Hip Fractures in Older Adults in Ontario, Canada—Monthly Variation, Insights, and Implications

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Abstract

Background

In older adults, hip fractures have been described to peak in cooler months. Seasonal differences in patient vulnerability to fracture and social/behavioural factors might contribute to these trends.

Methods

Using linked health-care databases in Ontario Canada, we examined monthly variation in hip fracture hospitalizations in those > 65 years (2011–2015). We stratified results by age category (66-79, ≥80 years). We then examined for variation in the demographic and comorbidity profiles of patients across the months, and as an index of contributing social/behavioural factors, noted variation in health-care behaviours.

Results

There were 47,971 and 52,088 hospitalizations for hip fracture in those 66–79, and ≥80 years, respectively. There was strong seasonality in fractures in both groups. Peaks occurred in October and December when patients appeared most vulnerable. Rates fell in the summer in those 66-79 years, and in the late winter in those ≥80 years (when health-care utilization also declined). A smaller peak in fractures occurred in May in both groups.

Conclusions

Hip fractures peak in the autumn, early winter, and spring in Canada. A dip in fractures occurs in the late winter in the oldest old. Environmental factors might play a role, but seasonal vulnerability to fracture and winter isolation might also be influential.

Key words: hip fractures, trends, variation, elderly

Introduction

Hip fractures can have catastrophic outcomes for older adults.[1] They lead to pain, loss of function, institutionalization, and even death.[2,3] With our aging population, hip fractures will continue to be a population health problem.

In Canada, there have been increased efforts to both prevent and improve the care and outcomes of patients with hip fractures.[4,5] In this setting, a thorough understanding of the risk factors for these fractures remains important.

The seasonality of health outcomes can provide insights about the etiology of disease, as well as help care professionals and policy makers anticipate and prepare for outcomes.[6] Where seasonal trends in hip fractures have been described across geographic regions previously, peaks were observed in cooler months.[7–9] Slippery surfaces due to freezing temperatures, and vitamin D deficiency due to lack of sunlight, have been proposed as contributors to these trends.[7,9–11] However, non-weather factors might also partly explain hip fracture trends. People might be more vulnerable to falls at different times of year due to underlying illness or comorbidities such as infections. Seasonal variation in fracture rates might also be driven by temporal differences in social or behavioural factors.[6] Patients, for example, might avoid or be unable to receive health care during particular times of the year (e.g., the holidays),[12] which could impact their susceptibility to health outcomes. Additionally, if people travel outside a region at different times of the year (i.e., seasonal migration from cold to warm climates),[12] their fractures might not be ascertainable in research studies.

There has been no recent evaluation of monthly variation in hip fractures in older adults in Canada. In the current study we provide an updated assessment of fracture trends in those >65 years in the province of Ontario. We hypothesized

that hip fractures would be most common during the cooler months. To examine potential reasons for seasonal variation in hip fractures, we ascertained the demographic characteristics and comorbidity profiles of patients with fractures over the months. To determine whether social or behavioural factors might influence fracture trends, we also examined variations in health-care utilization including visits to health-care professionals, blood tests, and prescription medication dispensing.

METHODS

Study Design and Setting

We conducted a population-based study of adults age >65 years in Ontario, Canada from January 1 2011 until December 31 2015. We divided our study period into one-month intervals.

Ontario is a northern region between the 42nd and 57th latitudes, with cold winters and subzero temperatures. We have over 13 million residents who have universal coverage for hospitalizations, physician visits, and diagnostic testing. [13] People aged ≥65 years have universal access to prescription medications. Information on their health-care utilization is maintained in databases held at ICES. Databases are linked using unique, encoded identifiers. We report our study using the RECORD recommendations (Appendix A). [14]

Our study was approved by the research ethics board at Sunnybrook Health Sciences Centre (Toronto, Ontario) and was analyzed at ICES according to a pre-specified protocol. Participant consent was not necessary as ICES is a named entity under Ontario's Personal Health Information Protection Act, and is able to receive and use health information to examine the province's health-care system.

Patients

We considered for inclusion all adults >65 years with a hospitalization for a hip fracture over the study period (defined as at least one code for a hip fracture during an inpatient hospital stay). Our coding algorithm for hip fracture included diagnostic and medical billing codes, [15] similar to one validated previously (positive predictive value 83%, sensitivity 99%) [16] (Appendix B).

Prior to each study interval, we excluded the records of those: 1) with a missing age, sex or an invalid identification number, 2) an extreme or invalid age (negative age or age >105), 3) who died on or before the study interval, or 4) who were not permanent residents of Ontario (i.e., did not have an Ontario residential postal code at the time of hospitalization). If patients had more than one encounter for a hip fracture over the study interval (i.e., month), we included only their first hospitalization.

Data Sources

We used the records of several databases as our data sources. A full description of each database is included in Appendix C.

In brief, the Registered Persons Database of Ontario provided demographic information for people who had been issued an Ontario health card. We used the Yearly Ontario Intercensal and Postcensal Population Estimates and Projection database to determine population denominators (Ontario Ministry of Health and Long-Term Care: IntelliHEALTH Ontario). We used the Ontario Drug Benefit (ODB) and the Drug Identification Number (DIN) databases to ascertain prescription medications. Prescription records are accurately maintained within the ODB with an error rate < 1%. [17] We assessed baseline comorbidities using the Ontario Diabetes Database (ODD), [18] the Ontario Chronic Obstructive Pulmonary Disease, [19] Rheumatoid Arthritis, [20] and Crohn's and Colitis Datasets. [21] Home care visits were captured using the Home Care Database, and physician visits were ascertained using the ICES Physician Database. We used the Canadian Institute for Health Information's Discharge Abstract Database (CIHI-DAD) and the National Ambulatory Care Reporting System (NACRS) Database to collect diagnostic and procedural information captured during hospital admissions and emergency department visits, respectively. We additionally used the Ontario Health Insurance Plan (OHIP) Database to capture patient diagnoses and procedures.

Covariates and outcomes were ascertained by a patient's presence in a derived database (e.g., the ODD), or administrative codes (Appendix D). Administrative codes are entered into databases including the CIHI-DAD and NACRS by trained personnel, based upon diagnoses recorded in the medical record by the health-care team. We used International Classification of Diseases 10th Revision (ICD-10), the enhanced Canadian version of the 10th Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10 CA), Canadian Classification of Health Interventions (CCI, post-2002), and OHIP fee and diagnostic codes.

Outcomes

Our primary outcome was monthly variation in hip fracture hospitalizations in those >65 years. Because the risk of osteoporosis and hip fracture is highest in the oldest old (i.e., ≥80 years), [22] we stratified trends by age group (i.e., 66–79, ≥80 years).

We performed several additional analyses. We noted monthly variation in the demographic characteristics, comorbidity profiles, and health-care utilization of patients with fractures between September 2012 and August 2013 (study midpoint). We also examined trends in prescription medication dispensing for statins, as statins are the most commonly prescribed medication to older adults in Canada. [23] Finally, to evaluate if seasonality in hip fractures might be due to older adults leaving our region over particular months of the year (i.e., 'snowbirding'), [24] we examined monthly variation in travel supplies for statins (i.e., a prescription dispensed for >100 tablets), over the study period. [25]

Statistical Analysis

Numerators were the number of patients with at least one hospital encounter with a hip fracture over the study period, stratified by age. Denominators for all months were the estimated population of Ontario on July 1st of the relevant year in the age strata. To consider population changes over time, we calculated monthly encounter rates and their associated 95% confidence intervals (CI).

Based upon prior methods,[6] we used time series analyses to assess for seasonality in hip fractures, as well as the strength of the relationship. We first visualized the raw data and then fitted regression lines to detect trends. We then used differencing methods to ensure data stationarity. Next, we used spectral analyses to detect statistically significant seasonality, the Fisher Kappa Test to determine if there was a major sinusoidal component, and the Bartlett Kolmogorov Smirnov Test to examine departures from the null hypothesis of pure white noise. We also examined spectral plots of the data (i.e., spectral density vs. data frequency) to identify the cyclic structure of the series, and we conducted multitaper spectral analyses. To examine the strength of the seasonal relationships, we generated R^2 autoregression coefficients, which are the coefficients of determination of the autoregressive regression models fitted to the data. Coefficients of 0 to < 0.4 represent weak seasonality, 0.4 to < 0.7 moderate to strong, and 0.7 to 1 very strong to perfect seasonality.[6,26]

We used descriptive statistics to summarize the characteristics, comorbidities, and health-care patterns of patients with a hip fracture from September 2012 until August 2013. If they had more than one encounter that year, we ascertained characteristics at the time of their first encounter only. We used Chi-squared analyses, one-way ANOVA, and Kruskal-Wallis tests to examine differences in covariates across the calendar months. For our prescription dispensing analysis, numerators were the number of patients 66–79 and ≥80 years with at least one statin prescription during the study interval, and denominators were the estimated population on July 1st of the relevant year in the age strata. We calculated monthly prescription rates and their associated 95% CIs. To evaluate for the possibility of snowbirding, we examined the maximum day supply of a statin per patient each month, and determined the number with a day supply of statins >100 days. The denominator for this analysis was the total number of people who filled a statin prescription within the calendar year, across the two age groups. All analyses were conducted in SAS version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Prior to each study interval, we excluded 12-51 (0.5–2.2%) records based upon an invalid identification number or sex, 141-220 (5.8–9.5%) records that had an invalid age, <6 records with a death recorded on or before the study interval, and <6 records for those who were not permanent residents of Ontario.

