

Risk Factors for Return to the Emergency Department for Asthma: A Population-Based Study



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What is already known about this topic? A significant proportion of those who visit the emergency department (ED) for asthma will return.

What does this article add to our knowledge? We found that 1 in 8 individuals with a first ED visit for asthma returned to the ED within a year. Younger age, being materially deprived, and comorbidities were significantly associated with increased ED return risk.

How does this study impact current management guidelines? Clinicians should encourage patients who visit the ED for asthma initially to attend a follow-up visit with their general practitioner, with particular attention paid to younger patients, those with chronic obstructive pulmonary disease, and those of lower socioeconomic status.

BACKGROUND: A substantial proportion of patients with asthma return after being discharged from the emergency department (ED). Given the high economic burden of acute care claims, and the impact on productivity and quality of life, a better understanding of risk factors for ED return is of interest. **OBJECTIVE:** To quantify the rate and determine factors associated with return to the ED for asthma within 1 year of an initial ED visit for asthma.

METHODS: Individuals aged 5 to 99 years living in Ontario, Canada, with an ED visit for asthma in the period 2008 to 2014 were included. Descriptive statistics were used to compare those with an ED return with those without an ED return. An adjusted modified Poisson regression model was used to estimate the

relative risk of ED return for asthma within 1 year after the initial discharge.

RESULTS: In total, 58,366 individuals met the inclusion criteria. At 1-year follow-up, 12.1% returned to the ED at least once. Younger age, being materially deprived, and having chronic obstructive pulmonary disease were significantly associated with increased risk of ED return within 1 year after the initial visit.

CONCLUSIONS: Nearly 1 in 8 individuals with a first ED visit for asthma returned to the ED within a year of the initial ED discharge. Targeting those at risk for ED return may help improve health care costs, productivity, and quality of life. © 2018 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2018;6:1907-13)

Key words: Asthma; Epidemiology; Emergency department visits; Readmissions; Risk factors

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INTRODUCTION

In Ontario, there are approximately 40,000 emergency department (ED) visits for asthma each year.¹ Population-based studies have estimated that 6% of adults and 7.5% of children with an ED visit will return within the next 7 days.^{2,3} Given the high burden on the health care system, as well as lost productivity and negative impact on quality of life, there is substantial interest in targeting interventions toward those with the highest risk of ED return.

Independent risk factors for ED return among children include younger age, family history of asthma, and having a native tongue other than English or French.^{3,4} These studies are limited in their focus on the pediatric population.³⁻¹²

Previous studies have also identified a number of factors associated with ED return for asthma after an initial asthma visit in the adult population.^{3-10,12-14} More severe disease,^{3,6,15-19} multiple comorbidities including mental illness,^{14,17} previous

Abbreviations used

COPD- Chronic obstructive pulmonary disease
ED- Emergency department
ICES- Institute for Clinical Evaluative Sciences
ON-Marg- Ontario marginalization index
RR_{adj}- Adjusted relative risk
SES- Socioeconomic status

hospitalizations or ED visits for asthma,^{15,16,20} lower socioeconomic status (SES),^{3,8,18} being uninsured,¹⁴ not being white or being Aboriginal,^{2,14,18} and not having a written asthma action plan¹⁵ have been found to be associated with increased risk of ED return. In addition, risk of ED return for asthma has been shown to increase with age,¹⁸ particularly among seniors with low levels of family or community support.²⁰ Finally, the relationship between sex and ED return is less clear. Some studies found that males were more likely to have repeat ED visits,¹⁹ but others did not find any significant relationship with sex.^{5,7,17,18} However, previous studies are limited by their use of small clinical samples and single center studies.^{4,7,8,10,12,13,16-18,20,21}

Asthma exacerbations that result in ED visits may signal either severe disease (difficult to treat), poor disease management health behaviors, or other underlying causes that influence health care utilization (eg, social determinants of health and access to care). As such, it is paramount to better understand risk factors for repeat ED visits to target interventions toward those with the highest risk of ED return. Therefore, the primary purpose of this study was to quantify the burden of ED return for asthma and identify important risk factors of ED return.

METHODS**Study population and data sources**

The study population was drawn from the Ontario Asthma Surveillance Information System, a registry of more than 2.1 million Ontario residents with physician-diagnosed asthma housed at the Institute for Clinical Evaluative Sciences (ICES). This registry uses health services claims data that are routinely collected by the government, the single payer of Ontario universal health care insurance, to classify individuals with incident asthma. The case definition for asthma includes those with 1 or more asthma hospital admissions or 2 or more asthma physician claims in 2 consecutive years (where the first claim is considered the diagnosis date). We have previously validated this case definition with 84% sensitivity and 76% specificity in adults²² and 89% sensitivity and 72% specificity in children (aged 0-17 years)^{23,24} compared with a clinical reference standard.

