Health outcomes in low-income children with current asthma in Canada

T To, PhD (1, 2); S Dell, MD (1,3); M Tassoudji, MSc (1); C Wang, MD (1)

Abstract

Data collected from the Canadian National Longitudinal Survey of Children and Youth (NLSCY) in 1994/95 and 1996/97 were used to measure longitudinal health outcomes among children with asthma. Over 10 000 children aged 1 to 11 years with complete data on asthma status in both years were included. Outcomes included hospitalizations and health services use (HSU). Current asthma was defined as children diagnosed with asthma by a physician and who took prescribed inhalants regularly, had wheezing or an attack in the previous year, or had their activities limited by asthma. Children having asthma significantly increased their odds of hospitalization (OR = 2.52; 95% CI: 1.71, 3.70) and health services use (OR = 3.80; 95% CI: 2.69, 5.37). Low-income adequacy (LIA) in 1994/95 significantly predicts hospitalization and HSU in 1996/97 (OR = 2.68; 95% CI: 1.29, 5.59 and OR = 0.67; 95% CI: 0.45, 0.99, respectively). Our results confirmed that both having current asthma and living in low-income families had a significant impact on the health status of children in Canada. Programs seeking to decrease the economic burden of pediatric hospitalizations need to focus on asthma and low-income populations.

Keywords: *asthma, low-income, hospitalization, health services use*

Introduction

Asthma has been determined to be the most common reason for preventable hospitalization in children.[1-4] It is generally agreed that asthma is an "ambulatory care sensitive condition," i.e. good outpatient management should result in decreased hospitalizations.[5] Inadequate control of asthma can be costly; it has physical consequences and can lower a person's quality of life. In 1998, the major direct health care costs (hospital care and drug expenditures) for asthma totalled over $402 million.[6] According to the Institute for Clinical Evaluative Sciences report by To et al., the total annual indirect and direct costs were reported to be $676 per Canadian child with asthma in 1995.[7] The largest single component was hospital admissions, accounting for 77% of the total cost. The use of other health services (i.e. visits to general practitioner, specialist and emergency department) contributed 21% to the total cost.[8]

Most information on HSU and health outcomes among children with asthma is ascertained from cross-sectional surveys or administrative records.[9,10] To our knowledge, no systematic longitudinal survey data based on a population have been collected to ascertain the prevalence of asthma in various age groups, their HSU and asthma-associated morbidities. The NLSCY, a longitudinal Canadian population-based survey, provides a unique opportunity to study childhood asthma prospectively and obtain stable estimates of asthma prevalence. Specifically, the asthma status ascertained longitudinally provides us with a means to delineate the "*persistent*" asthmatics from the "*transients*," and to evaluate prospectively the impact of factors present during the preschool years on outcomes in school-aged children. The three main purposes of this study are to create a population-based longitudinal cohort of Canadian children with current asthma; to measure their HSU and health outcomes compared to children without asthma; and to assess the impact of asthma on HSU and health outcomes in children, adjusting for other risk factors.

Methods

Data source

Longitudinal data from the NLSCY cycle 1 (C1) 1994/95 and cycle 2 (C2) 1996/97 were used in this study. The NLSCY is a prospective longitudinal survey designed to measure child development and health.[11,12] A multi-stage clustered sampling scheme was used in the survey for the study sample to be representative of the Canadian population of children. The clusters were designed to have sufficient sample sizes within large geographic areas and within seven key age groupings. Trained interviewers from Statistics Canada went to households and administered standardized questionnaires to the person most knowledgeable (PMK) about the child, i.e. the biological mother in 89.9% of cases. The overall response rate to the survey was 86.4% for C1 and 91.6% for C2. Informed consent was obtained from the legal guardians and/or the child, as appropriate. A full description of the NLSCY is available