We included a total of 47,971 and 52,088 hip fracture hospitalizations in those 66–79 and ≥80 years between 2011–2015 in Ontario, Canada (42,694 and 47,648 unique patients, respectively).

Variation in Hip Fractures

Hip fracture rates appeared stable over time across groups. Strong seasonality was apparent in both age groups (Table 1). Fractures peaked in October and December, with a smaller peak in May. In those ≥80 years, fractures fell to a minimum in February. Fracture rates appeared to drop to a minimum in August in those 66–79 (Figure 1).

Seasonal Characteristics of Fracture Patients

The monthly characteristics of patients with hip fractures are presented in Tables 2 and 3. Compared with those who fractured during other months, patients with an autumn and winter fracture were more likely to have experienced a fall or fracture in the year prior. Those who were 66–79 years also appeared to have more comorbidities (i.e., higher Charlson comorbidity index), and used more unique medications than those who fractured at other times of the year.

Health-care Utilization

The health-care utilization of patients varied monthly. Primary care visits appeared less frequent across groups in the late winter and, in the oldest old, blood tests and specialist visits also appeared slightly less frequent (Tables 2 and 3). Statin prescription rates declined across both age groups in the late winter (Figure 2). Both groups showed evidence of snowbirding over the winter months (i.e., higher rate of travel prescription fills in the late fall), but this appeared more common in those 66–79 years than in the oldest old (Figure 3).

DISCUSSION

Main Findings

In older adults in Ontario, hip fractures are most common in the late autumn, early winter, and spring. In the oldest old, hip fracture rates appeared lowest in the late winter.

As previously suggested, environmental factors might contribute to these trends. With exposure to ice and snow in the early winter (perhaps more so during the holidays),[8,27,28] older people might be predisposed to slips and falls. A systematic review of studies that examined the association between hip fractures and at least one weather variable across 18 locations found that snow and ice were positively correlated with hip fractures at all latitudes.[7] As hip fractures also peak in regions with no ice or snow,[29,30] colder temperatures (especially the acute lowering of temperature) might also contribute to monthly variation. When exposed to the cold, people might experience hypothermia and

TABLE 1.
Statistical summary of seasonality of hip fracture encounters

Age Group	Fisher Kappa	BKS (p-value)	Autoregression r^2 Ccoefficient[a]	Cycles (months)
66–79	5.714	0.2791 (0.022)	0.625	6, 4
≥80	4.460	0.2799 (0.021)	0.645	6, 3, 12
All ages	5.317	0.2965 (0.012)	0.725	6, 4, 3

[a]An r^2 coefficient of 0 to < 0.4 represents weak seasonality, 0.4 to < 0.7 moderate to strong seasonality, and 0.7 to 1 very strong to perfect seasonality.
BKS = Barlett Kolmogorov Smirnov
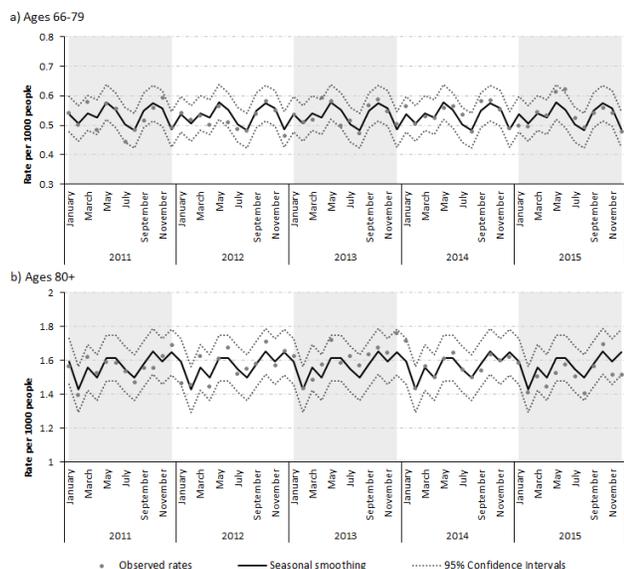
FIGURE 1. Rates of hip fracture encounters in patients 66–79 and ≥80 years in Ontario from 2011–2015

poor coordination. They might also dress in layers which could lead to trips and falls.[7] An acute drop in temperature from a warmer summer to a cooler autumn might have contributed to the fracture peak we saw in October, especially if people had not yet adapted to the temperature change.[31]

Vitamin D deficiency could have also contributed to fracture trends.[8,10,11,32] Vitamin D is typically lowest at the end of the winter when parathyroid hormone is high.[10] During winter months, bone turnover also increases and bone density declines.[11,33] These changes might have predisposed individuals to fracture. Vitamin D deficiency can also impair muscle strength and coordination.[34] A darker winter might have also impaired visual acuity.[35]

Beyond environmental influences, we found evidence that patient characteristics, comorbidities, and social/behavioural factors might contribute to hip fracture trends in older adults. Older adults who had a fracture appeared to be in poorer health in the autumn and winter. During these seasons, infections are more common,[6] and patients might have been predisposed to falls and fracture while they were ill.

Respiratory illnesses peak in the spring in the older age groups,[36] when we noted a second peak in fracture rates. This peak might have also been due to people becoming active again outside. In our study, people who had a hip fracture in the spring appeared healthier than those who fractured at other times of the year. Previous studies have noted that healthy active people are at higher risk of outdoor falls while engaging in vigorous activities.[37,38]

Of particular interest, we observed that in the oldest old, fractures appeared less common in the late winter. During the late winter it is coldest in Canada[39] and older adults might simply avoid the outdoors, especially if they have comorbidities, are immobilized, or institutionalized.[9,40,41] Aligned with this, their health care utilization also appeared to decline with fewer primary care visits and a lower rate of prescription medication dispensing. Although there was evidence of snowbirding in both age groups, the trend seemed most apparent in those 66–79 years. This trend wouldn't sufficiently explain the decline in health-care utilization in the oldest old, suggesting that older seniors might avoid going outside during the late winter.

Comparison with Previous Literature

Hip fractures have been described to peak in the autumn and winter in older Canadian studies from Montreal.[9,27] Outside of Canada, in a Spanish study of people >45 years (mean age 80 years), there was also an increased risk of fracture during these months.[29] Similar trends have been described in Taiwan,[8] as well as across the United States,[42] Israel,[28] Scotland, Hong Kong, New Zealand,[30] and Norway.[43]

The decline in fractures in those ≥80 in the late winter has not been thoroughly described. While most studies note a trough in fracture rates over the summer months,[41,44] our extreme winter climate where temperatures can drop below -30°C in areas, might partly explain our findings.

Strengths and Weaknesses

There are several strengths to the current study. It is a large, up-to-date, population-based study of 100,059 hip fracture encounters (89,913 unique individuals) in our province over a five-year period. Rather than simply describing fracture variation, we evaluated trends within two age strata, and examined variation in patient comorbidities and health services utilization.

TABLE 2.
Characteristics of patients aged 66–79 with hip fractures from September 2012 to August 2013 (N=9014)

