evidence has been found of an association between low income and ACSC-related hospitalization even under universal health coverage, largely derived from either ecological studies or from analyses grouping multiple categories of illness [3].

The ability to investigate which population subgroups are most at risk of an ACSC-related admission to inform prevention interventions has been enhanced in recent years through the increased availability of linked datasets from nationally representative household-based sources with hospital discharge records [3, 15]. Studies relying on social surveys may be able to consider a range of variables such as health status and health-related behaviours, but sample size limitations often preclude assessment of cause-specific hospital stays [15]. The use of linked data from the Canadian Population Census offers the benefit of a large sample size to provide more detailed investigation of the influences of the social determinants of health (e.g. income) on potentially avoidable COPD hospitalizations and rehospitalizations. The influence of patients' social context on COPD readmissions has been rarely examined [16]. The objective of this research is to examine the extent to which income influences the risk of acute-care hospitalizations and rehospitalizations for COPD, after controlling for other sociodemographic characteristics, leveraging data from the 2006 Census long-form questionnaire linked longitudinally to three years of hospital administrative records.

Methods

Data source

This study takes advantage of data from the 2006 Census long-form questionnaire linked longitudinally to hospital inpatient records from the 2006/07–2008/09 Discharge Abstract Database (DAD), a novel information resource made available for research use through Statistics

Canada's Social Data Linkage Environment. The long-form Census, completed by 4.65 million Canadians (20% of the household population), provides self-reported demographic and socioeconomic information for individuals [17] while the DAD provides basic demographic, diagnostic and administrative information on all acute-care hospital stays annually in all Canadian provinces and territories except Quebec. Following a microdata linkage process using hierarchical deterministic exact matching from three variables common to both data sources (sex, date of birth and residential postal code), 5.3% of census respondents were eligible to be linked to the three annual hospital databases [18]. Because the DAD contains information for each hospitalization, individuals may have information on multiple stays. The de-identified confidential microdata were accessed through the secure setting of the New Brunswick Research Data Centre, located at the University of New Brunswick in Fredericton, Canada.

Target population

We limited our analysis to the household population between the ages of 30–69, that is, including those in the age range most at risk of developing COPD but for whom a related hospitalization would be considered as potentially avoidable.

Outcome variables

The outcomes of interest were, first, ever-hospitalized for COPD throughout the three-year study period and, second, rehospitalized for COPD within six months of the first observed COPD-attributable admission. Cases were included in which COPD was listed as the most responsible diagnosis for the length of stay, based on the International Classification of Diseases, Tenth Revision (ICD-10-CA) as codes J41–J44 [19]. A validation study of Ontario provincial DAD data on most responsible diagnoses indicated a substantial level of agreement for COPD between the administrative source with the diagnosis originally provided in the patient chart (kappa value of 0.78) [20].

Exposure variables

The main independent variable of interest was respondents' income category based on total monetary income from all sources minus income taxes paid in the previous year. After-tax household income was captured by Statistics Canada in the census from either income tax files among those who allowed access or direct questionnaire responses. Following research elsewhere [15], we ranked the target population into income quintiles adjusted for both the number of people in the household as well as the size of the population centre of residence (excluding the sparsely populated northern territories), from the first income quintile (least affluent) to the fifth income quintile (most affluent).

The analysis further considered a number of variables identified in the literature as potentially influential on COPD outcomes which were also available in the census, including contextual variables (province of residence) and individual socio-demographics (age, sex, marital status, Aboriginal identity, immigrant status, educational attainment). Given

Canada's decentralized healthcare delivery system, the province of residence was included to control for differences in provincial healthcare policies, resource allocations, and other characteristics that may influence hospital admission rates. Aboriginal identity was based on self-identification of First Nations, Metis, or Inuit.

Statistical analysis

Multiple logistic regressions were used to assess the independent influence of income on the risk for a COPD hospitalization and on the risk for six-month readmission due to COPD, controlling for other confounding factors. Individuals who died during their first observed stay were excluded from the analysis, as these admissions are unlikely to be considered avoidable and they would not be susceptible to readmission [12, 15]. Person-level census sampling weights, provided by Statistics Canada to address possible biases that may arise from over- or under-representation of certain characteristics, were applied to the results to ensure generalization to the Canadian population [17]. Regression parameters, including odds ratios (ORs) and 95% confidence intervals ($\alpha=0.05$), were estimated using SAS statistical software. All descriptive counts were subject to rounding to respect the confidential nature of the data.