Author References

1 Child Health Evaluative Sciences, Research Institute, The Hospital for Sick Children, Toronto, Ontario, Canada.
2 Department of Public Health Sciences, University of Toronto, Toronto, Ontario, Canada.
3 The Division of Respiratory Medicine, The Hospital for Sick Children; University of Toronto, Faculty of Medicine, Toronto, Ontario, Canada.
Correspondence: Dr. Teresa To, Child Health Evaluative Sciences, Research Institute, The Hospital for Sick Children, 555 University Avenue, Toronto, Ontario M5G 1X8, Tel.: 416-813-8498, Fax: 416-813-5979, Email: teresa.to@sickkids.ca

at http://www.statcan.ca/bsolc/english/bsolc?catno=89F0078XIE[11]

The NLSCY was comprised of all children sampled for C1 in responding households. Although some children who were participants in C1 did not participate in C2 for a variety of reasons (e.g. random deliberate attrition to decrease sample size, loss to follow-up, or the biological parent not completing the survey), efforts were made to keep the number of these children to a minimum so that the longitudinal research by age cohort at the national level was still permitted.[12] Included in the analyses for the current study were a total of 10 148 children (i.e. a weighted sample of 3 128 645), aged 1 to 11 years at baseline (C1), whose biological parent had responded to the survey and who had complete data on asthma status in both cycles.

Definition of current asthma

Current asthma was ascertained if the PMK reported an asthma diagnosis in his or her child by a health professional and at least one of the following: 1) the child took prescribed inhalants on a regular basis; 2) the child had wheezing or whistling in the chest or had an attack of asthma in the previous 12 months; or 3) the child's asthma prevented or limited participation in school or other normal activities.[13] The asthma status in cycles 1 and 2 was further categorized into four groups: 1) "*no asthma*" (i.e. no current asthma in either cycle); 2) "*new asthma*" (i.e. current asthma in C2 only); 3) "*transient asthma*" (i.e. current asthma in C1 only); and 4) "*persistent asthma*" (i.e. current asthma in both cycles). The only children included in our longitudinal analysis were those categorized as having "*persistent asthma*" (PA) or "*no asthma*" (NA) (based on a total of 9 462 children or a weighted sample of 2 908 136). In the longitudinal multivariable analysis, the health outcomes of each child over time were examined using the General Estimating Equation (GEE) Model[14-17] incorporating current asthma status in both cycles while considering the correlation within individuals.

Outcome measures

Health outcomes included parental reports of child hospitalization and their HSU at both C1 and C2. Hospitalization was defined as an overnight stay in the hospital in the past 12 months. HSU was defined as help/advice the parents sought from a physician about a child's health, and was determined by the PMK's response to the question: "*In the past year, how many times have you seen or talked about your child's health with a physician?*" Both hospitalization and HSU were coded as dichotomous variables (i.e. yes/no) to minimize the impact of recall bias.

Risk factors

Other independent variables examined for potential confounding included sex, age, maternal and child health status, child chronic conditions, child history of wheeze, parental smoking, maternal history of asthma, maternal symptoms of depression (not previously examined in relation to hospitalization and HSU in asthmatics), markers of socio-economic status (SES) and maternal immigration status.

Child health status was based on the mother's rating of the child's health (i.e. excellent/very good or good/fair/poor). The child's health conditions were recorded if the PMK reported a diagnosis of allergies or bronchitis by a physician. Wheezing or whistling in the chest at any time in the last 12 months characterized the child as having wheeze.

Maternal health status was based on her self-rating of health (i.e. excellent/very good or good/fair/poor). Parental smoking was based on whether cigarettes were smoked daily, occasionally or not at all.

Income adequacy was classified into low-, middle- and high-income groups based on total household income and the number of household members.[11,18] A child's mother was considered an immigrant if she ever reported having immigrated to Canada. The child's age was measured by year and kept as a continuous variable.

Statistical analysis

GEE[14-17] for categorical longitudinal data was used to incorporate "time-dependent" covariates in modelling predictors of HSU or hospitalization. GEE was used to account for the longitudinal effects of the predictors on HSU or hospitalization in C1 and/or C2. Data on predictors collected in both cycles were used to measure the overall adjusted probability of HSU or hospitalization. The carry-over effects (i.e. the effect of a risk factor in C1 on HSU or hospitalization in C2) were also considered.

