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Original Research

# Income Inequalities and Risk of Early Rehospitalization for Diabetes, Hypertension and Congestive Heart Failure in the Canadian Working-Age Population

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## Key Messages

- The role of patient social context on timings and patterns of rehospitalizations for diabetes is unclear, including in contexts of universal health-care coverage.
- This study found that Canadian adults in the highest income group gained delays in readmission for diabetes and selected concordant conditions.

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## ABSTRACT

**Objectives:** In the Canadian context of universal health-care coverage, income inequalities are understudied as potentially predictive of the timings and patterns of repeat hospitalizations for diabetes, despite this condition requiring self-care practices entailing appreciable out-of-pocket expenses in daily life. In this study, we examined the relationships between income disparities and risk of earlier readmission for diabetes and commonly comorbid chronic conditions in the working-age population.

**Methods:** The cohort study exploited 2006 population census data linked longitudinally to 3 years of hospital records from the Discharge Abstract Database among adults 25 to 64 years of age. Multiple regression survival models were used to test the associations of income group with cause-specific times to rehospitalization for diabetes (types 1 and 2) and 5 additional conditions, controlling for other individual sociodemographics.

**Results:** The mean time to rehospitalization for diabetes was 223 days (N=4,540). Compared with those in the lowest income quintile, the adjusted risk of earlier readmission was significantly lower among inpatients in the highest income quintile for diabetes (hazard ratio [HR]=0.89; 95% confidence interval [CI], 0.80 to 0.99) and for the diabetes-concordant conditions of congestive heart failure (HR=0.81; 95% CI, 0.66 to 0.99) and hypertension (HR=0.85; 95% CI, 0.76 to 0.95). No significant associations between income and readmission intervals were observed for the discordant conditions of angina, asthma and chronic obstructive pulmonary disease.

**Conclusions:** Delays in rehospitalization for diabetes and concordant conditions among the most affluent suggest the persistence of income-mediated differences in individuals' ability to manage these conditions. Further research is needed to understand the specific financial burdens of disease management on patients and their households that may accelerate the risk of repeat hospitalization.

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## R É S U M É

**Objectifs :** Dans le contexte canadien du régime universel d'assurance maladie, peu d'études ont porté sur le rôle potentiellement prédicteur des inégalités de revenus quant au moment et au schéma des hospitalisations répétitives en raison du diabète, en dépit des pratiques d'autosoins requises par cette maladie qui entraînent de menues dépenses appréciables au quotidien. Dans la présente étude, nous avons examiné les relations entre la disparité des revenus et le risque de réadmission hâtive en raison du diabète et d'affections chroniques souvent comorbides dans la population en âge de travailler.

**Méthodes :** L'étude de cohorte a permis d'exploiter les données du recensement de la population de 2006 liées longitudinalement à 3 années de dossiers hospitaliers de la Base de données sur les congés des patients, en l'occurrence des adultes de 25 à 64 ans. Nous avons utilisé les modèles de régression multiple (survie) pour vérifier les associations entre les groupes de revenu et les intervalles selon la cause avant la réhospitalisation, soit en raison du diabète (de types 1 et 2), soit en raison de 5 autres maladies, tout en tenant compte des autres caractéristiques sociodémographiques individuelles.

**Résultats :** L'intervalle moyen avant la réhospitalisation en raison du diabète était de 223 jours (N = 4540). Comparativement aux patients hospitalisés du quintile de revenu inférieur, le rapport de risque (RR) était significativement plus faible parmi les patients du quintile de revenu supérieur pour des réadmissions hâtives en raison du diabète (RR = 0,89; intervalle de confiance [IC] à 95 %, de 0,80 à 0,99) et en raison d'affections en concordance avec le diabète, soit l'insuffisance cardiaque (RR = 0,81; IC à 95 %, de 0,66 à 0,99) et l'hypertension (RR = 0,85; IC à 95 %, de 0,76 à 0,95). Nous n'avons observé aucune association significative entre le revenu et les intervalles de réadmission pour ce qui est des affections ne concordant pas avec le diabète, soit l'angine, l'asthme et la maladie pulmonaire obstructive chronique.

**Conclusions :** Les intervalles entre les réhospitalisations en raison du diabète et d'affections chroniques en concordance chez les plus riches suggèrent la persistance de différences attribuables aux revenus dans la capacité des individus à prendre en charge ces maladies. Des recherches plus approfondies sont nécessaires pour comprendre le fardeau financier de la prise en charge de la maladie par les patients et leur famille qui peut accélérer le risque de réhospitalisation répétitive.

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## Introduction

The concept of ambulatory care sensitive conditions (ACSCs) was described by Billings and colleagues as a group of conditions for which “timely and effective outpatient care can help reduce the risk of hospitalization by either preventing the onset of illness or condition, controlling an acute episodic illness or condition, or managing a chronic disease or condition” (1). A practical implication of this concept is the ability to use hospitalization data to help inform health-care decisions from preadmission to postdischarge care plans and monitor equitable access to preventive care, to help reduce the impacts diabetes mellitus and other chronic diseases have on health-care systems and quality of life for patients (2–5). Studies focussing on measures of continuity of care for ACSCs drawing on data from hospital records shed light on the burden of these high-cost events, but they also demonstrate how much remains unknown regarding differences in the risks and impacts of hospitalizations and of readmissions within and across countries (6–15). Rehospitalizations after an ACSC-related admission and live discharge are increasingly acknowledged as reflective of health system performance beyond in-hospital quality; however, there is a lack of consensus on the most reliable measurement of readmissions to support performance monitoring and accountability (16,17). Many patients first admitted for 1 ACSC are readmitted for another condition (17), and the time window between admissions is not consistently defined in the literature (15,16). Evidence is limited in the patient pathways for reasons for early rehospitalization, particularly with regard to patient characteristics that may lead to vulnerability during care transitions and help reduce preventable readmission rates (18).

