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Article

Emergency department visit count: a practical tool to predict asthma hospitalization in children

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Objectives: Resource limitations and low rates of follow-up with primary care providers currently limit the impact of emergency department (ED)-based preventative strategies for children with asthma. A mechanism to recognize the children at highest risk of future hospitalization is needed to target comprehensive preventative interventions at discharge. The primary objective of this study was to determine if frequency of ED visits predicts future asthma hospitalization in children.

Methods: Children aged 2-16.99 years with asthma ED visits between 2012 and 2015 were identified through health administrative data. Survival analysis using Kaplan-Meier estimator and multivariable Cox regression models with time-varying covariates were used to quantify the number of ED visits in the previous year that would best predict hospitalization risk in the following year, after adjustment for age, sex and presentation severity.

Results: We identified 2669 patients with 3300 asthma ED visits. ED visit count was an independent predictor of future hospitalization risk ($P < 0.001$), demonstrating a dose-dependent response. Compared with zero previous visits, the adjusted hazard of future hospitalization in children with one visit or two or more visits was 2.9 (95% CI 1.6 to 5.0) and 4.4 (95% CI 1.9 to 10.4), respectively.

Conclusions: ED visit count is a reliable predictor of future asthma hospitalization risk. Future studies could aim to validate these findings to support using ED visit count as a practical and objective tool to predict the children at the highest risk of future hospitalization and therefore, those who may benefit most from ED-based preventative interventions.

Keywords: predict, risk, future, emergency department-based, preventative, frequency

Introduction

Asthma is one of the most common chronic diseases in childhood and when poorly controlled, leads to high rates of hospitalizations and emergency department (ED) visits (1, 2). In an effort to prevent future exacerbations, any child presenting to the ED with asthma should receive re-evaluation of their asthma management, including medications, inhaler technique, and environmental control measures (1). Given time and resource-constraints within the ED setting, this type of comprehensive

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review is rarely provided (3, 4). As such, international guidelines for acute management of asthma recommend outpatient follow-up with a primary care provider or local asthma clinic within one to four weeks of the ED visit (1, 5). Despite this recommendation, primary care follow-up within one month after an asthma ED visit is infrequent, with a number of pediatric studies demonstrating rates of only 33-46% (3, 6-8). Children with more severe asthma may benefit from referral to asthma specialist care, as this has been shown to reduce the number of asthma hospitalizations (9). However, guidelines for referral to asthma specialists or asthma educators from the ED are lacking and current referral rates range from only 1.5-2.8% among children (3, 7, 9). Resource limitations and lack of guidelines for discharge management post ED visit lead to significant variations in practice and currently limit the impact of available ED-based preventative strategies (3).

An alternative solution to reduce the frequency of future asthma hospitalization is to target ED-based preventative interventions specifically to children at highest risk of this outcome. Many studies document factors associated with increased risk of future asthma hospitalization including age, lower socioeconomic status, ethnicity, sex, medical comorbidities, exposure to tobacco smoke, family history of asthma and atopy, allergen exposure, baseline lung function, previous ED visits and hospitalizations (10-18). In a busy ED, it is time prohibitive to obtain a complete asthma history to assess whether a child is at high risk for future hospitalizations based on all these characteristics. Identifying a singular parameter or simple algorithm that could reliably predict risk of future hospitalization and/or recurrent ED visits would enable targeting of high-risk children to receive proven preventative interventions such as comprehensive asthma education or asthma specialist care directly from the ED, thereby preventing future acute asthma health care visits (19, 20). We propose that prior ED visit count could be used as a simple parameter to identify high risk children, but currently there is little literature regarding what frequency of prior ED visits best predicts future acute care visits (12, 14-16, 18). One previous study by Taylor et al. at a Canadian centre in 1999 found a dose-response relationship between asthma ED visit count and future hospitalization (21). However, these findings have not been widely accepted or translated to clinical practice. Due to methodological limitations in this previous study, including the use of a narrow window to identify the hospitalization outcome, inconsistent follow-up time and lack of adjustment for potential cofounders, as well as considerable advances in asthma treatment for children over the past two decades, it is not apparent whether these findings would still pertain to today's era of asthma care. We aimed to update the findings of this previous study and determine if the frequency of asthma ED visits in the past year predicts future asthma hospitalizations or repeat ED visits in children in the subsequent 12 months. We aimed to quantify the risk of future acute care visits associated with specific ED visit counts and determine the number of prior ED visits that should alert an ED physician to flag a child as high risk, after adjusting for key confounders.

Methods

In this retrospective cohort study, we used health administrative data to identify all patients with asthma visits to the ED at the Children's Hospital of Eastern Ontario (CHEO), within the 3-year period September 1, 2012 to August 31, 2015. CHEO is a tertiary care pediatric centre in Ottawa, Canada, that sees more than 60, 000 ED visits per year and uses a standard guideline-based algorithm for the acute management of asthma exacerbations in the emergency department. As shown by chart audits within our institution, this pathway is consistently used for over 95% of patients, excluding only patients with identified reasons such as an unclear diagnosis of asthma or contraindications to salbutamol or corticosteroids. All children 2 to 16.99 years of age presenting with asthma to the ED at CHEO were included in this study. The age cut-off ensured that participants would be under eighteen years of age one year later. We defined asthma ED visits as those with the Ontario Health Insurance Plan diagnostic billing code 493. The primary exposure was the number of ED asthma visits in the 12 months prior to the index ED visit. We defined the index ED visit as the first ED visit within the 3-year inclusion period. Each patient was followed for up to one year after the index ED

