

# Burden of Childhood Asthma



**ICES Investigative Report**

**May 2004**

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### Ontario's resource for informed health care decision-making

ICES is an independent, non-profit organization that conducts research on a broad range of topical issues to enhance the effectiveness of health care for Ontarians. Internationally recognized for its innovative use of population-based health information, ICES knowledge provides evidence to support health policy development and changes to the organization and delivery of health care services.

Unbiased ICES evidence provides fact-based measures of health system performance; a clearer understanding of the shifting health care needs of Ontarians; and a stimulus for discussion of practical solutions to optimize scarce resources.

Key to ICES' research is our ability to link anonymous population-based health information on an individual patient basis, using unique encrypted identifiers that ensure privacy and confidentiality. This allows scientists to obtain a more comprehensive view of specific health care issues than would otherwise be possible. Linked databases reflecting 12 million of 30 million Canadians allow researchers to follow patient populations through diagnosis and treatment, and to evaluate outcomes.

ICES brings together the best and the brightest talent under one roof. Many of our faculty are not only internationally recognized leaders in their fields, but are also practising clinicians who understand the grassroots of health care delivery, making ICES knowledge clinically-focused and useful in changing practice. Other team members have statistical training, epidemiological backgrounds, project management or communications expertise. The variety of skill sets and educational backgrounds ensures a multi-disciplinary approach to issues management and creates a real-world mosaic of perspectives that is vital to shaping Ontario's future health care.

ICES collaborates with experts from a diverse network of institutions, government agencies, professional organizations and patient groups to ensure research and policy relevance.

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## Executive Summary

### Background

Asthma is the most common chronic childhood illness in North America. Although prevalence estimates calculated from cross-sectional survey data are useful, they are less informative than estimates calculated from population-based longitudinal surveillance. In Canada, there has never been a population-based longitudinal surveillance program implemented to examine the burden of childhood asthma.

### Objectives

The purpose of this project was to assess the magnitude of the burden of childhood asthma in Ontario, and thus, to describe, among children aged 0 to 9 years between 1994/95 and 1998/99:

1. Incidence and prevalence of asthma;
2. All cause mortality of children with asthma and the general population of children;
3. Physician visits and hospitalizations for asthma and all causes among children with asthma and the general population of children; and,
4. Seasonal and geographical variation of asthma hospitalizations.

### Methods

Using Ontario health care administrative databases, a cohort of children aged 0 to 9 years were identified as having asthma between fiscal years 1994/95 and 1998/99 and followed forward until they turned 10 years of age or the end of the study. Children were identified as having asthma if they had at least one asthma hospitalization or two asthma Ontario Health Insurance Plan (OHIP) claims within a three-year follow up. After the initial creation of the asthma cohort, all hospitalizations and OHIP claims for all members of the cohort were extracted and examined in their incident year and each year proceeding, to create a longitudinal examination of their health care utilization.

### Results

There were over 228,000 new cases of asthma identified during the study. While the incidence of asthma decreased by over 30% between fiscal years 1994/95 and 1998/99, the prevalence of asthma had increased by approximately 35% in the same period. When the population of children with asthma was compared with the general population drastic differences were found. The mortality rate of children with asthma was relatively steady throughout the study, at about 0.02%, and was much lower than the mortality rate of the general population, which decreased from 1.04% to 0.79% during the study.

Although the health care utilization of children with asthma and the general population decreased over time, the decrease was much greater among children with asthma. As well, the health care utilization of children with asthma remained notably higher than the health care utilization of the general population of children, even when the health care utilization due to asthma was considered. Children with asthma cost over \$100 more per child per year than the general population, and contributed to over one-third of the total OHIP expenditures in Ontario. Finally, it was determined that there were notable seasonal trends and geographical variations among asthma hospitalizations in Ontario.

### Conclusions

Asthma causes an enormous burden of illness to Ontario's children and its health care system. As more data are collected for this population-based asthma surveillance cohort, more research questions will be answered by longitudinally examining the children and their health care utilization.



## Introduction

Asthma is the most common chronic childhood illness in North America.<sup>1</sup> Estimates from the National Longitudinal Survey of Children and Youth in Canada reveal that in 1994/95 there were 672,000 Canadian children with asthma, a prevalence of 11.2%.<sup>2</sup> Previous research has shown that the pediatric asthma incidence rate increased during the 1970s and 1980s, but had been decreased since the mid 1990s.<sup>3</sup> Prevalence estimates of asthma calculated from a standardized questionnaire used around the world, range between 1.6% and 36.8%, with westernized countries having the highest prevalence.<sup>4</sup>

Not only is asthma responsible for a large burden of illness, it contributes a large burden on health care costs. The total cost of asthma in Canada in 1990, including all ages, was estimated to be \$504 million.<sup>8</sup> Estimates for 1998, suggest that hospital expenditures alone for asthma were \$101.8 million.<sup>9</sup> For Canadian children aged 0 to 14 years in 1998, respiratory diseases caused the largest proportion of physician care expenditures, at approximately \$244 million.<sup>9</sup> In 1996, in Ontario, the annual cost per child with asthma under 15 years old was estimated to be between \$1,122 to \$1,386 depending on the child's age.<sup>10</sup>

The purpose of this project was to assess the magnitude of the burden of childhood asthma in Ontario.

The objectives of this study were to describe, among Ontario children aged 0 to 9 years between 1994/95 and 1998/99:

1. Incidence and prevalence of asthma;
2. All cause mortality of children with asthma and the general population of children;
3. Physician visits and hospitalizations for asthma and all causes among children with asthma and the general population of children; and,
4. Seasonal and geographical variation of asthma hospitalizations.

Although prevalence estimates calculated from cross-sectional survey data are useful, they are less informative than estimates calculated from population-based longitudinal surveillance, which provides the opportunity, not only to count the number of affected individuals, but to follow them forward in time and examine their health care utilization. Population-based surveillance is vital to providing information for decision-making and policy building for programs and services.

In Canada, there has never been a population-based longitudinal surveillance program implemented to examine the burden of childhood asthma. Using physician claims and hospital data to examine the burden of illness in Manitoba, researchers reported an increase in both the incidence and prevalence rates of asthma between 1985 and 1989 in children less than 5 years of age.<sup>5</sup> Furthermore, studies that used data from physician claims in Saskatchewan reported an increase in childhood asthma prevalence from 1981 to 1996, and a stabilized or declined prevalence from 1996 to 1998.<sup>6,7</sup>


### Key Messages

- Asthma is a common and significant health problem among children.
- Asthma surveillance is an important tool to guide decision-making about asthma prevention and management.
- Research is necessary to determine the burden of asthma in Ontario children aged 0 to 9 years.

## Findings

### Number of Ontario children aged 0 to 9 years

**Exhibit 1. Population aged 0 to 9 years over time in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
<b>0-2 years</b>	451,020	447,890	448,242	436,700	420,750	-6.71
<b>3-5 years</b>	458,010	464,700	463,750	462,297	461,759	0.82
<b>6-9 years</b>	587,150	592,590	604,399	617,656	632,190	7.67
<b>Total</b>	1,496,180	1,505,180	1,516,391	1,516,653	1,514,699	1.24
<b>% Change from 94/95</b>		0.60	1.35	1.37	1.24	
<b>% Change per year</b>		0.60	0.74	0.02	-0.13	
Data source: Ontario census data						 <b>ICES</b> Institute for Clinical Evaluative Sciences

### Highlights

- From 1994/95 to 1998/99, the total population of children under 10 years of age increased by 1%.
- The number of children 2 years old and under decreased by 7%, while the number of children 6 to 9 years increased by 8%, from 1994/95 to 1998/99.
- The total number of children increased each year, except in 1998/99, when it decreased slightly (0.1%).

## Incidence of asthma in children

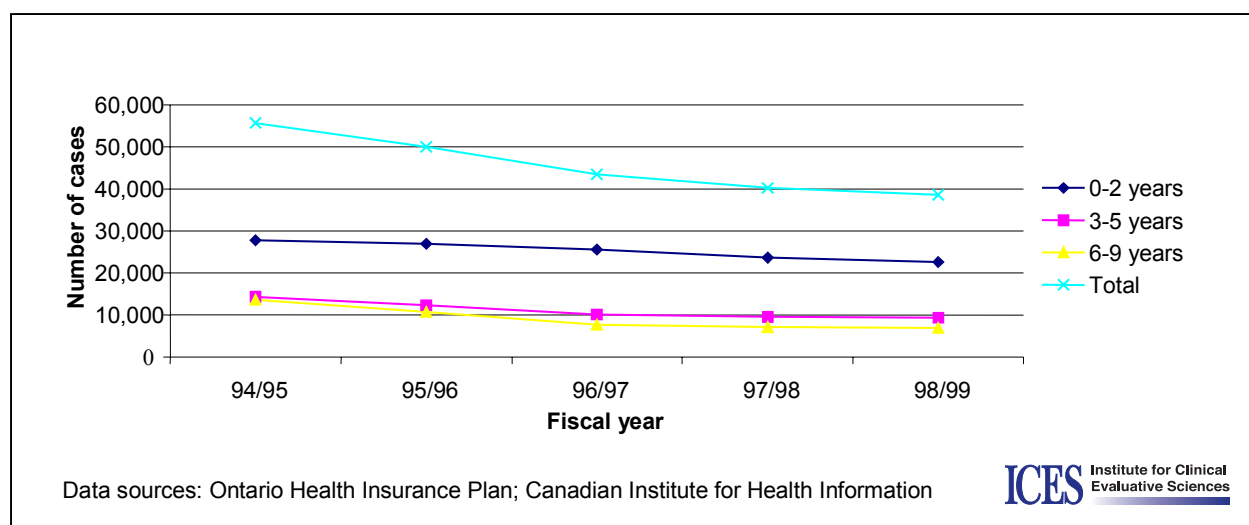
**Exhibit 2a. Number of new asthma cases per population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
0-2 years	27,824	26,929	25,629	23,659	22,505	126,546	-19.12
3-5 years	14,300	12,346	10,149	9,523	9,328	55,646	-34.77
6-9 years	13,582	10,686	7,669	7,100	6,808	45,845	-49.87
Total	55,706	49,961	43,447	40,282	38,641	228,037	-30.63
% Change from 94/95		-10.31	-22.01	-27.69	-30.63		
% Change per year		-10.31	-13.04	-7.28	-4.07		

Data sources: Ontario Health Insurance Plan; Canadian Institute for Health Information

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**Exhibit 2b. Number of new asthma cases per population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**



### Highlights

- There were more than 228,000 new cases of asthma from 1994/95 to 1998/99.
- Twice as many new cases were in children aged 0 to 2 years compared to the other age groups.
- The number of new cases of asthma in children aged 0 to 9 years decreased by over 30% between 1994/95 and 1998/99.
- The smallest decrease of incidence was in children aged 0 to 2 years (19%) while the largest decrease was in children aged 6 to 9 years (50%).