It is possible that the ability of persons living with diabetes to self-manage their condition at home, as mediated by socioeconomic status, may predict increased health services use and risk of hospitalization and readmission (6,19). A growing number of

studies show that, even in contexts of universal health coverage, economically disadvantaged individuals have a disproportionate burden of disease compared with their more affluent counterparts, with the risks and severity of chronic morbidity, use of health-care resources and hospitalization rates increasing with decreasing income and other (objective or self-perceived) financial barriers to care (7,20–24). National health insurance systems do not always cover medical supplies for the self-management of diabetes, hypertension and certain other chronic ACSCs, such as blood glucose test strips or equipment for measurement of blood pressure at home; moreover, they are even less likely to consider the many nonmedical costs of essential self-care behaviours that may impact hospitalization risks and patterns, such as purchasing nutritious foods, having a safe and appropriate place to exercise and other lifestyle modifications (25,26). Although many studies have focussed on older populations, differentials in rehospitalizations for selected ACSCs have also been attributed to employment status, which is a factor that is salient among the population of working age (27). In addition, studies often capture socioeconomic status only indirectly through area-based measures because household income and other patient social characteristics are not routinely captured in hospital information systems (5,9,18,28).

In Canada, as in many other countries, new opportunities for research on the social determinants of hospitalizations and readmissions for ACSCs are being offered through the availability of household-based survey data linked to hospital records (12,21,29,30). Studies relying on linkable sample surveys are typically limited by small sample sizes that may preclude the ability to tease associations for cause-specific rehospitalizations; those exploiting linkable population censuses offer the unique advantage of being able to examine such high-cost, but statistically infrequent, events (7,31).

Specifically, time to rehospitalization for chronic ACSCs is a less investigated outcome of health system performance, and the social

determinants of early rehospitalization are especially so. In practice, the settings, causes and cutoffs of the observation periods for defining readmissions impact on the calculation of readmission risks (32,33). This prospective cohort study aimed to address the relatively unexplored relationship between income inequalities and timings of hospital readmissions for diabetes (types 1 and 2), hypertension and selected other ACSCs among the working-age population in the Canadian setting of universal health coverage, drawing on linked national census and hospital data sets. The use of this population-wide data resource offers methodologic advances over studies limited to readmissions to the same facility, which underestimate overall readmission rates (16). We hypothesized that higher income confers a protective effect for preventing earlier rehospitalizations in patients with diabetes, hypertension and congestive heart failure, linked to lower sensitivity to out-of-pocket expenses in daily life for prevention of complications. Hypertension and congestive heart failure were considered diabetes-concordant conditions, that is, having management plans with some overlap with the management of diabetes (34). Comparative analyses were conducted against time to rehospitalization for angina, asthma and chronic obstructive pulmonary disease (COPD), for which there are fewer clinically and empirically supported predictions for relatively high expenses for enhanced everyday self-management (i.e. centring more on avoidance, such as of triggers of symptoms and of tobacco smoking). These were considered as diabetes-discordant conditions, that is, for which observed pathophysiologic risk profile clusterings or management plans have minimal overlap with diabetes care (34,35).

## Methods

### Data sources

We took advantage of a novel data resource made available through the Statistics Canada Social Data Linkage Environment: the 2006 Canadian Population Census, linked longitudinally to 3 years of nationally standardized hospital records from the Discharge Abstract Database (DAD) for the fiscal years 2006/2007 to 2008/2009. The long-form census questionnaire, distributed to 20% of all households, collected information on income and other socio-demographic variables, such as place of residence, education and ethnic ancestry. The annual records in the DAD describe administrative and clinical data pertinent to each hospital stay; owing to Canada's universal financing system for essential medical and hospital services, the data on acute care hospitalizations are considered complete for 9 of Canada's 10 provinces (except Québec).

Based on a deterministic microdata linkage process, 5.3% of the 4.65 million census respondents were linked to at least 1 DAD record by fiscal year (36). Because each DAD record pertains to a hospital stay, individuals could be linked to multiple DAD records. The use of linked data sets provides a powerful approach to delve into the relationships between social contexts and hospital-based health outcomes, as health-care administrative records do not routinely capture information on socioeconomic factors, whereas population censuses have limited data collection on health. The identified data sets were accessed in the secure university-based computing facilities of the Statistics Canada Research Data Centre (RDC) network. The 2006 census-linked data were the latest available at the time of this study, given both the lack of a long form in the 2011 census and the expected delays in availability for research use of the most recent census data linked to multiple years of hospital records. Our study was in compliance with research ethics board guidelines at the University of New Brunswick, which do not require an additional institutional review for research projects using data accessed through the New Brunswick RDC.

### Study population

The analysis targeted Canadians between 25 and 64 years of age (at the time of the census) who experienced at least 2 acute care hospitalizations during the 3-year reporting period (based on the DAD) associated with chronic complications of diabetes, or with the diagnosed presence of hypertension, congestive heart failure, angina, asthma or COPD—the most widely investigated chronic ACSCs in adults (20). Previous research has highlighted that many inpatients with diabetes experience comorbid conditions, on average 3.8 diagnosed comorbidities, which may not be recorded as the primary reason for the admission (37). We included individuals whose discharge abstract recorded a condition of interest within the first 5 most responsible diagnoses, indicating the condition was either the most responsible clinical reason for the patients' length of stay or among the main secondary diagnoses for which an intervention may or may not have been performed during the stay.