Individuals aged 5 to 99 years with an ED visit for asthma between April 1, 2008, and March 31, 2014, were included. Those younger than 5 years at initial ED visit were excluded because of challenges in establishing an objective diagnosis of asthma in very young children. Those without a valid health card number (including those who were visitors to Ontario); those without insurance coverage (because of moving out of the province or because of death) during the observation period; those with incomplete information for age, sex, or rurality of residence at the initial ED visit; and those who died during the initial ED visit or in the next 1 year were excluded. The Canadian Institute for Health Information Discharge Abstract Database and the National Ambulatory Care Reporting System were used to capture hospitalizations and ED

visits, respectively. Data were linked on an individual level using an encrypted unique health card number given to all Ontario residents.

This study received research ethics board approval from The Hospital for Sick Children and Sunnybrook Health Sciences Centre, both in Toronto, Ontario, Canada.

Measures

The number of ED return visits within 1 year after ED discharge was counted. Information about ED visits was obtained from the National Ambulatory Care Reporting System based on asthma diagnostic codes (J45 and J46) from the *International Classification of Diseases, Tenth Revision*.

Age, sex, and postal code were obtained from the Ontario Registered Persons Database. Postal code information was used to discern rurality of residence, neighborhood-level income quintiles, and the Ontario marginalization (ON-Marg) index. The ON-Marg index is a census-based index that measures inequalities in health and social well-being²⁵ with 4 dimensions: material deprivation (unemployed, without high school diploma, low income, etc), dependency (seniors, not participating in the labor force, etc), residential instability (living alone, apartment buildings, rental dwellings, etc), and ethnic concentration (recent immigrants, visible minorities, etc). A score is computed for each dimension and quintiles are produced, with quintile 5 being the most marginalized.

Comorbidities, including chronic obstructive pulmonary disease (COPD), hypertension, diabetes, congestive heart failure, acute myocardial infarction, cancers, ischemic heart disease, stroke, and angina, were determined from health administrative databases housed at the ICES (see details in Table E1 in this article's Online Repository at www.jaci-inpractice.org). These diseases were included because they are the most common or prevalent chronic diseases in Canada as well as globally.²⁶ The physician claims database was used to discern whether individuals had a follow-up visit with a physician within the 3 days of the initial ED visit. The ICES Physician Database was used to determine the physician type (general practitioner, respiratory specialist, or nonrespiratory specialist). Details of follow-up visits at further time points (ie, at 14, 28, 84, 180, and 366 days) are provided in Table E2 in this article's Online Repository at www.jaci-inpractice.org.

Statistical analysis

Descriptive statistics on covariates were conducted to compare people with asthma who did not return with those who returned at least once. Chi-square tests were used to measure statistical differences with *P* values less than .05. The ED return rate per 100 person-years was also calculated for each characteristic of the study population. A Kaplan-Meier curve was plotted to show the time to ED return visit within the first year. A modified Poisson regression model (using robust error variance estimates)²⁷ was used to estimate the relative risk of ED return within 1 year after ED discharge, adjusting for sex, age group, rurality, the ON-Marg index, and comorbid health conditions. Income quintile was excluded because it was collinear with the ON-Marg index variables. Follow-up visit was excluded from the model because of the small number of individuals who had a follow-up visit. Relative risks of ED return with 95% CIs were calculated. Overdispersion was adjusted using a scaling factor, which was estimated by the square root of the Pearson chi-square divided by its degree of freedom. To address effect modification by age, a stratified analysis was conducted as a sensitivity analysis (for results, see Tables E3, E4, and E5 in this article's Online Repository

