

ORIGINAL ARTICLE: ASTHMA

Agreement between a health claims algorithm and parent-reported asthma in young children

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Abstract

Introduction: Asthma prevalence is commonly measured in national surveys by questionnaire. The Ontario Asthma Surveillance Information System (OASIS) developed a validated health claims diagnosis algorithm to estimate asthma prevalence. The primary objective was to assess the agreement between two approaches of measuring asthma in young children. Secondary objectives were to identify concordant and discordant pairs, and to identify factors associated with disagreement.

Study design and setting: A measurement study to evaluate the agreement between the OASIS algorithm and parent-reported asthma (criterion standard). Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated. Multivariable logistic regression was used to determine factors associated with disagreement.

Results: Healthy children aged 1 to 5 years (n=3642) participating in the TARGet Kids! practice based research network 2008-2013 in Toronto, Canada were included. Prevalence of asthma was 14% and 6% by the OASIS algorithm and parent-reported asthma, respectively. The Kappa statistic was 0.43, sensitivity 81%, specificity 90%, PPV 34%, and NPV 99%. There were 3249 concordant and 393 discordant pairs. Statistically significant factors associated with asthma identified by OASIS but not parent report included: male sex, higher zBMI, and parent history of asthma. Males were less likely to have asthma identified by parent report but not OASIS.

Conclusion: The OASIS algorithm identified more asthma cases in young children than parent-reported asthma. The OASIS algorithm had high sensitivity, specificity, and NPV but low PPV relative to parent-reported asthma. These findings need replication in other populations.

KEYWORDS

asthma, health claims algorithm, OASIS algorithm, parent-reported asthma, preschool children

1 | INTRODUCTION

Asthma is the most common chronic illness of childhood and causes a large burden on individuals and the health care system.¹ Asthma surveillance is important in understanding and monitoring the disease to set priorities and inform public health policy.² Asthma prevalence is commonly measured in national surveys by parent-reported physician diagnosed asthma.^{3,4} National surveys are useful in understanding the prevalence and risk factors of a disease. However, they typically provide data at one point in time making comparisons over time challenging. Routinely collected health services data provide an opportunity for surveillance as individuals with asthma can be followed longitudinally through their contact with the healthcare system.⁵ With the rise of systematically collected health services data, a health claims diagnosis algorithm for asthma, which uses administrative data diagnosis codes, was developed by the Ontario Asthma Surveillance Information System (OASIS) to identify and monitor the incidence and prevalence of asthma.^{6,7}

Asthma symptoms often present before 6 years of age but diagnosing asthma in this young age group is challenging.⁸⁻¹⁰ There is currently no gold standard for diagnosing asthma in young children. As such clinical assessment represents the most appropriate standard for validating instruments in epidemiological studies.^{8,11} Many research studies use the parent-reported physician diagnosed asthma question developed by the International Study of Allergies and Asthma in Childhood (ISAAC) as a proxy for a clinical assessment.¹¹⁻¹⁸ Parent-reported physician diagnosed asthma has been found to have a high sensitivity (88-96%) and specificity (87-96%) when compared to a clinical diagnosis in children.¹⁹⁻²¹

The OASIS algorithm is currently being used for asthma surveillance in young children living in Ontario and similar health claims algorithms are being used throughout Canada and the United States.^{7,22-24} It is unclear how well the OASIS algorithm compares to parent-reported physician diagnosed asthma in early childhood. It is important to evaluate the agreement between the current method of asthma surveillance in Ontario and the national standard for measuring asthma prevalence. The primary objective was to assess the agreement between two approaches of measuring asthma in children ages 1 to 5 years: the health claims OASIS algorithm and parent-reported physician diagnosed asthma. Secondary objectives were to a) identify concordant and discordant pairs, and to identify factors associated with disagreement; and b) examine the agreement between the approaches for measuring asthma among subgroups (children 1-3 years and children 3-5 years).

2 | MATERIALS AND METHODS

A measurement study to evaluate the agreement between the OASIS algorithm using health administrative data and parent-reported asthma as the criterion measure, using data from TARGet Kids!, a large prospective childhood cohort study.