Results

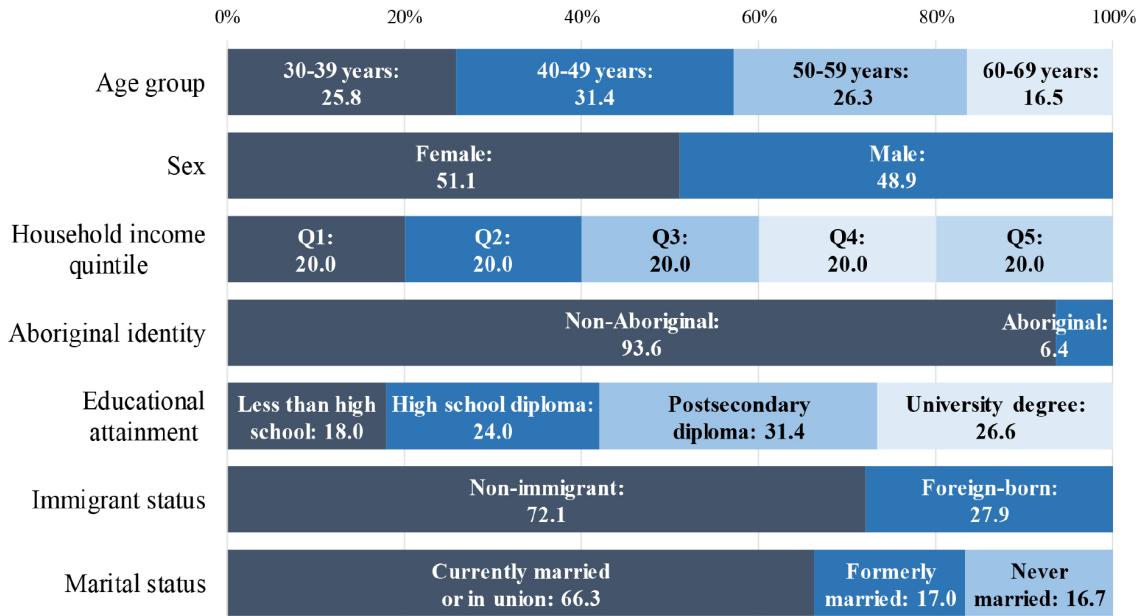
The study cohort included 2.41 million individuals aged 30–69 who completed the long-form census and were eligible to be matched to the DAD. This sample was designed to represent 11.9 million Canadians of the same age range residing in one of nine provinces (excluding Quebec). Just over half (51.1%) of the target population were female, and 42.8% were between the ages of 50 and 69 at the baseline time of the census (Figure 1). By definition, 20% of the cohort fell in each of the five income quintiles. One in fifteen (6.4%) were of Aboriginal identity, and 27.9% were foreign-born. Individuals with at most a high school diploma represented 42.0% of the population, and 66.3% were married or in a common-law union.

Among the target population, 0.22% were admitted to hospital at least once for COPD during the study period. Of these, 0.39% experienced a COPD-related readmission within six months.

Results of the multiple logistic regressions for the risk of COPD hospitalization and COPD readmission within six-months are presented in Table 1. A direct and significant income gradient for risk of ever-hospitalized for COPD was found (Table 1, model 1). Compared with those in the highest income quintile, adults in the lowest income quintile had 2.92 times the odds (95% CI: 2.77–3.10) of experiencing a COPD admission, those in the second quintile had 2.01 times the odds (95% CI: 1.90–2.13), the odds ratio for those in third quintile was 1.74 (95% CI: 1.64–1.85), and the OR for those in the fourth income quintile was 1.38 (95% CI: 1.30–1.47).