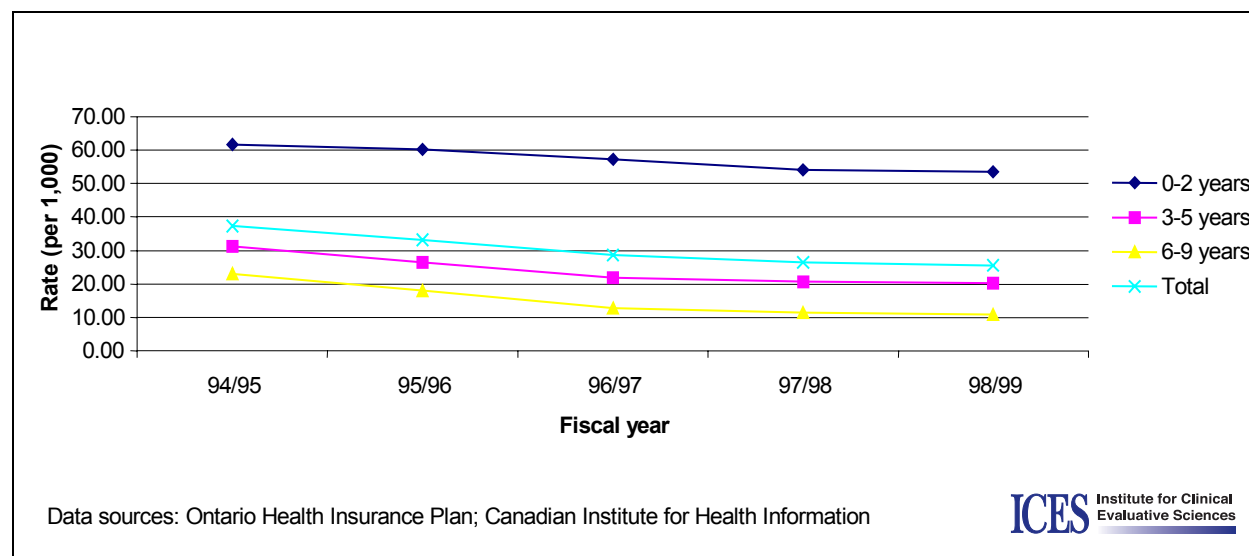
**Exhibit 3a. Overall and age-specific asthma incidence rate per 1,000 population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	61.69	60.12	57.18	54.18	53.49	-13.30
3-5 years	31.22	26.57	21.88	20.60	20.20	-35.30
6-9 years	23.13	18.03	12.69	11.50	10.77	-53.45
Total	37.23	33.19	28.65	26.56	25.51	-31.48
% Change from 94/95		-10.85	-23.05	-28.66	-31.48	
% Change per year		-10.85	-13.68	-7.30	-3.95	

Data sources: Ontario Health Insurance Plan; Canadian Institute for Health Information

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**Exhibit 3b. Overall and age-specific asthma incidence rate per 1,000 population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**




### Highlights

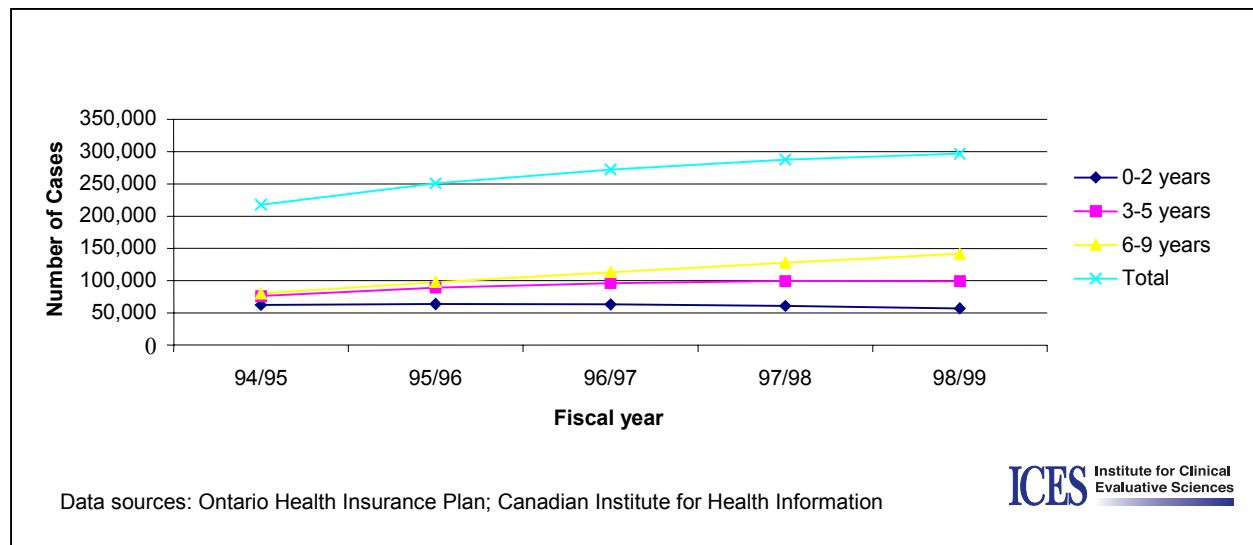
- The asthma incidence rate decreased in all age groups in every year since 1994/95.
- A more than 31% decrease in the overall asthma incidence rate occurred between 1994/95 and 1998/99.
- The greatest decrease in the asthma incidence rate was in children aged 6 to 9 years (53%), and the lowest decrease was in children aged 0 to 2 years (13%).

## Prevalence of asthma in children

**Exhibit 4a. Number of individuals with asthma aged 0 to 9 years\* in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	61,932	64,126	63,372	60,589	56,737	-8.39
3-5 years	75,805	88,959	95,939	99,034	99,163	30.81
6-9 years	80,047	97,433	112,989	127,960	141,305	76.53
<b>Total</b>	<b>217,784</b>	<b>250,518</b>	<b>272,300</b>	<b>287,583</b>	<b>297,205</b>	<b>36.47</b>
% Change from 94/95		15.03	25.03	32.05	36.47	
% Change per year		15.03	8.69	5.61	3.35	
<p>*Children's ages were calculated and re-categorized each year. Hence, in the following year some children remained in the same category and some moved to the older category.</p> <p>Data sources: Ontario Health Insurance Plan; Canadian Institute for Health Information</p>						


**Exhibit 4b. Number of individuals with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**



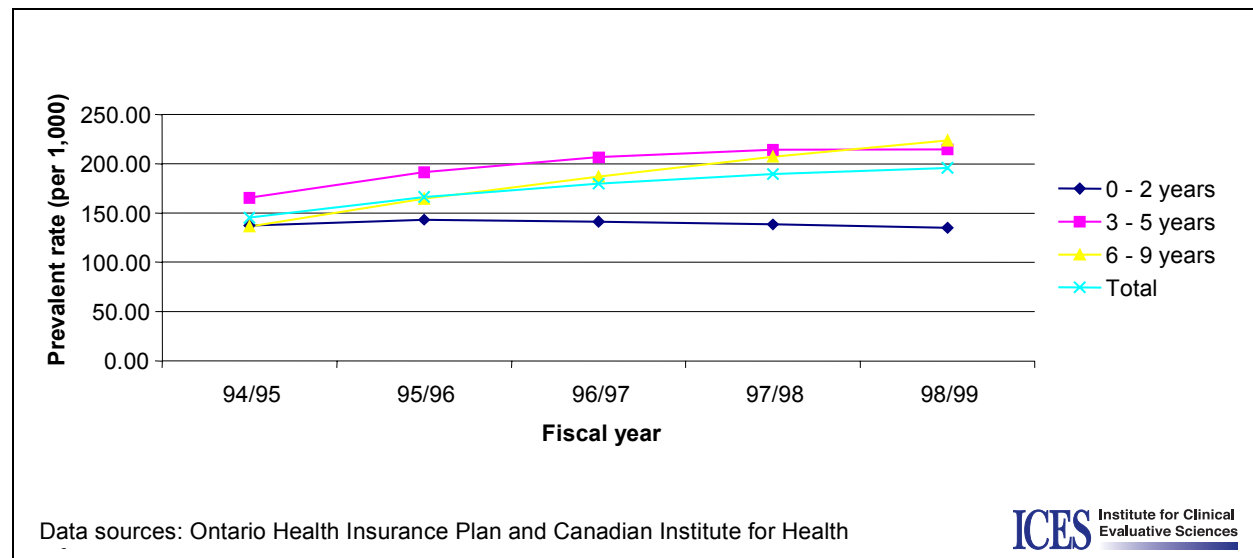
### Highlights

- The number of children with asthma increased every year from 1994/95 to 1998/99.
- The number of children with asthma increased among children aged 3 to 5 years (31%) and 6 to 9 years (77%), and decreased among children aged 0 to 2 years (8%) between 1994/95 and 1998/99.
- The number of children with asthma was lowest among children aged 0 to 2 years and highest among children aged 6 to 9 years.

**Exhibit 5a. Overall and age-specific asthma prevalence rate per 1,000 population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	137.32	143.17	141.38	138.74	134.85	-1.80
3-5 years	165.51	191.43	206.88	214.22	214.75	29.75
6-9 years	136.33	164.42	186.94	207.17	223.52	63.95
<b>Total</b>	<b>145.56</b>	<b>166.44</b>	<b>179.57</b>	<b>189.62</b>	<b>196.21</b>	<b>34.80</b>
% Change from 94/95		14.34	23.37	30.27	34.80	
% Change per year		14.34	7.89	5.59	3.48	
Data sources: Ontario Health Insurance Plan; Canadian Institute for Health Information						

**Exhibit 5b. Asthma prevalence rate per 1,000 population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

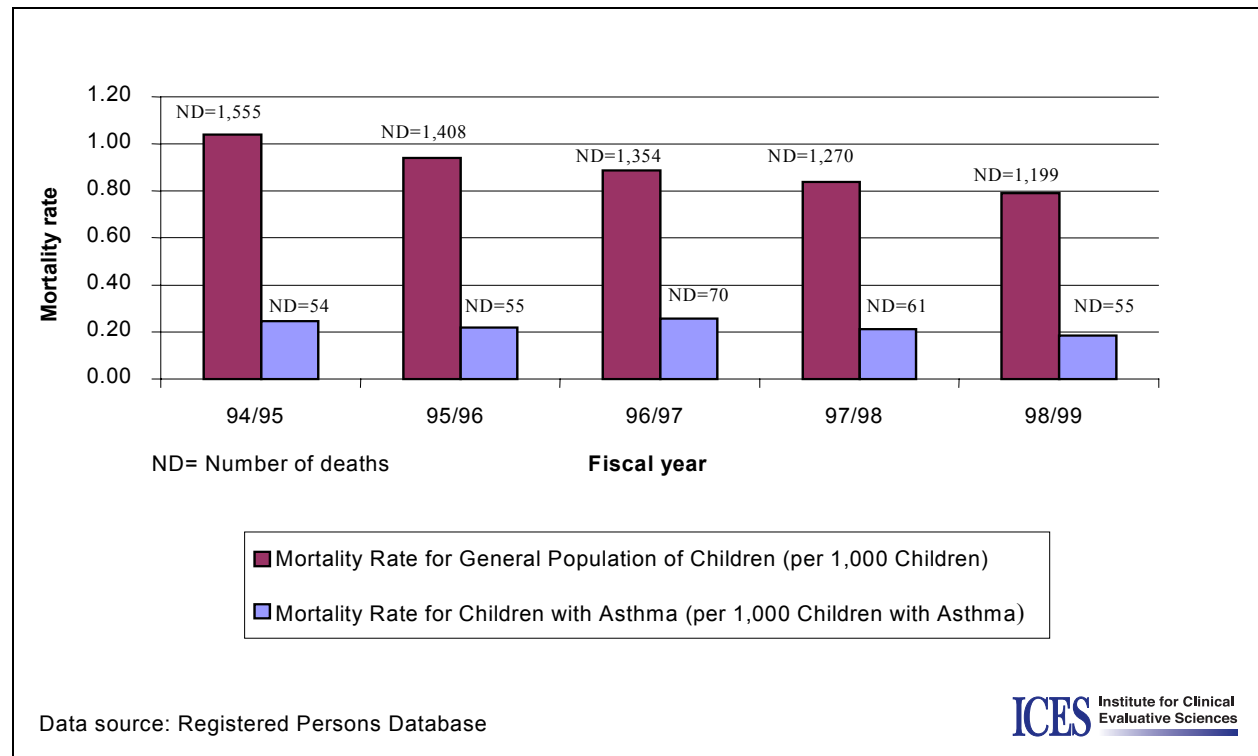


### Highlights

- The overall asthma prevalence rate in children aged 0 to 9 years increased almost 35% from 1994/95 to 1998/99.
- The greatest increase in the asthma prevalence rate was in children aged 6 to 9 years (64%).
- A slight decrease in the asthma prevalence rate was observed in children aged 0 to 2 years (2%).