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visit and at each subsequent ED visit (candidate visit) in this timeframe, the number of ED visits in the preceding 12 months was recalculated. In keeping with previous studies of outcomes post asthma ED visits, clustered ED visits occurring within a seven-day period were considered “bounce-backs” and were counted as one ED visit (22). The primary outcome was asthma hospitalization within one year following the index ED visit (defined using local health administrative data when ‘asthma’ was listed as the most responsible diagnosis for a given hospitalization as per diagnostic codes). For children with multiple candidate ED visits, the observation window was extended to ensure there was a full year to capture the primary outcome. We chose this methodology to avoid the confounding effect of seasonality and to better represent the “real-world” scenario for an ED physician when trying to determine “what was the number of asthma ED visits in the previous 1 year” for a child currently in the ED. The secondary outcome was repeat ED visit for asthma (ED visit or ED visit leading to hospitalization) within one year following the index ED visit.

We excluded patients admitted to the hospital on the index ED visit and those who had a hospitalization within one year prior to the index ED visit, as these patients would have likely already been identified as high risk and received interventions, such as asthma education or an asthma specialist referral. We excluded children whose only asthma ED visit within the study period occurred under two years of age, as the diagnosis of asthma is challenging in very young children given significant clinical overlap with other diagnoses such as bronchiolitis (1, 5).

In addition to the number of ED visits in the previous year for each index or candidate ED visit, we collected information on variables such as the patient’s age, sex, and severity of symptoms at ED presentation using the Canadian Triage and Acuity Scale (CTAS). The CTAS is a triage scale ranging from one to five that is used in emergency departments to identify the illness acuity and the time frame within which the patient should be seen (23). We analyzed CTAS in three groups: levels one and two (emergency), level three (urgency) and levels four and five (standard).

Ethics approval for this study was obtained from the Children’s Hospital of Eastern Ontario Research Ethics Board.

Statistical Methods

Children’s characteristics and number of previous ED visits at baseline were summarized descriptively. The association between the number of ED visits in the year prior to the index ED visit and asthma hospitalization (primary outcome) and repeat ED visit (secondary outcome) were investigated using time-to-event analysis with time-varying covariates. The analysis was performed separately for the primary outcome and the secondary outcome. Time was calculated as time from the index ED visit until the end of the one-year follow-up period or until the time of asthma hospitalization (primary analysis) or repeat ED visit (secondary analysis). The number of ED visits in the year prior to the index ED visit was categorized as either zero, one, or two or more previous ED visits. Age was dichotomized into children under six years old (preschoolers) and those over six years old, based on age cut-offs used for pediatric asthma management guidelines (24). For children with candidate ED visits following the index visit, time-varying covariates were updated at each candidate ED visit. These included the number of ED visits in the previous year, CTAS level, and age. The Kaplan-Meier estimator with time-varying covariates was used to obtain the cumulative incidence of asthma hospitalization and repeat ED visits by number of ED visits in the previous year, age group, and CTAS level. For multivariable analysis, Cox regression with time-varying covariates was used to estimate the hazard ratios and marginal means and corresponding standard errors of the effect of ED visit count in the previous year, age, sex and CTAS level.

To allow comparison of our results with studies that treated “bounce-back” ED visits within 7 days as separate ED visits, our analysis was repeated treating each individual ED visit as a separate

visit. All analyses were conducted using R statistical software version 3.5.1, including the emmeans package (version 1.2.3) for the marginal means estimates of hazard ratios (25). Two-sided p values <0.05 were considered statistically significant.

Results

There were 3016 eligible patients with 3988 ED visits identified in the index period. After accounting for “bounce-back” visits and exclusion criteria, there were 2669 patients with 3300 ED visits included in the study [Figure 1]. Table 1 shows baseline characteristics at the index ED visits. The majority of patients (95%) had zero previous ED visits.

Asthma hospitalization

The risk of hospitalization within one year increased with increasing number of previous ED visits [Figure 2A]. The one year cumulative incidence of asthma hospitalization was 2.0% (95%CI 1.5%-2.7%), 5.3% (95%CI 3.2%-8.7%), and 12.9% (95%CI 5.9%-26.9%) for children with zero, one, and two or more previous ED visits, respectively. The cumulative incidence curve in Figure 2A illustrates an increased risk and earlier timing of future hospitalization in children with increased number of ED visits in the previous year. Figure 3A shows an increased rate of future hospitalization in children with higher severity CTAS score. Figure 4A shows a mildly increased rate of future hospitalization in children 6 years and older. Figure 1A in the Supplement shows similar rates of future hospitalization in males and females.

After adjusting for age, sex, and CTAS, ED visit count was an independent predictor of asthma hospitalization ($p<0.001$) [Table 2]. Compared to children with no previous ED visits, the risk of future hospitalization in children with one previous visit and those with two or more visits was 2.9 and 4.4 times higher, respectively [Table 2]. CTAS was also an independent predictor of asthma hospitalization risk ($p<0.03$) [Table 2]. Age group ($p=0.42$) and sex ($p=0.63$) were not significantly associated with asthma hospitalization risk [Table 2].