TABLE I. Characteristics of study population

Characteristic	At least 1 return visit (N = 7,061)	Total (N = 58,366)	P value	ED return rate (per 100 person-years)
Sex				
Female	4,058 (12.2%)	33,368	.59	15.4
Male	3,003 (12.0%)	24,998		16.1
Age group (y)				
5-19	2,245 (12.2%)	18,352	<.01*	15.7
20-49	3,400 (12.5%)	27,203		16.5
≥50	1,416 (11.1%)	12,811		13.8
Rural				
No	5,552 (11.7%)	47,410	<.01*	15.1
Yes	1,509 (13.8%)	10,956		18.1
Material deprivation quintile				
1 (least marginalized)	1,259 (10.7%)	11,744	<.01*	13.6
2	1,398 (11.6%)	12,067		14.9
3	1,404 (12.0%)	11,704		15.4
4	1,409 (12.9%)	10,883		17.2
5 (most marginalized)	1,446 (13.2%)	10,949		17.2
Missing	145 (14.2%)	1,019		19.5
Dependency quintile				
1 (least marginalized)	1,484 (11.7%)	12,680	<.01*	15.2
2	1,431 (11.5%)	12,409		15.2
3	1,374 (11.9%)	11,518		15.4
4	1,309 (12.6%)	10,395		16.0
5 (most marginalized)	1,318 (12.7%)	10,345		16.4
Missing	145 (14.2%)	1,019		19.5
Ethnic concentration quintile				
1 (least marginalized)	1,157 (13.0%)	8,924	<.01*	16.8
2	1,287 (12.4%)	10,339		16.2
3	1,208 (11.7%)	10,336		15.2
4	1,280 (11.5%)	11,106		14.8
5 (most marginalized)	1,984 (11.9%)	16,642		15.4
Missing	145 (14.2%)	1,019		19.5
Residential instability quintile				
1 (least marginalized)	1,384 (10.6%)	13,013	<.01*	13.5
2	1,474 (12.2%)	12,107		15.1
3	1,271 (12.5%)	10,162		16.4
4	1,447 (12.2%)	11,829		16.3
5 (most marginalized)	1,340 (13.1%)	10,236		17.4
Missing	145 (14.2%)	1,019		19.5
Income quintile				
1 (lowest)	1,721 (12.8%)	13,466	<.01*	16.9
2	1,587 (12.7%)	12,533		16.7
3	1,385 (12.0%)	11,564		15.3
4	1,235 (11.2%)	11,031		14.1
5 (highest)	1,099 (11.6%)	9,515		14.9
Missing	34 (13.2%)	257		18.7
Follow-up visit (within 3 d)				
GP/FP	1,045 (10.7%)	9,782	<.01*	13.8
Specialist	96 (11.0%)	872		14.2
None	5,920 (12.4%)	47,712		16.1
Comorbidities				
Acute myocardial infarction	33 (8.7%)	378	.04*	11.6
Angina	523 (11.4%)	4,588	.13	14.1
Chronic heart failure	64 (9.4%)	680	.03*	12.2
COPD	934 (12.2%)	7,642	.72	15.8

(continued)

TABLE I. (Continued)

Characteristic	At least 1 return visit (N = 7,061)	Total (N = 58,366)	P value	ED return rate (per 100 person-years)
Diabetes	516 (11.4%)	4,525	.14	14.1
Hypertension	1,074 (11.0%)	9,722	<.01*	13.8
Ischemic heart disease	75 (10.9%)	686	.35	12.4
Cancer	135 (10.0%)	1,353	.02*	12.6
Stroke	237 (11.0%)	2,159	.10	14.4

FP, Family practitioner; GP, general practitioner.

* $P < .05$.

TABLE II. Number of and time to ED return visits by number and proportion of individuals

Return ED visits	N	Proportion (%)
Number of return ED visits		
0	51,305	87.9
1	5,635	9.7
2	1,043	1.8
3	246	0.4
4	81	0.1
≥5	56	0.1
Time to return ED visits		
0-3 d	850	12.0
4-7 d	405	5.7
8-28 d	765	10.8
29 d to 6 mo	2,631	37.3
>6 mo to 1 y	2,410	34.1

at www.jaci-inpractice.org). All analyses were carried out using SAS Enterprise Guide 6.1 (SAS Institute, Cary, NC).

RESULTS

A total of 64,053 individuals aged 5 to 99 years had an initial ED visit for asthma between April 1, 2008, and March 31, 2014, in Ontario and 58,366 met the study inclusion criteria. Of those, 7061 returned to the ED at least once during the 1-year follow-up period. This corresponds to nearly 1 in 8 (12.1%) individuals with a first ED visit for asthma who returned to ED 1 year after initial ED discharge. The ED return rate of the study population was 15.7 per 100 person-years.

Descriptive statistics

Table I presents the characteristics of the study population by the number and proportion of individuals with at least 1 return visit, as well as the ED return rate (per 100 person-years). A similar proportion of males and females had at least 1 return visit in the 1-year follow-up period (12.0% vs 12.2%; $P = .59$). Significant differences in the proportions of ED return were found by age group ($P < .01$), with those aged 20 to 49 years having the highest rate of ED return (12.5%) compared with those aged 5 to 19 years and those aged 50 years and older (12.2% and 11.1%, respectively). A higher percentage of ED return was found in those with rural residence compared with those with nonrural residence (13.8% vs 11.7%; $P < .01$).

SES was proxy measured by neighborhood income quintiles and the ON-Marg index. Lower income was associated with higher ED returns (12.8% vs 11.6%; $P < .01$). Similar inequalities were observed for the material deprivation,

dependency, and residential instability dimensions of the ON-Marg index, whereby those in the most marginalized groups had higher rates of ED return compared with those in the least marginalized groups.

Those who did not have a follow-up visit with a physician within 3 days of the initial ED visit had a higher ED return rate compared with those who did (12.4% vs 10.7%; $P < .01$). Significant differences in the proportion of ED return were observed for only some types of comorbidities, including acute myocardial infarction ($P = .04$), congestive heart failure ($P = .03$), hypertension ($P < .01$), and cancer ($P = .02$).

Table II presents the number and proportion of individuals by the number of ED return visits. Most of the individuals (87.9%) did not have a return visit. However, 9.7% of individuals returned to the ED 1 time and 2.4% returned to the ED multiple times. Table II and Figure 1 provide a description of the number and proportion of individuals who returned to the ED within 3 days, 7 days, 28 days, 6 months, and 1 year. Of those who returned to the ED within the first year, 1 in 8 (12%) returned within the first 3 days. More than 1 in 4 (28.5%) return visits happened within the first 28 days after the initial ED visit.