## Mortality of children in the general population and in children with asthma

**Exhibit 6. Number and rate of all cause mortality per 1,000 general population and per 1,000 population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**



### Highlights

- There were 6,786 deaths from “any cause” in the population aged 0 to 9 years, and 295 deaths from “any cause” in children with asthma aged 0 to 9 years from 1994/95 to 1998/99.
- The mortality rate per 1,000 population aged 0 to 9 years decreased yearly, from 1.04% in 1994/95 to 0.79% in 1998/99.
- The mortality rate per 1,000 population with asthma aged 0 to 9 years remained relatively constant over the study period, at approximately 0.02%.
- In 1998/99, children with asthma contributed almost 5% to the total number of deaths in the general population of Ontario children.

## Health care utilization of children

**Exhibit 7. Number of asthma OHIP claims per population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
0-2 years	150,322	147,728	141,957	132,283	123,233	695,523	-18.02
3-5 years	134,375	129,801	114,997	112,347	112,182	603,702	-16.52
6-9 years	131,211	125,774	109,280	107,970	109,903	584,138	-16.24
<b>Total</b>	<b>415,908</b>	<b>403,303</b>	<b>366,234</b>	<b>352,600</b>	<b>345,318</b>	<b>1,883,363</b>	<b>-16.97</b>
% Change from 94/95		-3.03	-11.94	-15.22	-16.97		
% Change per year		-3.03	-9.19	-3.72	-2.07		

Data source: Ontario Health Insurance Plan

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**Exhibit 8. Overall and age-specific asthma OHIP claim rate per population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	2.43	2.30	2.24	2.18	2.17	-10.51
3-5 years	1.77	1.46	1.20	1.13	1.13	-36.18
6-9 years	1.64	1.29	0.97	0.84	0.78	-52.55
<b>Total</b>	<b>1.91</b>	<b>1.61</b>	<b>1.34</b>	<b>1.23</b>	<b>1.16</b>	<b>-39.16</b>
% Change from 94/95		-15.70	-29.57	-35.80	-39.16	
% Change per year		-15.70	-16.46	-8.84	-5.24	

Data source: Ontario Health Insurance Plan


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### Highlights


- There were nearly 1.9 million asthma OHIP claims for children with asthma under age 10 between 1994/95 and 1998/99.
- The number and rate of asthma OHIP claims decreased in all age categories every year since 1994/95.
- In 1998/99, children aged 0 to 2 years had 2 claims per child with asthma, while children aged 6 to 9 years had only 1 claim per child with asthma.



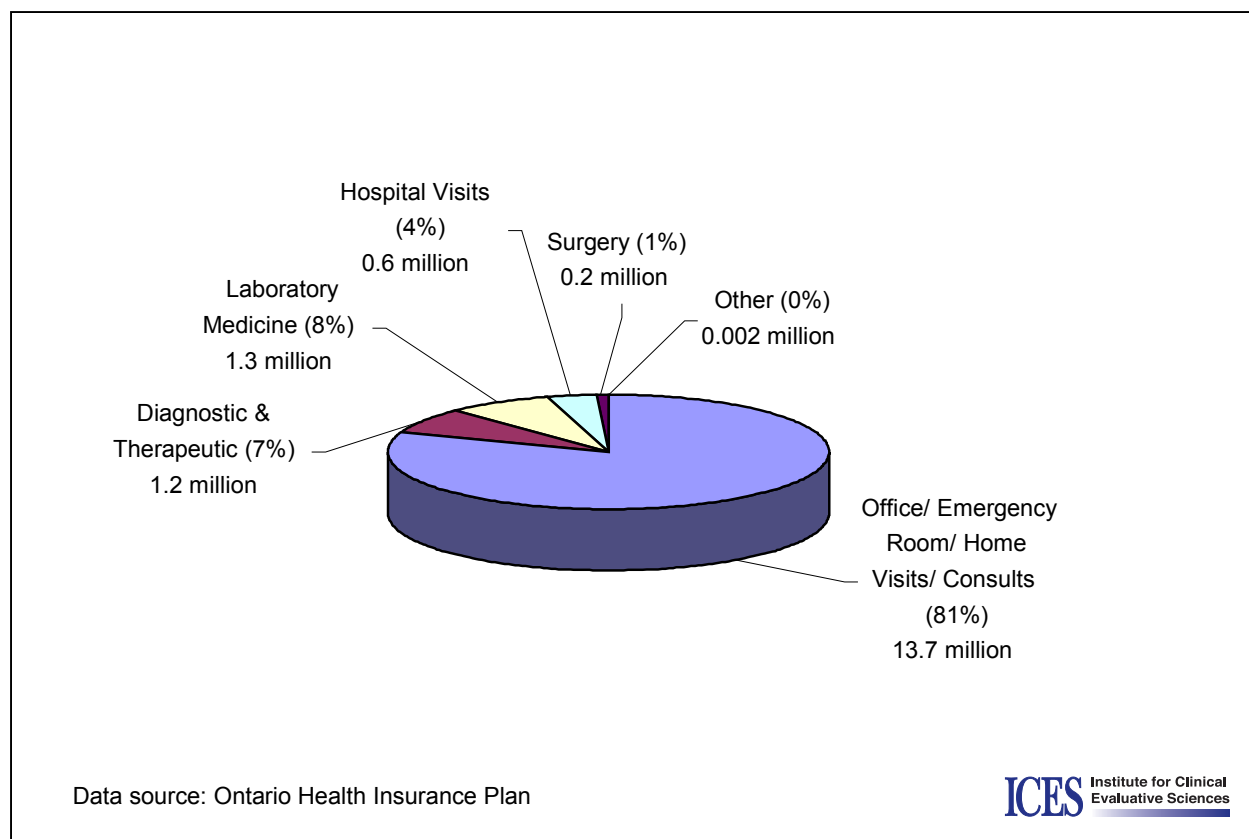
**Exhibit 9. Number of OHIP claims from all causes per population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
<b>0-2 years</b>	1,740,875	1,639,854	1,466,278	1,310,447	1,133,781	7,291,235	-34.87
<b>3-5 years</b>	1,106,005	1,094,272	1,000,741	983,738	949,374	5,134,130	-14.16
<b>6-9 years</b>	873,014	902,780	877,994	936,667	978,413	4,568,868	12.07
<b>Total</b>	3,719,894	3,636,906	3,345,013	3,230,852	3,061,568	16,994,233	-17.70
<b>% Change from 94/95</b>		-2.23	-10.08	-13.15	-17.70		
<b>% Change per year</b>		-2.23	-8.03	-3.41	-5.24		
Data source: Ontario Health Insurance Plan						 <b>ICES</b> Institute for Clinical Evaluative Sciences	

**Exhibit 10. Overall and age-specific OHIP claim rate per individual with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
<b>0-2 years</b>	28.11	25.57	23.14	21.63	19.98	-28.91
<b>3-5 years</b>	14.59	12.30	10.43	9.93	9.57	-34.38
<b>6-9 years</b>	10.91	9.27	7.77	7.32	6.92	-36.51
<b>Total</b>	17.08	14.52	12.28	11.23	10.30	-39.69
<b>% Change from 94/95</b>		-15.01	-28.08	-34.23	-39.69	
<b>% Change per year</b>		-15.01	-15.38	-8.55	-8.31	
Data source: Ontario Health Insurance Plan					 <b>ICES</b> Institute for Clinical Evaluative Sciences	

**Exhibit 11. Distribution of OHIP claims in the population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**



### Highlights

- There were approximately 17 million OHIP claims for children with asthma under age 10 between 1994/95 and 1998/99.
- The number and rate of OHIP claims decreased every year since 1994/95; the overall OHIP claim rate decreased by nearly 40% between 1994/95 and 1998/99.
- In 1998/99, children aged 0 to 2 years had approximately 20 claims per child with asthma, while children aged 6 to 9 years had nearly 7 claims per child with asthma.
- At least 10% of OHIP claims for children with asthma are attributable to asthma.
- Almost all of the OHIP claims were for physician visits or consults at the office, emergency room, or home.

**Exhibit 12. Number of OHIP claims from all causes per population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
0-2 years	5,333,428	5,184,126	4,918,213	4,801,727	4,676,571	24,914,065	-12.32
3-5 years	3,330,141	3,194,852	2,880,309	2,888,371	2,906,056	15,199,729	-12.73
6-9 years	3,345,298	3,153,105	2,884,690	2,956,332	2,996,061	15,335,486	-10.44
<b>Total</b>	12,008,867	11,532,083	10,683,212	10,646,430	10,578,688	55,449,280	-11.91
% Change from 94/95		-3.97	-11.04	-11.35	-11.91		
% Change per year		-3.97	-7.36	-0.34	-0.64		