Six inpatient cohorts hospitalized with ACSCs were identified by diagnostic category as mapped according to codes of the *International Classification of Diseases—tenth revision*, including complications of type 1 or type 2 diabetes (codes E10.1, E10.6, E10.7, E10.9, E11.0, E11.1, E11.6, E11.7, E11.9, E13.0, E13.1, E13.6, E13.7, E13.9, E14.0, E14.1, E14.6, E14.7, E14.9), angina (codes I20, I23.82, I24.0, I24.8, I24.9), asthma (J45), congestive heart failure (I50, J81), COPD (J41, J42, J43, J44, J47) and hypertension (I10.0, I10.1, I11) (38). Excluded from the analyses were discharge records for internal and external hospital transfers, records for childbirth, and records for any subsequent admissions beyond the first 2 that met our inclusion criteria.

### Time to rehospitalization

The outcome of interest was measured as the length of time (in days) between the discharge date of the first observed hospitalization (referred to as the index hospitalization) and the date of admission of a subsequent hospitalization for the same condition. Adjoining hospitalizations may be considered as an “episode of care” from a patient perspective (39). Because the novel research interest was on the timing rather than risk of readmission, individuals without a second cause-specific hospitalization were excluded. To focus on potentially avoidable rehospitalizations, and to minimize confounding factors related to palliative and end-of-life care, records that ended with patient death were also excluded. Research has supported the use of singular readmission measures, rather than composite measures such as readmission combined with mortality, as the latter may inadequately reflect health system performance and may be highly skewed by sex (40,41).

### Income inequality

We measured income as our key hypothesized predictor from census data based on the total after-tax income from all sources within the household, adjusted for household size and spatial differences associated with cost of living. Following previous research (7), individuals were assigned to income quintiles as a gauge of income adequacy, stratified within their geographic region: the Atlantic region (the provinces of Newfoundland and Labrador, Nova Scotia, Prince Edward Island and New Brunswick), Ontario (the most populous province) and the western region (the provinces of Manitoba, Saskatchewan, Alberta and British Columbia).

### Statistical analysis

Cox proportional hazard regression analyses were used to assess associations between income inequality and time to

rehospitalization for each ACSC in turn. All cause-specific models were adjusted for a series of individual-level sociodemographic characteristics widely associated with differentials in population health and health-care outcomes, including age group, sex, marital status, labour force status, education level, immigration status, Indigenous identity (including First Nations, Inuit and Métis peoples) and place of residence (rural or urban). Baseline characteristics at the time of the census were assumed to represent those at the time of readmission. Population counts were randomly rounded with Statistics Canada control algorithms to a base of 5 to ensure data privacy and confidentiality. Results of the regression models are expressed as hazard ratios (HRs) with 95% confidence intervals (CIs) (42,43).

## Results

### Descriptive analysis

A total of 71,780 individuals, aged 25 to 64 years, were found to have experienced at least one acute-care hospitalization for any of the 6 ACSCs during the observation period. Among these patients, 12,940 (18.0%) were hospitalized more than once. The number of inpatients with cause-specific index admissions ranged from 3,945 for asthma to 27,915 for hypertension (Table 1). The proportion of individuals rehospitalized with a given condition varied from 11.3% for angina-associated readmissions to 23.0% for diabetes-associated readmissions to 26.1% for COPD-associated readmissions. The mean (unadjusted) time to rehospitalization ranged from 172 days for congestive heart failure to 236 days for asthma, with diabetes at 223 days.

Individuals in the lowest income quintile were overrepresented in terms of ACSC-attributable rehospitalizations, accounting for at least one-fourth of each cohort (e.g. 26.3% of inpatients readmitted with angina), vs the expected 20% based on overall population distribution. Over one-third of the cohort readmitted with each of diabetes (35.1%), congestive heart failure (35.2%) and COPD (40.2%) were found in the lowest income group (Figure 1).

Such income–health gradients were further illustrated in the cause-specific rehospitalization rates, which were consistently higher among those in the lowest income quintile; for example, approximately 28% to 29% of low-income individuals were readmitted for diabetes, congestive heart failure or COPD as compared with 18% to 19% of those in the most affluent group (Table 2).

Other differentials in proportions rehospitalized by socio-demographic characteristics were also found. Females were readmitted somewhat more often than males for diabetes (24% vs 22%), but in similar proportions for hypertension (14% each) (Table 2). Those with less than secondary schooling had consistently higher readmission rates than did those with postsecondary education. Persons of Indigenous identity had markedly higher readmission rates than non-Indigenous persons for all 6 ACSCs under consideration—notably, 29% vs 21% for diabetes and 20% vs 13% for hypertension.

### Time to rehospitalization

Cox hazard regression analysis revealed that high income was associated with significantly reduced risk of earlier rehospitalization for inpatients with diabetes, hypertension or congestive heart failure, after controlling for other patient characteristics. Compared with those in the lowest income quintile, persons in the highest quintile showed efficacy benefit for diabetes-attributable readmissions (HR=0.89; 95% CI, 0.80 to 0.99;  $p<0.05$ ), hypertension-attributable readmissions (HR=0.85; 95% CI, 0.76 to 0.95) and congestive heart failure-attributable readmissions (HR=0.81; 95% CI, 0.66 to 0.99) (Table 3). For both diabetes and hypertension, relative hazard reductions compared with the least affluent group were seen across the 3 upper quintiles; however, no appreciable linear gradient was observed with each increasing wealth group. For example, regarding hypertension-related readmissions, the adjusted HR remained similar for those in the third, fourth and fifth quintiles (at 0.85). No significant differences in hazard reduction were found by income group for angina, asthma or COPD.