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	P-value[e]
	n=774	n=822	n=778	n=644	n=774	n=722	n=749	n=846	n=815	n=712	n=724	n=654	
Age (mean ± SD)	72.7 ± 4.0	72.5 ± 4.1	72.6 ± 4.0	73.1 ± 4.0	72.8 ± 4.2	72.7 ± 3.93	72.63 ± 4.0	72.7 ± 4.1	72.80 ± 4.09	72.8 ± 4.1	72.7 ± 4.0	72.8 ± 4.2	0.513
Female	467 (60.3)	503 (61.2)	462 (59.4)	393 (61.0)	478 (61.8)	439 (60.8)	471 (62.9)	517 (61.1)	511 (62.7)	450 (63.2)	447 (61.7)	410 (62.7)	0.949
Income Quintile													0.452
1 (lowest)	129 (16.7)	150 (18.2)	131 (16.8)	136 (21.1)	149 (19.3)	151 (20.9)	131 (17.5)	161 (19.0)	130 (16.0)	130 (18.3)	125 (17.3)	98 (15.0)	
2	152 (19.6)	162 (19.7)	154 (19.8)	120 (18.6)	160 (20.7)	145 (20.1)	156 (20.8)	152 (18.0)	159 (19.5)	148 (20.8)	150 (20.7)	130 (19.9)	
3 or missing	161 (20.8)	177 (21.5)	165 (21.2)	135 (21.0)	152 (19.6)	131 (18.1)	161 (21.5)	174 (20.6)	161 (19.8)	119 (16.7)	141 (19.5)	129 (19.7)	
4	155 (20.0)	154 (18.7)	160 (20.6)	120 (18.6)	134 (17.3)	149 (20.6)	138 (18.4)	156 (18.4)	184 (22.6)	151 (21.2)	156 (21.5)	131 (20.0)	
5 (highest)	177 (22.9)	179 (21.8)	168 (21.6)	133 (20.7)	179 (23.1)	146 (20.2)	163 (21.8)	203 (24.0)	181 (22.2)	164 (23.0)	152 (21.0)	166 (25.4)	
Residence													
Long-term care	32 (4.1)	23 (2.8)	26 (3.3)	30 (4.7)	27 (3.5)	19 (2.6)	20 (2.7)	22 (2.6)	30 (3.7)	22 (3.1)	30 (4.1)	33 (5.0)	<0.001
Missing	16 (2.1)	23 (2.8)	19 (2.4)	30 (4.7)	10 (1.3)	23 (3.2)	19 (2.5)	27 (3.2)	24 (2.9)	17 (2.4)	24 (3.3)	19 (2.9)	
Discharge disposition													
Acute care institution	56 (7.2)	39 (4.7)	26 (3.3)	45 (7.0)	49 (6.3)	35 (4.8)	52 (6.9)	34 (4.0)	49 (6.0)	43 (6.0)	40 (5.5)	43 (6.6)	
Home without support	183 (23.6)	235 (28.6)	204 (26.2)	130 (20.2)	179 (23.1)	189 (26.2)	177 (23.6)	153 (18.1)	188 (23.1)	149 (20.9)	154 (21.3)	148 (22.6)	
Home with support	299 (38.6)	325 (39.5)	328 (42.2)	254 (39.4)	330 (42.6)	299 (41.4)	319 (42.6)	409 (48.3)	349 (42.8)	309 (43.4)	297 (41.0)	269 (41.1)	
Long-term care	91 (11.8)	67 (8.2)	60 (7.7)	62 (9.6)	68 (8.8)	63 (8.7)	66 (8.8)	75 (8.9)	74 (9.1)	77 (10.8)	86 (11.9)	69 (10.6)	
Rehab or other ambulatory facility or missing	145 (18.7)	156 (19.0)	160 (20.6)	153 (23.8)	148 (19.1)	136 (18.8)	135 (18.0)	175 (20.7)	155 (19.0)	134 (18.8)	147 (20.3)	125 (19.1)	
Comorbidities[a]													
Fall in the 1 yr. prior	43 (5.6)	34 (4.1)	21 (2.7)	30 (4.7)	34 (4.4)	31 (4.3)	24 (3.2)	23 (2.7)	13 (1.6)	20 (2.8)	23 (3.2)	18 (2.8)	0.001
Fracture in the 1 yr. prior	81 (10.5)	74 (9.0)	52 (6.7)	42 (6.5)	45 (5.8)	53 (7.3)	46 (6.1)	40 (4.7)	31 (3.8)	28 (3.9)	30 (4.1)	18 (2.8)	<0.001
Chronic liver disease	29 (3.7)	30 (3.6)	35 (4.5)	34 (5.3)	42 (5.4)	37 (5.1)	31 (4.1)	42 (5.0)	35 (4.3)	34 (4.8)	32 (4.4)	28 (4.3)	0.847
Dementia	95 (12.3)	91 (11.1)	92 (11.8)	83 (12.9)	98 (12.7)	87 (12.0)	91 (12.1)	93 (11.0)	86 (10.6)	83 (11.7)	72 (9.9)	92 (14.1)	0.585
CKD	76 (9.8)	68 (8.3)	63 (8.1)	58 (9.0)	79 (10.2)	65 (9.0)	63 (8.4)	63 (7.4)	57 (7.0)	58 (8.1)	69 (9.5)	62 (9.5)	0.503
RA	35 (4.5)	48 (5.8)	30 (3.9)	29 (4.5)	28 (3.6)	37 (5.1)	35 (4.7)	33 (3.9)	29 (3.6)	31 (4.4)	35 (4.8)	30 (4.6)	0.626
COPD	209 (27.0)	221 (26.9)	207 (26.6)	184 (28.6)	210 (27.1)	199 (27.6)	198 (26.4)	193 (22.8)	213 (26.1)	195 (27.4)	175 (24.2)	181 (27.7)	0.452
IBD	10 (1.3)	≤5	6 (0.8)	6 (0.9)	≤5	8 (1.1)	13 (1.7)	10 (1.2)	8 (1.0)	7 (1.0)	7 (1.0)	8 (1.2)	0.728
Diabetes	219 (28.3)	236 (28.7)	222 (28.5)	203 (31.5)	224 (28.9)	235 (32.5)	217 (29.0)	255 (30.1)	212 (26.0)	214 (30.1)	198 (27.3)	181 (27.7)	0.315
Major cancer	132 (17.1)	126 (15.3)	129 (16.6)	101 (15.7)	106 (13.7)	119 (16.5)	115 (15.4)	129 (15.2)	121 (14.8)	115 (16.2)	106 (14.6)	102 (15.6)	0.902
Alcoholism	28 (3.6)	21 (2.6)	23 (3.0)	22 (3.4)	22 (2.8)	23 (3.2)	24 (3.2)	26 (3.1)	17 (2.1)	27 (3.8)	21 (2.9)	24 (3.7)	0.819
Seizure	16 (2.1)	12 (1.5)	14 (1.8)	8 (1.2)	12 (1.6)	9 (1.2)	10 (1.3)	19 (2.2)	≤5	11 (1.5)	9 (1.2)	16 (2.4)	0.238

TABLE 2.
Continued

	Sep n=774	Oct n=822	Nov n=778	Dec n=644	Jan n=774	Feb n=722	Mar n=749	Apr n=846	May n=815	Jun n=712	Jul n=724	Aug n=654	P-value[e]
Other Conditions at Time of Encounter[b]													
Acute kidney injury	11 (1.4)	12 (1.5)	11 (1.4)	14 (2.2)	12 (1.6%)	11 (1.5)	≤5	13 (1.5)	9 (1.1)	16 (2.2)	13 (1.8)	14 (2.1)	0.469
Sepsis	≤5	7 (0.9)	≤5	≤5	≤5	≤5	≤5	6 (0.7)	≤5	≤5	≤5	≤5	0.347
Rhabdomyolysis	≤5	≤5	≤5	≤5	≤5	≤5	≤5	7 (0.8)	≤5	≤5	≤5	6 (0.9)	0.655
AMI	11 (1.4)	12 (1.5)	12 (1.5)	10 (1.6)	8 (1.0)	10 (1.4)	11 (1.5)	9 (1.1)	10 (1.2)	9 (1.3)	11 (1.5)	≤5	0.978
Charlson Comorbidity Index													
Mean ± SD	1.2 ± 1.9	1.1 ± 1.9	1.0 ± 1.7	1.3 ± 1.8	1.0 ± 1.6	1.2 ± 1.8	1.10 ± 1.82	1.0 ± 1.8	0.9 ± 1.6	1.1 ± 1.7	1.0 ± 1.8	1.00 ± 1.7	0.009
Median (IQR)	0 (0-2)	0 (0-2)	0 (0-1)	1 (0-2)	0 (0-1)	0 (0-2)	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-1)	<0.001
0 (no hospitalization)	428 (55.3)	467 (56.8)	457 (58.7)	317 (49.2)	434 (56.1)	378 (52.4)	407 (54.3)	490 (57.9)	487 (59.8)	393 (55.2)	441 (60.9)	386 (59.0)	0.006
1	132 (17.1)	147 (17.9)	150 (19.3)	135 (21.0)	153 (19.8)	151 (20.9)	165 (22.0)	155 (18.3)	156 (19.1)	144 (20.2)	121 (16.7)	109 (16.7)	
2	80 (10.3)	86 (10.5)	71 (9.1)	81 (12.6)	90 (11.6)	81 (11.2)	76 (10.1)	85 (10.0)	76 (9.3)	69 (9.7)	66 (9.1)	77 (11.8)	
3+	134 (17.3)	122 (14.8)	100 (12.9)	111 (17.2)	97 (12.5)	112 (15.5)	101 (13.5)	116 (13.7)	96 (11.8)	106 (14.9)	96 (13.3)	82 (12.5)	
Medications[c]													
Statins	332 (42.9)	352 (42.8)	365 (46.9)	277 (43.0)	348 (45.0)	328 (45.4)	339 (45.3)	376 (44.4)	355 (43.6)	299 (42.0)	318 (43.9)	282 (43.1)	0.827
Bisphosphonate (1 yr)	147 (19.0)	135 (16.4)	154 (19.8)	129 (20.0)	151 (19.5)	127 (17.6)	128 (17.1)	144 (17.0)	140 (17.2)	131 (18.4)	135 (18.6)	112 (17.1)	0.667
Denosumab (1 yr)	≤5	7 (0.9)	≤5	6 (0.9)	10 (1.3)	≤5	6 (0.8)	9 (1.1)	13 (1.6)	14 (2.0)	11 (1.5)	12 (1.8)	0.075
Glucocorticoid (1 yr)	74 (9.6)	68 (8.3)	79 (10.2)	55 (8.5)	69 (8.9)	68 (9.4)	54 (7.2)	63 (7.4)	68 (8.3)	65 (9.1)	64 (8.8)	65 (9.9)	0.650
PPI	270 (34.9)	287 (34.9)	255 (32.8)	211 (32.8)	260 (33.6)	228 (31.6)	231 (30.8)	275 (32.5)	222 (27.2)	234 (32.9)	237 (32.7)	217 (33.2)	0.128
Anticonvulsant	≤5	≤5	7 (0.9)	≤5	≤5	≤5	≤5	≤5	≤5	≤5	≤5	≤5	0.040
Antineoplastic	13 (1.7)	11 (1.3)	7 (0.9)	6 (0.9)	≤5	11 (1.5)	8 (1.1)	8 (0.9)	7 (0.9)	10 (1.4)	≤5	13 (2.0)	0.278
Number of Unique Drugs													
Mean ± SD	8.8 ± 6.4	8.8 ± 6.3	8.3 ± 6.1	8.3 ± 5.9	8.5 ± 5.8	8.5 ± 5.9	8.3 ± 6.0	7.9 ± 5.8	7.6 ± 5.7	8.2 ± 6.2	8.3 ± 6.1	8.5 ± 6.4	0.005
Median (IQR)	8 (4-12)	7 (4-12)	7 (4-11)	8 (4-11)	7 (5-11)	8 (4-12)	7 (4-11)	7 (4-11)	7 (3-11)	7 (4-12)	7 (4-12)	8 (4-12)	0.007
Health-care Visits[d]													
At least one GP visit	606 (78.3)	665 (80.9)	662 (85.1)	506 (78.6)	593 (76.6)	566 (78.4)	584 (78.0)	660 (78.0)	652 (80.0)	565 (79.4)	553 (76.4)	488 (74.6)	<0.001
Any blood test	190 (24.5)	201 (24.5)	167 (21.5)	139 (21.6)	179 (23.1)	186 (25.8)	160 (21.)	190 (22.5)	199 (24.4)	168 (23.6)	159 (22.0)	157 (24.0)	0.558
Any specialist visit	640 (82.7)	710 (86.4)	672 (86.4)	543 (84.3)	649 (83.9)	621 (86.0)	616 (82.2)	743 (87.8)	677 (83.1)	594 (83.4)	623 (86.0)	530 (81.0)	0.005
Home-care visit	207 (26.7)	210 (25.5)	196 (25.2)	142 (22.0)	191 (24.7)	167 (23.1)	208 (27.8)	216 (25.5)	193 (23.7)	180 (25.3)	161 (22.2)	165 (25.2)	0.32