Data source: Ontario Health Insurance Plan

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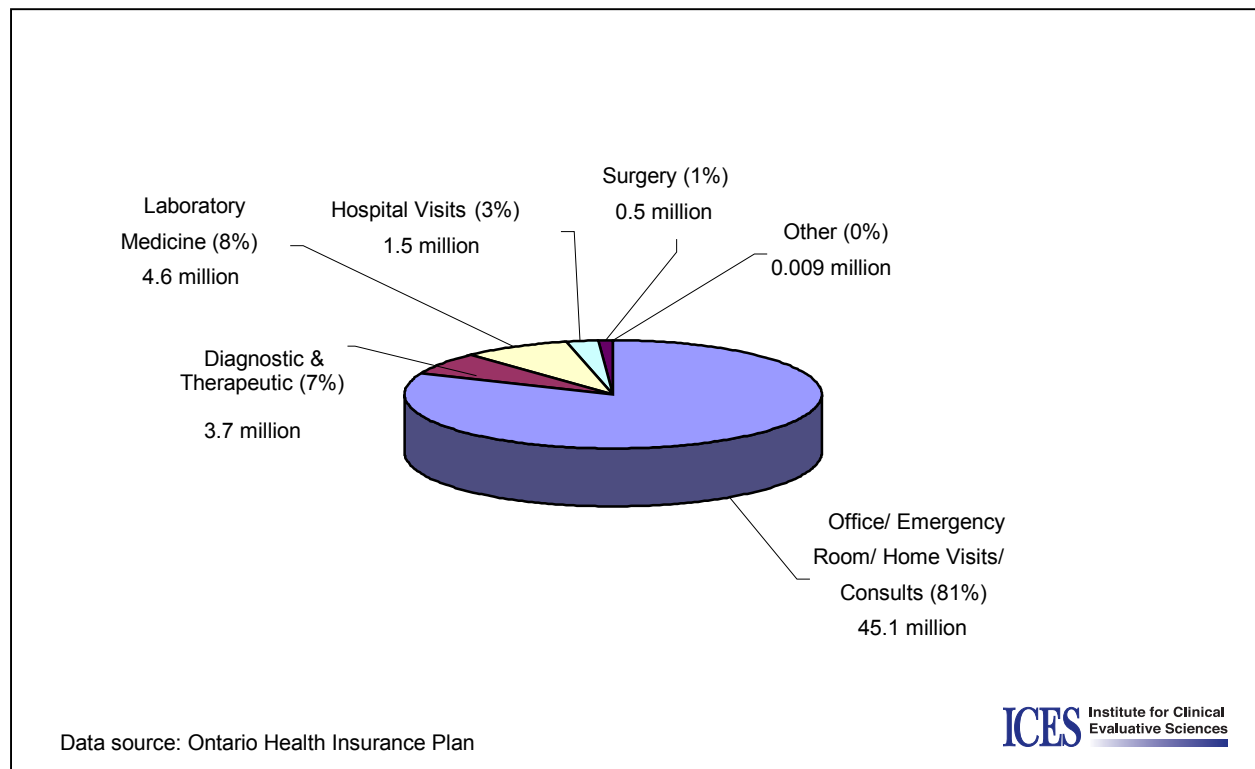
**Exhibit 13. Overall and age-specific OHIP claim rate per individual aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	11.83	11.57	10.97	11.00	11.11	-6.01
3-5 years	7.27	6.88	6.21	6.25	6.29	-13.44
6-9 years	5.70	5.32	4.77	4.77	4.74	-16.82
<b>Total</b>	8.03	7.66	7.05	7.02	6.98	-12.99
% Change from 94/95		-4.54	-12.22	-12.54	-12.99	
% Change per year		-4.54	-8.05	-0.36	-0.51	

Data source: Ontario Health Insurance Plan

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**Exhibit 14. Distribution of OHIP claims per population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**




### Highlights

- There were more than 55 million OHIP claims for children under age 10 from 1994/95 to 1998/99.
- The number and rate of OHIP claims decreased every year since 1994/95; the overall OHIP claim rate decreased by nearly 13% between 1994/95 and 1998/99, almost one-third of the reduction in the claim rate of children with asthma (40%).
- In 1998/99, children aged 0 to 2 years had approximately 11 claims per child while children aged 6 to 9 years had nearly 5 claims per child.
- Children with asthma had greater decreases in the number and rate of claims per year than the general population.

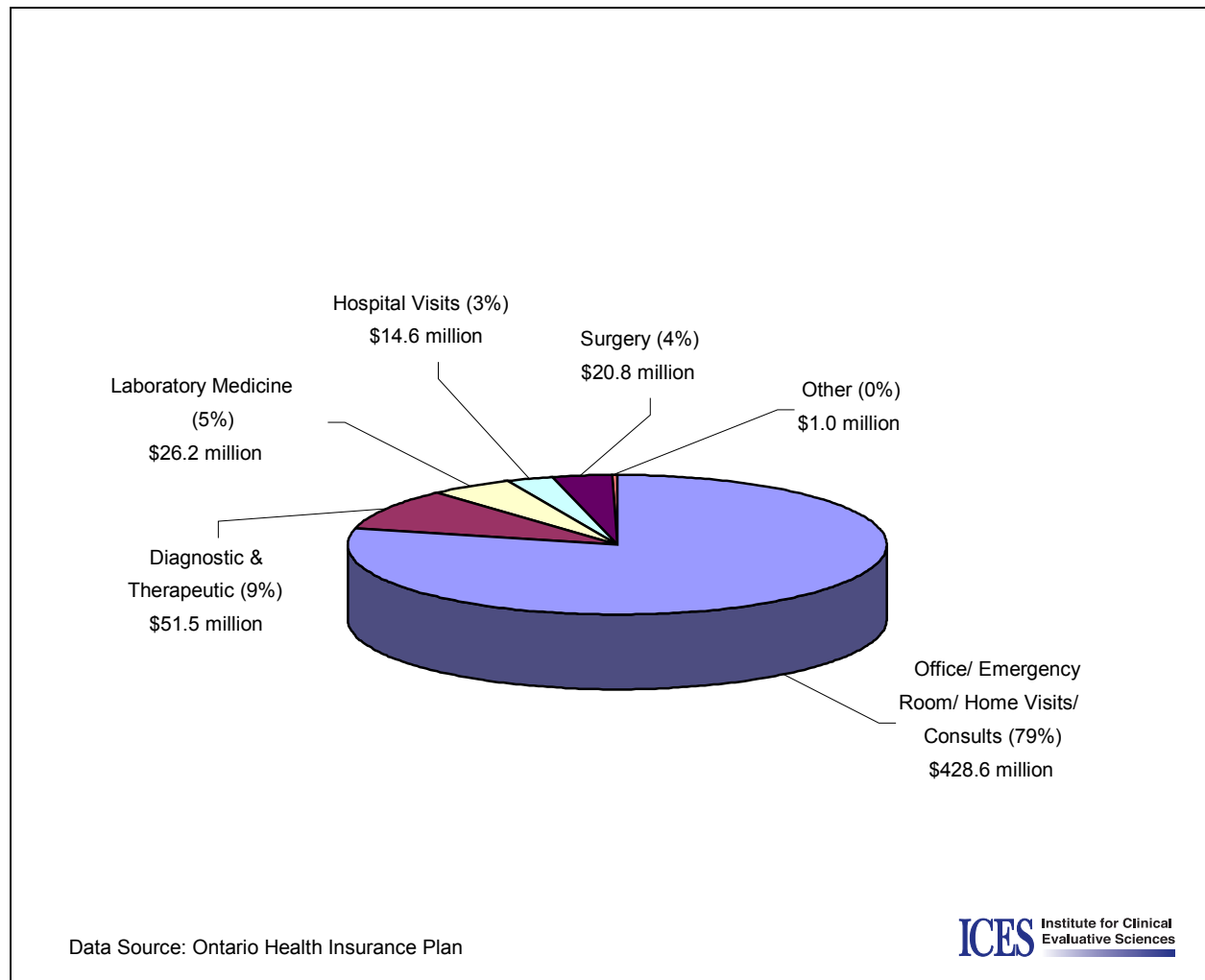
**Exhibit 15. OHIP expenditures\* for the population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
<b>0-2 years</b>	54,408,888	51,457,968	46,473,892	42,367,245	36,328,905	231,036,898	-33.23
<b>3-5 years</b>	34,742,172	34,587,896	32,002,527	32,006,000	30,516,017	163,854,612	-12.16
<b>6-9 years</b>	27,563,173	28,759,278	28,425,195	30,958,351	32,084,965	147,790,962	16.41
<b>Total</b>	116,714,233	114,805,142	106,901,613	105,331,597	98,929,887	542,682,472	-15.24
<b>% Change from 94/95</b>		-1.64	-8.41	-9.75	-15.24		
<b>% Change per year</b>		-1.64	-6.88	-1.47	-6.08		
*Adjusted to the Canadian dollar in 2000 Data source: Ontario Health Insurance Plan							

**Exhibit 16. OHIP expenditure\* rate per individual with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
<b>0-2 years</b>	878.53	802.45	733.35	699.26	640.30	-27.12
<b>3-5 years</b>	458.31	388.81	333.57	323.18	307.74	-32.85
<b>6-9 years</b>	344.34	295.17	251.57	241.94	227.06	-34.06
<b>Total</b>	535.92	458.27	392.59	366.27	332.87	-37.89
<b>% Change from 94/95</b>		-14.49	-26.74	-31.66	-37.89	
<b>% Change per year</b>		-14.49	-14.33	-6.70	-9.12	
*Adjusted to the Canadian dollar in 2000 Data source: Ontario Health Insurance Plan						

**Exhibit 17. Distribution of OHIP expenditures for the population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**



**Highlights**

- Approximately \$543 million was spent on OHIP claims for children with asthma under age 10 from 1994/95 to 1998/99.
- In 1998/99, children with asthma aged 0 to 2 years cost the most (\$640 per child) while children with asthma aged 6 to 9 years cost the least (\$227 per child).
- OHIP expenditures per child with asthma decreased by more than 37% from 1994/95 to 1998/99.
- More than 75% of OHIP expenditures were for physician office visits, emergency room visits, home visits, or physician consults.
- The distribution of expenditures reflected the distribution of the volume of claims.

**Exhibit 18. OHIP expenditures\* for the population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
0-2 years	163.73	159.65	152.68	151.05	145.81	772.92	-10.94
3-5 years	103.61	99.90	91.13	92.58	92.13	479.35	-11.08
6-9 years	106.23	100.74	93.73	97.68	97.99	496.36	-7.76
<b>Total</b>	<b>373.56</b>	<b>360.29</b>	<b>337.55</b>	<b>341.31</b>	<b>335.92</b>	<b>1,748.63</b>	<b>-10.08</b>
% Change from 94/95		-3.55	-9.64	-8.63	-10.08		
% Change per year		-3.55	-6.31	1.12	-1.58		

\*Adjusted to the Canadian dollar in 2000  
Data source: Ontario Health Insurance Plan