Other patient factors were associated with the time to rehospitalization, depending on the condition. Compared with females, males had a reduced risk of earlier rehospitalization for diabetes (HR=0.94; 95% CI, 0.89 to 1.00;  $p<0.05$ ), but a higher risk for congestive heart failure (HR=1.13; 95% CI, 1.01 to 1.25). Being married or in union was associated with prolonged time to readmission for each of diabetes and hypertension, all else being equal. The hazard of earlier rehospitalization was significantly greater among individuals identifying as Indigenous, compared with their non-Indigenous counterparts, for diabetes (HR=1.20; 95% CI, 1.10 to 1.30), hypertension (HR=1.33; 95% CI, 1.21 to 1.46), congestive heart failure (HR=1.33; 95% CI, 1.14 to 1.56) and COPD (HR=1.21; 95% CI, 1.05 to 1.40). Persons of working age who indicated they were not in salaried employment (including those who were self-employed or unpaid) had significantly higher HRs than did salaried employees for readmissions related to diabetes (HR=1.26; 95% CI, 1.18 to 1.34), hypertension (HR=1.18; 95% CI, 1.10 to 1.26) and congestive heart failure (HR=1.24; 95% CI, 1.10 to 1.40), but not asthma (HR=1.09; 95% CI, 0.88 to 1.35).

Rural residence was associated with an increased risk of earlier readmission for hypertension (HR=1.11; 95% CI, 1.03 to 1.19) and angina (HR=1.32; 95% CI, 1.14 to 1.53). Not surprisingly, younger adults tended to be at less risk of earlier readmission for congestive heart failure, hypertension and COPD compared with those aged 55 to 64 years. A significant age gradient was not seen for diabetes-associated readmissions, which may include inpatients diagnosed with either type 1 or type 2 diabetes.

## Discussion

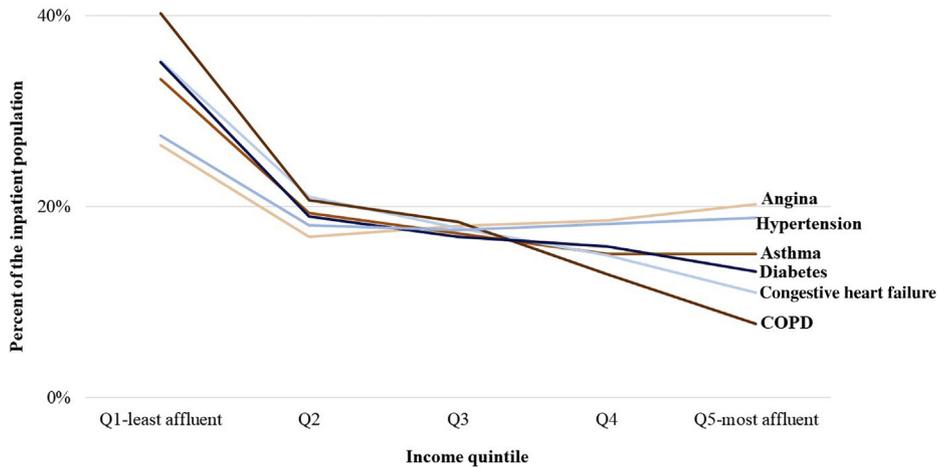
This study represents, to our knowledge, the first national cohort study of income inequalities as a driver of time to rehospitalization for diabetes and other common ACSCs among the working-age population in Canada. We quantified the role of

**Table 1**  
Population aged 25 to 64 years hospitalized and rehospitalized for diabetes and selected concordant and discordant ambulatory care sensitive conditions

	Angina	Asthma	CHF	COPD	Diabetes (types 1 and 2)	Hypertension
Number hospitalized at least once	7,935	3,945	5,550	6,675	19,740	27,915
Number readmitted	895	470	1,410	1,740	4,540	3,885
Proportion readmitted	11.3%	11.9%	25.4%	26.1%	23.0%	13.9%
Mean time to rehospitalization (days)	180	236	172	222	223	213

CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

Note: Cohorts reflect individuals whose discharge abstract recorded the same condition within the first 5 most responsible diagnoses for the index and subsequent hospital stays. Source: Linked 2006 Census–2006/2007–2008/2009 Discharge Abstract Database data sets (data exclude residents of Québec and the territories).



**Figure 1.** Distribution of inpatients aged 25 to 64 years readmitted with selected ambulatory case sensitive conditions by income quintile. The cohorts reflect individuals whose discharge abstract recorded the same condition within the first 5 most responsible diagnoses for the index and subsequent hospital stays. Source: Linked 2006 Census–2006/2007–2008/2009 Discharge Abstract Database data sets. COPD, chronic obstructive pulmonary disease; Q1–Q5, quintiles 1–5.

income inequalities as an important predictor of earlier readmissions for diabetes and selected concordant conditions, even in the Canadian context of universal coverage for primary care physician services. Based on population-wide linked census and hospital data, and after controlling for age, sex and other socio-demographics, the time between potentially avoidable hospitalizations was found to be significantly reduced for inpatients in the most affluent income quintile compared with their least affluent

counterparts for readmissions associated with each of diabetes (HR=0.89; 95% CI, 0.80 to 0.99), hypertension (HR=0.85; 95% CI, 0.76 to 0.95) and congestive heart failure (HR=0.81; 95% CI, 0.66 to 0.99). Conversely, no significant associations between income inequality and timing of rehospitalizations were found for the diabetes-discordant conditions of angina, asthma and COPD.