Unless indicated, data represents number (percent); cell sizes <6 are not presented for privacy.

[a]Unless specified, comorbidities were ascertained in the 5 years prior.

[b]Conditions present at the time of the encounter were those coded during the hip fracture hospitalization.

[c]Unless specified, medication use was ascertained in the 180 days prior.

[d]Unless specified, health-care visits were ascertained in the 30 days prior.

[e]We used Chi-squared analyses, one-way ANOVA, and Kruskal-Wallis tests to determine if there were differences in covariates across the calendar months.

CKD = chronic kidney disease; RA = rheumatoid arthritis; COPD = chronic obstructive pulmonary disease; IBD = inflammatory bowel disease; AMI = acute myocardial infarction; PPI = proton pump inhibitor; GP = general practitioner.

TABLE 3.
Characteristics of patients aged 80+ with hip fractures from September 2012 to August 2013 (N=10,096)

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	P-value[e]
	n=849	n=914	n=823	n=861	n=872	n=757	N=776	n=838	n=912	n=823	n=845	n=826	
Age (mean ± SD)	86.8 ± 4.8	86.4 ± 4.6	86.7 ± 4.7	86.6 ± 4.6	86.6 ± 4.9	86.5 ± 4.7	86.5 ± 4.7	86.3 ± 4.5	86.4 ± 4.6	86.5 ± 4.8	86.8 ± 4.8	86.9 ± 4.9	0.214
Female	637 (75.0)	644 (70.5)	605 (73.5)	612 (71.1)	610 (70.0)	558 (73.7)	574 (74.0)	592 (70.6)	660 (72.4)	591 (71.8)	609 (72.1)	618 (74.8)	0.231
Income Quintile													0.631
1 (lowest)	167 (19.7)	184 (20.1)	168 (20.4)	162 (18.8)	195 (22.4)	140 (18.5)	159 (20.5)	169 (20.2)	183 (20.1)	172 (20.9)	179 (21.2)	173 (20.9)	
2	164 (19.3)	211 (23.1)	180 (21.9)	177 (20.6)	168 (19.3)	138 (18.2)	139 (17.9)	175 (20.9)	191 (20.9)	168 (20.4)	150 (17.8)	175 (21.2)	
3 or missing	172 (20.3)	154 (16.8)	167 (20.3)	178 (20.7)	184 (21.1)	160 (21.1)	157 (20.2)	166 (19.8)	187 (20.5)	173 (21.0)	173 (20.5)	160 (19.4)	
4	162 (19.1)	178 (19.5)	145 (17.6)	193 (22.4)	164 (18.8)	164 (21.7)	165 (21.3)	159 (19.0)	168 (18.4)	163 (19.8)	174 (20.6)	165 (20.0)	
5 (highest)	184 (21.7)	187 (20.5)	163 (19.8)	151 (17.5)	161 (18.5)	155 (20.5)	156 (20.1)	169 (20.2)	183 (20.1)	147 (17.9)	169 (20.0)	153 (18.5)	
Residence													0.397
Long-term care	151 (17.8)	139 (15.2)	123 (14.9)	150 (17.4)	148 (17.0)	122 (16.1)	119 (15.3)	121 (14.4)	148 (16.2)	130 (15.8)	141 (16.7)	155 (18.8)	
Missing	16 (1.9)	21 (2.3)	16 (1.9)	11 (1.3)	21 (2.4)	19 (2.5)	12 (1.5)	16 (1.9)	10 (1.1)	21 (2.6)	18 (2.1)	11 (1.3)	
Discharge Disposition													0.196
Acute care	81 (9.5)	77 (8.4)	80 (9.7)	89 (10.3)	78 (8.9)	73 (9.6)	69 (8.9)	74 (8.8)	80 (8.8)	75 (9.1)	91 (10.8)	94 (11.4)	
Home without support	65 (7.7)	60 (6.6)	62 (7.5)	54 (6.3)	60 (6.9)	50 (6.6)	44 (5.7)	67 (8.0)	55 (6.0)	45 (5.5)	54 (6.4)	48 (5.8)	
Home with support	145 (17.1)	176 (19.3)	168 (20.4)	155 (18.0)	168 (19.3)	128 (16.9)	141 (18.2)	191 (22.8)	187 (20.5)	169 (20.5)	177 (20.9)	144 (17.4)	
Long-term care	250 (29.4)	247 (27.0)	210 (25.5)	246 (28.6)	232 (26.6)	231 (30.5)	232 (29.9)	235 (28.0)	268 (29.4)	249 (30.3)	252 (29.8)	238 (28.8)	
Rehab or other ambulatory facility or missing	308 (36.3)	354 (38.7)	303 (36.8)	317 (36.8)	334 (38.3)	275 (36.3)	290 (37.4)	271 (32.3)	322 (35.3)	285 (34.6)	271 (32.1)	302 (36.6)	
Comorbidities[a]													
Fall in 1 yr. prior	83 (9.8)	87 (9.5)	64 (7.8)	74 (8.6)	61 (7.0)	44 (5.8)	49 (6.3)	53 (6.3)	56 (6.1)	49 (6.0)	55 (6.5)	59 (7.1)	0.005
Fracture in 1 yr. prior	80 (9.4)	88 (9.6)	70 (8.5)	63 (7.3)	61 (7.0)	42 (5.5)	44 (5.7)	54 (6.4)	43 (4.7)	47 (5.7)	46 (5.4)	45 (5.4)	<0.001
Chronic liver disease	19 (2.2)	18 (2.0)	22 (2.7)	30 (3.5)	18 (2.1)	14 (1.8)	23 (3.0)	19 (2.3)	22 (2.4)	23 (2.8)	19 (2.2)	26 (3.1)	0.565
Dementia	361 (42.5)	370 (40.5)	328 (39.9)	382 (44.4)	360 (41.3)	320 (42.3)	334 (43.0)	331 (39.5)	370 (40.6)	313 (38.0)	344 (40.7)	358 (43.3)	0.322
CKD	124 (14.6)	122 (13.3)	111 (13.5)	140 (16.3)	129 (14.8)	131 (17.3)	115 (14.8)	120 (14.3)	120 (13.2)	115 (14.0)	119 (14.1)	134 (16.2)	0.359
RA	29 (3.4)	34 (3.7)	30 (3.6)	29 (3.4)	35 (4.0)	36 (4.8)	24 (3.1)	34 (4.1)	42 (4.6)	44 (5.3)	24 (2.8)	37 (4.5)	0.28
COPD	247 (29.1)	306 (33.5)	254 (30.9)	267 (31.0)	266 (30.5)	239 (31.6)	235 (30.3)	271 (32.3)	275 (30.2)	249 (30.3)	267 (31.6)	241 (29.2)	0.794
IBD	≤5	≤5	9 (1.1)	7 (0.8)	≤5	≤5	8 (1.0)	≤5	7 (0.8)	≤5	≤5	≤5	0.356
Diabetes	239 (28.2)	253 (27.7)	218 (26.5)	260 (30.2)	236 (27.1)	223 (29.5)	221 (28.5)	228 (27.2)	259 (28.4)	246 (29.9)	251 (29.7)	245 (29.7)	0.796
Major cancer	140 (16.5)	142 (15.5)	127 (15.4)	134 (15.6)	138 (15.8)	109 (14.4)	111 (14.3)	123 (14.7)	131 (14.4)	96 (11.7)	117 (13.8)	105 (12.7)	0.245
Alcoholism	7 (0.8)	19 (2.1)	13 (1.6)	8 (0.9)	8 (0.9)	≤5	11	≤5	≤5	9 (1.1)	14 (1.7)	8 (1.0)	0.021
Seizure	8 (0.9)	9 (1.0)	12 (1.5)	13 (1.5)	6 (0.7)	15 (2.0)	7 (0.9)	9 (1.1)	14 (1.5)	11 (1.3)	13 (1.5)	13 (1.6)	0.537