2.1 | Population and inclusion criteria

Children ages 1 to 5 years of age enrolled in the TARGet Kids! (The Applied Research Group for Kids, www.targetkids.ca) cohort study between December 2008 and March 2013 were included. This age range was chosen in accordance with the Canadian guidelines for diagnosing asthma in preschool children.⁸ It is challenging to diagnose asthma in this young age group making it particularly important to understand measurement properties of the OASIS algorithm and identify these children early for population surveillance.⁸ The TARGet Kids! cohort includes an ethnically diverse sample of healthy urban children recruited from seven primary care practices in Toronto, the most culturally diverse city in Canada.²⁵ Detailed description of the TARGet Kids! methodology has been previously published.²⁵

2.2 | Measurements

Demographic data of the children were obtained using a parent completed questionnaire adapted from the Canadian Community Health Survey (CCHS) at the time of enrolment.³

2.2.1 | Parent-reported asthma (criterion standard)

Parent-reported asthma was defined as an affirmative response to the ISAAC parent-reported physician diagnosed asthma question "Has your child been diagnosed with asthma?"^{26,27} The validated ISAAC questionnaire is currently the standard survey measurement of asthma in epidemiological studies²⁶ and is commonly used in national health surveys.^{4,18} The single ISAAC question, parent-reported physician diagnosed asthma, was used as a proxy for physician diagnosis through clinical assessment.⁸ Previous studies found the parent-reported physician diagnosed asthma question had a high sensitivity (88-96%) and specificity (87-96%) in children¹⁹⁻²¹ when compared to physician diagnosis, thus was used as the criterion standard in this study.

2.2.2 | OASIS algorithm

OASIS was established in 2003 to provide longitudinal population-based asthma surveillance using an algorithm to identify individuals with asthma from health administrative databases.^{6,7} The OASIS algorithm identifies children and adults as having asthma if they have a hospital admission for asthma or two separate ambulatory or emergency department visits for asthma within a 2-year time frame, using all potential administrative diagnosis codes.⁷ Hospital admission for asthma was identified using the International classification of Disease 10th revision (ICD-10) codes J45 and J46 from The Canadian Institute for Health Information (CIHI) Discharge Abstract Database (DAD). Ambulatory or emergency department visits for asthma were identified using the Ontario Health Insurance Plan (OHIP) fee-for-service physician diagnostic code 493. The large amount of data available from electronic health records can be

utilised for research, but the diagnosis codes outlined in CIHI, DAD, and OHIP do not represent formal diagnoses from a physician and thus come with some challenges (ie, accuracy and different coding criteria between individuals and institutions).

2.2.3 | Predictors of asthma diagnosis

Potential predictors of asthma diagnosis were identified a priori through a literature review and were included as covariates in the analysis. Child factors included age, sex, and body mass index (zBMI).^{7,24,28-32} A parent completed questionnaire, adapted from the Canadian Community Health Survey,³ was used to define parental and household factors which included median household income, parental smoking, child's history of atopy (eczema or atopic dermatitis), child's history of allergies, daycare attendance, and family history of asthma.^{7,24,32,33} Median after tax neighbourhood household income was calculated using the Statistics Canada Postal Code Conversion File and data from the 2006 Canadian Census.³⁴ Parental smoking was defined by an affirmative response to smoking reported by any member of the household. Child's history of atopy or allergies was defined using the question "Has your child been diagnosed with eczema or atopic dermatitis?" and "Has your child been diagnosed with allergies?" Family history of asthma was defined as 1 or both parents having a previous diagnosis of asthma. Physical measurements were collected during each primary care clinic visit by trained TARGet Kids! research staff and included weight measured using a precision digital scale and height measured using a stadiometer (>2 years) or a length board (<2 years). BMI was calculated as weight in kilograms divided by height in meters squared,³⁵ and z scores were calculated using World Health Organization growth standards.³⁶

2.2.4 | Data linkage

TARGet Kids! data were linked at the individual level, using each child's unique encrypted OHIP number, to health administrative databases at the Institute for Clinical Evaluative Sciences (IC/ES) in Ontario, Canada with 98% success. IC/ES is a prescribed registry under the Ontario's *Personal Health Information Protection Act* (PHIPA), which allows the collection of health service data without patient consent. The OASIS algorithm uses health administrative databases to identify individuals with asthma including CIHI, DAD, and OHIP, which are housed at IC/ES.