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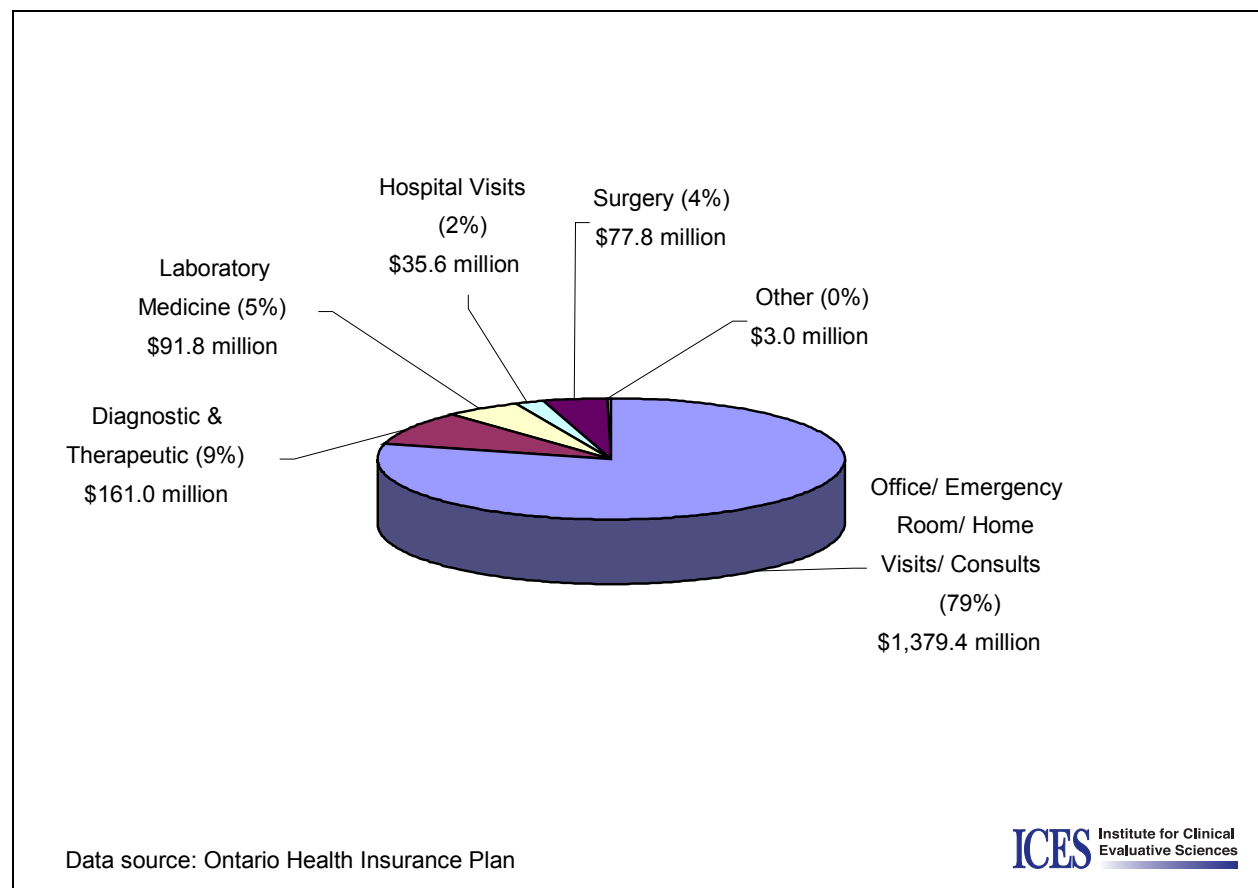
**Exhibit 19. OHIP expenditure rate\* per individual aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	363.01	356.45	340.63	345.89	346.54	-4.54
3-5 years	226.21	214.98	196.52	200.27	199.51	-11.80
6-9 years	180.92	170.00	155.08	158.15	155.00	-14.33
<b>Total</b>	<b>249.68</b>	<b>239.37</b>	<b>222.60</b>	<b>225.04</b>	<b>221.77</b>	<b>-11.18</b>
% Change from 94/95		-4.13	-10.85	-9.87	-11.18	
% Change per year		-4.13	-7.01	1.10	-1.45	

\*Adjusted to the Canadian dollar in 2000  
Data source: Ontario Health Insurance Plan

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**Exhibit 20. Distribution of OHIP expenditures for the population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**



**Highlights**

- Approximately \$1.7 billion was spent on OHIP claims for children under age 10 from 1994/95 to 1998/99.
- Children aged 0 to 2 years cost the most per year per child (\$347) while children aged 6 to 9 years cost the least (\$155) in 1998/99.
- OHIP expenditures per child decreased by more than 11% from 1994/95 to 1998/99.
- Children with asthma cost over \$100 more per child in 1998/99 compared to the general population, and had three times the decrease of the general population in per child price-adjusted billings since 1994/95 (38% vs. 11%).



**Exhibit 21. Number of hospitalizations with asthma included as a diagnosis code, per population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
0-2 years	7,155	6,813	6,343	5,512	4,921	30,744	-31.22
3-5 years	3,814	3,772	3,056	2,921	2,708	16,271	-29.00
6-9 years	2,262	2,487	1,896	1,818	1,540	10,003	-31.92
<b>Total</b>	<b>13,231</b>	<b>13,072</b>	<b>11,295</b>	<b>10,251</b>	<b>9,169</b>	<b>57,018</b>	<b>-30.70</b>
% Change from 94/95		-1.20	-14.63	-22.52	-30.70		
% Change per year		-1.20	-13.59	-9.24	-10.56		

Data source: Ontario Health Insurance Plan

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**Exhibit 22. Overall and age-specific asthma hospitalization rate per 1,000 population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	115.53	106.24	100.09	90.97	86.73	-24.93
3-5 years	50.31	42.40	31.85	29.49	27.31	-45.72
6-9 years	28.26	25.53	16.78	14.21	10.90	-61.43
<b>Total</b>	<b>60.75</b>	<b>52.18</b>	<b>41.48</b>	<b>35.65</b>	<b>30.85</b>	<b>-49.22</b>
% Change from 94/95		-14.11	-31.72	-41.33	-49.22	
% Change per year		-14.11	-20.51	-14.07	-13.45	

Data source: Canadian Institute for Health Information

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### Highlights

- More than 57,000 hospitalizations of children under age 10, with asthma included as a diagnosis code, occurred from 1994/95 to 1998/99.
- The number and rate of asthma hospitalizations decreased in all age groups and in every year since 1994/95.
- The largest decrease in the asthma hospitalization rate was in children aged 6 to 9 years (61%) and the smallest decrease was in children aged 0 to 2 years (25%).
- The asthma hospitalization rate decreased almost 50% from 1994/95 to 1998/99.

**Exhibit 23. Number of hospitalizations from all causes per population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
0-2 years	30,910	30,228	26,258	23,631	20,859	131,886	-32.52
3-5 years	15,547	15,521	14,025	13,814	13,452	72,359	-13.48
6-9 years	8,973	9,406	8,787	9,400	9,404	45,970	4.80
Total	55,430	55,155	49,070	46,845	43,715	250,215	-21.13
% Change from 94/95		-0.50	-11.47	-15.49	-21.13		
% Change per year		-0.50	-11.03	-4.53	-6.68		

Data source: Canadian Institute for Health Information

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**Exhibit 24. Overall and age-specific hospitalization rate per 1,000 population with asthma aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	499.10	471.38	414.35	390.02	367.64	-26.34
3-5 years	205.09	174.47	146.19	139.49	135.66	-33.86
6-9 years	112.10	96.54	77.77	73.46	66.55	-40.63
Total	254.52	220.16	180.21	162.89	147.09	-42.21
% Change from 94/95		-13.50	-29.20	-36.00	-42.21	
% Change per year		-13.50	-18.15	-9.61	-9.70	

Data source: Canadian Institute for Health Information

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### Highlights

- More than 250,000 hospitalizations from all causes among children with asthma under age 10 occurred from 1994/95 to 1998/99.
- The number of hospitalizations decreased from 1994/95 to 1998/99 in all age categories except for those aged 6 to 9 years whose hospitalizations increased by 5%.
- The hospitalization rate decreased in all age groups with the largest decrease in children with asthma aged 6 to 9 years (41%) and the smallest decrease in children with asthma aged 0 to 2 years (26%).
- Approximately one-fifth of hospitalizations of children with asthma were attributable to asthma.

**Exhibit 25. Number of hospitalizations from all causes per population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					Cumulative Total	% Change from 94/95
	94/95	95/96	96/97	97/98	98/99		
0-2 years	53,964	56,474	49,325	47,326	45,293	252,382	-16.07
3-5 years	20,858	19,453	15,886	15,054	14,782	86,033	-29.13
6-9 years	17,854	16,051	13,464	12,873	12,364	72,606	-30.75
<b>Total</b>	<b>92,676</b>	<b>91,978</b>	<b>78,675</b>	<b>75,253</b>	<b>72,439</b>	<b>411,021</b>	<b>-21.84</b>
% Change from 94/95		-0.75	-15.11	-18.80	-21.84		
% Change per year		-0.75	-14.46	-4.35	-3.74		

Data source: Canadian Institute for Health Information

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**Exhibit 26. Overall and age-specific hospitalization rate per 1,000 population aged 0 to 9 years in Ontario, 1994/95 to 1998/99**

Age group	Fiscal Year					% Change from 94/95
	94/95	95/96	96/97	97/98	98/99	
0-2 years	119.65	126.09	110.04	108.37	107.65	-10.03
3-5 years	45.54	41.86	34.26	32.56	32.01	-29.71
6-9 years	30.41	27.09	22.28	20.84	19.56	-35.68
<b>Total</b>	<b>61.94</b>	<b>61.11</b>	<b>51.88</b>	<b>49.62</b>	<b>48.82</b>	<b>-22.79</b>
% Change from 94/95		-1.35	-16.24	-19.90	-22.79	
% Change per year		-1.35	-15.10	-4.37	-3.62	

Data source: Canadian Institute for Health Information

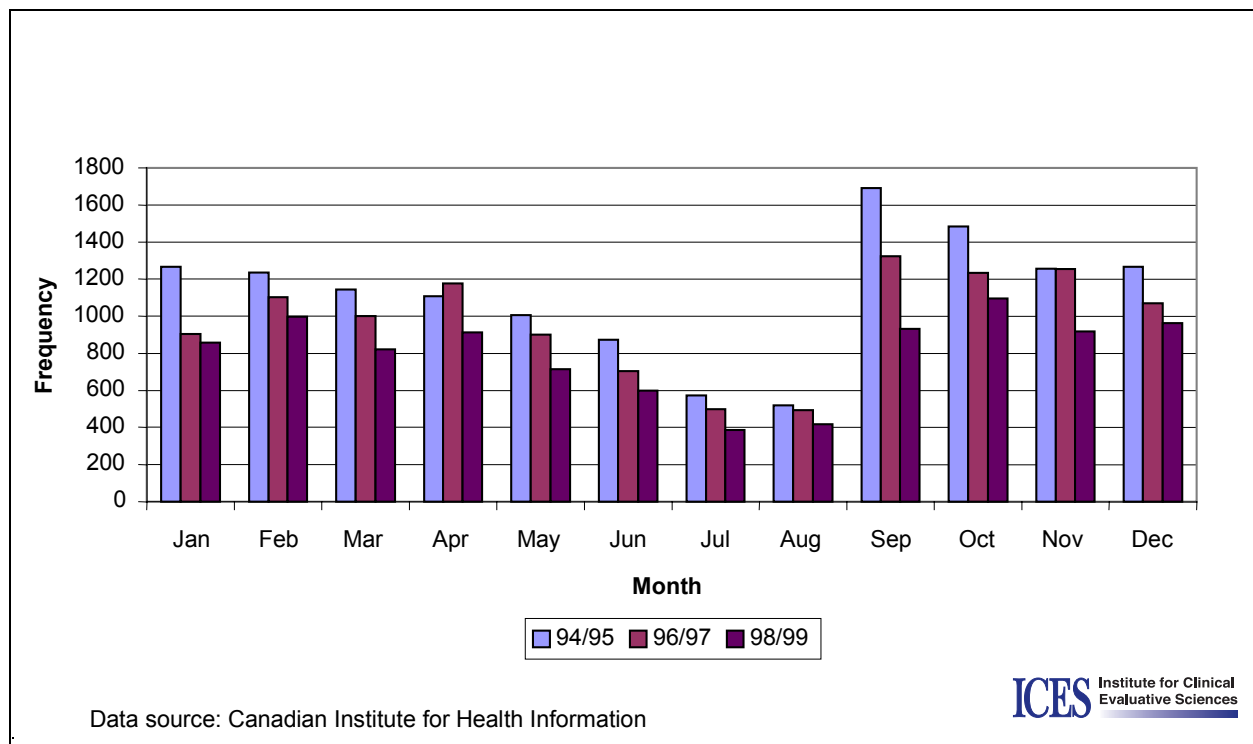
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### Highlights

- More than 411,000 hospitalizations from all causes among children under age 10 occurred from 1994/95 to 1998/99.
- The number and rate of hospitalizations decreased in all age categories every year since 1994/95.
- The largest decrease in hospitalization rate was in children aged 6 to 9 years (36%) and the smallest decrease was in children aged 0 to 2 years (10%).
- In 1998/99, children with asthma had nearly 3 times more all cause hospitalizations per 1,000 population than that of the general population (147 vs. 48 hospitalizations).