The data publication guides by Statistics Canada were followed.[11,12] Longitudinal sample weights derived by Statistics Canada[11,12] were applied in analyzing study population characteristics so that the derived estimates could be considered representative of the total population of children aged 1 to 11 years at baseline. Coefficients of variation derived by Statistics Canada[11] were used to determine the quality of the estimates. Accordingly, estimates that did not meet the Statistics Canada criteria were flagged.

For multiple variable analyses, standardized sample weights were used to preserve the original sample size, thereby avoiding an overestimation of significance while maintaining the same distributions as those obtained when using population weights.[19] Only statistically significant variables ($p < 0.05$) or known confounders such as sex, age, LIA and maternal immigration status were included in the final models.[20] The correlations between the covariates were examined. The SAS statistical package (i.e. SAS version 8.0, Cary, North Carolina, USA) was used for all analyses.[21]

Results

Demographics/characteristics

Table 1 shows the overall prevalence of asthma, hospitalization and HSU by the four categories of asthma status. The overall prevalence of reported asthma was 8.4% in C1 and 9.4% in C2. Using our previously defined asthma classification scheme, 4.0% had new asthma, 3.0% had transient asthma and 5.3% had PA. Overall, 87.6% of children had NA in both cycles. The prevalence of hospitalization was the highest in children with PA in both cycles (i.e.

16.8% and 8.3%) and lowest in children with NA. Compared to the NA children, the hospitalization rate was four times higher in children with PA (i.e. 16.8% vs. 3.8%; $p < 0.0001$); their HSU was also higher (i.e. 95.3% vs. 80.3%; $p < 0.0001$).

Table 2 shows a comparison of baseline characteristics between the NA children and those with PA. Overall, in children with PA, there was a higher percentage of boys aged 1 to 11 years compared to girls (i.e. 62.6% vs. 37.4%; $p < 0.001$). Children aged 9 to 11 years had the highest prevalence of PA compared with children aged 1 to 4 years and 5 to 8 years (i.e. 6.8% vs. 4.2%; $p < 0.001$ and 6.8% vs. 6.6%; $p < 0.001$). At baseline, the NA children reported better health status than those with PA (i.e. 91.8% vs. 61.0%; $p < 0.001$). More children with PA were hospitalized (i.e. 16.8% vs. 3.8%; $p < 0.001$) and used health services (i.e. 95.3% vs. 80.3%; $p < 0.001$) when compared with the NA children. Furthermore, children with PA had a higher percentage of allergy (i.e. 45.0% vs. 11.8%; $p < 0.001$) and a lower percentage of mothers who were immigrants (i.e. 13.9% vs. 18.8%; $p < 0.001$).

Estimates of HSU and hospitalization

Our regression model in Table 3 showed that being younger with current asthma (OR = 2.52, 95% CI: 1.71, 3.70) or not having excellent or very good current health status (OR = 3.10, 95% CI: 2.38, 4.03) increased the risk of hospitalization; however, a child whose mother is an immigrant (OR = 0.65, 95% CI: 0.43, 0.98) decreased the child's risk of hospitalization. However, a child's being younger, having asthma (OR = 3.80, 95% CI: 2.69, 5.37), having allergy (OR = 1.61, 95% CI: 1.33, 1.94) and not having a very good or excellent current health status (OR = 1.56, 95% CI: 1.27, 1.92) increased the risk of HSU.

The carry-over effects of the covariates were examined. Among all covariates studied, LIA showed a statistically significant carry-over effect on hospitalization and HSU (OR = 2.68, 95% CI: 1.29, 5.59 and OR = 0.67, 95% CI: 0.45, 0.99). This indicates that LIA, as measured at baseline, had lasting effects on the hospitalization and HSU in C2. Cross-sectional logistic regression analyses using the same risk factors at baseline were also explored and similar results were obtained (results not shown).