To allow for direct comparison of children based on age, CTAS and number of previous ED visits, we plotted the hazard ratios for each group relative to a reference group with the lowest risk of hospitalization [Figure 5]. Hazard ratios for hospitalization are higher for children with a higher ED visit count and with higher acuity presentation. As shown in Table 1 in the Supplement, the children at highest risk of future asthma hospitalization are those 6 years and older with two or more previous ED visits, and the highest acuity CTAS (HR 15.3; 95% CI 5.3-44.1).

Repeat ED visits

The risk of repeat ED visit within one year increased with increasing number of previous ED visits [Figure 2B]. The one year cumulative incidence of repeat ED visit was 18.4% (95%CI 16.9%-20.0%), 37.5% (95%CI 28.7%-48.0%), and 58.6% (95%CI 41.7%-76.4%) for children with zero, one, and two or more previous ED visits, respectively. Figure 2B, 3B, and 4B show the cumulative incidence curves for repeat ED visit as a function of ED visit count, CTAS and age, respectively. Figure 1B in the Supplement shows the cumulative incidence curve for repeat ED visit as a function of sex.

After adjusting for age, sex, and CTAS, the number of previous ED visits was an independent predictor of risk of repeat ED visit ($p<0.001$) [Table 2]. CTAS level ($p<0.001$) was also significantly associated with risk of repeat ED visit, while age ($p=0.48$) and sex ($p=0.94$) showed no statistically significant association [Table 2].

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When plotting hazard ratios of repeat ED visits compared to the reference group, we found increased hazard ratios with a higher previous number of ED visits, higher acuity of presentation and age under 6 years [Figure 6]. As shown in Table 2 in the Supplement, the children at highest risk of repeat ED visit are those under 6 years old with two or more previous ED visits, and the highest acuity CTAS (HR 10.2; 95% CI 5.8, 17.1).

When the analysis was repeated without accounting for “bounce back” visits, the results were similar [Tables 3-8 and Figures 2-7 in the Supplement].

Discussion

Our study demonstrates high rates of future hospitalizations and repeat ED visits among children in the year following presentation to the ED for asthma at a pediatric tertiary care centre. This is despite evidence-based asthma care provided during the ED visit and routine provision of asthma action plans and prescriptions for oral corticosteroids for the majority of children with moderate to severe asthma exacerbations discharged from the ED at our institution. We found the cumulative incidence of asthma hospitalization ranges from 2-13%, while cumulative incidence of repeat ED visit ranges from 18-59%. This compares to previous studies, which have found that the risk of repeat ED visits for asthma is up to 25% (7, 20).

This study found that ED visit count is an independent predictor of both future hospitalization and repeat ED visit risk, when accounting for patient age, sex and severity of asthma exacerbation. Despite adjusting for key cofounders and other differences in study methodology, these findings are consistent with the study by Taylor et al., who found that children with one previous ED visit had a 5% risk of future hospitalization and those with two or more visits had approximately double the risk of future hospitalization (13%) (21). To address multiple limitations in this previous study, we used a revised methodology. The study by Taylor et al. only identified asthma hospitalizations between January and June of a single calendar year (1998), which would not have accounted for the effects of seasonality, year to year variability in odds of hospitalization (due to differences in virus outbreaks, climate, pollution, etc.), and peak asthma season which is typically in September to October in North America. In addition, this study counted hospitalization outcomes in 1998 for 1503 patients identified with an ED asthma visit in 1997. This method would have led to variable follow up periods for patients and would not have accounted for any hospitalization that could have happened in 1997 or any additional ED visits in 1998 prior to hospitalization. In contrast, our study methodology ensured a continuous one-year observation period after each index visit for the hospitalization outcome. By also using a consistent one year look-back period, we were able to mimic the real world situation encountered by ED physicians to allow them to practically evaluate the risk of future hospitalization for a given patient on the day of presentation to the ED based on the number of ED visits in the year prior to this visit and a limited number of additional objective indicators. Our study also controlled for age and severity of presentation, and included 3 entire calendar years for accrual, which improved the sample size and generalizability of findings. Our study adds to the literature as it demonstrates that in the current era of ED management, there remains a direct dose-response relationship between number of previous ED visits and future asthma hospitalization. We have shown that ED visit count continues to be a valuable predictor of future asthma hospitalization, even after the adjustment for important confounders, such as asthma severity at presentation and patient age (which has not been evaluated in previous studies). Though we did not adjust for all possible confounders that contribute to asthma ED visits and hospitalizations, our study findings suggest that ED visits could act as a useful and practical “downstream” surrogate marker of multiple risk factors for asthma hospitalization and ED visits.

Previous studies have assessed the relationship between markers of asthma severity and hospitalization occurring immediately or within two weeks after the ED visit (26, 27). There is a

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paucity of literature on the relationship between severity of asthma at ED presentation and future hospitalization or repeat ED visits over a longer observation period. Our findings are consistent with the few previous studies which have examined this and show that increased severity of asthma presentation at an ED visit predicts future asthma hospitalization and repeat ED visits (3). CTAS, or severity of respiratory distress at the time of index ED presentation, is an important predictor of future asthma acute care visits and must be considered when evaluating a child's individualized risk.