2.2.5 | Statistical analysis

Population descriptive statistics by OASIS algorithm (yes/no) and parent-reported asthma (yes/no) were explored to identify clinically meaningful differences (See Table 1). Kappa statistic, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using parent-reported asthma as the criterion standard. Sensitivity was calculated as the proportion of children with asthma correctly identified by the OASIS algorithm

according to parent-reported asthma.¹¹ Specificity was calculated as the proportion of children without asthma correctly identified by the OASIS algorithm according to parent-reported asthma.¹¹ PPV was calculated as the proportion of responders identified by the OASIS algorithm that had agreement between the two measures (ie, children identified as having asthma by both OASIS and parent-report).¹¹ The NPV was calculated as the proportion of children not identified by the OASIS algorithm that had agreement between the two measures (ie, children identified as not having asthma by both OASIS and parent-report).¹¹

Concordant and discordant pairs were identified. To determine factors that may have led to disagreement of the data, children identified as having asthma by both OASIS and parent-report were compared to children identified as having asthma by parent-report but not OASIS; and children identified as not having asthma by both OASIS and parent-report were compared to children identified as having asthma by OASIS but not parent-report, using multiple logistic regressions, while controlling for known predictors of asthma.

The population was dichotomized into younger (children 1-3 years) and older (children 3-5 years) subgroups to examine the agreement between the two approaches while considering the age of the children. Multiple imputation was conducted using the R package Multivariate Imputation by Chained Equations (mice)³⁷ for all covariates to avoid bias that can be introduced from missing data.³⁸ Models were run on five imputed datasets for logistic regression and the results were pooled to obtain the final estimates. Statistical analyses were conducted using SAS statistical software version 9.3 (SAS Institute Inc., Cary, NC) and the R project version 3.3 (<http://www.R-project.org>). Two-tailed $P < .05$ were considered statistically significant.

2.3 | Ethics approval

Parents of TARGet Kids! participants provided informed consent for primary data collection and for this data to be linked with health administrative data. This study was approved by the Hospital for Sick Children and Institute for Clinical Evaluative Sciences (IC/ES) Research Ethics Boards and a data sharing agreement was in place.

3 | ROLE OF THE FUNDING SOURCE

The funding source had no involvement in the study design, collection, analysis, and interpretation of the data or writing of the report. The corresponding author confirms that she had full access to all of the data and all authors are responsible for the final report.

4 | RESULTS

A total of 3642 children age 1 to 5 years from the TARGet Kids! cohort were included in this analysis. In this sample 530 children were identified with asthma according to the OASIS algorithm

TABLE 1 Population characteristics of children with asthma according to the Ontario Asthma Surveillance Information System (OASIS) algorithm and the parent-reported asthma

	OASIS algorithm				Parent-reported asthma			
	(n=3642)				(n=3642)			
	Asthma Yes (n = 530)		Asthma No (n = 3112)		Asthma Yes (n = 223)		Asthma No (n = 3419)	
	Frequency (%)	Mean (std*)	Frequency (%)	Mean (std*)	Frequency (%)	Mean (std*)	Frequency (%)	Mean (std*)
Ethnicity								
European	342 (64.5)		2013 (64.7)		139 (62.3)		2216 (64.8)	
East Asian	29 (5.5)		208 (6.7)		13 (5.8)		224 (6.6)	
Southeast Asian	63 (11.9)		320 (10.3)		28 (12.6)		355 (10.4)	
West Asian	13 (2.5)		56 (1.8)		7 (3.1)		62 (1.8)	
African/Caribbean	38 (7.2)		199 (6.4)		20 (9.0)		217 (6.3)	
Other	23 (4.3)		179 (5.8)		9 (4.0)		193 (5.6)	
Child age								
1- <2 y	69 (13.0)		614 (19.7)		13 (5.8)		670 (19.5)	
2- <3 y	75 (14.2)		572 (18.4)		21 (9.4)		626 (18.3)	
3- <4 y	84 (15.8)		537 (17.3)		35 (15.7)		586 (17.1)	
4- <5 y	156 (29.4)		780 (25.1)		80 (35.9)		856 (25.0)	
5- <6 y	146 (27.5)		609 (19.6)		74 (33.2)		681 (19.9)	
Sex, male	332 (62.6)		1578 (50.7)		143 (64.1)		1767 (51.7)	
zBMI**		0.37 (1.1)		0.20 (1.1)		0.24 (1.0)		0.22 (1.1)
Maternal Education								
Public and/or high school	66 (12.5)		297 (9.4)		30 (13.4)		333 (9.7)	
College/university	464 (87.5)		2815 (90.4)		193 (86.5)		3086 (90.2)	
Median neighborhood level income		59,134 (27,856)		58,741 (25,519)		58,179 (25,026)		58,837 (25,925)
Parental smoking status, yes	60 (13.0)		345 (13.2)		24 (11.7)		381 (13.3)	
Child history of physician diagnosed atopy, yes	124 (23.4)		400 (12.9)		84 (37.7)		440 (12.9)	
Child history of physician diagnosed allergy, yes	63 (18.6)		119 (6.5)		49 (32.0)		133 (6.6)	
Daycare attendance, yes	233 (45.5)		1280 (42.5)		101 (46.3)		1412 (42.7)	
Parental history of asthma, yes	114 (30.3)		380 (17.6)		67 (40.4)		427 (18.0)	