Discussion

Results from this longitudinal population-based study quantify the magnitude of hospitalizations and HSU in children with current asthma. Our findings support the hypothesis that childhood asthma has a significant impact on the risks of all-cause hospitalization and HSU. Few previous studies have examined this relationship in children. Chen et al. reported that among Canadians aged over 12 years, asthma was a significant risk factor for overall hospitalization, and that the odds ratio for asthma differ by socio-demographic variables, such as age and household income.[22] These findings were based on cross-sectional survey data and did not take into account the potential changes in asthma status over time. In the current study, asthma status was assessed longitudinally, both at baseline and follow-up. A major strength of this study was the ability to examine the temporal relationships between risk factors and health outcomes, and assess children who are persistently asthmatic or non-asthmatic over time. Children with persistent asthma had almost triple the risk of hospitalization and quadruple the risk of HSU compared to those with no asthma. The longitudinal nature of this study makes the results more powerful, as the analysis incorporated the risk factors and outcomes over time while taking into account the correlation within individuals between baseline and follow-up.

Our study showed that children from low-income families were at higher risk for hospitalization over time regardless of asthma status, yet they had lower HSU. Interestingly, other Canadian studies have shown similar findings, especially in hospitalization. A study conducted in Manitoba showed that children aged 0 to 19 years in the lowest income quintile were three times more likely to be hospitalized than those living in the highest income quintile in 1999.[23] The Canadian Institute of Child Health also reported a similar trend in hospitalization by household income among children.[24] A recent study in children born in a major Canadian urban centre found that the relationship between socio-economic disadvantage and hospitalization for ambulatory care-sensitive conditions (with asthma being the most frequent diagnosis) and all-cause hospitalization was large, consistent across many conditions, remained stable over time and persisted up to 9 years of age.[25] Since Canada has a universal health care system, access barrier to health care due to affordability cannot account for these differences. Factors leading to higher risk of acute care use among children in the lowest socio-economic stratum may include higher disease prevalence, increased disease severity, multiple comorbidities, poor health habits, crowded living conditions, inconsistent patterns of preventative care, nutritional problems and poor physical fitness.[25,26] Moreover, socio-economic differences in the use of inhaled corticosteroids have been reported in children with asthma.[27-30] Although detailed information on asthma medication use is not available in the current study, it could have contributed significantly to the differences in asthma and asthma-related hospitalizations, which account for a significant proportion of the overall morbidity in the asthma population.[31] Finally, health system factors such as distribution of specialist care may also contribute to the differences in health outcomes. It has been reported that in Canada, general practitioner care is distributed fairly equally by income according to needs; however, people with higher incomes are significantly more likely to seek specialist care than those with lower incomes, making total doctor utilization somewhat higher in the rich.[32]

Our finding on the distribution of asthma by socio-economic status (SES) is also interesting. We found that children with persistent asthma were less likely to come from low-income families. This means that the effect of asthma as a risk factor for health care utilization could be confounded by the effect of low income; however, this potential bias was minimized by adjustments in multivariable analysis. Previous evidence for the distribution of asthma by SES is mixed, and findings varied depending on the definition of asthma and the study design. Cross-sectional survey studies in the US found that SES was associated with increased asthma prevalence in

TABLE 1
Prevalence of hospitalization and health service use by asthma status

			Hospitalization		Health service use	
			(Cycle 1) (n = 147 800)	(Cycle 2) (n = 116 000)	(Cycle 1) (n = 2 562 300)	(Cycle 2) (n = 2 341 300)
Asthma status	**n***	**%**	**%**	**%**	**%**	**%**
Persistent asthma	166 600	5.33	16.77	8.29	95.27	91.45
New asthma	126 000	4.03	6.07	5.84	89.84	92.94
Transient asthma	94 600	3.02	9.41	4.75	93.78	76.72
No asthma	2 741 500	87.62	3.77	3.29	80.32	73.03

* The number of children is weighted and values are rounded to the nearest 100; the unweighted n = 10 148.