Although previous studies have shown that younger age is associated with higher risk of asthma hospitalization or ED re-visit (7, 28), our study found no statistically significant association between age group and asthma hospitalization. This may be in part because our study accounted for severity of asthma symptoms at ED presentation. Prior studies may not have captured the influence of CTAS, as CTAS and age may be related collinearly, and this may have contributed to the association between age and hospitalization. These findings suggest that children with asthma at any age could be at high risk of future hospitalization. This is an important message for ED physicians that children with asthma should not be assessed for the need of ED-based preventative strategies based on age alone, but in conjunction with number of previous ED visits and severity of presentation.

Repeat ED visits are predicted predominantly by number of previous ED visits and CTAS score (19, 20). This is important to consider when making decisions around allocation of ED-based interventions toward patients with high healthcare resource utilization.

While we did not identify sex to be an independent predictor of future hospitalization or repeat ED visit, we did identify a higher proportion of males with ED visits in our study, representing 62.7% of the study sample. This is consistent with previous literature that also shows higher rates of pediatric asthma acute care visits in males (3, 18).

In addition to showing the direction of the relationship between the number of prior asthma ED visits and future hospitalization and repeat ED visits, our study also provides reference values which allow for individualized prediction of future hospitalization or repeat ED visits in children presenting to the ED with asthma [Table 1 and Table 2 in the Supplement]. These reference values stratify patients into higher and lower risk groups based on age, CTAS and number of previous ED visits in the past year. Each of these elements are objective and easily and quickly attainable from the patient's medical record. This gives ED physicians a tool to identify individual children at high risk of future hospitalization and repeat ED visits for asthma. This information can be valuable for counselling of patients and families and to help guide the allocation of ED-based interventions to the children at highest risk of future acute care visits.

This study has several strengths, including the use of health administrative data to allow capture of all patients with a physician diagnosis of asthma at ED discharge and the avoidance of parental recall bias when counting prior asthma ED visits. However, this method introduced the limitation that ED visits to centres outside CHEO were not captured in this study. This is likely a minor limitation, as CHEO is the only pediatric centre in the Ottawa region and it is estimated that more than 95% of asthma ED visits would have been captured (29). Also, by including only CHEO ED visits, this replicates the information that an ED physician would typically have available to them and would allow development of a simpler and more relevant algorithm for prompting ED-based preventative interventions. We chose to include only a few key variables, as our aim was to obtain results that were practical and simple to translate into clinical ED care. However, there are other confounding variables that could also influence the risk of future hospitalization that could be explored in future studies. Our study reflects data from an urban, tertiary care pediatric centre, which may limit the generalizability of this study to more rural emergency departments. Therefore, results from this study would have to be validated in other settings before widespread implementation.

Conclusions

Any childhood ED visit for asthma represents an opportunity to provide an intervention to prevent a future ED visit or hospitalization. This study aimed to lay the groundwork to develop an evidence-based approach to identifying children at highest risk of future asthma hospitalization in the ED. We have demonstrated that frequency of previous asthma ED visits has a direct dose-response relationship with future asthma hospitalization risk, a finding that is consistent with previous literature despite many changes to asthma guidelines and therapies over time (21). CTAS is also an important predictor of asthma hospitalizations in children. This study provides a reference for individualized risk prediction for future asthma hospitalizations and ED visits, based on number of previous ED visits, age, and CTAS. We believe this can be used as a practical and objective tool for ED physicians to predict which children are at highest risk for future asthma hospitalization or repeat ED visit, and therefore identify the children who may benefit most from ED-based preventative interventions. Future studies should aim to validate the findings of this study when used as a prediction tool in other settings or could focus on the high-risk groups identified in this study as a target population for implementation of new therapies aimed to reduce asthma acute care visits.

Declaration of interest

The authors report no conflicts of interest. This work was supported by the Children's Hospital of Eastern Ontario Research Institute.

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Table 1. Baseline characteristics at index emergency department visit

	Overall, n(%) N=2669	Prior Visits=0, n(%), N=2544	Prior Visits=1, n(%), N=96	Prior Visits>=2, n(%), N=29
Age (years)				
<6	1571 (58.9)	1497 (58.8)	55 (57.3)	19 (65.5)
6+	1098 (41.1)	1047 (41.2)	41 (42.7)	10 (34.5)
Sex				
Male	1673 (62.7)	1589 (62.5)	63 (65.6)	21 (72.4)
Female	996 (37.3)	955 (37.5)	33 (34.4)	8 (27.6)
CTAS ^a level				
Standard ^b	549 (20.6)	532 (20.9)	12 (12.5)	5 (17.2)
Urgency ^c	1258 (47.1)	1191 (46.8)	54 (56.2)	13 (44.8)
Emergency ^d	862 (32.3)	821 (32.3)	30 (31.2)	11 (37.9)

^aCanadian Triage and Acuity Scale

^bStandard: CTAS 4,5

^cUrgency: CTAS 3

^dEmergency: CTAS 1,2

Table 2. Multivariable regression analysis of future hospitalization and repeat ED visit risk

Predictors	Outcome			
	Asthma hospitalization		Repeat ED ^a visit	
	HR ^c (95% CI ^d)	p	HR (95% CI)	p
Age Group (years)		0.42		0.48
<6	Reference		Reference	