Relative risk of ED return

The results of the adjusted modified Poisson regression model are presented in Table III. The analysis identified a number of significant risk factors for ED return. Adjusted for other risk factors, younger age was associated with the highest risk of ED return. Compared with those aged 50 years and older, those aged 20 to 49 years had an 18% increased risk of ED return for asthma (RR_{Adj} , 1.18; 95% CI, 1.08-1.28; $P \leq .01$). Moreover, those aged 5 to 19 years had a 13% increased risk of ED return for asthma compared with the oldest age group (RR_{Adj} , 1.13; 95% CI, 1.03-1.25; $P = .01$). Sex was not a significant risk factor for ED return. Those who lived in rural areas had 18% higher risk of returning to the ED compared with those who lived in urban areas (RR_{Adj} , 1.18; 95% CI, 1.10-1.27; $P < .01$). Having COPD increased the risk of ED return for asthma by 14% (RR_{Adj} , 1.14; 95% CI, 1.04-1.25; $P \leq .01$). The presence of other comorbidities was not significantly associated with asthma-specific ED return.

Lower SES was a significant risk factor for ED return. Individuals who were most materially deprived had a 16% higher risk of returning to the ED compared with those who were least deprived (RR_{Adj} , 1.16; 95% CI, 1.05-1.27; $P \leq .01$). A strong and consistent social gradient was observed for another measure of marginalization—residential instability. For example, those who lived in residential areas with the most instability had a higher risk of ED return (RR_{Adj} , 1.24; 95% CI, 1.13-1.36; $P < .01$).

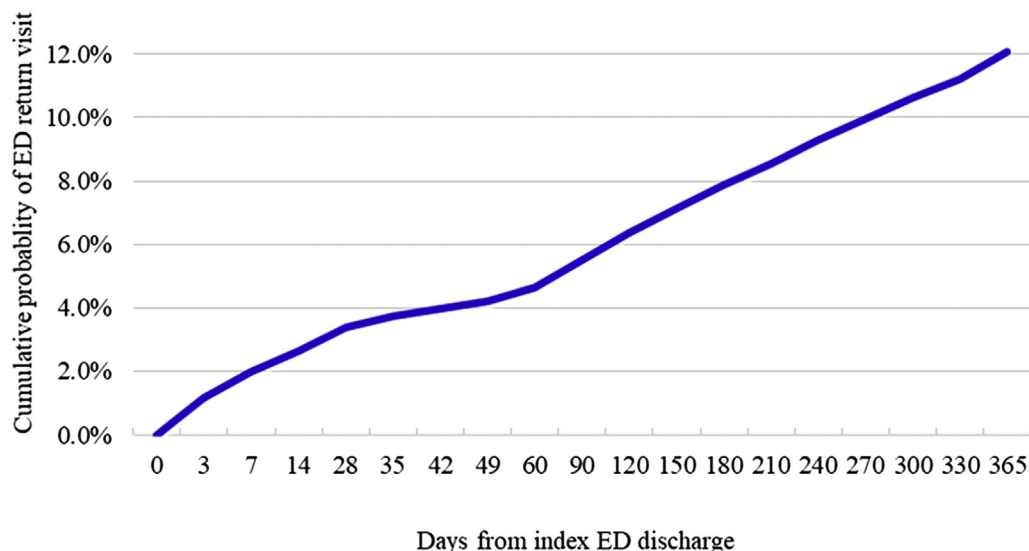


FIGURE 1. Kaplan-Meier curve on cumulative probability of time to ED return visits.

DISCUSSION

Our study examined return to the ED for asthma using health administrative records from a universal health care insurance and included all individuals (aged 5-99 years) with an initial ED visit during a 6-year study period. This study estimates that nearly 1 in 8 (12%) individuals with a first ED visit for asthma returned to ED within 1 year after initial ED discharge. This implies that a significant proportion of those with a first ED visit for asthma will return to the ED within 1 year for the same cause. This study also identified and quantified a number of risk factors that were associated with ED return, including younger age (ie, younger than 50 years), lower SES, and comorbid COPD. These results add to the few population-based studies that examined repeat ED visits for asthma using real-world data.^{2,3} This study used a large real-world population of more than 2.1 million individuals with prevalent asthma that contained a blend of urban and rural residents as well as a mixture of SESs that could be generalized to other health care settings.