TABLE 2
Characteristics of study population by asthma status

	Total (n = 2 908 100)*	Persistent asthma (n = 166 600)	No asthma (n = 2 741 500)
Baseline (cycle 1) characteristic	**%**	**%**	**%**
Sex			
male	50.54	62.58	49.81
female	49.46	37.42	50.19
Age in years (row %)			
1 to 4	37.87	27.62 (4.18)	38.50 (95.82)
5 to 8	35.14	40.46 (6.60)	34.81 (93.40)
9 to 11	26.99	31.92 (6.78)	26.69 (93.22)
Child with wheeze	13.69	85.22	9.34
Child with allergy	13.69	44.98	11.79
Child current health status			
excellent or very good	90.06	61.01	91.82
good, fair, or bad	9.94	38.99	8.18
Low income adequacy	9.77	6.94 †	9.94
Immigrant mother	18.56	13.92 †	18.84
Biological mother with asthma	4.78	15.45	4.14
Health service use	81.18	95.27	80.32
Hospitalization	4.51	16.77 †	3.77

* The number of children is weighted and values are rounded to the nearest 100; the unweighted n = 9 462. Percentages are adjusted for missing data and may not total to 100 due to rounding.

† The coefficient of variation is between 16.6% and 33.3%, which is considered marginal by Statistics Canada.

TABLE 3
Adjusted odds ratios for hospitalization and health service use based on longitudinal logistic regression*

	Hospitalisation				Health service use			
Risk factors	OR	95% CI		*p*-value†	OR	95% CI		*p*-value†
Male sex	1.25	0.99	1.57	NS	0.96	0.85	1.08	NS
Age (per 1 year increase)	0.91	0.88	0.94	< 0.001	0.84	0.82	0.85	< 0.001
Child current asthma	2.52	1.71	3.70	< 0.001	3.80	2.69	5.37	< 0.001
Child allergy	1.30	0.96	1.78	NS	1.61	1.33	1.94	< 0.001
Child current health status (good, fair, or bad)	3.10	2.38	4.03	< 0.001	1.56	1.27	1.92	< 0.001
Low income adequacy	1.54	0.91	2.61	NS	0.58	0.44	0.76	< 0.001
Low income adequacy carry-over effect	2.68	1.29	5.59	0.008	0.67	0.45	0.99	0.046
Immigrant mother	0.65	0.43	0.98	0.039	1.06	0.88	1.28	NS
Cycle 2‡	1.01	0.79	1.29	NS	0.87	0.78	0.98	0.019

CI: confidence interval; OR: odds ratio; NS: not significant (at $p < 0.05$).

* Based on unweighted n = 9 462.

† Based on longitudinal logistic regression using normalized weights.

‡ Controlled for time in both cycles.

children.[33,34] In Ontario, a longitudinal population-based study using health administrative data showed that neighbourhood income had no impact on the distribution of asthma persistence in school-age children after adjusting for other risk factors.[35]

The influence of immigration status is also important to examine given that Canada has a high immigration rate and the immigrant population may be viewed as vulnerable. Our results showed that children with persistent asthma were less likely to be born to immigrant mothers. This agrees with studies from the US and other countries[36-39] and adds to the documentation of the importance of immigration and acculturation in the development of asthma and allergy. The lower reported asthma prevalence in the immigrant population[40-42] may be explained by immunoprotection as a multifactorial phenomenon, the health-selection involved in the immigration process and the potential reporting bias due to language barriers and cultural differences. Our study also found that children with immigrant mothers are less likely to be hospitalized. This is consistent with a recent study conducted by Quah et al. using the 2001 Canadian Community Health Survey, which showed that hospitalizations among visible minorities (81% were immigrants) in Canada were lower than among white Canadians.[43] The lower rate of hospitalization also may be partly explained by the good health status of immigrants, rather than poor access, thus highlighting the unique health patterns among them.