*Std: standard deviation.

**Body mass index z-score (zBMI).

(prevalence of 14%) and 223 children had parent-reported asthma (prevalence of 6%). See Table 1 and 2a. The OASIS algorithm identified more children with asthma than parent-reported asthma in all age groups, but this difference was the largest among younger children. More males had asthma (332 [63%] and 143 [64%] using the OASIS algorithm and parent-reported asthma, respectively). Children with parent-reported asthma were more likely to have received a diagnosis of atopy and allergy and were more likely to have a family history of asthma than children identified with asthma using the OASIS algorithm.

The agreement between the OASIS algorithm and parent-reported asthma was moderate (Kappa statistic: 0.43; 95% CI:

0.38–0.47). The OASIS algorithm had a sensitivity of 81% (95% CI: 75–86%) and specificity of 90% (95% CI: 89–91%) for detecting asthma using parent-reported asthma as the criterion standard. The positive predictive value (PPV) was 34% (95% CI: 30–38%) and negative predictive value (NPV) was 99% (95% CI: 98–99%). See Table 2a. The agreement was lower among younger children (children 1–3 years): Kappa statistic 0.23 (95% CI: 0.14–0.31), sensitivity of 68% (95% CI: 49–83%), specificity of 91% (95% CI: 89–92%), PPV of 16% (95% CI: 10–23%), and NPV of 99% (95% CI: 98–100%) compared to older children (children 3–5 years): Kappa statistic 0.49 (95% CI: 0.44–0.54), sensitivity of 83% (95% CI: 77–88%), specificity of 89% (95% CI: 88–90%), PPV of 41% (95% CI:

TABLE 2a The Ontario Asthma Surveillance Information System (OASIS) algorithm compared to parent-reported asthma (n = 3642)

	Parent-reported asthma ^b +	Parent-reported asthma ^b -	Total
OASIS algorithm ^a +	180	350	530
OASIS algorithm ^a -	43	3069	3112
Total	223	3419	3642

Parent-reported asthma was the criterion standard

Kappa = 0.43 (95% CI: 0.38 - 0.47)

Sensitivity = 81% (95% CI: 75 - 86)

Specificity = 90% (95% CI: 89 - 91%)

PPV = 34% (95% CI: 30 - 38%)

NPV = 99% (95% CI: 98 - 99%)

^aOASIS algorithm (one asthma hospitalization and/or two asthma physician visit claims within two years).

^bParent-reported asthma, affirmative response to question "Has your child been diagnosed with asthma?"

36-46%), and NPV of 98% (95% CI: 98-99%). See Table 2b and Table 2c.