These results support notions that an income threshold exists for which out-of-pocket expenses for daily self-management of

**Table 2**  
Percent of inpatient population aged 25 to 64 years rehospitalized, by cause, according to select socioeconomic and demographic characteristics

	Angina (n=895)	Asthma (n=740)	CHF (n=1,410)	COPD (n=1,740)	Diabetes (n=4,540)	Hypertension (n=3,885)
<b>Income quintile</b>						
Q1 (least affluent)	14.2%	14.6%	29.0%	29.3%	27.8%	17.4%
Q2	10.9%	11.8%	26.5%	27.3%	23.1%	14.5%
Q3	10.5%	11.9%	25.5%	26.1%	20.6%	13.0%
Q4	10.4%	9.3%	22.3%	22.6%	20.3%	12.4%
Q5 (most affluent)	10.1%	9.9%	19.3%	18.0%	19.7%	12.1%
<b>Sex</b>						
Female	12.5%	12.7%	24.8%	27.3%	24.1%	14.2%
Male	10.9%	9.9%	25.7%	24.8%	21.8%	13.7%
<b>Marital status</b>						
Married or in union	11.0%	11.3%	24.4%	24.3%	21.9%	13.4%
Formerly married	12.8%	11.9%	26.8%	29.1%	24.0%	15.9%
Never married	11.0%	14.0%	27.9%	28.0%	26.7%	14.4%
<b>Highest level of education</b>						
Less than high school	13.9%	13.9%	29.5%	29.3%	25.9%	16.5%
High school diploma	9.1%	12.6%	23.1%	23.7%	22.5%	13.1%
Postsecondary	10.8%	11.0%	23.0%	23.4%	21.0%	12.8%
<b>Immigration status</b>						
Non-immigrant	11.8%	12.3%	26.2%	26.5%	24.2%	14.4%
Immigrant	9.2%	10.0%	21.7%	23.2%	17.4%	12.2%
<b>Indigenous self-identity</b>						
Non-Indigenous	10.7%	11.2%	23.7%	25.3%	21.1%	12.9%
Indigenous	15.1%	15.1%	34.0%	30.3%	29.1%	20.1%
<b>Labour force status</b>						
Paid employment	9.7%	10.8%	21.0%	19.3%	20.6%	12.2%
Self-employed/unpaid	13.6%	13.5%	28.9%	31.1%	26.4%	16.4%
<b>Place of residence</b>						
Urban	9.9%	11.2%	23.4%	25.9%	21.2%	12.7%
Rural	14.0%	13.6%	29.1%	26.1%	26.0%	16.4%
<b>Age group</b>						
25–34 years	15.4%	13.3%	23.1%	9.5%	25.7%	12.0%
35–44 years	9.7%	11.2%	19.2%	18.6%	24.2%	12.3%
45–54 years	11.3%	11.3%	23.0%	21.4%	23.2%	12.8%
55–64 years	11.5%	11.6%	27.0%	28.5%	22.2%	14.7%

CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease. Source: Linked 2006 Census–2006/2007–2008/2009 Discharge Abstract Database data sets.

**Table 3**  
Adjusted hazard ratios (and 95% CIs) from Cox regression analyses for predictors of time to rehospitalization among the inpatient population aged 25 to 64 years