Canadian studies using administrative data have examined the seasonal patterns of asthma hospitalizations in the province of Ontario from 1988 to 2000.[44, 45] Children aged 0 to 4 and 5 to 9 years accounted for the highest hospitalization rates. Furthermore, young males were hospitalized at a rate of two to three times that of females of the same age,[44, 45] a finding consistent with our results. A downward trend in the total number of hospitalizations in the general population, most notably among young males has been reported since the early 1990s.[44,45] Our study also showed that hospitalizations among children with persistent asthma almost halved from 1994/95 to 1996/97 (i.e. 16.8% vs. 8.3%). Among children participating in both cycles, the percentage of children who were hospitalized in 1996/97 decreased from 1994/95 figures, while the number of children diagnosed with asthma increased during the same period. This trend may be explained partially by the aging of the cohort between the two time periods, but may also reflect improvement in asthma therapy and changes in health care practices that have resulted in decreased hospitalizations overall.

Some limitations were present in this study. First, as in all studies based on survey data, information on health care utilization was reported by parents and is subject to recall bias. There was a risk of undercounting hospitalizations given that a child who was hospitalized on numerous occasions was counted only once in each year; in addition, hospitalization was defined as admission for any reason, and not just for respiratory illnesses. However, the consistency between the decreasing trend in hospitalization observed in the current study and that previously reported validates our findings. HSU was defined based on the question, "*In the past year, how many times have you seen or talked about your child's health with a physician?*" This question may bias the number of consultations with physicians by double counting the number of same-day phone calls/visits and excluding emergency visits to the hospital. Therefore, we chose to dichotomize the HSU outcome in order to reduce the potential bias, and this may underestimate the number of overall physician visits. In general, these limitations on the reporting of HSU variables may tend to decrease the detectable differences in HSU in the population; therefore, it is unlikely that the burden attributable to asthma was

overestimated. Another limitation of this study was the lack of information regarding the severity of asthma. Some evidence exists that the most severe asthmatics have the highest morbidity and the most HSU; therefore, it is possible that the most severe asthmatics account for most of the increased HSU.[46-49]

Conclusions

This longitudinal population-based study confirms that asthma is significantly associated with higher hospitalization and HSU in the pediatric population, while children in low-income families are susceptible to higher hospitalization and lower HSU. Programs seeking to decrease the economic burden of pediatric hospitalizations need to focus on asthma and low-income populations.

Acknowledgements

Funding for this project was made available through the Research Institute of The Hospital for Sick Children in Toronto, Ontario, Canada. Dr. Teresa To is supported by the University of Toronto, Life Sciences Committee, Dales Award in Medical Research for 2007.

Disclaimer

This analysis was based on the Statistics Canada master file, *National Longitudinal Survey of Children and Youth*, which contains anonymised data collected in the 1994/95 and 1996/97 Special Survey. All computations were prepared by the Child Health Evaluative Sciences program at The Hospital for Sick Children's Research Institute, and the responsibility for the use and interpretation of these data is entirely that of the authors. The opinions expressed do not represent the views of Statistics Canada.