## Seasonal trend of asthma hospitalizations

**Exhibit 27. Number of asthma hospitalizations per population aged 0 to 9 years by month in Ontario, 1994/95, 1996/97 and 1998/99**




### Highlights

- Asthma hospitalizations were the highest during the fall and lowest during the summer in each of the years examined.
- There were fewer hospitalizations in each month in 1998/99 than in 1994/95.

## Geographical variation of children with asthma

**Exhibit 28. Age- and sex-adjusted asthma hospitalization rates per 100,000 population aged 0 to 9 years in Ontario, by District Health Council of residence, 1994/95 to 1998/99**

District Health Council	Fiscal Years 94/95 - 96/97				Fiscal Years 96/97 - 98/99			
	Number of Hospitalizations/ Years	Age/Sex-Adjusted Hospitalization Rate per 100,000 Children	P-Value	Rank	Number of Hospitalizations/ Years	Age/Sex-Adjusted Hospitalization Rate per 100,000 Children	P-Value	Rank
Algoma-Cochrane-Manitowlin-Sudbury	425	753.0	***	4	347	663.2	***	3
Champlain	565	405.0	***	13	385	285.1	***	14
Durham-Haliburton-Kawartha-Pine Ridge	593	522.1		10	455	419.7		10
Essex-Kent-Lambton	656	807.8	***	2	481	598.3	***	4
Grand River	253	794.0	***	3	219	722.7	***	2
Grey-Bruce-Huron-Perth	240	604.9	**	7	173	467.7	*	7
Halton-Peel	788	429.8	***	11	746	393.2		11
Hamilton	150	234.6	***	16	159	252.1	***	15
Toronto	1,284	420.0	***	12	1,065	336.9	***	12
Northern Shores	161	587.0	*	8	107	425.1		9
Niagara	346	659.2	***	6	268	530.3	***	6
Northwestern Ontario	302	822.8	***	1	263	752.8	***	1
Southeastern Ontario	442	702.6	***	5	331	558.5	***	5
Simcoe-York	480	350.4	***	14	394	286.9	***	13
Thames Valley	262	317.7	***	15	173	215.0	***	16
Waterloo Region-Wellington-Dufferin	514	550.7	*	9	398	425.7		8
<b>Total Ontario</b>	<b>7,468</b>	<b>493.3</b>			<b>5,969</b>	<b>365.24</b>		
Coefficient of Variation (%) [CV]		31.81				33.1		
Extremal Quotient [EQ]		3.51				3.5		
Systematic Component of Variation [SCV]		148				176.05		
Adjusted Chi-square (likelihood ratio)		725.19 (d.f 15, p<0.0001)				597.8 (d.f 15, p<0.0001)		
* significant at 5% level, ** significant at 1% level, *** significant at 0.1% level								
Data source: Canadian Institute for Health Information								

### Highlights

- The age- and sex-adjusted asthma hospitalization rate for children with asthma decreased by more than 100 per 100,000 population aged 0 to 9 years between 1994/95-1996/97 and 1996/97-1998/99.
- Northwestern Ontario had the highest asthma hospitalization rate in both periods while Hamilton and Thames Valley had the lowest asthma hospitalization rate.

## **Summary of findings**

### **Population**

The change in the Ontario population of children aged 0 to 9 years can be observed in Exhibit 1. There was an increase of 1% in the Ontario population of children from 1994/95 to 1998/99. The incidence and prevalence of asthma in Ontario children aged 0 to 9 years between 1994/95 and 1998/99 is documented in Exhibits 2 through 5. The number of new cases of asthma and the asthma incidence rate decreased by approximately 30% (Exhibits 2 and 3), while the number of children with asthma and the asthma prevalence rate increased by approximately 35% (Exhibits 4 and 5).

The all cause mortality of children with asthma and children of the general population was examined (Exhibit 6). There were 295 (0.1%) deaths from various causes in children with asthma from 1994/95 to 1998/99. The mortality rate remained relatively constant throughout the study, between 0.23 and 0.27 per 1,000 children with asthma aged 0 to 9 years. The mortality rate of children with asthma was drastically lower than that of the general population. In children aged 0 to 9 years of the general population, the all cause mortality rate decreased every year, from 1.04 per 1,000 children in 1994/95, to 0.79 per 1,000 children in 1998/99.

### **Health care utilization**

The health care utilization of children with asthma and the general population children can be seen in Exhibits 7 to 20. When Ontario Health Insurance Plan (OHIP) claims were examined, it was determined that there was an overall decrease in the number of OHIP claims and rate of OHIP claims between 1994/95 and 1998/99 (Exhibits 7 and 8). There was a 17% decrease in the number of asthma OHIP claims, and a 39% decrease in the asthma OHIP claim rate.

There was also an 18% decrease in the number of all cause OHIP claims of children with asthma and a 40% decrease in the all cause OHIP claim rate of children with asthma (Exhibits 9 and 10). Approximately 10% of the all cause OHIP claims of children with asthma could be attributed to asthma. Meanwhile, there was a 12% decrease in the number of all cause OHIP claims of the general population of Ontario children, and only a 13% decrease in the all cause OHIP claim rate (Exhibits 12 and 13). Therefore, the reduction of the OHIP claim rate of the general population of Ontario children had one-third the reduction of the OHIP claim rate of Ontario children with asthma.

In 1998/99, children with asthma had 10 claims per child, while the general population of Ontario children had 7 claims per child. Since children with asthma had, on average, only one asthma OHIP claim per year, there were an additional 2 OHIP claims per year for children with asthma than for the general population of Ontario children that could not be explained by asthma alone.

### **Health expenditures**

The OHIP expenditures for children in Ontario with asthma were very large. During the study period over \$542 million was spent on OHIP claims for children aged 0 to 9 years with asthma (Exhibit 15). In 1998/99, one child with asthma cost \$333 (Exhibit 16). Although the cost seems very high, there had been a 38% decrease since 1994/95. However, the OHIP expenditures for the general population of children in Ontario decreased by only 11% between 1994/95 and 1998/99, and the cost per child was at least \$100 less than that of a child with asthma in all age groups and in every year (Exhibits 18 and 19).

The distribution of the number of OHIP claims and the distribution of OHIP expenditures were similar between children with asthma and the general population of children; three-quarters of the claims and expenditures resulted from physician office visits, emergency room visits, home visits and consults (Exhibits 11, 14, 17, and 20).

## **Hospitalizations**

When hospitalizations were examined, a similar pattern was seen. In 1998/99, children with asthma had 147 hospitalizations per 1,000 children with asthma (Exhibit 24), and the general population of Ontario children had only 48 hospitalizations per 1,000 children (Exhibit 26). Children with asthma had 3 times the number of all cause hospitalizations of children of the general population. This could not be accounted for through asthma alone, as children with asthma had only 31 asthma hospitalizations per 1,000 children with asthma in 1998/99 (Exhibit 22).

While the number and rate of hospitalizations that occurred in 1998/99 seem to be large, the number and rate had dramatically decreased since 1994/95. Children with asthma had a 49% decrease in the asthma hospitalization rate and a 42% decrease in the hospitalization rate from all causes (Exhibits 22 and 24). Conversely, the general population of children had only half the decrease in the hospitalization rate of children with asthma. There was a 23% decrease in the all cause hospitalization rate of the general population of Ontario children between 1994/95 and 1998/99 (Exhibit 26).

The seasonal trends of asthma hospitalizations and the geographical variation of the asthma hospitalization rate were also examined. The highest proportion of asthma hospitalizations occurred during the fall months and the lowest proportion of asthma hospitalizations occurred in the summer months (Exhibit 27). The distribution of the asthma hospitalization rate among children with asthma varied across Ontario's District Health Council areas. Northwestern Ontario had the highest age- and sex-adjusted asthma hospitalization rate per 100,000 children in both 1994/95-1996/96 and 1996/97-1998/99, while Hamilton and Thames Valley had the lowest or second lowest asthma hospitalization rate in the two periods (Exhibit 28).

## Discussion

Previous research has indicated that the asthma incidence rate increased until the mid 1990s and has been decreasing since.<sup>3</sup> This study concurs and indicates that the number of new cases of asthma and incidence rate of asthma in children has been decreasing since 1994/95. A decrease in the asthma incidence rate of 30% was shown in this study; one possible explanation for the drastic decrease may be that there was a diagnostic shift. Physicians may have been less likely to diagnose a child with asthma and may have used wheeze or asthma-related diagnoses as an alternative. A diagnostic shift in asthma was observed in the 1980s, although in the opposite direction. There was a shift in labeling bronchitis or bronchiolitis as asthma among children, resulting in an increase in the calculated incidence of asthma, which is an artifact.<sup>6,14</sup>

More recently, research in the UK has indicated that a diagnostic shift may have been responsible for a portion of the increased rates shown in one study, however they do conclude that there was a true rise in asthma in children despite the diagnostic shift.<sup>3</sup> In this study, to address the possibility of decreased rates due to a diagnostic shift, the volume of asthma-related diagnoses were examined. No simultaneous increase in asthma-related claims was found; therefore, it is unlikely that the decrease in the incidence of asthma in Ontario children aged 0 to 9 years was due to a diagnostic shift. Furthermore, the incidence rate shown in this study is similar to that previously reported.<sup>15</sup>

The asthma prevalence rate reported in this study ranged between 15% in 1994/95, to 20% in 1998/99; a 35% increase. This indicates that asthma affects a large number of Ontario children and that number is growing yearly. Even though the asthma incidence rate is decreasing, every year there are still children developing asthma and, thus, the number of children with asthma is increasing. Since all children classified as having asthma were included as prevalent cases in every year preceding their incident year until age 10, regardless of whether or not they had an asthma claim that year, the prevalence increased. Hence, the asthma prevalence estimated in this study is more of a measure of “ever asthma”.

This “ever asthma” definition of asthma may account for the high prevalence rate in the latter years and in the older age categories. However, previous research has indicated that 80% of children who wheeze before the age of 3 still wheeze at the age of 6.<sup>3</sup> This suggests that there should not be a large overestimation of the prevalence of “active asthma” when using the definition of “ever asthma”. Additionally, although the lack of a universally applied definition of asthma makes it difficult to compare asthma prevalence between studies, the prevalence shown in this study is within the ranges previously reported.

