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ASSOCIATION BETWEEN INCOME ADEQUACY AND ASTHMA IN CANADIANS

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ABSTRACT

To examine the association between income adequacy and asthma, we used the cross-sectional and longitudinal data from the National Population Health Surveys. Rao-Wu bootstrap method was used for variance estimation. Of 173,032 subjects 12+ years of age, 5.7% of males and 7.9% of females reported having asthma. The prevalence of asthma increased with decreasing household income in both sexes. In the basis of longitudinal data from 12,636 study subjects, the 2-year cumulative incidence of asthma was not significantly associated with income adequacy. Statistical power for the longitudinal analysis is limited due to the short follow-up period and relatively small sample size.

KEY WORDS: Asthma; Hospitalization; Income adequacy; Socioeconomic factors.

1. INTRODUCTION

Asthma is a common respiratory disease, reported by approximately 10 percent of adolescents and young adults, and 5 percent of adults in Canada (Chen et al, 1999). It represents a heavy burden on the health care system in all countries studied (Barnes et al, 1996). In an analysis based on the 1987 US National Medical Expenditure Survey, Smith et al (1997) estimated direct expenditures of $5.1 billion and indirect expenditures of 673 million for asthma. Half of these expenditures could be accounted for by inpatient care. In Canada, total expenditures on asthma were between $504 million and $648 million in 1990 (Krahn et al, 1996). Prevention of asthma hospitalizations could, therefore, potentially result in substantial health care resource savings. Identifying high risk populations will be particularly useful in the targeting of asthma intervention programs.

Socioeconomic and demographic factors are important determinants of health (Coultas et al, 1994). Studies in the United States have found that low income is associated with increased prevalence of asthma, as well as with increased hospitalization and mortality rates (McConnochie et al, 1999; Persky et al, 1998; Ray et al, 1998). Low income Americans are more likely to be uninsured, which may limit the quality of care they receive. However, it has also been observed in a previous study that Canadians with low incomes are at increased risk of asthma (Chen et al, 1999). Based on data from 17,605 subjects who participated in the first cycle of National Population Health Survey (NPHS) in 1994-1995, men and women with low incomes had 1.44- and 1.33-fold increases in the prevalence of asthma compared with their counterparts with high incomes, respectively; however, there was no significant difference observed between middle and high income categories (Chen et al, 1999). Therefore, it is not clear if there is a more systematic relationship between income adequacy and asthma occurrence. A much larger sample size of the second cycle of NPHS allowed us to further explore if the prevalence of asthma increases with decreasing income adequacy among Canadians. We also used the longitudinal data from the NPHS to examine a possible association between income adequacy and the incidence of asthma.

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2. MATERIAL AND METHODS

2.1 Prevalence data

We analyzed the cross-sectional data of the NPHS general component, conducted by Statistics Canada in 1996-1997. The design and execution of the survey have been detailed elsewhere (Peaudet et al, 1998). In brief, the target population included household residents in all ten provinces, excluding Indian Reserves, Canadian Forces Bases and some remote areas in Quebec and Ontario. The NPHS used a two-stage stratified sampling design to draw a representative sample of approximately 80,000 household in ten provinces, with every household member asked to complete a short questionnaire. A total of 173,032 aged 12 years or more who responded to the question about asthma was included in this analysis. Respondents who answered the following question affirmatively were considered as having asthma: "Do you have asthma diagnosed by a health professional?" Based on total household income adjusted for the number of household members, subjects were classified into three income categories: low income (<$15,000 with 1 or 2 people; $10,000-$19,999 with 3 or 4 people; $15,000-$29,999 with 5 or more people), middle income ($15,000-$29,999 with 1 or 2 people; $20,000-$39,999 with 3 or 4 people; $30,000-$59,999 with 5 or more people) and high-income groups ($30,000-$59,999 with 1 or 2 people; $40,000-$79,999 with 3 or 4 people; $60,000+ with 5 or more people). Other variables included in the analysis were sex (male, female), age (12-24, 25-39, 40-54, 55-69, or 70+ years), history of allergy (yes, no), household size (1, 2, 3, or 4+ people), and number of bedrooms (<3, 3+). Other important determinants of asthma such as smoking and body mass index were not measured in the NPHS general component.