TABLE 3.
Continued

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	P-value[e]
	n=849	n=914	n=823	n=861	n=872	n=757	N=776	n=838	n=912	n=823	n=845	n=826	
Other Conditions at Time of Encounter[b]													
Acute kidney injury	24 (2.8)	38 (4.2)	29 (3.5)	28 (3.3)	26 (3.0)	30 (4.0)	25 (3.2)	31 (3.7)	34 (3.7)	34 (4.1)	25 (3.0)	28 (3.4)	0.886
Sepsis	7 (0.8)	≤5	≤5	11 (1.3)	≤5	≤5	6 (0.8)	≤5	6 (0.7)	≤5	8 (0.9)	≤5	0.335
Rhabdomyolysis	≤5	6 (0.7)	7 (0.9)	≤5	12 (1.4)	≤5	6 (0.8)	≤5	12 (1.3)	8 (1.0)	9 (1.1)	14 (1.7)	0.054
AMI	36 (4.2)	40 (4.4)	25 (3.0)	31 (3.6)	30 (3.4)	34 (4.5)	26 (3.4)	27 (3.2)	29 (3.2)	28 (3.4)	28 (3.3)	20 (2.4)	0.56
Charlson Comorbidity Index													
Mean ± SD	1.5 ± 1.8	1.4 ± 1.7	1.7 ± 1.8	1.5 ± 1.9	1.4 ± 1.8	1.5 ± 1.7	1.4 ± 1.9	1.5 ± 1.8	1.3 ± 1.7	1.5 ± 1.8	1.5 ± 1.8	1.4 ± 1.7	0.586
Median (IQR)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	0.246
0 (no hospitalization)	314 (37.0)	356 (38.9)	328 (39.9)	322 (37.4)	354 (40.6)	274 (36.2)	324 (41.8)	331 (39.5)	389 (42.7)	297 (36.1)	332 (39.3)	321 (38.9)	0.186
1	234 (27.6)	245 (26.8)	223 (27.1)	232 (26.9)	228 (26.1)	199 (26.3)	183 (23.6)	200 (23.9)	225 (24.7)	235 (28.6)	192 (22.7)	204 (24.7)	
2	105 (12.4)	130 (14.2)	116 (14.1)	119 (13.8)	126 (14.4)	126 (16.6)	114 (14.7)	125 (14.9)	123 (13.5)	123 (14.9)	143 (16.9)	133 (16.1)	
3+	196 (23.1)	183 (20.0)	156 (19.0)	188 (21.8)	164 (18.8)	158 (20.9)	155 (20.0)	182 (21.7)	175 (19.2)	168 (20.4)	178 (21.1)	168 (20.3)	
Medications[c]													
Statins	347 (40.9)	366 (40.0)	302 (36.7)	346 (40.2)	350 (40.1)	346 (45.7)	304 (39.2)	350 (41.8)	352 (38.6)	345 (41.9)	354 (41.9)	340 (41.2)	0.091
Bisphosphonate (1 yr)	232 (27.3)	244 (26.7)	239 (29.0)	234 (27.2)	234 (26.8)	200 (26.4)	219 (28.2)	222 (26.5)	238 (26.1)	205 (24.9)	195 (23.1)	202 (24.5)	0.331
Denosumab (1 yr)	12 (1.4)	13 (1.4)	10 (1.2)	12 (1.4)	19 (2.2)	19 (2.5)	12 (1.5)	17 (2.0)	18 (2.0)	20 (2.4)	22 (2.6)	27 (3.3)	0.072
Glucocorticoid (1 yr)	60 (7.1)	69 (7.5)	62 (7.5)	73 (8.5)	74 (8.5)	56 (7.4)	46 (5.9)	69 (8.2)	60 (6.6)	76 (9.2)	58 (6.9)	53 (6.4)	0.316
PPI	319 (37.6)	333 (36.4)	291 (35.4)	300 (34.8)	305 (35.0)	266 (35.1)	281 (36.2)	303 (36.2)	322 (35.3)	294 (35.7)	315 (37.3)	312 (37.8)	0.963
Anticonvulsant	≤5	≤5	≤5	≤5	≤5	≤5	≤5	≤5	≤5	≤5	≤5	≤5	0.243
Antineoplastic	13 (1.5)	23 (2.5)	20 (2.4)	11 (1.3)	19 (2.2)	8 (1.1)	19 (2.4)	9 (1.1)	12 (1.3)	7 (0.9)	12 (1.4)	9 (1.1)	0.023
Number of Unique Drugs													
Mean ± SD	10.2 ± 6.1	9.8 ± 6.0	9.6 ± 6.2	10.3 ± 6.2	10.0 ± 6.3	10.0 ± 6.5	10.0 ± 6.4	10.2 ± 6.3	9.9 ± 6.2	10.1 ± 6.5	10.0 ± 6.3	10.3 ± 6.4	0.442
Median (IQR)	9 (6-14)	9 (5-13)	9 (5-13)	9 (6-14)	9 (5-14)	9 (5-13)	9 (5-14)	10 (6-14)	9 (5-14)	9 (5-14)	9 (5-14)	10 (6-14)	0.307
Health-care Visits[d]													
At least one GP visit	640 (75.4)	725 (79.3)	678 (82.4)	673 (78.2)	666 (76.4)	561 (74.1)	583 (75.1)	633 (75.5)	676 (74.1)	620 (75.3)	653 (77.3)	594 (71.9)	<0.001
Any blood test	257 (30.3)	276 (30.2)	253 (30.7)	270 (31.4)	227 (26.0)	228 (30.1)	218 (28.1)	231 (27.6)	283 (31.0)	240 (29.2)	247 (29.2)	227 (27.5)	0.329
Any specialist visit	694 (81.7)	745 (81.5)	682 (82.9)	702 (81.5)	697 (79.9)	616 (81.4)	637 (82.1)	715 (85.3)	734 (80.5)	681 (82.7)	702 (83.1)	669 (81.0)	0.316
Home care visit	263 (31.0)	278 (30.4)	253 (30.7)	291 (33.8)	280 (32.1)	239 (31.6)	264 (34.0)	261 (31.1)	297 (32.6)	260 (31.6)	267 (31.6)	258 (31.2)	0.906

Unless indicated, data represents number (percent); cell sizes <6 are not presented for privacy.

[a]Unless specified, comorbidities were ascertained in the 5 years prior.

[b]Conditions present at the time of the encounter were those coded during the hip fracture hospitalization

[c]Unless specified, medication use was ascertained in the 180 days prior.

[d]Unless specified, healthcare utilization was ascertained in the 30 days prior.

[e]We used Chi-squared analyses, one-way ANOVA, and Kruskal-Wallis tests to determine if there were differences in covariates across the calendar months.