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6+	1.2 (0.7,2.0)		0.94 (0.8,1.1)	
Number of previous ED Visits		<0.001		<0.001
No previous visits	Reference		Reference	
One previous visit	2.85 (1.6,5.0)		2.3 (1.7,3.3)	
Two or more previous visits	4.44 (1.6,10.4)		4.6 (2.6,8.0)	
Sex		0.63		0.94
Female	Reference		Reference	
Male	1.1 (0.7,1.9)		1.0 (0.8,1.2)	
CTAS ^b level		0.03		<0.001
Standard	Reference		Reference	
Urgency	2.0 (0.9,4.5)		1.4 (1.1,1.9)	
Emergency	2.8 (1.2,6.6)		2.2 (1.7,2.9)	

^aEmergency Department

^bCanadian Triage and Acuity Scale

^cHazard Ratio

^dConfidence Interval

Table 3. Baseline characteristics at index emergency department visit (not accounting for “bounce back” visits)

	Overall, % (n), N=2688	Visits=0, % (n), N=2563	Visits=1, % (n), N=94	Visits>=2, % (n), N=31
Age (years)				
<6	58.8 (1580)	58.8 (1506)	57.4 (54)	64.5 (20)
6+	41.2 (1108)	41.2 (1057)	42.6 (40)	35.5 (11)
Sex				
Male	62.5 (1681)	62.3 (1597)	64.9 (61)	74.2 (23)
Female	37.5 (1007)	37.7 (966)	35.1 (33)	25.8 (8)
CTAS ^a level				
Standard	20.2 (544)	20.6 (528)	11.7 (11)	16.1 (5)
Urgency	46.9 (1261)	46.5 (1193)	56.4 (53)	48.4 (15)
Emergency	32.8 (883)	32.9 (842)	31.9 (30)	35.5 (11)

^aCanadian Triage and Acuity Scale

Table 4. Cumulative incidence of hospitalization at one year by previous ED visit count (not accounting for “bounce back” visits)

Previous ED Visit	Cumulative	Lower 95% Confidence	Upper 95% Confidence
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Count	incidence	Limit	Limit
0	2.6	5.0	14.4
1	2.1	3.1	7.5
2+	3.4	8.3	26.7

Table 5: Cumulative incidence of repeat emergency department visit at one year by previous ED visit count (not accounting for “bounce back” visits)

Previous ED Visit Count	Cumulative incidence	Lower 95% Confidence Limit	Upper 95% Confidence Limit
0	20.1	39.4	61.3
1	18.6	30.3	44.9
2+	21.7	50.0	78.0

Table 6. Multivariable regression analysis of future hospitalization and repeat ED visit risk (not accounting for “bounce back” visits)

	Outcome			
	Asthma hospitalization		Repeat ED ^a visits	
Predictor	N(ED visits)= 3393		N(ED visits)= 2688	
	HR ^c (95% CI ^d)	p	HR (95% CI)	p
Age Group (years)		0.14		0.60
<6	Reference		Reference	
6+	1.4 (0.9,2.2)		1.0 (0.8,1.1)	
Number of previous ED Visits		<0.001		<0.001
No previous visits	Reference		Reference	
One previous visit	2.3 (1.4,4.0)		2.2 (1.6,3.1)	
Two or more previous visits	5.0 (2.5,10.1)		4.3 (2.6,7.0)	
Sex		0.54		0.61
Female	Reference		Reference	
Male	0.9 (0.6,1.3)		1.0 (0.8,1.1)	
CTAS ^b level		<0.001		<0.001

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Standard	Reference		Reference	
Urgency	2.9 (1.3,6.9)		1.6 (1.2,2.1)	
Emergency	4.9 (2.0,11.8)		2.5 (1.9,3.2)	

^aEmergency Department

^bCanadian Triage and Acuity Scale

^cHazard Ratio

^dConfidence Interval

Table 7. Marginal mean estimates of hazard ratios for future hospitalization for patient groups defined by age, Canadian triage and acuity scale and number of previous emergency department visits (not accounting for “bounce back” visits)

Age (years)	CTASa	Previous EDb Visit Count	HRc (95% CI ^d)
<6	Standard	0	1.0 (0.5, 2.2)
6+	Standard	0	1.4 (0.7, 2.8)
<6	Urgency	0	2.9 (2.1, 4.0)
6+	Urgency	0	4.1 (2.8, 5.9)
<6	Emergency	0	4.9 (3.5, 6.7)
6+	Emergency	0	6.8 (4.1, 11.3)
<6	Standard	1	2.3 (1.0, 5.4)
6+	Standard	1	3.3 (1.6, 6.7)
<6	Urgency	1	6.8 (3.7, 12.5)
6+	Urgency	1	9.5 (5.3, 17.0)
<6	Emergency	1	11.3 (6.7, 19.3)
6+	Emergency	1	15.8 (8.6, 29.1)
<6	Standard	2+	5.0 (2.0, 12.4)
6+	Standard	2+	6.9 (2.9, 16.7)
<6	Urgency	2+	14.6 (7.2, 29.3)

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6+	Urgency	2+	20.3 (9.5, 43.6)
<6	Emergency	2+	24.2 (11.5, 50.8)
6+	Emergency	2+	33.8 (14.1, 80.9)

^aCanadian Triage and Acuity Scale

^bEmergency Department

^cHazard Ratio

^dConfidence Interval

Table 8. Marginal mean estimates of hazard ratios for repeat ED visits for patient groups defined by age, Canadian triage and acuity scale (CTAS) and number of previous emergency department (ED) visits (not accounting for “bounce back” visits)