We observed in our study that lower SES, as measured by the material deprivation and residential instability dimensions of the ON-Marg Index, was significantly associated with an increased risk of ED return for asthma. It has been suggested by others that those living in neighborhoods with greater levels of deprivation and lower incomes have higher morbidity and acute care utilizations for ambulatory care-sensitive conditions.²⁸ In particular, a population-based study using administrative databases from California and Florida found low SES to be a significant predictor of multiple asthma-related ED visits.²⁹ This study adds to the body of knowledge and further suggests that socioeconomic disparities persist, even within publicly funded health care systems. In addition, individuals of lower SES may not have access to medications that are necessary to control their chronic disease such as asthma. A previous study found that individuals without drug coverage were more likely to have an asthma-specific ED return visit.¹¹ Moreover, Kenyon et al³⁰ found that after adjusting for patient characteristics, receiving beta-agonist (RR, 0.67; 95% CI, 0.51-0.87) and inhaled steroid (RR, 0.59; 95%

CI, 0.42-0.85) prescriptions was associated with significant reductions in hospital readmission at 14 days. The high cost of medication can be compounded in those with more severe asthma, who require more medication and whose asthma symptoms may have a negative impact on their employment opportunities.²¹ As such, there is a need to address economic barriers to filling prescriptions and target health promotion interventions for individuals of lower SES.

This study observed a significantly higher risk of ED return visits among those with COPD compared with those without COPD. This finding is well supported by the literature on asthma and COPD overlap syndrome that indicates that those with both conditions have more exacerbations and health services use than do those with asthma alone.³¹⁻³⁴

We also found that more than 80% of individuals with an initial ED visit in Ontario did not have a follow-up visit with a general practitioner or respirologist within 3 days of their ED discharge and that those individuals were more likely to return to the ED. These findings are consistent with 1 multicenter study on frequent ED users, which found that 85% of patients with an ED visit for asthma were not evaluated by a specialist in the past 12 months.¹⁹ Increasing physician follow-up visits in the 3 days after initial ED visits could be an important means to reduce returns to the ED.³⁵

Strengths of this study include the use of population-based health administrative data to collect information about all asthma-specific ED visits in Ontario, Canada. This real-world data source allowed us to study longitudinal ED visits without introducing selection or response bias. However, we were limited in our ability to adjust for asthma medication use because currently in Ontario, the Ontario Drugs Benefit database includes only prescriptions paid for by the provincial government for those aged 65 years or older and those on social assistance. Moreover, we were not able to adjust for other important lifestyle factors (eg, smoking and health-seeking behaviors) that were not available in the health administrative data but could confound the relationship between certain risk factors and repeat ED visits.

TABLE III. Adjusted relative risk of asthma-specific ED return visit within 1 y after ED discharge

Risk factor	Relative risk	95% CI	P value
Age group (y) (reference: ≥ 50)			
5-19	1.13	1.03 1.25	.01*
20-49	1.18	1.08 1.28	<.01*
Sex (reference: Female)			
Male	1.04	0.99 1.10	.13
Rural (reference: No)			
Yes	1.18	1.10 1.27	<.01*
Material deprivation quintile (reference: 1)			
2	1.07	0.98 1.16	.14
3	1.07	0.98 1.17	.11
4	1.17	1.07 1.28	<.01*
5 (most marginalized)	1.16	1.05 1.27	<.01*
Missing	1.35	1.09 1.66	<.01*
Dependency quintile (reference: 1)			
2	0.99	0.91 1.08	.85
3	0.97	0.89 1.06	.48
4	0.96	0.88 1.06	.42
5 (most marginalized)	0.96	0.87 1.05	.35
Ethnic concentration quintile (reference: 1)			
2	0.99	0.90 1.08	.82
3	0.94	0.86 1.04	.23
4	0.93	0.84 1.03	.18
5 (most marginalized)	0.95	0.86 1.06	.36
Residential instability quintile (reference: 1)			
2	1.08	0.99 1.18	.07
3	1.15	1.05 1.25	<.01*
4	1.13	1.03 1.24	<.01*
5 (most marginalized)	1.24	1.13 1.36	<.01*
Comorbidities (reference: No)			
Acute myocardial infarction	0.87	0.59 1.29	.49
Angina	0.97	0.87 1.09	.65
Cancer	0.88	0.72 1.06	.18
Chronic heart failure	0.90	0.68 1.20	.47
COPD	1.14	1.04 1.25	<.01*
Diabetes	0.96	0.86 1.07	.47
Hypertension	0.92	0.84 1.01	.07
Ischemic heart disease	0.93	0.70 1.26	.65
Stroke	0.99	0.85 1.15	.90

* $P < .05$.

In addition, this study was limited by the nature of health administrative databases that do not collect information on disease severity, symptoms, or other clinical measurements that are relevant when studying chronic diseases such as asthma.

CONCLUSIONS

This study estimated that nearly 1 in 8 (12%) individuals with a first ED visit for asthma returned to ED 1 year after initial ED discharge. Significant risk factors for asthma-specific ED return visits include younger age, lower SES, and comorbid COPD. Frequent ED visits for asthma will adversely affect productivity

and quality of life. Given asthma is an ambulatory care—sensitive condition, identifying areas to strengthen in the primary care setting may help lower the burden on the health care system and improve productivity and quality of life. Increasing follow-up after initial ED visits and reducing economic barriers to filling prescription medications may be important areas for improvement.