As expected, the risk of admission for COPD increased significantly with age; the odds increased by 12% with each additional year of age. Being female was somewhat protective of the hospitalization risk (3% less odds compared to males), as was being married or in a union (the odds

Figure 1: Distribution by sociodemographic characteristics of the 2006 Canadian census population aged 30–69 years



Source: 2006 Canadian Population Census linked to the 2006/07–2008/09 Discharge Abstract Database (N = 2,413,560). Data exclude residents of Quebec and the territories [15].

were approximately 34%–64% higher among those not in union). The admission risk decreased significantly with level of education; compared with those who did not complete high school, individuals who had a high school diploma had 41% decreased odds of being hospitalized for COPD, those who had postsecondary diploma had 44% decreased odds, and those who had a university degree had 76% decreased odds. Individuals of Aboriginal identity had 56% greater odds of hospitalization due to COPD compared with non-Aboriginals, after controlling for income, education and other socio-demographics. Those who were foreign-born had 63% decreased odds of a COPD hospitalization compared with non-immigrants. Compared with residents of Ontario (the most populous province), individuals from Newfoundland and Labrador, Nova Scotia, Manitoba, and British Columbia had lower odds of hospitalization for COPD, while those from New Brunswick or Prince Edward Island (two of the least populous and most rural provinces) had significantly higher odds, and those from Saskatchewan and Alberta had statistically similar odds.

The second analysis showed that individuals' income group was a significant predictor of the risk for six-month COPD readmission (Table 1, model 2), albeit the gradient was less pronounced compared to the risk for ever-hospitalization. Compared with individuals in the wealthiest income quintile, those in the least affluent group had 1.39 (95% CI: 1.22–1.58) times the odds of readmission, those in the third income quintile had 1.28 (95% CI: 1.11–1.47) times the odds, and the OR for those in the fourth income quintile was 1.17 (95% CI: 1.00–1.36).

A person's age remained a significant predictor of COPD rehospitalization (OR: 1.03; 95% CI: 1.02–1.03), but their sex did not significantly influence the risk. Aboriginal identity was not a significant predictor for risk of rehospitalization. Compared with those who were married or in union, individuals

who were formerly or never married had approximately 18%–25% greater odds of readmission. Level of education attained showed a social gradient in the risk of rehospitalization: compared with those who did not complete high school, the odds decreased among individuals who had a high school diploma (OR: 0.88; 95% CI: 0.82–0.94), those with post-secondary diploma (OR: 0.83; 95% CI: 0.78–0.89), and those with a university degree (OR: 0.85; 95% CI: 0.76–0.96). Immigrants had reduced odds of readmission (OR: 0.87; 95% CI: 0.79–0.94) compared with non-immigrants. Compared with residents of Ontario, individuals who lived in Nova Scotia, New Brunswick or Prince Edward Island, and Alberta had decreased odds of rehospitalization, while those in British Columbia had higher odds and those in Newfoundland and Labrador, Manitoba and Saskatchewan had statistically similar odds.

Discussion

This study utilized multiple years of hospital inpatient data linked longitudinally with population census data to investigate the associations between income inequalities and risks of COPD-related admissions and readmissions among Canadian adults. Health inequalities by income have historically been examined in Canada using area-based approaches; the use of census linked datasets offers a more robust tool to advance understanding of gradients in health for specific conditions and outcomes [21]. The present results demonstrated a significant social gradient for household income on COPD admission risks. After controlling for age, sex, education and other socio-demographics, an independent association remained between the risk for potentially avoidable COPD hospitalization and relative household income. Compared with individuals in the most affluent income group, those in the lowest income quintile were nearly three times as likely to be hospitalized

Table 1: Adjusted odds ratios (and 95% confidence intervals) for the risk of COPD hospitalization and six-month readmission among the population 30–69 years