	Angina	Asthma	CHF	COPD	Diabetes	Hypertension
Income quintile (ref: Q1—least affluent)						
Q2	0.85 (0.69–1.05)	0.81 (0.62–1.06)	0.99 (0.85–1.15)	1.03 (0.90–1.18)	0.92 (0.84–1.00)	0.91 (0.82–1.00)
Q3	0.85 (0.69–1.06)	0.85 (0.63–1.13)	1.06 (0.90–1.25)	1.09 (0.95–1.26)	0.86 * (0.78–0.94)	0.85 * (0.77–0.95)
Q4	0.92 (0.74–1.14)	0.74 (0.55–1.05)	0.90 (0.75–1.07)	0.97 (0.82–1.14)	0.89 * (0.80–0.98)	0.85 * (0.77–0.95)
Q5—most affluent	0.89 (0.71–1.11)	0.76 (0.55–1.05)	0.81 * (0.66–0.99)	0.85 (0.70–1.04)	0.89 * (0.80–0.99)	0.85 * (0.76–0.95)
Sex (ref: female)						
Male	0.92 (0.80–1.06)	0.75 * (0.60–0.93)	1.13 * (1.01–1.25)	0.95 (0.86–1.05)	0.94 * (0.89–1.00)	1.00 (0.94–1.07)
Marital status (ref: married or in union)						
Formerly married	1.07 (0.89–1.29)	0.88 (0.67–1.53)	1.05 (0.92–1.21)	1.12 (1.00–1.26)	1.03 (0.95–1.11)	1.10 * (1.01–1.20)
Never married	0.98 (0.75–1.28)	1.21 (0.95–1.55)	1.13 (0.97–1.32)	1.19 * (1.02–1.39)	1.13 * (1.04–1.23)	1.02 (0.91–1.14)
Highest level of education (ref: less than high school)						
High school diploma	0.72 * (0.59–0.88)	1.02 (0.79–1.33)	0.92 (0.80–1.07)	0.87 * (0.76–0.98)	0.99 (0.91–1.08)	0.94 (0.86–1.03)
Postsecondary	0.89 (0.76–1.04)	0.94 (0.75–1.19)	0.90 (0.80–1.02)	0.86 * (0.77–0.96)	0.95 (0.88–1.02)	0.93 (0.86–1.00)
Immigration status (ref: non-immigrant)						
Immigrant	0.88 (0.73–1.07)	0.90 (0.67–1.19)	0.92 (0.79–1.07)	0.90 (0.76–1.05)	0.81 (0.74–0.88)	0.99 (0.91–1.08)
Indigenous self-identity (ref: non-Indigenous)						
Indigenous	1.16 (0.95–1.42)	1.20 (0.92–1.57)	1.33 * (1.14–1.56)	1.21 * (1.05–1.40)	1.20 * (1.10–1.30)	1.33 * (1.21–1.46)
Labour force status (ref: paid employment)						
Self-employed/unpaid	1.27 * (1.10–1.47)	1.09 (0.88–1.35)	1.24 * (1.10–1.40)	1.51 * (1.35–1.68)	1.26 * (1.18–1.34)	1.18 * (1.10–1.26)
Place of residence (ref: urban)						
Rural	1.32 * (1.14–1.53)	1.04 (0.83–1.30)	1.09 (0.96–1.24)	0.94 (0.84–1.05)	1.04 (0.97–1.12)	1.11 * (1.03–1.19)
Age group (ref: 55–64 years)						
25–34 years	0.86 (0.38–1.92)	1.05 (0.79–1.39)	0.84 (0.57–1.23)	0.38 * (0.21–0.67)	1.12 (0.99–1.27)	0.72 * (0.56–0.93)
35–44 years	0.84 (0.64–1.11)	0.93 (0.72–1.22)	0.65 * (0.51–0.84)	0.66 * (0.51–0.85)	1.02 (0.93–1.12)	0.80 * (0.71–0.90)
45–54 years	1.01 (0.87–1.17)	0.95 (0.74–1.22)	0.87 * (0.76–0.99)	0.77 * (0.69–0.87)	1.05 (0.98–1.12)	0.89 * (0.83–0.96)

CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; ref, reference category.

\*  $p < 0.05$ .

Source: Linked 2006 Census–2006/2007–2008/2009 Discharge Abstract Database data sets.

diabetes, hypertension and congestive heart failure outside of primary care delivery become increasingly meaningful. The findings are consistent with other studies indicating that self-care adherence to mitigate disease progression and severity for these ACSCs may be particularly dependent on lifestyle factors that may be less accessible to lower income individuals, such as food security (21,44).

Our results indicate that persons of working age who were in salaried employment had significantly lower adjusted risks of earlier rehospitalization for diabetes and concordant conditions compared with nonsalaried individuals. Employed Canadians may have fewer financial barriers not tied to income to manage their chronic conditions, such as supplemental insurance for medications and other outpatient services not covered by the public system (21). A study from Denmark, another context of universal health-care coverage, linked employment with decreased rehospitalization risks for congestive heart failure, possibly related to income but also indirect benefits for well-being and quality of life (27). We found further evidence of poorer health outcomes associated with diabetes and other ACSCs among Canadians identifying as Indigenous, echoing research elsewhere, as attributed to a wide range of political, cultural, economic and social factors (45,46). Early readmissions among Indigenous Australian hospitalized patients have been attributed to social isolation, high incidence of self-discharge against medical advice and relative socioeconomic disadvantage (47).

#### Strengths and limitations of the study

A key strength of this study is the use of population-based linked census and medical-administrative data sets to identify measures of the social context of patients rehospitalized for diabetes and other commonly comorbid chronic diseases using continuous time data. Although some studies have used linked sample survey and administrative data, the census alone offered the statistical power to comprehensively examine timings of cause-specific rehospitalizations. Moreover, because many persons with

ACSCs have multiple morbidities, we did not limit identification of relevant hospital events to those based solely on the primary diagnosis for the length of stay, but extended the data capture to the first 5 diagnosis fields in each hospital record.

Attention is increasingly being paid to preventable hospital readmissions as the “low-hanging fruit” for diabetes management assessment (7); however, there is a lack of consensus in the literature on which metric best represents early readmissions (e.g. often focussing on the risk of readmission within 7 days, 1 month or 2 months) or late readmissions (e.g. within 6 months, 1 year or 3 years). This study has added to the growing evidence describing factors that may contribute to the timing of a readmission, which could help support interventions for reducing readmissions, but it has not accounted for all potential sources of bias, such as severity of disease, clinical history, length of the initial hospital stay, postdischarge support and transition of care, health literacy, use of emergency department services and in-hospital mortality, which may hamper generalizability of the results to the whole inpatient population. In particular, the data did not capture equal representations of readmissions by ACSC diagnostic category. Although we hypothesized that income inadequacy could mediate the capability of patients with certain chronic conditions to adhere to self-care practices, a major limitation was our inability to investigate the associations of behavioural and lifestyle factors due to the absence of such information in the census. A large body of literature has shown that poor dietary intake, physical inactivity and tobacco smoking are themselves closely correlated with low-income status. Use of population-based data has allowed us to track individuals' admissions across facilities; however, readmissions may have been underestimated due to right-censoring of the observational data. We also acknowledge there could be concern raised about reverse causality, because recurrent hospitalizations may impact an individual's income-earning opportunities.