References

1. Casanova C, Starfield BJ. Hospitalizations of children and access to primary care: A cross-sectional comparison. Int J Health Serv. 1995;25:283-94.
2. Gadomski A, Jenkins P, Nichols M. Impact of a medicaid primary care provider and preventive care on pediatric hospitalization. Pediatrics. 1998;101(3):1-10.
3. Flores G, Abreu M, Chaisson CE, Sun D. Keeping children out of hospitals: parents' and physicians' perspectives on how pediatric hospitalizations for ambulatory sensitive conditions can be avoided. Pediatrics. 2003;112:1021-30.
4. Flores G, Abreu M, Tomany-Korman S, Meure J. Keeping children with asthma out of hospitals: parents' and physicians' perspectives on how pediatric asthma hospitalizations can be prevented. Pediatrics. 2005;116:957-65.
5. Brownson RC, Remington PL, Davis JR. Chronic disease epidemiology and control. 2nd ed. Washington (D.C.): American Public Health Association; 1998.
6. Health Canada. Economic burden of illness in Canada. Ottawa: Health Canada; 1998. Report No.: ISBN 0-662-33144-3.
7. To T, Ungar W. Outpatient health services use by children in Ontario. Toronto: Institute of Clinical Evaluative Studies; 2001. Report No.: ISBN 0-9686318-6-X."
8. Ungar WJ, Coyte PC, Pharmacy Medication Monitory Program Advisory Board. Prospective study of the patient-level cost of asthma care in children. Pediatr Pulmonol. 2001;32:101-8.
9. Health Canada. Respiratory disease in Canada. Ottawa: Health Canada; 2001 Sep. Report No.: ISBN 0-662-30968-5.
10. To T, Dell S, Dick P, et al. Burden of childhood asthma [Internet]. Toronto: Institute for Clinical Evaluative Sciences; 2004 May. Available from: http://www.ices.on.ca/file/ACF77.pdf. Accessed: March 17, 2008.
11. Human Resources Development Canada, Statistics Canada. National longitudinal survey of children and youth. User's handbook and microdata guide. Cycle 1, release 2. Ottawa: Minister of Industry; 1997.
12. Human Resources Development Canada, Statistics Canada. National longitudinal survey of children and youth. User guide. Cycle 2, release 3. Ottawa: Minister of Industry; 1999.
13. To T, Vydykhan T, Dell S. Is obesity associated with asthma in young children? J Pediatr. 2004;144:162-8.
14. Diggle PJ, Liang KY, Zeger SL. Analysis of longitudinal data. Oxford: Claredon Press; 1994. Chapter 8, Marginal models; p. 146-68.
15. Carey V, Zeger SL, Diggle P. Modelling multivariate binary data with alternating logistic regressions. Biometrika. 1993; 80(3):517-26.
16. Lipsitz SR, Fitzmaurice GM, Orav EJ, Laird NM. Performance of generalized estimating equations in practical situations. Biometrics. 1994;50:270-8.
17. Stokes ME, Davis CS, Koch GG. Categorical Data Analysis: using the SAS system. First ed. SAS Publishing; 1995. Advanced topic: The generalized estimating equation (GEE) method. p. 413-23.
18. Statistics Canada. Low income cut-offs. Ottawa: Statistics Canada; 1996.
19. Hosmer DW, Lemeshow S. Applied logistic regression. New York: John Wiley and Sons, Inc.; 1989.
20. To T, Cadarette SM, Liu Y. Biological, social, and environmental correlates of preschool development. Child Care Health Dev. 2001; 27(2):187-200.
21. SAS Institute Inc. SAS/STAT user's guide, version 8. STATS Publishing Inc.; 1999: 1375-428.
22. Chen Y, Dales R, Krewski D. Asthma and the risk of hospitalization in Canada: the role of socioeconomic and demographic factors. Chest. 2001;119(3):708-13.
23. Brownell M, Martens P, Kozyrskyj A, et al. Assessing the health of children in Manitoba: a population-based study. Winnipeg, Manitoba: Manitoba Centre for Health Policy; 2001.

24. Canadian Institute for Child Health. The health of Canada's children: a CICH profile. Ottawa: Canadian Institute for Child Health; 1994.

25. Agha MM, Glazier RH, Guttmann A. Relationship between social inequalities and ambulatory care-sensitive hospitalizations persists for up to 9 years among children born in a major Canadian urban center. Ambul Pediatr. 2007;7(3):258-62.

26. Sin DD, Svenson LW, Cowie RL, Man SF. Can universal access to health care eliminate health inequities between children of poor and nonpoor families? A case study of childhood asthma in Alberta. Chest. 2003;124(1):51-6.

27. Kozyrskyj AL, Mustard CA, Simons FE. Inhaled corticosteroids in childhood asthma: income differences in use. Pediatr Pulmonol. 2003;36(3):241-7.

28. Kozyrskyj AL, Mustard CA, Simons FE. Socioeconomic status, drug insurance benefits, and new prescriptions for inhaled corticosteroids in schoolchildren with asthma. Arch Pediatr Adolesc Med. 2001;155(11):1219-24.