Predictor variable	(1)		(2)	
	Hospitalized at least once		Rehospitalized within six months	
Age (years)	1.12*	(1.12-1.13)	1.03*	(1.02-1.03)
Sex				
Male (ref)	1.00		1.00	
Female	0.97*	(0.95-0.99)	0.99	(0.94-1.05)
Household income group				
Quintile 1	2.92*	(2.77-3.09)	1.39*	(1.22-1.58)
Quintile 2	2.01*	(1.90-2.13)	1.15*	(1.00-1.31)
Quintile 3	1.74*	(1.64-1.85)	1.28*	(1.11-1.47)
Quintile 4	1.38*	(1.30-1.47)	1.17*	(1.00-1.36)
Quintile 5 (ref)	1.00		1.00	
Aboriginal identity				
Non-Aboriginal (ref)	1.00		1.00	
Aboriginal identity	1.56*	(1.48-1.64)	1.06	(0.94-1.18)
Marital status				
Currently married or in union	1.00		1.00	
Formerly married or in union	1.64*	(1.60-1.69)	1.18*	(1.11-1.26)
Never married or in union	1.34*	(1.29-1.40)	1.25*	(1.14-1.37)
Educational attainment				
Less than high school (ref)	1.00		1.00	
High school diploma	0.59*	(0.57-0.61)	0.88*	(0.82-0.94)
Post secondary diploma	0.56*	(0.53-0.57)	0.83*	(0.78-0.89)
University degree	0.24*	(0.23-0.26)	0.85*	(0.76-0.96)
Immigrant status				
Non-immigrant (ref)	1.00		1.00	
Foreign-born	0.37*	(0.35-0.38)	0.87*	(0.79-0.94)
Province of residence				
Newfoundland and Labrador	0.83*	(0.77-0.89)	1.06	(0.91-1.23)
Nova Scotia	0.87*	(0.82-0.92)	0.88*	(0.78-0.99)
New Brunswick/Prince Edward Island	1.17*	(1.11-1.23)	0.88*	(0.79-0.98)
Ontario (ref)	1.00		1.00	
Manitoba	0.72*	(0.68-0.76)	1.07	(0.94-1.22)
Saskatchewan	0.97	(0.91-1.02)	1.02	(0.91-1.16)
Alberta	1.00	(0.96-1.03)	0.80*	(0.73-0.87)
British Columbia	0.81*	(0.78-0.84)	1.20*	(1.11-1.30)

Note: *= $p < 0.05$; ref=reference group. Characteristics are those at the time of the census.

Source: Linked 2006 Census—2006/07–2008/09 DAD data (n=5620 persons admitted for COPD and 1580 readmitted within six-months among 2,407,090 census respondents with valid information for all variables of interest).

(OR: 2.92; 95% CI: 2.77–3.10), and those in the second lowest quintile were twice as likely (OR: 2.01; 95% CI: 1.90–2.13). Similarly, income was found to be an important predictor of the risk for six-month COPD readmission, albeit with a less pronounced gradient: compared with the wealthiest group, the odds of readmission remained significantly higher among those in the lowest income quintile (OR: 1.39; 95%CI: 1.22–1.58) and the second income quintile (OR: 1.15; 95%CI: 1.00–1.31).

These results add to the growing body of literature demonstrating significant associations between income inequalities and the risk of potentially avoidable hospitalization for chronic non-communicable diseases, even in contexts of publicly-funded universal healthcare coverage. Previous Canadian studies using linked datasets have found that hospitalizations for diabetes and other ACSCs were more likely

to be in the lowest household income quintile [3, 10, 15]. In England, socioeconomic deprivation was demonstrated to be one of the variables with the highest explanatory power in predicting COPD hospitalizations [22]. In Italy, an assessment of the relationship of income with the risk of ACSC-related hospitalizations found the strongest income gradient for COPD admissions, with a relative risk of 4.23 in the lowest income quintile compared with the highest quintile [23]. Such findings may reflect disparities in individuals' health literacy, lived experiences and ability to navigate the healthcare system, undiagnosed conditions, smoking cessation, among other unmeasured factors [22, 23].

Consistent with research elsewhere, the present findings found a protective influence of having a marital companion on odds of COPD hospitalization and readmission, which

may reflect social capital within a household and informal caregiving support for individuals to self-manage their disease, making them less susceptible to acute exacerbations [3, 16]. Our study demonstrated an inverse relationship between level of education and risk for COPD hospitalization – similar to evidence from the United States, where the hazard ratio was found to be 1.5 times higher for the lowest education group [24]. We also observed a protective role of immigrant status on adverse chronic disease outcomes, consistent with the literature on the “healthy immigrant effect” [25]. On the other hand, we found a person’s sex to be only somewhat associated with differences in COPD hospitalizations; international data from OECD countries pointed to men having a 53% higher hospitalization rate for COPD than women [12].

We did not control for tobacco use in our analyses, although smoking status is often included in both population- and clinical-based studies of COPD outcomes. This was related to the lack of information on behavioural risk factors in the census as well as the likely multi-collinearity between income and tobacco use. Moreover, research elsewhere has pointed to unexpected observations of the associations between smoking and acute cardiovascular-related outcomes (and other high-mortality problems), attributable to selective survival bias from the (unmeasured) earlier net probability of death from tobacco use before hospitalization in health assessments using population-based data [26, 27].