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TABLE E1. ICD-9 and ICD-10 codes of chronic diseases

Conditions	ICD-9	ICD-10	Algorithm
Acute myocardial infarction	410	I21	Ages 20-105 y: All patients with a most responsible diagnosis of listed ICD codes in the CIHI-DAD, CIHI-SDS database, and then several exclusion criteria were applied
Angina	413	I20	Ages 20-105 y: All patients with a most responsible diagnosis of listed ICD codes in the CIHI-DAD, CIHI-SDS database, NACRS, and OHIP claims
COPD	491, 492, 496	J41, J42, J43, J44	(COPD database) Ages 35-105 y: Individuals with ≥ 1 COPD diagnoses in OHIP or CIHI-SDS or CIHI-DAD database
Congestive heart failure	428	I500, I501, I509	Ages 45-105 y: Individuals with ≥ 1 hospital admissions with a CHF diagnosis or ≥ 1 OHIP claims/NACRS ED records with a CHF diagnosis followed within 1 y by a second record with a CHF diagnosis from any source
Diabetes	250	E10, E11, E13, E14	Ontario Diabetes Database: Pediatric definition (≤ 18 y): ≥ 4 OHIP claims with diagnostic code 250 or ≥ 1 OHIP claims with fee code Q040, K029, or K030 within 2 y Adult definition (> 18 y): ≥ 2 OHIP claims with diagnostic code 250 or ≥ 1 OHIP claims with fee code Q040, K029, or K030 or ≥ 1 CIHI admissions within 2 y
Hypertension	401, 402, 403, 404, 405	I10, I11, I12, I13, I15	Ages 20-105 y: Individuals with ≥ 1 hospital admissions with a hypertension diagnosis, or ≥ 1 OHIP claims with a hypertension diagnosis followed within 2 y by either ≥ 1 OHIP claims or ≥ 1 hospital admissions with a hypertension diagnosis
Ischemic heart disease	411, 414	I24, I251, I258, I259	Ages 20-105 y: All patients with a most responsible diagnosis of any of listed ICD codes in the CIHI-DAD, CIHI-SDS database, NACRS, and OHIP claims
Lung cancer	162, 163	C34.0-C34.9, C38.4, C45.0	Ages 20-105 y: The OCR is a computerized database of information on all adult Ontario residents who have been newly diagnosed with cancer ("incidence") or who have died of cancer ("mortality"). All new cases of cancer are registered, except non-melanoma skin cancer Individuals aged 20-105 y in the OCR database who had any of listed ICD codes indicated as primary cancer
Non-lung cancers	140-239 (except for 162 and 163)	C00-D29 (except for C34.0-C34.9, C38.4, and C45.0)	Ages 20-105 y: Individuals in the OCR database who had any of listed ICD codes (except for lung cancer specified earlier) indicated as primary cancer
Stroke	433, 434, 435, 436	G45, G46, I63, I64	Ages 20-105 y: All patients with a most responsible diagnosis of any of listed stroke ICD codes in the CIHI-DAD, CIHI-SDS database, NACRS, and OHIP claims

CHF, Congestive heart failure; CIHI-DAD, discharge abstract data collected by the Canadian Institute for Health Information; CIHI-SDS, same-day surgery data collected by the Canadian Institute for Health Information; ICD, International Classification of Disease; ICD-9, International Classification of Disease, Ninth Revision; ICD-10, International Classification of Disease, Tenth Revision; NACRS, National Ambulatory Care Reporting System; OCR, Ontario Cancer Registry; OHIP, Ontario Health Insurance Plan.

TABLE E2. Follow-up visits at further time points

No. of days from discharge from initial ED visit	At least 1 return visit (N = 7,061)		No return visit (N = 51,305)	
	N	%	N	%
≤ 14 d	2,278	32%	19,935	39%
15-28 d	602	9%	5,804	11%
29-84 d	914	13%	9,709	19%
85-180 d	431	6%	6,423	13%
181-366 d	127	2%	4,678	9%
No follow-up visit (within 1 y)	2,709	38%	4,756	9%