29. Ungar WJ, Kozyrskyj A, Paterson M, Ahmad F. Effect of cost-sharing on use of asthma medication in children. Arch Pediatr Adolesc Med. 2008;162(2):104-10.

30. Blais L, Beauchesne MF, Levesque S. Socioeconomic status and medication prescription patterns in pediatric asthma in Canada. J Adolesc Health. 2006;38(5):607 e9-16.

31. To T, Gershon A, Tassoudji M, et al. The burden of asthma in Ontario. Toronto, Ontario: Institute for Clinical Evaluative Sciences; 2006 Sep.

32. van Doorslaer E, Masseria C, Koolman X. Inequalities in access to medical care by income in developed countries. CMAJ. 2006;174(2):177-83.

33. Halfon N, Newacheck PW. Childhood asthma and poverty: differential impacts and utilization of health services. Pediatrics. 1993;91(1):56-61.

34. Higgins PS, Wakefield D, Cloutier MM. Risk factors for asthma and asthma severity in nonurban children in Connecticut. Chest. 2005;128(6):3846-53.

35. To T, Gershon A, Wang C, Dell S, Cicutto L. Persistence and remission in childhood asthma – a population-based asthma birth cohort study. Arch Pediatr Adolesc Med. 2007;161(12):1197-204.

36. Eldeirawi K, McConnell R, Freels S, Persky VW. Associations of place of birth with asthma and wheezing in Mexican American children. J Allergy Clin Immunol. 2005;116(1):42-8.

37. Hjern A, Haglund B, Bremberg S, Ringback-Weitoft G. Social adversity, migration and hospital admissions for childhood asthma in Sweden. Acta Paediatr. 1999;88(10): 1107-12.

38. Netuveli G, Hurwitz B, Sheikh A. Ethnic variations in incidence of asthma episodes in England & Wales: national study of 502,482 patients in primary care. Respir Res. 2005;6:120.

39. Gibson PG, Henry RL, Shah S, Powell H, Wang H. Migration to a western country increases asthma symptoms but not eosinophilic airway inflammation. Pediatr Pulmonol. 2003;36(3):209-15.

40. Gold DR, Acevedo-Garcia D. Immigration to the United States and acculturation as risk factors for asthma and allergy. J. Allergy Clin. Immunol. 2005;116(1):38-41.

41. Kalyoncu AF. Symptoms of asthma, bronchial responsiveness and atopy in immigrants and emigrants in Europe. Eur Respir J. 2002;19(5):980-81.

42. Choudhry S, Seibold MA, Borrell LN, et al. Dissecting complex diseases in complex populations: asthma in Latino Americans. Proc Am Thorac Soc. 2007;4(3):226-33.

43. Quan H, Fong A, De Coster C, et al. Variation in health services utilization among ethnic populations. CMAJ. 2006:174:787-91.

44. Crighton EJ, Mamdani MM, Upshur RE. A population based time series analysis of asthma hospitalizations in Ontario, Canada: 1998 to 2000. BMC Health Serv Res. 2001:1-7.

45. To T, Guttmann A, Dick P. Inpatient and day surgery use by children in Ontario. Toronto: Institute for Clinical Evaluative Sciences; 2001. Report No.: 0-9699405-9-9.

46. Van Ganse E, Antonicelli L, Zhang Q, et al. Asthma-related resource use and cost by GINA classification of severity in three European countries. Respir Med. 2005;100:140-47.

47. Bootman JL, Crown WH, Luskin AT. Clinical and economic effects of suboptimally controlled asthma. Manag Care Interface. 2004;17(1):31-6.

48. Berggren F, Hjelmgren J, Lindgren B. Differences in health care utilisation and workdays lost between individuals with and without asthma. Appl Health Econ Health Policy. 2003;2(3):165-70.

49. Halterman JS, Yoos HL, Sidora K, Kitzman H, McMullen A. Medication use and health care contacts among symptomatic children with asthma. Ambul Pediatr. 2001;1(5):275-9.