Study strengths and limitations

Certain limitations to this study should be taken into consideration when interpreting the results. Diagnostic misclassifications are possible in the administrative hospital records used here; while validation data indicate the most responsible diagnoses have tended to be well coded in the DAD overall, coding of comorbid diagnoses were frequently of poor quality [20]. For example, an individual may have a primary diagnosis as pneumonia, with COPD coded as the secondary diagnosis (or not at all), and so it is likely that not all individuals with COPD have been captured. Moreover, the present analysis was limited in its rehospitalization measure to a readmission within the six-month period following the first observed COPD admission; it is possible that multiple readmissions were underestimated and, in turn, any “dose response relationship” with income and the number of rehospitalizations was missed. It is also possible that an individual may have experienced a loss of income as a result of poor health, signifying that a prior hospitalization could itself be a driver of lower income.

Significantly, we lacked information on a number of variables which have been reported elsewhere to influence risk of COPD hospitalization, including smoking and other lifestyle behaviours, disease diagnosis in primary care, quantity and quality of ambulatory visits, severity of disease, and the number of comorbidities diagnosed in primary care. Previous studies have found comorbidities, which tend to be more prevalent among lower income individuals, as a particularly important factor influencing ACSC-related hospitalizations [3, 28]. It is also possible that COPD severity may be a mediating factor for income in terms of predictor for hospitalization [16, 24]. There is some evidence challenging the notion that improvements in ambulatory care will reduce COPD

hospitalizations. A study from Winnipeg, Canada, found little change in COPD hospitalizations when accounting for both patient socio-demographics as well as amount of ambulatory care use and characteristics of the usual physician [29]. In Vancouver, authors looking at predictors for readmission rates found that pre-admission treatment and post-discharge follow-up with either a family physician or respirologist was not significantly associated with risk of readmission [16]. On the other hand, research from England found that variances in COPD hospitalization rates could be partly explained by a quality of practice indicator, notably influenza immunization as an indicator for preventative care [22].

Despite these limitations, there are several strengths of the study worth highlighting. The data used comprised a large sample that can be generalized to the Canadian population, allowing sufficient information for assessing income inequalities in healthcare outcomes while controlling for education and other sociodemographic measures, offering broad applicability to support policy and planning. Second, the linking across population-based and administrative health datasets affords the opportunity to assess influences of a wide range of socio-demographics on cause-specific hospital admissions, which had historically been hindered by the lack of variables on patients’ social context in hospital discharge records. Third, the linked data allowed for detailed information on the relatively rare outcome event of a COPD readmission with little cohort loss to follow-up [30].

Conclusion

This study presented the first comprehensive national investigation into the associations between income inequalities and the cause-specific risk of hospitalization and the risk of six-month readmission for COPD among a population-representative cohort of Canadian adults. Due to the significant influence of income inequality on likelihood of potentially avoidable hospitalizations for COPD found in this study, it can be inferred that universal public health insurance in Canada continues to inadequately address the social determinants of health, widely postulated as crucial for reducing health inequalities and persistent unmet medical needs of the most vulnerable populations [31]. The exclusion of the long form in the 2011 quinquennial Canadian census [32], coupled with the widely acknowledged time lags between the collection and linkage of data sources and their readiness of use for research purposes [30], meant that only data from the 2006 census linked to the DAD were available at the time of this study. Given the emerging conflicting evidence regarding improvement in ambulatory care to prevent ACSC-related hospitalizations, future research should seek to better understand changes over time in hospital-based COPD outcomes and whether variations in the use of primary care and preventive services within and across income groups are able to explain the differences, and if so, which policy actions at the federal and provincial levels are most amenable to advancing health equity for all.

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Statement on conflicts of interest

The authors declare they have no competing interests.

Ethics statement

This study complied with the University of New Brunswick's Research Ethics Board, which does not require an additional institutional review for research projects using data accessed through the NB-RDC.

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Abbreviations

ACSC:	ambulatory care sensitive condition
CI:	confidence interval
COPD:	chronic obstructive pulmonary disease
DAD:	Discharge Abstract Database
ICD-10-CA:	International Classification of Diseases, Tenth Revision, Canada
OR:	odds ratio