Age (years)	CTAS ^a	Previous ED ^b Visit Count	HR ^c (95% CI ^d)
<6	Standard	0	1.0 (0.8, 1.3)
6+	Standard	0	1.0 (0.8, 1.2)
<6	Urgency	0	1.6 (1.4, 1.8)
6+	Urgency	0	1.5 (1.3, 1.8)
<6	Emergency	0	2.5 (2.2, 2.8)
6+	Emergency	0	2.3 (2.0, 2.8)
<6	Standard	1	2.2 (1.5, 3.3)
6+	Standard	1	2.1 (1.4, 3.1)
<6	Urgency	1	3.5 (2.5, 4.9)
6+	Urgency	1	3.35 (2.39, 4.68)
<6	Emergency	1	5.4 (3.8, 7.6)

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6+	Emergency	1	5.1 (3.6, 7.3)
<6	Standard	2+	4.3 (2.5, 7.3)
6+	Standard	2+	4.1 (2.4, 7.0)
<6	Urgency	2+	6.8 (4.1, 11.3)
6+	Urgency	2+	6.5 (3.9, 10.8)
<6	Emergency	2+	10.4 (6.3, 17.3)
6+	Emergency	2+	10.0 (5.9, 16.8)

^aCanadian Triage and Acuity Scale

^bEmergency Department

^cHazard Ratio

^dConfidence Interval

Figure 1. Inclusion and exclusion flowsheet

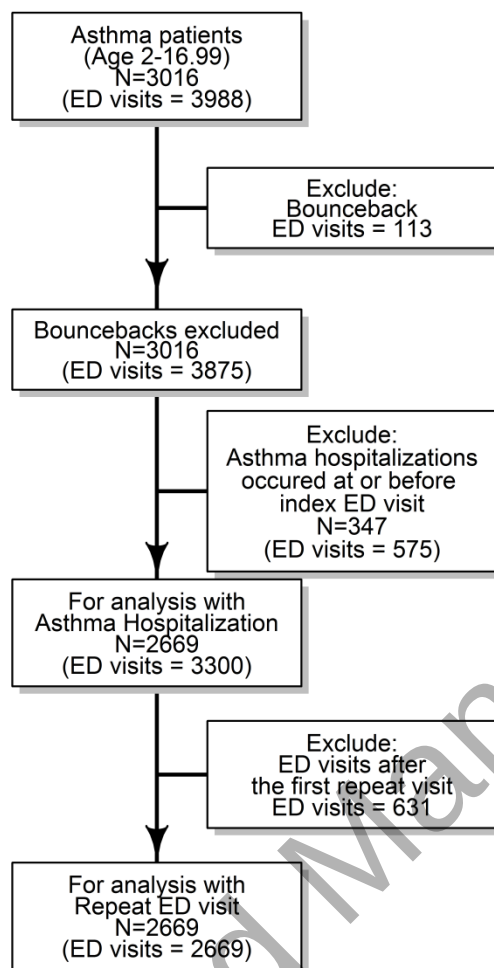


Figure 2. Cumulative incidence of future hospitalization (A) and repeat ED visits (B) as a function of ED visit count in the previous year

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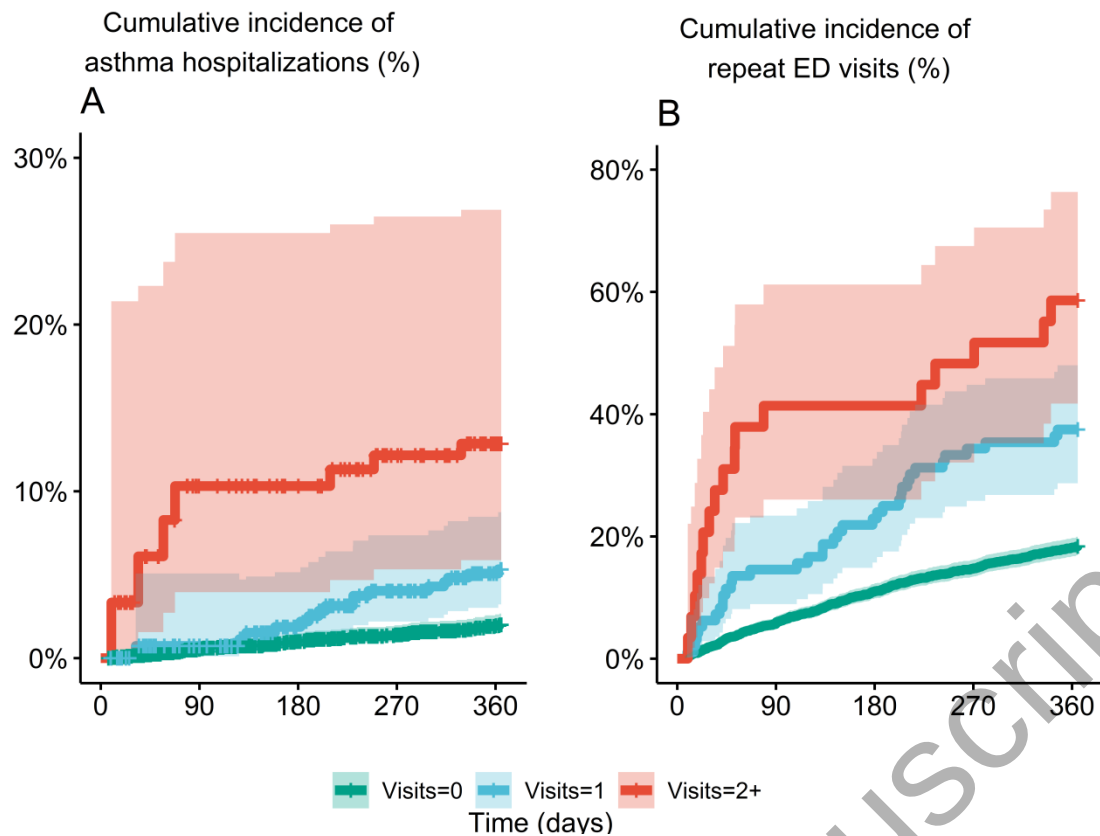