CKD = chronic kidney disease; RA = rheumatoid arthritis; COPD = chronic obstructive pulmonary disease; IBD = inflammatory bowel disease; AMI = acute myocardial infarction; PPI = proton pump inhibitor; GP = general practitioner.
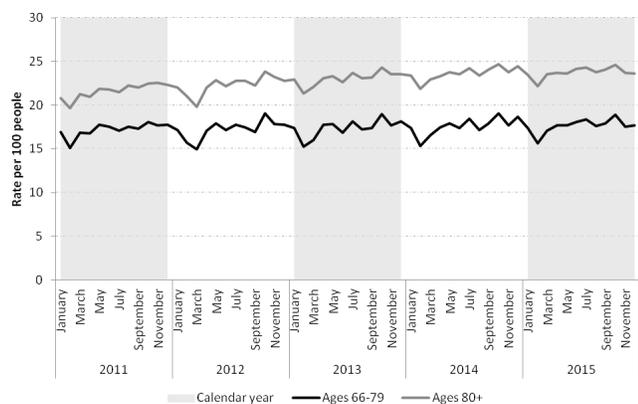
FIGURE 2. Statin prescription rates per 100 people aged 66–79 and ≥80 in Ontario

FIGURE 3. Rate of statin prescriptions with greater than 100 days supply per 10,000 people in Ontario, categorized by age groups, 66-79 and ≥80 years

There are some limitations to discuss. We could not exclude high-velocity fractures (i.e., from motor vehicle collisions) or pathological hip fractures, although it is estimated that over 95% of hip fractures are due to a fall.[45] We also included procedural codes for hip fractures, and thus, double counting of encounters could have occurred. However, we minimized this risk by limiting to one hip fracture encounter per month. We used administrative data to ascertain our outcomes and this data were not specifically created to address our research question. However, our data can minimize the bias associated with self-report and surveys.[16] Changes in coding definitions might have occurred over the study period and may have affected our temporal trend analyses. We also could not determine the location of the hip fractures (i.e., indoors vs. outdoors). Our study population also included a mix of both community and long-term care residents.

Due to the size and duration of our study, we were only able to ascertain the characteristics and comorbidities of patients over one year. We were unable to evaluate factors, including frailty and balance, which can impact fracture risk. Importantly, this was an ecological study and we cannot infer causation at an individual level. Our results are only fully generalizable to those living in Ontario.

Implications

Our study has implications for practice, policy, and research. First, given the possible link between hip fractures and environmental factors, patients should be advised to be cautious while traversing snow and ice, and to wear proper footwear. [46] Even if indoors during the cooler months, they might be warned of tripping hazards, especially when layering for the colder weather. When people are in poorer health, they might be cautioned about the risk of falls. Further, physicians might replace vitamin D and ensure adequate calcium intake during the winter months, especially in the frail and institutionalized. [34,47,48] A role for UV light exposure in the winter has also been suggested.[8]
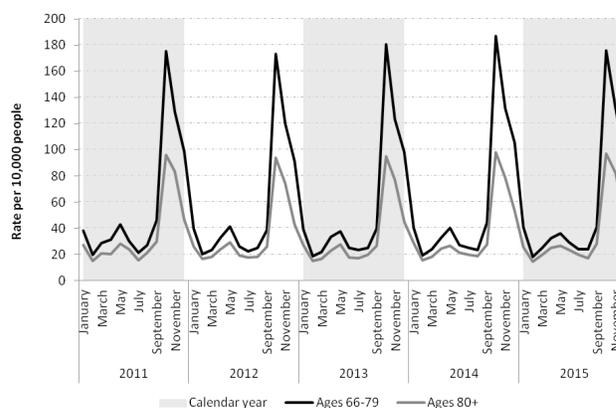
From a policy standpoint, health administrators might plan resources accordingly. Operating times for hip fractures might be opened in the cooler seasons, and hospitals might be prepared for more consultations. Awareness of fracture peaks might promote timely assessments and treatment.[4] Troughs in fracture rates and health services utilization over the winter might raise the possibility of social isolation; as a result, ensuring that home-based resources are available might be of importance (e.g., home care services, exercise programs, food delivery). This might be especially needed by those who are too frail to leave their residence.[35] For city workers and planners, timely ice and snow removal also remains important.[35]

Finally, from a research perspective, researchers might better consider snowbirding when conducting trend analyses, to ensure accurate denominators.

CONCLUSIONS

In our region, the oldest old have a unique pattern of hip fracture hospitalizations across the months. Beyond environmental influences, complex patient, social, and behavioural factors might contribute to observed trends.

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Conflict of Interest Disclosures

KC received a Diabetes Canada Junior Investigator Award sponsored by Astra Zeneca. She has also attended conferences sponsored by Merck. There are no other conflicts of interest to disclose and no endorsement by ICES, AMOSO, SSMD, LHRI or the MOHLTC is intended or should be inferred.

References

1. Carnevale V, Fontana A, Scillitani A, *et al*. Incidence and all-cause mortality for hip fracture in comparison to stroke, and myocardial infarction: a fifteen years population-based longitudinal study. *Endocrine* [Internet]. 2017 Sep 20 [cited 2017 Oct 26]; 58(2):320–31. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28933053

2. Papadimitropoulos EA, Coyte PC, Josse RG, *et al*. Current and projected rates of hip fracture in Canada. *CMAJ* [Internet]. 1997 Nov 15 [cited 2017 Jul 4];157(10):1357–63. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9371065

3. Morin S, Lix LM, Azimaee M, *et al*. Institutionalization following incident non-traumatic fractures in community-dwelling men and women. *Osteoporos Int* [Internet]. 2012 Sep 19 [cited 2017 Jul 4];23(9):2381–86. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22008882

4. Health Quality Ontario. Hip fracture: care for people with fragility fractures [Internet]. Toronto: Health Quality Ontario; 2017. Available from: http://www.hqontario.ca/portals/0/documents/evidence/quality-standards/qs-hip-fracture-clinical-guide-en.pdf

5. Osteoporosis Canada. Osteoporosis: toward a fracture free future [Internet]. Toronto: Osteoporosis Canada; 2011. [cited 2018 Dec 20]. Available from: http://fls.osteoporosis.ca/wp-content/uploads/white-paper-march-2011.pdf

6. Upshur REG, Moineddin R, Crighton E, *et al*. Simplicity within complexity: seasonality and predictability of hospital admissions in the province of Ontario 1988–2001, a population-based analysis. *BMC Health Serv Res* [Internet]. 2005 Feb 4 [cited 2015 Jun 12];5(1):13. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=549216&tool=pmcentrez&rendertype=abstract

7. Román Ortiz C, Tenías JM, Estarlich M, *et al*. Systematic review of the association between climate and hip fractures. *Int J Biometeorol* [Internet]. 2015 Oct 13 [cited 2017 Jul 4];59(10):1511–22. Available from: http://link.springer.com/10.1007/s00484-014-0945-y

8. Lin H-C, Xiraxagar S. Seasonality of hip fractures and estimates of season-attributable effects: a multivariate ARIMA analysis of population-based data. *Osteoporos Int* [Internet]. 2006 May 11 [cited 2017 Jul 4];17(6):795–806. Available from: http://link.springer.com/10.1007/s00198-005-0060-3

9. Modarres R, Ouarda TBMJ, Vanasse A, *et al*. Modeling seasonal variation of hip fracture in Montreal, Canada. *Bone* [Internet]. 2012 Apr [cited 2017 Jul 4];50(4):909–16. Available from: http://linkinghub.elsevier.com/retrieve/pii/S8756328212000129

10. Vecino-Vecino C, Gratton M, Kremer R, *et al*. Seasonal variance in serum levels of vitamin d determines a compensatory response by parathyroid hormone: study in an ambulatory elderly population in Quebec. *Gerontology* [Internet]. 2006 Jan 27 ;52(1):33–39. Available from: www.karger.com/Article/Abstract/89823

11. Storm D, Eslin R, Porter ES, *et al*. Calcium supplementation prevents seasonal bone loss and changes in biochemical markers of bone turnover in elderly New England women: a randomized placebo-controlled trial. *J Clin Endocrinol Metab* [Internet]. 1998 Nov [cited 2017 Jul 4];83(11):3817–25. Available from: https://academic.oup.com/jcem/article-lookup/doi/10.1210/jcem.83.11.5289

12. Walker NJ, Van Woerden HC, Kiparoglou V, *et al*. Identifying seasonal and temporal trends in the pressures experienced by hospitals related to unscheduled care. *BMC Health Serv Res* [Internet]. 2016 Dec 26 [cited 2018 Dec 23];16(1):307. Available from: http://bmchealthservres.biomedcentral.com/articles/10.1186/s12913-016-1555-7

13. Statistics Canada. Population by sex and age group, by province and territory (Number, both sexes). Ottawa: Government of Canada, Statistics Canada; 2014. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501

14. Benchimol EI, Smeeth L, Guttmann A, *et al*. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. *PLoS Med* [Internet]. 2015 Oct [cited 2016 Jan 22];12(10):e1001885. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4595218&tool=pmcentrez&rendertype=abstract

15. Lix LM, Yogendran MS, Leslie WD, *et al*. Using multiple data features improved the validity of osteoporosis case ascertainment from administrative databases. *J Clin Epidemiol* [Internet]. 2008 Dec [cited 2017 Jul 4];61(12):1250–60. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0895435608000504

16. Jean S, Candas B, Belzile E, *et al*. Algorithms can be used to identify fragility fracture cases in physician-claims databases. *Osteoporos Int* [Internet]. 2012 Feb 19 [cited 2017 Jul 4];23(2):483–501. Available from: http://link.springer.com/10.1007/s00198-011-1559-4

17. Levy AR, O'Brien BJ, Sellors C, *et al*. Coding accuracy of administrative drug claims in the Ontario Drug Benefit database. *Can J Clin Pharmacol*. 2003;10(2):67–71.