TABLE E3. Characteristics of study population by age group

Characteristic	Age 5-19 y			Age 20-49 y			Age ≥50					
	At least 1 return visit (N = 2,245)	Total (N = 18,352)	P value	At least 1 return visit (N = 3,400)	Total (N = 27,203)	P value	At least 1 return visit (N = 1,416)	Total (N = 12,811)	P value			
Age (y), mean ± SD	12.01 ± 4.54	12.15 ± 4.43	.11	33.45 ± 8.92	33.44 ± 8.97	.99	60.84 ± 8.88	61.70 ± 9.52	<.01*			
Sex												
Female	1,070	13.6%	7,845	<.01*	2,033	12.2%	16,609	.11	955	10.7%	8,914	.06
Male	1,175	11.2%	10,507		1,367	12.9%	10,594		461	11.8%	3,897	
Rural												
No	1,820	12.1%	15,089	.13	2,684	12.0%	22,376	<.01*	1,048	10.5%	9,945	<.01*
Yes	425	13.0%	3,263		716	14.8%	4,827		368	12.8%	2,866	
Material deprivation quintile												
1 (least marginalized)	465	11.3%	4,107	<.01*	543	10.5%	5,187	<.01*	251	10.2%	2,450	.47
2	468	11.8%	3,955		619	11.4%	5,416		311	11.5%	2,696	
3	416	11.6%	3,599		707	13.0%	5,445		281	10.6%	2,660	
4	406	12.9%	3,145		726	13.8%	5,280		277	11.3%	2,458	
5 (most marginalized)	457	14.0%	3,253		724	13.5%	5,382		265	11.5%	2,314	
Missing	33	11.3%	293		81	16.4%	493		31	13.3%	233	
Dependency quintile												
1 (least marginalized)	503	11.5%	4,360	.03*	738	12.0%	6,151	<.01*	243	11.2%	2,169	.70
2	474	11.5%	4,112		702	12.0%	5,871		255	10.5%	2,426	
3	446	12.0%	3,705		640	12.0%	5,332		288	11.6%	2,481	
4	427	13.6%	3,150		618	12.9%	4,783		264	10.7%	2,462	
5 (most marginalized)	362	13.3%	2,732		621	13.6%	4,573		335	11.0%	3,040	
Missing	33	11.3%	293		81	16.4%	493		31	13.3%	233	
Ethnic concentration quintile												
1 (least marginalized)	350	13.3%	2,629	.24	534	13.7%	3,901	<.01*	273	11.4%	2,394	.06
2	382				607	12.6%	4,818		298	12.5%	2,389	
3	357	11.4%	3,130		618	12.5%	4,935		233	10.3%	2,271	
4	440	12.8%	3,436		627	11.4%	5,519		213	9.9%	2,151	
5 (most marginalized)	683	11.9%	5,732		933	12.4%	7,537		368	10.9%	3,373	
Missing	33	11.3%	293		81	16.4%	493		31	13.3%	233	
Residential instability quintile												
1 (least marginalized)	526	10.8%	4,892	<.01*	578	10.5%	5,493	<.01*	280	10.7%	2,628	.11
2	515	12.3%	4,181		642	12.1%	5,303		317	12.1%	2,623	
3	402	12.7%	3,166		605	13.1%	4,617		264	11.1%	2,379	
4	454	13.0%	3,483		746	12.8%	5,821		247	9.8%	2,525	
5 (most marginalized)	315	13.5%	2,337		748	13.7%	5,476		277	11.4%	2,423	
Missing	33	11.3%	293		81	16.4%	493		31	13.3%	233	
Income quintile												
1 (least marginalized)	510	13.2%	3,871	.12	878	13.2%	6,665	<.01*	333	11.4%	2,930	.78
2	474	12.5%	3,796		800	13.3%	5,995		313	11.4%	2,742	
3	425	11.7%	3,619		677	12.4%	5,444		283	11.3%	2,501	
4	416	11.2%	3,711		565	11.5%	4,930		254	10.6%	2,390	
5 (most marginalized)	412	12.6%	3,273		460	11.4%	4,044		227	10.3%	2,198	
Missing	8	9.8%	82		20	16.0%	125		6	12.0%	50	
Follow-up visit												
GP/FP	349	11.5%	3,023	.45	429	10.4%	4,112	<.01*	267	10.1%	2,647	.02*
Specialist	23	12.5%	184		50	13.2%	379		23	7.4%	309	
None	1,873	12.4%	15,145		2,921	12.9%	22,712		1,126	11.4%	9,855	
Comorbidities												
Acute myocardial infarction	Not applicable to children			≤5	—	41	.60	29	8.6%	337	.15	
Angina	27	17.4%	155	.05*	152	12.7%	1,201	.87	344	10.6%	3,232	.39
Cancer	≤5	—	23	.60	34	11.9%	285	.77	99	9.5%	1,045	.09
Chronic heart failure	Not applicable to children			8	23.5%	34	.05	56	8.7%	646	.05*	
COPD				271	14.0%	1,942	.04	663	11.6%	5,700	.06	

(continued)

TABLE E3. (Continued)

Characteristic	Age 5-19 y			Age 20-49 y			Age ≥50		
	At least 1 return visit (N = 2,245)	Total (N = 18,352)	P value	At least 1 return visit (N = 3,400)	Total (N = 27,203)	P value	At least 1 return visit (N = 1,416)	Total (N = 12,811)	P value
Diabetes	12 16.9%	71	.23	184 12.3%	1,499	.79	320 10.8%	2,955	.66
Hypertension	12 12.2%	98	.99	335 12.4%	2,705	.85	727 10.5%	6,919	.03*
Ischemic heart disease	<i>Not applicable to children</i>			9 14.8%	61	.59	66 10.6%	624	.70
Stroke	27 15.5%	174	.18	72 12.3%	584	.90	138 9.9%	1,401	.13

FP, Family practitioner; GP, general practitioner.

*P < .05.