There were 3249 concordant pairs (3069 children were identified as not having asthma by both OASIS and parent-report and 180 children were identified as having asthma by both OASIS and parent-report) and 393 discordant pairs (350 children identified as having asthma by OASIS but not parent-report and 43 children identified as having asthma by parent-report but not OASIS). Statistically significant factors associated with asthma identified by OASIS but not parent-report included: male sex (aOR: 1.03; 95% CI: 1.01-1.05), higher zBMI (aOR: 1.02; 95% CI: 1.01-1.03), and parent history of asthma (aOR: 1.05; 95% CI: 1.02-1.08). See Table 3. These are well-established predictors of asthma^{7,24,28-32} suggesting that children identified by the OASIS algorithm and not by parent-reported asthma may represent future asthma cases (ie, those who have not yet received a formal diagnosis by their primary care physician). A statistically significant factor associated with asthma identified by parent-

TABLE 2b The Ontario Asthma Surveillance Information System (OASIS) algorithm compared to parent-reported asthma in children 1-3 y (n = 1330)

	Parent-reported asthma ^b +	Parent-reported asthma ^b -	Total
OASIS algorithm ^a +	23	121	144
OASIS algorithm ^a -	11	1175	1186
Total	34	1296	1330

Parent-reported asthma was the criterion standard

Kappa = 0.23 (95% CI: 0.14 - 0.31)

Sensitivity = 68% (95% CI: 49 - 83%)

Specificity = 91% (95% CI: 89 - 92%)

PPV = 16% (95% CI: 10 - 23%)

NPV = 99% (95% CI: 98 - 100%)

^aOASIS algorithm (one asthma hospitalization and/or two asthma physician visit claims within two years).

^bParent-reported asthma, affirmative response to question "Has your child been diagnosed with asthma?"

TABLE 2c The Ontario Asthma Surveillance Information System (OASIS) algorithm compared to parent-reported asthma in children 3-5 y (n = 2312)

	Parent-reported asthma ^b +	Parent-reported asthma ^b -	Total
OASIS algorithm ^a +	157	229	386
OASIS algorithm ^a -	32	1894	1926
Total	189	2123	2312

Parent-reported asthma was the criterion standard

Kappa = 0.49 (95% CI: 0.44 - 0.54)

Sensitivity = 83% (95% CI: 77 - 88)

Specificity = 89% (95% CI: 88 - 90%)

PPV = 41% (95% CI: 36 - 46%)

NPV = 98% (95% CI: 98 - 99%)

^aOASIS algorithm (one asthma hospitalization and/or two asthma physician visit claims within two years).

^bParent-reported asthma, affirmative response to question "Has your child been diagnosed with asthma?"

report but not OASIS was male sex (aOR: 0.86; 95% CI: 0.77-0.96). See Table 4.

5 | DISCUSSION

In this study, the agreement between the OASIS algorithm and parent-reported asthma was evaluated in children ages 1 to 5 years. There were more children identified with prevalent asthma using the OASIS algorithm compared to parent-reported asthma (14% and 6%, respectively). The overall agreement was moderate (kappa = 0.43). The OASIS algorithm was sensitive (81%) and specific (90%) for identifying asthma in early childhood compared to parent-reported asthma. While the NPV of the OASIS algorithm was high (99%), the PPV was low (34%) when compared to parent-reported asthma. The PPV was lower among children 1 to 3 years (16%) compared to children 3 to 5 years of age (41%). Many patients with asthma according to the OASIS algorithm did not have asthma according to parent-reported asthma and statistically significant factors related to this included male sex, higher adiposity, and parent history of asthma. Children with these risk factors appear to have an increased frequency of asthma related health care utilization (according to administrative data diagnostic codes either in the inpatient or outpatient setting) compared to children without these risk factors. A factor related to children with asthma identified by parent-report but not OASIS was male sex but the numbers were quite low (n = 43).

Population health surveillance is important for understanding the health of populations and monitoring the progression of diseases over time.³⁹ Prospective clinical disease registries, including all individuals with a disease, would be ideal for longitudinal asthma surveillance. However, given the relatively high prevalence of asthma, the cost of establishing such a registry is likely unfeasible. Algorithms using routinely collected health services data provide an opportunity to follow individuals longitudinally through their contact with the healthcare system.⁵ The

TABLE 3 Multivariate logistic regression model of factors associated with false positives [yes according to The Ontario Asthma Surveillance Information System (OASIS) algorithm and no according to parent-reported asthma] among children ages 1-5 y in Toronto, Canada.