Figure 3. Cumulative incidence of future hospitalization (A) and repeat ED visits (B) as a function of CTAS

Standard: CTAS 4,5

Urgency: CTAS 3

Emergency: CTAS 1,2

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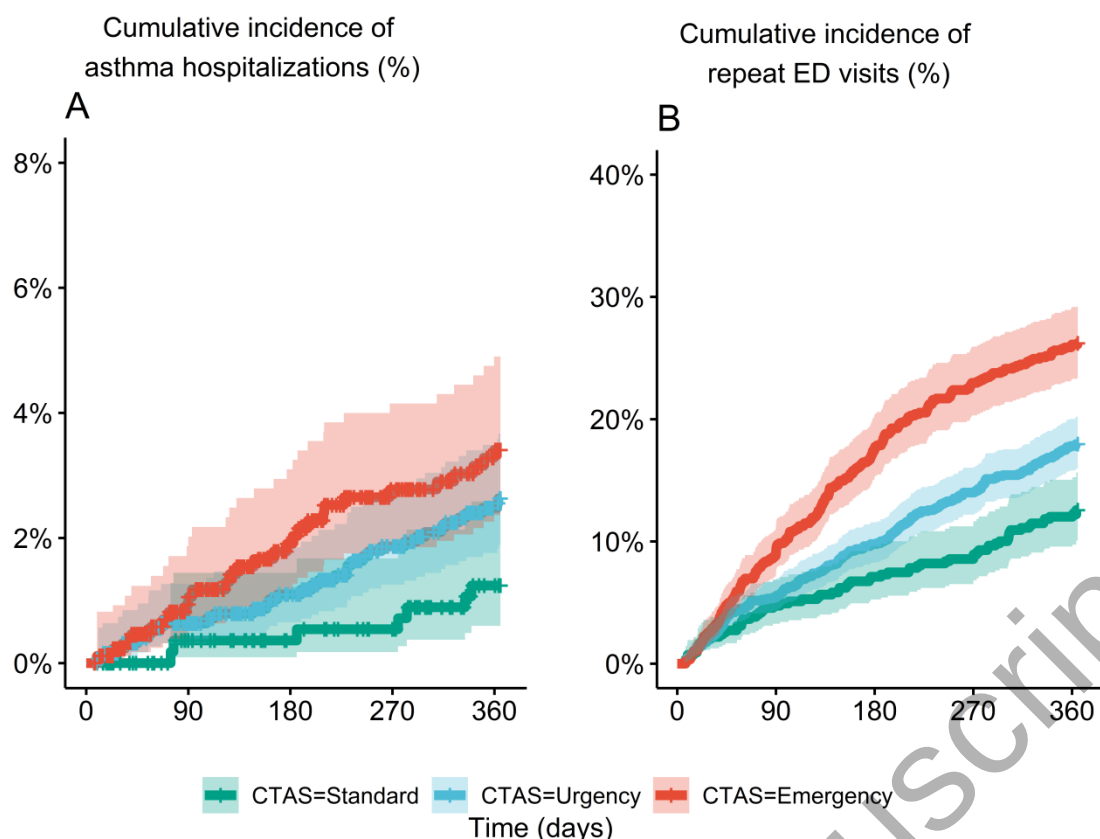


Figure 4. Cumulative incidence of future hospitalization (A) and repeat ED visits (B) as a function of age