In conclusion, our study strengthens the evidence base on the social determinants of hospital-based diabetes health outcomes and reinforces the notion that social policy should be an integral component of health services infrastructure for diabetes and concordant conditions, notably in terms of the relatively

unknown outcome of timing of potentially avoidable repeat hospitalizations among the working-age population. Opportunities for evidence-informed policymaking have been hindered by limited profiling of the characteristics and temporal patterns of rehospitalized patients, including predictors of shorter vs longer interval readmissions (15). We found that the ability of Canadians aged 25 to 64 years to manage their health and potentially delay rehospitalization for diabetes, hypertension and congestive heart failure is sensitive to their income group membership. Being in the wealthiest income quintile was protective against earlier readmission for these 3 conditions, but not for other conditions with presumably fewer daily self-care expenditures, including angina, asthma and COPD. Our models were based on inpatient data from 2006 to 2009; it remains difficult to predict how prevention and treatment interventions to positively impact glycemic management and cardiometabolic health will influence future population profiles for risk of complications and hospitalizations for diabetes (48). More research is needed to understand whether an income threshold could help predict longer readmission intervals for diabetes and other chronic ACSCs, how the causal pathways differ from absolute readmission risks at different cut points and over time, and whether the patterns hold in the context of both single-payer and mixed health-care financing systems.

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### Author Disclosures

Conflicts of interest: None.

### Author Contributions

N.G., P.S.J.L. and E.C. contributed to the study design and methodology. E.C. prepared the data and performed the data analyses and also prepared the first draft of the manuscript. All authors contributed to interpretation of the results and provided critical revisions to the manuscript. All authors read and approved the final version submitted for publication.

### References

- Billings J, Zeitel L, Lukomnik J, Carey TS, Blank AE, Newman L. Impact of socioeconomic status on hospital use in New York City. *Health Aff (Millwood)* 1993;12:162–73.
- Billings J, Anderson GM, Newman LS. Recent findings on preventable hospitalizations. *Health Aff (Millwood)* 1996;15:239–49.
- Gibson OR, Segal L, McDermott RA. A systematic review of evidence on the association between hospitalisation for chronic disease related ambulatory care sensitive conditions and primary health care resourcing. *BMC Health Serv Res* 2013;13:1–13.
- Monette M. Hospital readmission rates under the microscope. *CMAJ* 2012;184:E651–2.
- Buttigieg SC, Abela L, Pace A. Variables affecting hospital length of stay: A scoping review. *J Health Organ Manag* 2018;32:463–93.
- Bennett KJ, Probst JC, Vyavaharkar M, Glover SH. Lower rehospitalization rates among rural Medicare beneficiaries with diabetes. *J Rural Health* 2012;28:227–34.
- Gupta N, Crouse DL, Balram A. Individual and community-level income and the risk of diabetes rehospitalization among women and men: A Canadian population-based cohort study. *BMC Public Health* 2020;20:1–9.
- Gusmano M, Rodwin V, Weisz D, Cottenet J, Quantin C. Comparison of rehospitalization rates in France and the United States. *J Health Serv Res Policy* 2015;20:18–25.
- Roos LL, Walld R, Uhanova J, Bond R. Physician visits, hospitalizations, and socioeconomic status: Ambulatory care sensitive conditions in a Canadian setting. *Health Serv Res* 2005;40:1167–85.
- Weinberger M, Oddone EZ, Henderson WG. Does increased access to primary care reduce hospital readmissions? *N Engl J Med* 1996;334:1441–7.
- Robbins JM, Webb DA. Diagnosing diabetes and preventing rehospitalizations—The Urban Diabetes Study. *Med Care* 2006;44:292–6.
- Waller LE, Rosella LC. Risk factors for avoidable hospitalizations in Canada using national linked data: A retrospective cohort study. *PLoS One* 2020;15:e0229465.
- Mulpuru S, McKay J, Ronksley P, Thavorn K, Kobewka D, Forster AJ. Factors contributing to high-cost hospital care for patients with COPD. *Int J COPD* 2017;12:989–95.
- Ng E, McGrail KM, Johnson JA. Hospitalization risk in a type 2 diabetes cohort. *Health Rep* 2010;21:8.
- Liu X, Liu Y, Lv Y, Li C, Cui Z, Ma J. Prevalence and temporal pattern of hospital readmissions for patients with type I and type II diabetes. *BMJ Open* 2015;5:e007362.
- Fischer C, Lingsma HF, Marang-van de Mheen PJ, Kringos DS, Klazinga NS, Steyerberg EW. Is the readmission rate a valid quality indicator? A review of the evidence. *PLoS One* 2014;9:e112282.
- Porter J, Herrington J, Lacroix J, Levinton C. Avoidable admissions and repeat admissions: What do they tell us? *Healthc Q* 2007;10:26–8.
- Harhay M, Lin E, Pai A, et al. Early rehospitalization after kidney transplantation: Assessing preventability and prognosis. *Am J Transplant* 2013;13:3164–72.
- Grintsova O, Maier W, Mielck A. Inequalities in health care among patients with type 2 diabetes by individual socio-economic status (SES) and regional deprivation: A systematic literature review. *Int J Equity Health* 2014;13:43.
- Agabiti N, Pirani M, Schifano P, et al. Income level and chronic ambulatory care sensitive conditions in adults: A multicity population-based study in Italy. *BMC Public Health* 2009;9:1–8.
- Campbell DJT, Manns BJ, Weaver RG, Hemmelgarn BR, King-Shier KM, Sanmartin C. Financial barriers and adverse clinical outcomes among patients with cardiovascular-related chronic diseases: A cohort study. *BMC Med* 2017;15:33.
- Fujita M, Sato Y, Nagashima K, Takahashi S, Hata A. Income related inequality of health care access in Japan: A retrospective cohort study. *PLoS One* 2016;11:e0151690.
- Khalil D, Corsten MJ, Holland M, Balram A, McDonald JT, Johnson-Obaseki S. Does socioeconomic status affect stage at presentation for larynx cancer in Canada's universal health care system? *Otolaryngol Neck Surg* 2019;160:488–93.
- Lysy Z, Booth GL, Shah BR, Austin PC, Luo J, Lipscombe LL. The impact of income on the incidence of diabetes: A population-based study. *Diabetes Res Clin Pract* 2013;99:372–9.
- Riddle MC, Herman WH. The cost of diabetes care—An elephant in the room. *Diabetes Care* 2018;41:929–32.
- Shrivastava SR, Shrivastava PS, Ramasamy J. Role of self-care in management of diabetes mellitus. *J Diabetes Metab Disord* 2013;12:1–5.
- Rørth R, Fosbøl EL, Mogensen UM, et al. Employment status at time of first hospitalization for heart failure is associated with a higher risk of death and rehospitalization for heart failure. *Eur J Heart Fail* 2018;20:240–7.
- Amin L, Shah BR, Bierman AS, et al. Gender differences in the impact of poverty on health: Disparities in risk of diabetes-related amputation. *Diabet Med* 2014;31:1410–7.
- Sanmartin CA, Khan S, LHAD Research Team. Hospitalizations for Ambulatory Care Sensitive Conditions (ACSC): The Factors That Matter. Ottawa: Statistics Canada, 2011. Health Research Working Paper No. 007.
- Waller LE, Rosella LC. Individual and neighbourhood socioeconomic status increase risk of avoidable hospitalizations among Canadian adults: A retrospective cohort study of linked population health data. *Int J Popul Data Sci* 2020;5:1–15.
- Quinn N, Gupta N. Income inequalities in the risk of potentially avoidable hospitalisation and readmission for chronic obstructive pulmonary disease: A population data linkage analysis. *Int J Popul Data Sci* 2020;5:1–8.