	Parameter estimates B*	Adjusted odds ratio	95% confidence interval for B	p-value
Age				
2- <3y	-0.004	0.996	0.963 – 1.030	0.93
3- <4 y	-0.0003	1.000	0.966 – 1.035	
4- <5 y	0.008	1.008	0.977 – 1.039	
5- <6 y	0.030	1.030	0.998 – 1.064	
(Reference 1- <2 y)				
Sex, male	0.031	1.031	1.010 – 1.052	0.003
zBMI**	0.018	1.018	1.008 – 1.028	0.0005
Median neighbourhood level income, change in \$10,000	0.013	1.000	1.000 – 1.000	0.53
Parental smoking status, yes	0.010	1.010	0.973 – 1.047	0.60
Child history of atopy, yes	0.019	1.020	0.988 – 1.052	0.23
Child history of allergy, yes	0.042	1.043	0.981 – 1.108	0.17
Daycare attendance, yes	0.011	1.011	0.989 – 1.033	0.32
Parent history of asthma, yes	0.049	1.050	1.021 – 1.079	0.0005
Maternal education, primary and/or high school	0.025	1.025	0.989 – 1.062	0.17

A logistic regression model was used to estimate the probability of a child being a false positive based on predictor variables: age, sex, zBMI, median neighbourhood level income, parental smoking status, child history of atopy, child history of allergy, daycare attendance, parent history of asthma and maternal education.

*Parameter estimates (also called Beta coefficients or B) are the change in the response associated with a one-unit change of the predictor, with all other predictors being held constant.

**body mass index z-score (zBMI).

OASIS algorithm for asthma used in this study performed well when compared to the clinical record for children⁷ and adults.²⁴ A previous study examined agreement between the OASIS algorithm and parent-reported asthma in older children (age 5-9 years) where the diagnosis of asthma may be less challenging. They found the OASIS algorithm had a sensitivity of 79%, specificity of 90%, PPV of 59%, and NPV of 96%.⁴⁰ The results in the current study in younger children are similar to these findings with the exception of a lower PPV (34% vs 59% in children 1-5 years vs 5-9 years, respectively). Given that PPV is known to increase with increasing disease prevalence,⁴¹ we suggest that this difference may be due to a higher prevalence of asthma among older children. Alternatively, it may be related to a higher proportion of older children with asthma who have received a formal physician diagnoses compared to younger children, as physicians may be more likely to diagnose asthma in older children. To our knowledge, the current study is unique in assessing the agreement of the OASIS algorithm with parent-reported asthma among children ages 1 to 5 years.

While a true "gold standard" of asthma diagnosis among young children remains elusive, physician diagnosis of asthma in early childhood represents the best available standard for validating instruments in epidemiological studies.¹¹ Questionnaire diagnosis using the ISAAC parent-reported physician diagnosed asthma question is the most common method of estimating the prevalence of childhood asthma in national health surveys.^{4,18} The ISAAC questionnaire has been used internationally to compare prevalence of asthma and self-reported

symptoms.⁴² The parent-reported physician diagnosed asthma question had high sensitivity and specificity compared to physician diagnosed asthma in children (sensitivity (Sn)= 88% and specificity (Sp)= 96% in children ages 7.5 years)¹⁹ (Sn= 96% and Sp= 96% in children 3-17 years)²⁰ (Sn= 96% and Sp= 87% in children 7-14 years).²¹

In early childhood, asthma is more common among boys than girls but the prevalence appears to equalize during adolescence and then is more common among females in adulthood.^{43,44} Studies have suggested that there may be a sex-related component to health care utilization; male sex was one predictor of emergency department visits and hospital admissions for wheezing even after adjusting for asthma diagnosis.^{45,46} A temporal relationship between being overweight and development of asthma has been reported in multiple studies.^{30,31} Children with more rapid weight gain were at increased risk of developing asthma within the first 6 years of life.³⁰ A study in 2013 found that higher weight was associated with increased frequency of asthma related health care utilization and asthma exacerbations among children ages 6 to 19 years.⁴⁷ Children who have a family history of allergies or family history of asthma were more likely to be diagnosed with asthma compared to children who do not have these risk factors.⁴⁸⁻⁵⁰ These well-established predictors of asthma^{7,24,28-32} suggest that children identified by the OASIS algorithm and not by parent-reported asthma may represent children who utilized health services similar to children diagnosed with asthma but were not yet formally diagnosed by their primary care physician (ie, future asthma cases). The original OASIS algorithm

TABLE 4 Multivariate logistic regression model of factors associated with false negatives [no according to The Ontario Asthma Surveillance Information System (OASIS) algorithm and yes according to parent-reported asthma] among children ages 1-5 y in Toronto, Canada.