The prevalence of asthma in different regions of the world has been studied through the International Study of Allergies and Asthma in Childhood (ISAAC) project.<sup>4</sup> Using a one-page questionnaire to assess symptoms, the prevalence of asthma symptoms has been estimated to range between 1.6% and 36.8% in children aged 13 to 14 years.<sup>4</sup> English-speaking westernized, affluent countries had the highest prevalence, with Canada having the fifth highest prevalence of asthma symptoms in children aged 13-14 years, at approximately 25%.<sup>4</sup> Moreover, research conducted in the UK reported an asthma prevalence of 20.7% in children aged 2 to 15 years between 1994 and 1997.<sup>3</sup>

Recent surveys in Australia indicated the prevalence of diagnosed ever asthma in children to be between 11.2% and 14.5% for 0 to 4 year olds, and to be between 21.6% and 30.4% for 5 to 9 year olds.<sup>16</sup> Finally, the yearly increase of asthma prevalence reported in this study is in accordance with that previously reported by some studies, but is in contrast to other reported results. On one hand, studies conducted in the US have suggested that the prevalence of current asthma in children and young adults has been increasing by 5% to 6% per year.<sup>15</sup> On the other hand, a study in Saskatchewan reported that while the prevalence of asthma increased from 1991 to 1996, the prevalence had stabilized and in some age categories declined in 1997 and 1998.<sup>7</sup> Though the prevalence rates shown in this study increased annually, the amount of annual increase had decreased.



While the prevalence of asthma reported in this study was high, the all cause mortality among children with asthma was low. There were 295 deaths between 1994/95 and 1998/99; this was only 0.1% of the cohort. The all cause mortality rate of children with asthma remained relatively constant throughout the study. Unfortunately, the specific causes of death were unable to be determined for this study and thus, the mortality due to asthma remains unknown. In the US, it has been estimated that between 1995/96 and 1997/98, the mortality rate due to asthma ranged between 3.8 and 3.3 per 1,000,000 children under 18 years of age.<sup>14</sup>

When the mortality rate of children with asthma was compared to that of the general population of Ontario children, it could be seen that the mortality rate of the general population was much higher than that of children with asthma. Since the specific cause of death was not known for these children, it is difficult to speculate as to why the general population had a higher mortality rate than children with asthma. However, one possible explanation may be that a large proportion of mortality among the general population may have been due to premature babies and babies born with low birth weight. Due to the inclusion criteria for the asthma cohort, it was necessary that all children were alive long enough to have at least one asthma hospitalization or 2 asthma claims within three years. Hence, it is likely that deaths due to premature babies and babies born with low birth weight were not included in the mortality rate of children with asthma thus, the mortality rate was lower. Nevertheless, it is unlikely that this explanation accounts for the entire discrepancy and future research should be directed towards examining this phenomenon.

Although the mortality of children with asthma may not have been elevated as compared to the general population, the health care utilization of children with asthma was much higher. There were striking differences between the health care utilization of children with asthma and children of the general population. Children with asthma had more OHIP claims than the general population children, in addition to that which could be accounted for by asthma claims alone.

In 1998/99, children with asthma had three more OHIP claims per child as compared to the general population of Ontario. Children with asthma had, on average, one asthma OHIP claim per child in 1998/99, therefore there were an additional two OHIP claims per child with asthma that were not directly due to asthma. Furthermore, although the general population of Ontario children experienced a decrease in the OHIP claim rate between 1994/95 and 1998/99, it was less than half the decrease seen in the all cause OHIP claim rate for children with asthma. However, the results from this study are on par with that previously reported. Previous research has shown that the general population of Ontario children aged 0 to 19 years had 11.7 claims per child in fiscal year 1997/98, which was a decrease of 17% from fiscal year 1991/92.<sup>17</sup>

The OHIP expenditures calculated in this study were also very large, of which children with asthma caused a substantial proportion. Ontario children with asthma contributed to approximately one-third of the total OHIP expenditures of the general population. In the general population of children and the population of children with asthma, children aged 0 to 2 years cost more per child than 3 to 5 year olds, who in turn cost more per child than 6 to 9 year olds. However, children with asthma cost at least \$100 more per child in all of the age categories than children of the general population. Obviously, children with asthma are a burden on the Ontario health care system. Previous research has reported that the combined direct and indirect cost of Ontario children aged 0 to 14 years with asthma is between \$1,122 and \$1,386 per child depending on their age.<sup>10</sup> The calculated unadjusted Ministry of Health and Long-Term Care annual cost was \$676 per patient per year with the largest component being hospital admissions, followed by physician services.<sup>10</sup>

OHIP is only one component of the burden of asthma on the Ontario health care system. When the hospitalizations of children with asthma were compared to the hospitalizations of the general population of children, striking differences were observed. Children with asthma had three times more hospitalizations due to all causes than the general population of children.

Since approximately one-fifth of the all cause hospitalizations among children with asthma could be attributed to asthma, some of the discrepancy between the hospitalization rates of the two populations

could be explained. However, asthma hospitalizations do not account for all of the discrepancy. Children with asthma have more hospitalizations despite their asthma and are a larger burden to the Ontario health care system than children of the general population. One possible explanation for the greater hospitalization rate among children with asthma may be the fact that children with asthma are at higher risk for other respiratory diseases, for instance pneumonia, bronchitis, and bronchiolitis, than the general population of children. Respiratory conditions were the leading cause of hospitalizations in children under 15 years of age in Ontario in 1997/98.<sup>18</sup>

The hospitalization rate of children with asthma is similar to that previously reported. In 1994/95 the hospitalization rate per 1,000 Canadian children aged 0 to 14 years with asthma was 43.26.<sup>2</sup> This is slightly lower than that found in the Ontario children aged 0 to 9 years examined in this study, due to the different geographical regions and age categories examined. In Australia, the asthma hospitalization rate per 1,000 children with asthma was reported to be between 25 and 180 depending on the sex and age category.<sup>16</sup>

Despite the high number of hospitalizations, both the number and the rate of asthma hospitalizations have decreased since 1994/95. It is unknown if this drastic drop in asthma hospitalizations was from better management on an outpatient basis or if more children were using asthma medication. Further research is necessary to determine the basis of this drop in health care utilization. Previous research in Ontario has also found a downward trend in asthma hospitalizations. One study found a decline of 32% in the Ontario asthma hospital admission rates of children aged 0 to 19 years between 1991/92 and 1997/98, while another study found only a 13% decrease.<sup>18,19</sup> The smaller decrease was attributed to the examination of the entire Ontario population and the use of a larger time frame, from 1988 to 2000.<sup>19</sup>

Furthermore, studies in the UK and Australia have reported that the hospitalization rate for asthma has decreased in the last decade.<sup>3,16</sup> When hospitalizations from all causes were examined among children with asthma, it was determined that the number and rate of all hospitalizations were also decreasing. However, when the general population of children was examined it was determined that the decrease in the hospitalization rate of the general population of children was only half that of the decrease in the hospitalization rate of children with asthma.

This suggests that while the hospitalization rate of children is decreasing in general, the hospitalization rate of children with asthma is decreasing at an accelerated pace and becoming more like the desired baseline hospitalization rate of the general population. This greater decrease in hospitalization rate among children with asthma may be due to a more efficient outpatient asthma care and better treatment. However, despite the large decrease in the hospitalization rate among children with asthma it remains much higher than that of the general population.

When asthma hospitalizations were examined by month, marked seasonal trends were found. The trends are consistent with previous research based on Canadian data.<sup>2,19</sup> The number of asthma claims increased sharply in September and then gradually decreased, with the lowest number of claims occurring in the summer months. This trend may reflect the return of the children to school. Perhaps, the children would spend more time indoors, be exposed to more allergens and have more contact with other children, and hence an increase in viral infections would occur, all of which may exacerbate asthma attacks in susceptible children.<sup>2,19</sup>

There were also distinctive geographical variations in the rate of asthma hospitalizations observed in this study. Some regions of Ontario maintained higher asthma hospitalization rates over time, while other regions maintained lower hospitalizations rates. It remains unknown if the differences between regions are from differences in outpatient services, or if there are environmental factors exacerbating asthma in susceptible children in some regions. Further research is needed to determine the basis of the geographical variation of asthma in Ontario children.

## **Future directions**

This is the first report of many that will utilize the population-based surveillance cohort of children with asthma. As more data are collected and the cohort can be followed for a longer period, many important questions regarding the burden of asthma in Ontario children can be examined. For instance, different definitions of asthma will be explored. Over time, it will be possible to reassess and revisit the sensitivity and specificity of the current asthma definition and explore other asthma definitions. The use of a “current asthma” definition as opposed to the “ever asthma” definition currently used will be investigated. Additionally, the longitudinal aspect of the cohort will allow the examination of the changes in the burden of asthma and potentially determine the implications of the introduction of new treatments, guidelines or policies. Furthermore, future examinations of the health care utilization of children with asthma as compared to children with other chronic diseases, like diabetes, and the population without asthma will be conducted.

## Conclusion

Asthma causes an enormous burden of illness to Ontario's children and health care system. While the incidence of asthma decreased between 1994/95 and 1998/99, the prevalence of asthma has increased by over 30% during the same period. When the population of children with asthma was compared to the general population, drastic differences were found.

The mortality rate of children with asthma was relatively steady throughout the study and was much lower than the mortality rate of the general population, which decreased during the study. In addition, although the health care utilization of children with asthma and the general population decreased over time, the decrease was much greater among children with asthma. Furthermore, the health care utilization of children with asthma remained notably higher than the health care utilization of the general population of children, even when the health care utilization due to asthma was considered. Finally, it was determined that there were notable seasonal trends and geographical variations among asthma hospitalizations in Ontario.

## Appendices

### Appendix A. How the research was done

#### Data sources

This study used three Ontario health care administrative databases:

1. Hospital discharge abstract database, Canadian Institute for Health Information (CIHI);
2. Ontario Health Insurance Plan (OHIP) records database; and,
3. Registered persons database (RPDB).

The hospital discharge abstract database from CIHI includes the records for all provincial hospitalizations, while the OHIP records database contains the fee-for-service codes billed by health care workers. The billings are grouped into broad categories, including diagnostic and therapeutic procedures, hospital visits, laboratory medicine, office/emergency room/home visits/consults, surgery, and other (see Appendix B for more detail). The registered persons database contains the birth date and date of death, if applicable, for all Ontario residences and was used to calculate age and determine mortality. The three databases contain a reproducible scrambled unique identifier that permits the linkage of records across databases and across time while still preserving patient confidentiality.

#### Analyses

For the purposes of this study, children were identified as having asthma if they had at least one asthma hospitalization or two asthma OHIP claims within a three-year follow up, between fiscal years 1991/92 and 2000/2001. An asthma hospitalization was defined as a hospitalization that included the ICD-9 diagnosis code 493 (asthma). An asthma OHIP claim was defined as a claim in which the diagnosis code was 493.