32. Ruff C, Gerharz A, Groll A, et al. Disease-dependent variations in the timing and causes of readmissions in Germany: A claims data analysis for six different conditions. *PLoS One* 2021;16:e0250298.
33. Heggstad T. Measuring readmissions: Focus on the time factor. *Int J Qual Health Care* 2003;15:147–54.
34. Petrosyan Y, Bai YQ, Koné Pefoyo AJ, et al. The relationship between diabetes care quality and diabetes-related hospitalizations and the modifying role of comorbidity. *Can J Diabetes* 2017;41:17–25.
35. Chidumwa G, Maposa I, Corso B, et al. Identifying co-occurrence and clustering of chronic diseases using latent class analysis: Cross-sectional findings from SAGE South Africa Wave 2. *BMJ Open* 2021;11:e041604.
36. Rotermand M, Sanmartin C, Trudeau R, St-Jean H. Linking 2006 Census and hospital data in Canada. *Health Rep* 2015;26:13.
37. Wielgosz A, Dai S, Walsh P, McCrea-Logie J, Celebican E. Comorbid conditions in Canadians hospitalized because of diabetes. *Can J Diabetes* 2018;42:106–11.
38. Fransoo R, Martens P, et al. The 2013 RHA Indicators Atlas. Winnipeg: Manitoba Centre for Health Policy, 2013.
39. Canadian Institute for Health Information. All-cause Readmission to Acute Care and Return to the Emergency Department. Ottawa: Canadian Institute for Health Information, 2012.
40. Hoang-Kim A, Parpia C, Freitas C, et al. Readmission rates following heart failure: A scoping review of sex and gender based considerations. *BMC Cardiovasc Disord* 2020;20:223.
41. Gance LG, Li Y, Dick AW. Impact on hospital ranking of basing readmission measures on a composite endpoint of death or readmission versus readmissions alone. *BMC Health Serv Res* 2017;17:1–9.
42. Greenland S, Senn SJ, Rothman KJ, et al. Statistical tests, P values, confidence intervals, and power: A guide to misinterpretations. *Eur J Epidemiol* 2016;31:337–50.
43. Sashegyi A, Ferry D. On the interpretation of the hazard ratio and communication of survival benefit. *Oncologist* 2017;22:484–6.
44. Pilkington FB, Daiski I, Bryant T, Dinca-Panaitescu M, Dinca-Panaitescu S, Raphael D. The experience of living with diabetes for low-income Canadians. *Can J Diabetes* 2010;34:119–26.
45. Adelson N. The embodiment of inequity: health disparities in Aboriginal Canada. *Can J Public Health* 2005;96(Suppl. 2):S45–61.
46. Beckett M, Firestone MA, McKnight CD, Smylie J, Rotondi MA. A cross-sectional analysis of the relationship between diabetes and health access barriers in an urban First Nations population in Canada. *BMJ Open* 2018;8:e018272.
47. Sharma Y, Miller M, Kaambwa B, et al. Factors influencing early and late readmissions in Australian hospitalised patients and investigating role of admission nutrition status as a predictor of hospital readmissions: A cohort study. *BMJ Open* 2018;8:e022246.
48. Bilandzic A, Rosella L. The cost of diabetes in Canada over 10 years: Applying attributable health care costs to a diabetes incidence prediction model. *Health Promot Chronic Dis Prev Can* 2017;37:49–53.