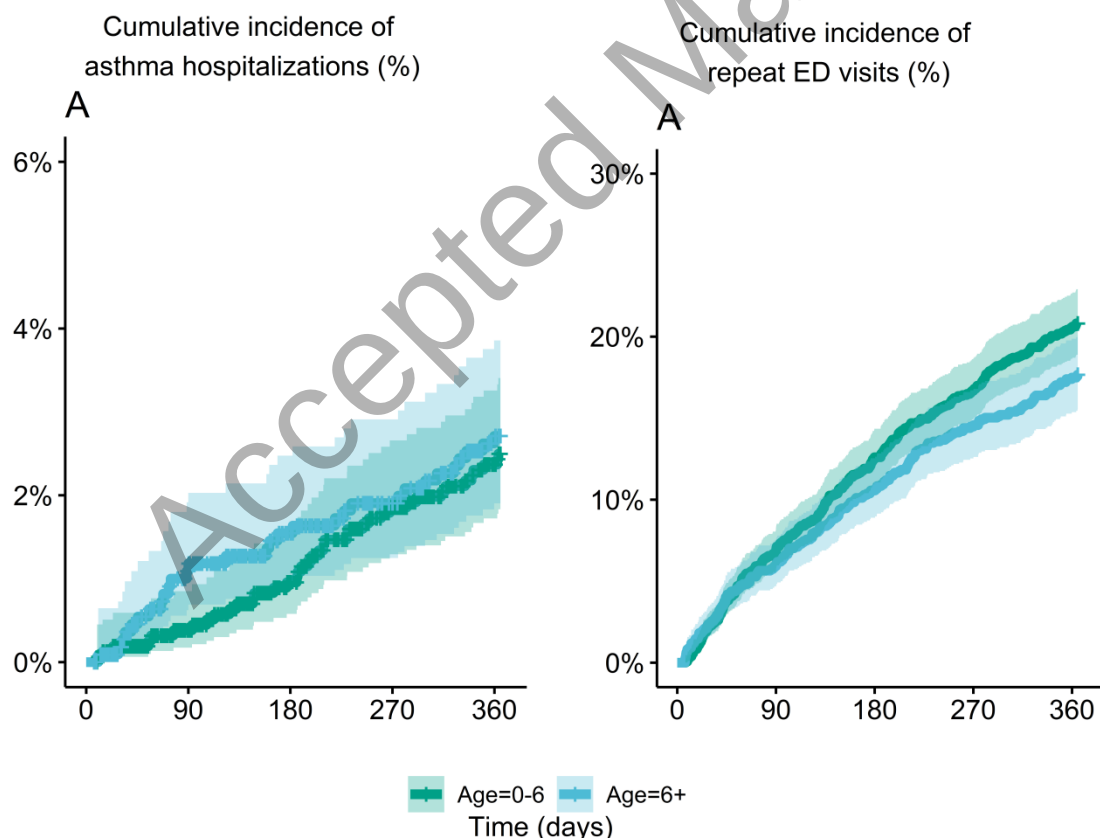


Figure 5. Marginal mean estimates of hazard ratios for future hospitalization for patient groups defined by age, CTAS and number of previous ED visits

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Estimates have been divided by the hazard ratio for the reference group (age under 6 years, standard CTAS and zero ED visits in the previous year). The bars represent the risk of future hospitalization in the other groups, compared to the reference group (which is the lowest risk group).

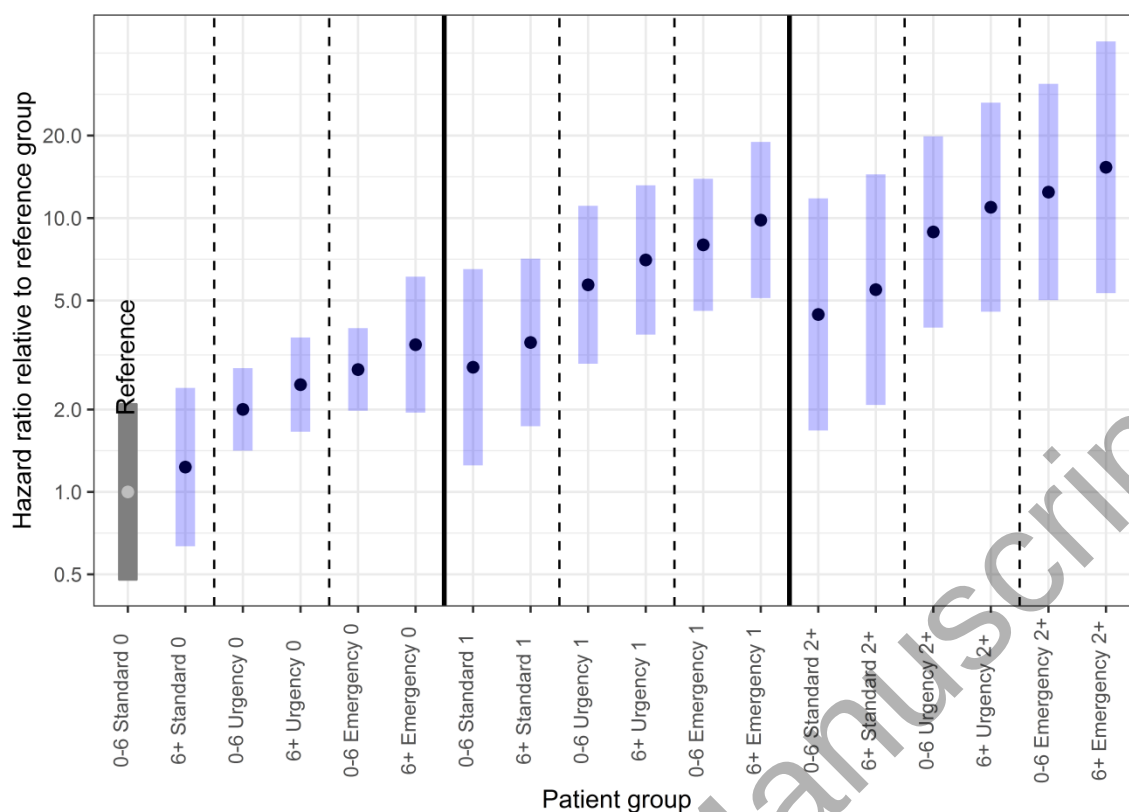


Figure 6. Marginal mean estimates of hazard ratios for repeat ED visits for patient groups defined by age, CTAS and number of previous ED visits.

Estimates have been divided by the hazard ratio for the reference group (age under 6 years, standard CTAS and zero ED visits in the previous year). The bars represent the risk of future emergency department visits in the other groups, compared to the reference group.

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