The inclusion criteria was based on the results of the asthma case verification study.<sup>11</sup> Briefly, the case verification study involved the chart abstractions of 630 patients from primary care physicians' offices around Ontario which were then assigned an asthma status by two independent physicians blinded to the chart diagnosis code. These charts were then linked to the administrative data and the utility of several algorithms were explored using standard diagnostic test evaluations.

The algorithms ranged from:

- 1 to 5 asthma OHIP claims without a specified time period;
- 2 to 5 asthma OHIP claims in 2 years;
- 2 to 5 asthma OHIP claims in 3 years;
- 2 to 5 asthma OHIP claims in 2 years and/or 1 asthma hospitalization;
- 2 to 5 asthma OHIP claims in 3 years and/or 1 asthma hospitalization.

Using the chart review diagnosis as the gold standard, the calculated sensitivities ranged from 98.5% to 62.5% and the specificities ranged from 50.1% to 91.0%. The case verification study demonstrated that an algorithm of 2 asthma OHIP claims in 3 years or 1 asthma hospitalization created a cohort with the highest sensitivity and lowest false negative rate while still maintaining a satisfactory specificity.<sup>13</sup> This is the first time that this algorithm has been used to form a cohort for the purposes of ongoing surveillance and research.

All children between the ages of 0 to 9 years who met the inclusion criteria for having asthma were entered into the asthma cohort. After the creation of the asthma cohort, all CIHI and OHIP claims for members of the cohort were extracted and examined in their incident year and each year following, to create a longitudinal examination of their health care utilization. The asthma cohort was divided into three age categories: 0 to 2 years, 3 to 5 years, and 6 to 9 years.

Though the children were followed longitudinally, their ages were calculated cross-sectionally and they were included in the appropriate age category each year until the end of the study or they turned 10 years old. Once a child was included in the cohort he/she was not removed until they reached age 10, and consequently the cohort undertook a “once asthma, always asthma” approach (see Appendix B for more detail).

Once the cohort was created and all data extracted, the incidence and prevalence of asthma in Ontario children aged 0 to 9 years were calculated for each year under study. The year of a child’s first asthma OHIP claim or asthma hospitalization was defined as the asthma incident year. The child was defined as a prevalent asthma case in every year following the incident year, until removal from the cohort at 10 years of age. To ensure accurate estimates of incidence and prevalence, only the data from fiscal years 1994/95 to 1998/99 were reported (see Appendix B for more detail). At least three years of prior data was necessary to confirm incidence, hence data from 1991/92 to 1993/94 were not exhibited, and data from 1999/00 to 2000/01 were not exhibited because three years follow-up were necessary to accurately define the child as having asthma.

The asthma cohort was linked to the registered persons database to determine the all cause mortality of children with asthma and similarly, the all cause mortality of the general population was determined for comparison. The health care utilization due to asthma and all causes for the children with asthma was examined through the already extracted hospitalizations and OHIP claims. The volume, rates, and expenditures were examined yearly. In addition, the CIHI and OHIP databases were examined to determine the health care utilization due to all causes for the general population of Ontario children aged 0 to 9 years (see Appendix B for more detail). The distribution of the seasonal trend of asthma hospitalizations was examined by month for the beginning (1994/95), middle (1996/97), and end (1998/99) of the study, and the average age- and sex-adjusted asthma hospitalization rate was examined geographically to compare the geographical variation between the first half, 1994/95 to 1996/97, and the last half, 1996/97 to 1998/99, of the study. See Appendix B for more detail.

## Limitations

Apart from the usual limitations inherent in analyzing and interpreting administrative data, there are specific interpretive cautions required when examining the magnitude of the burden of asthma reported from this cohort.<sup>12</sup> The methodology used in this study has not been validated. However, to validate the use of administrative data diagnosis codes for identifying children with asthma, a case verification study was conducted.<sup>11</sup> The case verification study indicated that an algorithm based on one asthma hospitalization or two OHIP asthma claims within three years was a sensitive and specific method for identifying children with asthma.<sup>13</sup> As well, it demonstrated accuracy for the diagnostic coding of outpatient asthma in children aged 0 to 18 years. Some difficulties were thought to exist in the diagnosis of asthma among children under the age of 2 years, however, the case verification study demonstrated that for children aged 0 to 2 years, and the asthma algorithm produced an equally high sensitivity and specificity as for the older age categories.<sup>11</sup>

The way in which the cohort was created may have inflated the number of children with asthma in the older age group. Once a child was deemed to have asthma they remained in the cohort for every year (i.e. “once asthma, always asthma”) until reaching the age limit, regardless of whether or not a claim was made in that year. The child was followed longitudinally through the years and was included in the appropriate age category each year. The child was removed from the cohort after turning 10 years old. It is possible that the older age groups contained children that no longer had asthma, though previous research has indicated that 80% of children who wheeze before 3 years of age still wheeze at the age of 6 years.<sup>3</sup> Therefore, the potential overestimation of prevalence of asthma in the older age group of this cohort is possible, but it should not be large.

Additional caution should be taken when examining the data of the general population. Data shown in the general population tables includes the entire general population, including children with asthma. Traditionally, the diseased population is removed from the comparison group. In this study, a comparison to the general population was felt to be more informative, because, even if children with asthma were removed, the population would still not be “healthy” as it included children with many other chronic

diseases. In addition, the proportion of children with asthma is very small compared to that of the general population and there would have been negligible change had the children with asthma been removed from the general population data. Some health care centres across Ontario have started an alternative fee-for-service payment plan. Physicians under this plan do not bill to OHIP for payment, rather they submit “shadow billings” for administrative purposes only. The completeness and validity of shadow billing is unknown. Therefore, there may be an underestimation of the volume of billings if shadow billing is incomplete.

## Appendix B. Detailed analytic methods

### Data sources

The primary sources of data used in this study were two Ontario health care administrative databases: the hospital discharge abstract database, which is prepared by the Canadian Institute for Health Information (CIHI); and the Ontario Health Insurance Plan (OHIP) records database. The hospital discharge abstract database from CIHI includes the records for all provincial hospitalizations, while the OHIP records database contains the fee-for-service codes billed by health care workers.

The billings are grouped into broad categories including, diagnostic and therapeutic procedures, hospital visits, laboratory medicine, office/emergency room/home visits/consults, surgery, and other. It is possible for physicians to complete one billing for each consult, procedure, and test done on a patient. Therefore, there may be multiple OHIP billings per patient physician visit. These databases were available at an individual level and included information from fiscal year 1991/92 to 2000/01.

Data used from the OHIP database included a unique identifier, service date, 1 diagnosis code in OHIP, and 1 fee code. Data used from the CIHI database included a unique identifier, patient residence code, admission and discharge date, and 16 diagnosis codes. The unique identifier included in both databases is a reproducible scrambled identifier per person and it permits the linkage of the records across databases and across time while preserving patient confidentiality. A third database, the registered persons database (RPDB), which uses the same unique identifier per person, was also used and contains the most reliable information for the birth date and date of death. However, if the patient was missing from RPDB, the birth date from CIHI was used.

### Cohort assembly

For the cohort assembly, a child was considered to have asthma if he/she had one asthma hospitalization or two asthma OHIP claims within three years. All OHIP claims with a service date within the admission and discharge dates of a CIHI record were excluded, as were all birth records. Since it is possible for there to be multiple OHIP billings per patient per physician visit, for the purposes of this study, all OHIP billings were extracted, however, when calculating the number of OHIP claims one claim per physician per day was used to be representative of a health care visit, while when calculating the OHIP expenditures all claims were used in order to be representative of the whole cost.

Age was calculated for each year in the cohort, if the patient had a claim in that year, the age on the date of the claim was used. If the patient did not have a claim in that year, they were still included in the calculations of prevalence, and age was calculated on September 30 of that year. The cohort was stratified into three age categories: 0 to 2 years, 3 to 5 years, and 6 to 9 years. Though the children were followed longitudinally, their age was calculated cross-sectionally and they were included in the appropriate age category each year. Since the children's ages were individually calculated each year, they were re-categorized each year; hence, some children remained in the same age category for the following year while some moved to the older age category. For instance, a child aged 2 years in 1995/96 was included in the 0 to 2 years strata in 1995/96, but was included in the 3 to 5 years strata from 1996/97 to 1998/99. Patients were only removed from the database once they turned 10 years of age.

### Analyses

For the construction of the tables, incidence was defined as the first hospitalization or OHIP claim with a diagnosis of asthma, for the children who satisfied the asthma criteria. A child was considered a prevalent asthma case each year after the incidence; hence a "once asthma, always asthma" approach was utilized. To ensure accurate estimates of incidence and prevalence only data from fiscal years 1994/95 to 1998/99 were reported. Although data were available from fiscal years 1991/92 to 2000/01, data from 1991/92 to 1993/94 were excluded because at least three years of prior data were needed to confirm incident cases, while data from 1999/00 to 2000/01 were excluded because three years follow-up was necessary to accurately define the child as having asthma.



The mortality of children with asthma was examined by linking the cohort to the RPDB database and identifying if a date of death was registered. This was also done to determine the mortality rate for the general population. Unfortunately, the cause of death could not be determined for this study.

In the hospitalization tables of children with asthma and the general population, annual rates were calculated per 1,000 children with asthma and per 1,000 children of the general population, respectively, while in the OHIP tables, annual rates were calculated per child with asthma and per child, respectively. The denominator used to calculate the rates was Exhibit 4, the number of children with asthma, and Exhibit 1, the number of children in Ontario. Exhibit 1 was calculated from the 1996 census population data and post-censal estimates.

The OHIP expenditures tables were determined from OHIP fee-for-service codes. The total billing volume (percentage of claims) was calculated for each category for each of the fiscal years. The price-adjusted billings for each year were calculated by multiplying the billing volume by a standard price for each fee code according to the 2000 OHIP Schedule of Benefits and Fees.

Finally, the distribution of the seasonal trends of asthma hospitalization was examined monthly for three of the beginning (1994/95), middle (1996/97), and end (1998/99) of the study. The age- and sex-adjusted asthma hospitalization rate was calculated per 100,000 children for the fiscal years 1994/95 to 1996/97 and fiscal years 1996/97 to 1998/99, by the geographic region or Ontario District Health Councils of the child's residence. A more detailed description of the methodology used in this report for the analysis of area variation can be found in the *Patterns of Health Care in Ontario: ICES Practice Atlas, 2<sup>nd</sup> Ed.*<sup>20</sup>

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## Glossary

**asthma.** A child was defined as having asthma if the child had one asthma hospitalization or two asthma OHIP claims within three years.

**asthma claim.** Either an OHIP claim or a hospitalization that included the diagnosis code for asthma (ICD-9 493).

**OHIP claim.** OHIP claims were included as one claim per physician per day.

**incidence.** The number of new cases of asthma that occurred in one year

**incident asthma case.** The first time the child, who fulfilled the asthma definition, had a claim with the diagnosis of asthma. There was a minimum look back window of three years to confirm incidence.

**prevalence.** The proportion of the population that is affected with asthma in one year

**prevalent asthma case.** A child was included each year after the incident year as having asthma, regardless if the child had a claim in that year. Therefore, the child was considered “once asthma, always asthma”.

**area rate variations.** Rates of asthma can differ across areas, these variations could be random or a function of service availability, patient population characteristics, physician characteristics, etc.