	Parameter estimates B*	Adjusted odds ratio	95% confidence interval for B	p-value
Age				
2- <3y	-0.122	0.885	0.673 – 1.165	0.79
3- <4 y	-0.140	0.869	0.672 – 1.123	
4- <5 y	-0.226	0.798	0.632 – 1.006	
5- <6 y	-0.247	0.781	0.617 – 0.988	
(Reference 1- <2 y)				
Sex, male	-0.148	0.862	0.770 – 0.964	0.01
zBMI**	-0.037	0.963	0.912 – 1.017	0.17
Median neighbourhood level income, change in \$10,000	-1.504	1.000	1.000 – 1.000	0.90
Parental smoking status, yes	0.039	1.040	0.877 – 1.232	0.65
Child history of atopy, yes	-0.016	0.984	0.867 – 1.118	0.81
Child history of allergy, yes	0.051	1.052	0.900 – 1.126	0.48
Daycare attendance, yes	-0.036	0.964	0.864 – 1.077	0.52
Parent history of asthma, yes	-0.022	0.978	0.848 – 1.129	0.76
Maternal education, primary and/or high school	0.059	1.061	0.898 – 1.253	0.49

A logistic regression model was used to estimate the probability of a child being a false negative based on predictor variables: age, sex, zBMI, median neighbourhood level income, parental smoking status, child history of atopy, child history of allergy, daycare attendance, parent history of asthma and maternal education.

*Parameter estimates (also called Beta coefficients or B) are the change in the response associated with a one-unit change of the predictor, with all other predictors being held constant.

**body mass index z-score (zBMI).

validation study in children also found a relatively high number of cases (84/630) coded as asthma based on the administrative data but assigned a non-asthma diagnosis based on the review of the clinical record.⁷ Approximately one-fifth of these were due to diagnostic uncertainty in the clinical record.⁷ The authors concluded these cases should more accurately be called “non-confirmed asthma” as reviewers were unable to confirm a diagnosis from the data available in the clinical record.⁷ Findings from the present study, relating to the high number of children identified by the OASIS algorithm but not by parent-report are consistent with these findings (ie, children with “non-confirmed asthma” could be future asthma cases).

This study had a number of limitations. Parent-reported asthma measured using the ISAAC question may have been imperfect. Although there is no accepted gold standard for asthma diagnosis in young children a diagnosis from the clinical record (rather than parent-report) would have been preferable.⁵¹ Further, identifying young children (1-5 years) with asthma using the OASIS algorithm may have been more challenging than for older children. For example, children younger than 2 years with bronchiolitis may have been misclassified and coded asthma according to health administrative data, as there are no specific OHIP fee-for-service physician diagnostic codes for bronchiolitis (exception there is an ICD-10 code [J21]).⁵² This may, in part, explain why asthma prevalence was higher using the OASIS algorithm compared to parent-reported asthma. Parent-reported asthma may also have been subject to recording error, misunderstanding of the question by parents or recall bias.

In this study, both the OASIS algorithm and parent-reported asthma identified a high prevalence of asthma in early childhood in Ontario, Canada. The two measures had moderate agreement among children 1 to 5 years (and fair agreement among children 1-3 years). The OASIS algorithm had high sensitivity, specificity, and NPV but low PPV relative to parent-reported asthma. It identified more asthma cases in young children than parent-reported asthma and its diagnostic properties among young children were similar in a previous study, which involved older children. Future studies are needed to determine whether children identified by the OASIS algorithm early in life and not by parent-reported asthma are in fact future asthma cases. Replication of these findings in other populations is needed.

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CONFLICT OF INTEREST

The authors declare that there are no conflict of interest.

AUTHOR CONTRIBUTIONS

JAO conducted the literature search. JAO, JLM, and TT designed the research study. DLO, PCP, CSB, and JZ helped to refine the study design. JAO, JLM, and KET analyzed the data. All authors contributed to the interpretation of results. JAO, JLM, and TT drafted the manuscript. All authors read and approved the final manuscript. JAO had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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