18. Hux JE, Ivis F, Flintoft V, *et al*. Diabetes in Ontario: determination of prevalence and incidence using a validated administrative data algorithm. *Diabetes Care*. 2002;25(3):512–16.

19. Gershon AS, Wang C, Guan J, *et al*. Identifying individuals with physcian diagnosed COPD in health administrative databases. *COPD: J Chronic Obstr Pulm Dis* [Internet]. 2009 Jan 8 [cited 2019 Jan 7];6(5):388–94. Available from: http://www.tandfonline.com/doi/full/10.1080/15412550903140865

20. Widdifield J, Bombardier C, Bernatsky S, *et al*. An administrative data validation study of the accuracy of algorithms for identifying rheumatoid arthritis: the influence of the reference standard on algorithm performance. *BMC Musculoskelet Disord*

[Internet]. 2014 Jun 23 [cited 2019 Jan 7];15:216. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24956925

21. Benchimol EI, Guttmann A, Mack DR, *et al*. Validation of international algorithms to identify adults with inflammatory bowel disease in health administrative data from Ontario, Canada. *J Clin Epidemiol* [Internet]. 2014 Aug [cited 2019 Jan 7];67(8):887–96. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24774473

22. Odén A, McCloskey E V., Johansson H, *et al*. Assessing the impact of osteoporosis on the burden of hip fractures. *Calcif Tissue Int* [Internet]. 2013 Jan 8 [cited 2018 Dec 20];92(1):42–49. Available from: http://link.springer.com/10.1007/s00223-012-9666-6

23. Rotermann M, Sanmartin C, Hennessey D, *et al*. Prescription medication use by Canadians aged 6-79 [Internet]. Ottawa: Statistics Canada (archived); 2015 [cited 2017 Jul 4]. Available from: http://www.statcan.gc.ca/pub/82-003-x/2014006/article/14032-eng.htm

24. Migration and Geographic Distribution—Snowbirds [Internet]. [cited 2017 Jul 4]. Available from: http://medicine.jrank.org/pages/1164/Migration-Geographic-Distribution-Snowbirds.html

25. The Ontario Drug Benefit (ODB) Program: If you travel.[Internet]. Toronto: MOHLTC. [cited 2018 Dec 20]. Available from: http://health.gov.on.ca/en/public/programs/drugs/programs/odb/opdp_travel_supply.aspx

26. Moineddin R, Upshur RE, Crighton E, *et al*. Aggression as a means of assessing the strength of seasonality in a time series. *Popul Health Metr* [Internet]. 2003 Dec 15 [cited 2015 Jun 12];1(1):10. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=317382&tool=pmcentrez&rendertype=abstract

27. Levy AR, Bensimon DR, Mayo NE, *et al*. Inclement weather and the risk of hip fracture. *Epidemiology* [Internet]. 1998 Mar [cited 2017 Jul 4];9(2):172–77. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9504286

28. Koren L, Barak A, Norman D, *et al*. Effect of seasonality, weather and holidays on the incidence of proximal hip fracture. *Isr Med Assoc J* [Internet]. 2014 May [cited 2017 Jul 4];16(5):299–302. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24979835

29. Tenías JM, Estarlich M, Fuentes-Leonarte V, *et al*. Short-term relationship between meteorological variables and hip fractures: an analysis carried out in a health area of the Autonomous Region of Valencia, Spain (1996-2005). *Bone* [Internet]. 2009 Oct [cited 2017 Jul 4];45(4):794–98. Available from: http://linkinghub.elsevier.com/retrieve/pii/S8756328209016706

30. Douglas S, Bunyan A, Chiu KH, *et al*. Seasonal variation of hip fracture at three latitudes. *Injury* [Internet]. 2000 Jan [cited 2017 Jul 4];31(1):11–19. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10716045

31. Lee M, Nordio F, Zanobetti A, *et al*. Acclimatization across space and time in the effects of temperature on mortality: a time-series analysis. *Environ Health* [Internet]. 2014;13:89. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4271464&tool=pmcentrez&rendertype=abstract

32. Costa AG, Wyman A, Siris ES, *et al*. When, where and how osteoporosis-associated fractures occur: an analysis from the Global Longitudinal Study of Osteoporosis in Women (GLOW). Harvey N, editor. *PLoS One* [Internet]. 2013 Dec 11 [cited 2017 Jul 4];8(12):e83306. Available from: http://dx.plos.org/10.1371/journal.pone.0083306

33. Rosen CJ, Morrison A, Zhou H, *et al*. Elderly women in northern New England exhibit seasonal changes in bone mineral density and calciotropic hormones. *Bone Miner* [Internet]. 1994 May [cited 2017 Nov 1];25(2):83–92. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8086854

34. Laird E, Ward M, McSorley E, *et al*. Vitamin D and bone health: potential mechanisms. *Nutrients* [Internet]. 2010 [cited 2017 Nov 1];2(7):693–724. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22254049

35. Bulajic-Kopjar M. Seasonal variations in incidence of fractures among elderly people. *Inj Prev* [Internet]. 2000 Mar [cited 2017 Oct 26];6(1):16–19. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10728535

36. Crighton EJ, Moineddin R, Mamdani M, *et al*. Influenza and pneumonia hospitalizations in Ontario: a time-series analysis. *Epidemiol Infect* [Internet]. 2004 Dec [cited 2017 Jul 4];132(6):1167–74. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15635976

37. Kelsey JL, Procter-Gray E, Hannan MT, *et al*. Heterogeneity of falls among older adults: implications for public health prevention. *Am J Public Health* [Internet]. 2012 Nov [cited 2017 Oct 26];102(11):2149–56. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22994167

38. Speechley M, Tinetti M. Falls and injuries in frail and vigorous community elderly persons. *J Am Geriatr Soc* [Internet]. 1991 Jan [cited 2017 Oct 26];39(1):46–52. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1987256

39. Environment & Natural Resources. Station Results – 1981–2010 Climate Normals and Averages (for Ontario) [Internet]. Ottawa: Government of Canada; 2010. Available from: http://climate.weather.gc.ca/climate_normals/station_select_1981_2010_e.html?searchType=stnProv&lstProvince=ON

40. Mondor L, Charland K, Verma A, *et al*. Weather warnings predict fall-related injuries among older adults. *Age Ageing* [Internet]. 2015 May 1 [cited 2017 Jul 4];44(3):403–08. Available from: https://academic.oup.com/ageing/article-lookup/doi/10.1093/ageing/afu199

41. Bischoff-Ferrari HA, Orav JE, Barrett JA, *et al*. Effect of seasonality and weather on fracture risk in individuals 65 years and older. *Osteoporos Int* [Internet]. 2007 Sep 21 [cited 2017 Jul 4];18(9):1225–33. Available from: http://link.springer.com/10.1007/s00198-007-0364-6

42. Mirchandani S, Aharonoff GB, Hiebert R, *et al*. The effects of weather and seasonality on hip fracture incidence in older adults. *Orthopedics* [Internet]. 2005 Feb [cited 2017 Jul 4];28(2):149–55. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15751369

43. Diamantopoulos AP, Rohde G, Johnsrud I, *et al*. Incidence rates of fragility hip fracture in middle-aged and elderly men and

women in southern Norway. *Age Ageing* [Internet]. 2012 Jan 1 [cited 2017 Jul 4];41(1):86–92. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21896555

44. Emaus N, Olsen LR, Ahmed LA, *et al.* Hip fractures in a city in Northern Norway over 15 years: time trends, seasonal variation and mortality. The Harstad Injury Prevention Study. *Osteoporos Int* [Internet]. 2011 Oct 20 [cited 2017 Jul 4];22(10):2603–10. Available from: http://link.springer.com/10.1007/s00198-010-1485-x

45. Parkkari J, Kannus P, Palvanen M, *et al.* Majority of hip fractures occur as a result of a fall and impact on the greater trochanter of the femur: a prospective controlled hip fracture study with 206 consecutive patients. *Calcif Tissue Int* [Internet]. 1999 Sep [cited 2019 Jan 7];65(3):183–87. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10441647

46. Kelsey JL, Procter-Gray E, Nguyen Uyen-Sa, *et al.* Footwear and falls in the home among older individuals in the MOBILIZE Boston study. *Footwear Sci* [Internet]. 2010 Sep [cited 2017 Oct 26];2(3):123–29. Available from: http://www.tandfonline.com/doi/abs/10.1080/19424280.2010.491074

47. Bischoff-Ferrari HA, Dawson-Hughes B, Willett WC, *et al.* Effect of vitamin D on falls: a meta-analysis. *JAMA* [Internet]. 2004 Apr 28 [cited 2017 Jul 4];291(16):1996–2006. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15113819

48. Avenell A, Gillespie WJ, Gillespie LD, et al. Vitamin D and vitamin D analogues for preventing fractures associated with involutional and post-menopausal osteoporosis. Cochrane Database System Rev [Internet]. 2009 [cited 2017 Jul 4];Apr. 15(2):CD000227. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19370554