TABLE E4. Number of ED return visits by number and proportion of individuals stratified by age group

No. of return ED visits	Overall		Age 5-19 y		Age 20-49 y		Age ≥50 y	
	N	Proportion (%)	N	Proportion (%)	N	Proportion (%)	N	Proportion (%)
0	51,305	87.9	16,107	87.8	23,803	87.5	11,395	88.9
1	5,635	9.7	1,793	9.8	2,676	9.8	1,166	9.1
2	1,043	1.8	330	1.8	527	1.9	186	1.5
3	246	0.4	87	0.5	114	0.4	45	0.4
4	81	0.1	22	0.1	48	0.2	11	0.1
≥5	56	0.1	13	0.1	35	0.1	8	0.1

TABLE E5. Adjusted relative risk of asthma-specific ED return visit within 1 y after ED discharge stratified by age group

Risk factor	Age 5-19 y				Age 20-49 y				Age ≥50 y			
	Relative risk	95% CI	P value		Relative risk	95% CI	P value		Relative risk	95% CI	P value	
Sex (reference: Female)												
Male	0.83	0.76 0.91	<.01*		1.14	1.06 1.23	<.01*		1.24	1.10 1.39	<.01*	
Rural (reference: No)												
Yes	1.03	0.90 1.18	.63		1.28	1.15 1.42	<.01*		1.21	1.04 1.41	.01*	
Material deprivation quintile (reference: 1)												
2	1.02	0.88 1.18	.79		1.09	0.96 1.24	.19		1.10	0.91 1.32	.31	
3	0.97	0.83 1.13	.69		1.18	1.03 1.34	.01*		1.02	0.85 1.24	.82	
4	1.09	0.93 1.28	.26		1.24	1.08 1.42	<.01*		1.14	0.94 1.39	.19	
5 (most marginalized)	1.18	1.00 1.40	.05		1.16	1.00 1.33	.04*		1.15	0.93 1.42	.21	
Missing	1.11	0.74 1.66	.62		1.56	1.16 2.11	<.01*		1.19	0.76 1.87	.45	
Dependency quintile (reference: 1)												
2	1.00	0.87 1.15	.96		1.03	0.92 1.16	.58		0.85	0.70 1.03	.11	
3	1.03	0.89 1.19	.70		0.94	0.83 1.07	.37		0.92	0.76 1.11	.39	
4	1.07	0.91 1.26	.40		0.95	0.83 1.09	.46		0.83	0.67 1.02	.07	
5 (most marginalized)	1.08	0.91 1.29	.36		0.95	0.83 1.09	.46		0.80	0.65 0.99	.04*	
Ethnic concentration quintile (reference: 1)												
2	0.92	0.78 1.08	.30		0.97	0.85 1.11	.69		1.15	0.95 1.38	.14	
3	0.89	0.75 1.06	.20		0.99	0.86 1.14	.86		0.91	0.74 1.12	.38	
4	1.02	0.85 1.22	.85		0.87	0.75 1.02	.08		0.95	0.76 1.19	.64	
5 (most marginalized)	0.88	0.73 1.05	.15		1.00	0.86 1.17	.98		0.98	0.79 1.23	.88	
Residential instability quintile (reference: 1)												
2	1.12	0.97 1.28	.12		1.08	0.95 1.23	.24		1.03	0.85 1.23	.79	
3	1.11	0.95 1.30	.18		1.21	1.06 1.39	<.01*		1.06	0.87 1.28	.58	
4	1.11	0.95 1.30	.20		1.24	1.09 1.42	<.01*		0.91	0.74 1.12	.38	
5 (most marginalized)	1.20	1.01 1.43	.04*		1.32	1.15 1.52	<.01*		1.14	0.93 1.40	.22	
Comorbidities (reference: No)												
Acute myocardial infarction	<i>Not applicable to children</i>				0.95	0.35 2.56	.92		0.87	0.57 1.32	.50	
Angina	1.59	1.08 2.35	.02*		0.98	0.81 1.18	.79		0.94	0.81 1.09	.39	
Cancer	1.29	0.44 3.80	.64		1.06	0.74 1.53	.74		0.82	0.65 1.03	.08	
Chronic heart failure	<i>Not applicable to children</i>				2.46	1.25 4.86	.01*		0.83	0.61 1.12	.22	
COPD	<i>Not applicable to children</i>				1.18	1.03 1.36	.02*		1.12	1.00 1.26	.05	
Diabetes	1.88	1.11 3.18	.02*		0.94	0.79 1.12	.48		0.95	0.82 1.09	.45	
Hypertension	1.29	0.75 2.22	.35		0.97	0.85 1.11	.68		0.89	0.79 1.00	.06	
Ischemic heart disease	<i>Not applicable to children</i>				0.94	0.41 2.15	.88		0.98	0.72 1.33	.89	
Stroke	1.50	1.02 2.20	.04*		0.99	0.76 1.28	.93		0.94	0.78 1.14	.55	

* $P < .05$.