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APPENDICES

APPENDIX A. RECORD checklist of recommendations for the reporting of studies conducted using routinely collected health data

	Item No	Recommendation	Reported
		1.1 The type of data used should be specified in the title or abstract. When possible, the name of the databases should be included.	Abstract
Title and abstract	1	1.2 If applicable, the geographic region and time frame within which the study took place should be reported in the title or abstract.	Abstract
		1.3 If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction
Objectives	3	State specific objectives, including any pre-specified hypotheses	Introduction
Methods			
Study design	4	Present key elements of study design early in the paper	Methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods
		6.1 The methods of study population selection should be listed in detail. If this is not possible, an explanation should be provided.	Methods
Participants	6	6.2 Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.	Methods
		6.3 If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the linkage process, including the number of individuals with linked data at each stage.	Not feasible
Variables	7	A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Methods, Appendix B-D
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods, Appendix B-D
Bias	9	Describe any efforts to address potential sources of bias	Methods
Study size	10	Explain how the study size was arrived at	Methods
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Methods, Tables 2-3
		12.1 Describe all statistical methods, including those used to control for confounding	Methods
		12.2 Describe methods used to examine subgroups and interactions	Methods
Statistical methods		12.3 Explain how missing data were addressed	Methods
		12.4 If applicable, explain how loss to follow-up was addressed	Not applicable
		12.5 Describe any sensitivity analyses	Not applicable
	12	12.6 Authors should describe the extent to which the investigators had access to the database population used to create the study population.	Methods
Data access and cleaning methods		12.7 Authors should provide information on the data cleaning methods used in the study	Methods
		12.8 State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	Methods
Linkage			

Results			
Participants	13	13.1 Describe in detail the selection of the persons included in the study (i.e. study population selection), including filtering based on data quality, data availability, and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Results
Descriptive data	14	14.1 Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	Results, Tables 2-3
		14.2 Indicate number of participants with missing data for each variable of interest	Tables 2-3
		14.3 Summarize follow-up time (e.g. average and total amount)	Results
Outcome data	15	Report numbers of outcome events or summary measures over time	Results, Figure 1
Main results	16	16.1 Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Results
		16.2 Report category boundaries when continuous variables were categorized	Tables 2-3
		16.3 If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarize key results with reference to study objectives	Discussion
Limitations	19	Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data and changing eligibility over time, as they pertain to the study being reported.	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion
Generalizability	21	Discuss the generalizability (external validity) of the study results	Discussion
Other information			
Funding		22.1 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Acknowledgments
Accessibility of protocol, raw data and programming code	22	22.2 Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS.

APPENDIX B. Hip fracture coding algorithm

Variable	Database	Codes
Hip fracture	CIHI-DAD	ICD 10/ICD 10-CA: S720, S721
		CCI: 1VA73, 1VC73, 1VA74, 1VA53, 1VC74, 1VA80

CIHI-DAD = Canadian Institute for Health Information's-Discharge Abstract Database; CCI = Canadian Classification of Health Interventions; ICD-10/ICD 10-CA = International Classification of Diseases 10th Revision/Enhanced Canadian version of the 10th Revision of the International Statistical Classification of Diseases and Health Related Problems.

APPENDIX C. Description of ICES databases

Database	Details
Registered Persons Database of Ontario	Contains vital statistics for all residents who have been issued an Ontario health card.
Yearly Ontario Intercensal and Postcensal Population Estimates and Projection Database	Contains Ontario population estimates by sex, age and geographic areas.
Ontario Drug Benefits Database	Contains prescription medication for adults ≥65 years and those using social assistance.
Drug Identification Number Database	Contains Drug Identification Numbers used in Canada from 1990.
Ontario Diabetes Database	Contains all patients with diabetes identified since 1991 (based upon hospitalization codes and physician diagnoses).
Ontario Chronic Obstructive Pulmonary Disease Database	Contains all patients with COPD identified since 1991 (based upon hospitalization codes, physician services claims).
Ontario Rheumatoid Arthritis Database	Contains all patients with rheumatoid arthritis identified since 1991 (based upon hospitalization codes, physician services claims).
Ontario Crohn's and Colitis Cohort Database	Includes all Ontarians with Crohn's or colitis identified since 1991 (defined by hospitalization codes, prescription medications, and physicians' services claims).
Home Care Database	Contains information about home care services acquired from the Ontario Association of Community Care Access Centres.
ICES Physicians Database	Contains information about all physicians in Ontario (ascertained from the Ontario Health Insurance Plan and the Ontario Physician Human Resource Data Centre).
Canadian Institute for Health Information's Discharge Abstract Database	Contains diagnostic and procedural information coded during inpatient hospitalizations.
National Ambulatory Care Reporting System Database	Contains diagnostic and procedural information coded during emergency room encounters.
Ontario Health Insurance Plan Database	Contains physician diagnostic and billing codes.

Appendix D. Variable definitions

Variable	Database	Codes/Notes
Comorbidities		
Acute kidney injury	CIHI-DAD	ICD 10/ICD 10-CA: N17
Acute myocardial infarction	CIHI-DAD NACRS	ICD10/ICD 10-CA: I21, I22
Alcoholism	CIHI-DAD	ICD 10/ICD 10-CA: E244, E512, F10, G312, G621, G721, I426, K292, K70, K860, T510, X45, X65, Y15, Y573, Z502, Z714, Z721, T519
Chronic kidney disease	CIHI-DAD OHIP	ICD 10/ICD10-CA: E102, E112, E132, E142, I12, I13, N08, N18, N19 OHIP DX: 403, 585
Chronic liver disease	CIHI-DAD OHIP	ICD 10/ICD 10-CA: B16, B17, B18, B19, I85, R17, R18, R160, R162, B942, Z225, E831, E830, K70, K713, K714, K715, K717, K721, K729, K73, K74, K753, K754, K758, K759, K76, K77 OHIP DX: 571, 573, 070 OHIP Fee: Z551, Z554
Chronic obstructive pulmonary disease	COPD	In COPD database
Crohn's or colitis	OCCD	In OCCD database
Dementia	CIHI-DAD OHIP	ICD 10/ICD 10-CA: F065, F066, F068, F069, F09, F00, F01, F02, F03, F051, G30, G31, R54 OHIP DX: 290, 331, 797
Diabetes	ODD	In ODD database
Fall	CIHI-DAD NACRS OHIP	ICD 10/ICD 10-CA: W00-W19
Fracture	CIHI-DAD NACRS OHIP	Hip ICD10/ICD 10-CA: S720, S721 CCI: 1VA73, 1VC73, 1VA74, 1VA53, 1VC74, 1VA80 Forearm ICD10/ICD 10-CA: S52 CCI: 1TV73, 1TV74, 1TV03 OHIP FEE: F014, F022, F023, F025, F026, F028, F030, F032, F033, F046, F024, F027, F031, Z203 Humerus ICD10/ ICD 10-C: S422 Pelvis ICD10/ICD 10-CA: S321, S322, S324, S323, S325, S327, S328
Major cancer	CIHI-DAD OHIP	ICD10/ICD 10-CA: 971, 980, 982, 984, 985, 986, 987, 988, 989, 990, 991, 993, C15, C18, C19, C20, C22, C25, C34, C50, C56, C61, C82, C83, C85, C91, C92, C93, C94, C95, D00, D05, D010, D011, D012, D022, D075 OHIP DX: 203, 204, 205, 206, 207, 208, 150, 154, 155, 157, 162, 174, 175, 183, 185
Seizure	CIHI-DAD	ICD 10/ ICD 10-CA: G40, G41, R560, R568
Sepsis	CIHI-DAD	ICD 10/ ICD 10-CA: A021, A392, A393, A394, A400, A401, A402, A408, A409, A410, A411, A412, A403, A414, A4159, A413, A4150, A4151, A4152, A4158, A4180, A4188, A427, A419
Rhabdomyolysis	CIHI-DAD	ICD 10/ ICD 10-CA: M628, T296, G210
Rheumatoid arthritis	ORAD	In ORAD database
Medications	ODB DIN	
Health Care Utilization		
General practitioner visit	IPDB	Evidence of at least 1 GP visit

Any blood test	OHIP	At least one OHIP lab test
Specialist visit	IPDB	Evidence of at least one specialist visit
Home care visit	HCD	Evidence of at least one home care visit

CIHI-DAD = Canadian Institute for Health Information's-Discharge Abstract Database; CCI = Canadian Classification of Health Interventions; COPD = Chronic Obstructive Pulmonary Disease Dataset; ICD 10/ICD 10-CA = International Classification of Diseases 10th Revision/ Enhanced Canadian version of the 10th Revision of the International Statistical Classification of Diseases and Health Related Problems; OCCD = Ontario Crohn's and Colitis Dataset; OHIP DX = Ontario Health Insurance Plan Diagnostic; OHIP Fee = Ontario Health Insurance Plan Fee; ORAD = Ontario Rheumatoid Arthritis Dataset; RPDB = Registered Persons Database of Ontario.