2.2 Incidence data

The analysis of relationship between income adequacy and the cumulative incidence of asthma was based on the longitudinal data from first and second cycles of the NPHS health component conducted by Statistics Canada in 1994-1995 and 1996-1997, respectively. These two NPHS cycles provided information on a panel of individuals followed over a two-year period. The NPHS 1994-1995 used a two-stage stratified sampling design to draw a representative sample of approximately 19,600 households with a national response rate of 88%. In each household, some information was collected from all household members, with one person in each household randomly selected for a more in-depth interview. The survey included questions related to the determinants of health, health status, and use of health services (Statistics Canada, 1995)

The second cycle of the NPHS was conducted in 1996-1997 using similar methodology, but with a longitudinal component. Every member of the household was asked to complete a short general questionnaire, and one member of the household was selected to answer an in-depth health questionnaire. The longitudinal panel comprised every selected household member who had completed at least the general questionnaire in the first cycle (Fobes & Geran, 1998). Of the 17,626 subjects who participated in the NPHS 1994-1995 who were 12 years of age or older, 14,786 were eligible for the NPHS longitudinal panel. Of the 2,383 subjects less than 12 years of age, 2,022 were eligible for the longitudinal panel.[12] Ineligible subjects were those sponsored by provincial governments to enlarge the sample size in their respective provinces. Of the total of 17,276 eligible subjects, 16,168 participated in the longitudinal panel for a response rate of 94%, and 15,670 provided both general and in-depth health information for both 1994-1995 and 1996-1997 surveys.

In the present analysis, we excluded subjects less than 12 years of age, and those who had reported having asthma in the first cycle and who did not respond to questions about asthma in either the first or second cycles. This left 12,636 subjects (5,747 males and 6,889 females) for analysis.

Respondents who answered the following question affirmatively were considered as having asthma: "Do you have asthma diagnosed by a health professional?" Incident asthma cases were those who reported no asthma in the first cycle, but reported having asthma in the second cycle.

In addition to income adequacy, a number of other important determinants were measured in the NPHS health surveys. Based on the information from the baseline survey, current smokers were defined as respondents who reported smoking cigarettes every day at the time of the survey. Ex-smokers were those who reported smoking

cigarettes daily in the past, but not smoking at the time of survey. Otherwise, subjects were classified as nonsmokers. Two educational strata were defined: subjects in the low education category did not proceed beyond secondary school; the high education category included subjects admitted to college or university, and those with a post-secondary school certificate or diploma. A positive history of allergy was indicated if an affirmative response was given to either of the questions: Do you have any food allergies diagnosed by a health professional? or "Do you have other allergies diagnosed by a health professional?". Other variables included in the analysis were age (12-24, 25-39, 40-54, 55-69, or ≥70 years), immigrant status (yes, no), household size (1, 2, 3, or ≥4 people), number of bedrooms (<3, ≥3), any pets at home (yes, no), regular drinking (yes, no), and regular exercise (yes, no).

2.3 Complex survey data analysis

The NPHS used a complex survey design incorporating stratification, multiple stages of selection, and unequal probabilities of selection of respondents. The effect of the complex survey design on variance estimates is represented by the design effect, defined as the ratio of the estimated variance taking into account the nature of the survey design to a comparable estimate of variance based on a simple random sample of the target population (Chen et al, 2002; Skinner et al, 1989). In the present analysis, the Rao-Wu bootstrap method (Rao & Wu, 1998; Rao et al, 1992) was used for variance estimation to take both the population weights and design effects into consideration. First, bootstrap weights were calculated by using the Rao-Wu bootstrap approach provided to us by Statistics Canada. In each stratum, clusters were used as the resampling units, including all observations within each cluster. Within stratum h, $n_h - 1$ of n_h clusters was randomly selected with replacement, and the bootstrap weight $w^*_{hik} = [n_h /(n_h - 1)]\, m^*_{hi}\, w_{hik}$ calculated, where m^*_h denotes the number of times that the h_i^{th} cluster was selected, and w_{hik} denotes the original survey weight. If a cluster was not selected ($m^*_{hi} = 0$), then the bootstrap weight (w^*_{hik}) of the observations in the cluster was zero.

A total of 500 bootstrap samples were provided for the 1994--1996 longitudinal panel, permitting calculation of 500 point estimates of each parameter of interest. The standard error of each parameter estimate is then given by a standard deviation of the values for the 500 bootstrap replications. SAS software macros for the bootstrap approach were developed by Statistics Canada, and the statistical analyses were conducted by using SAS software, release 6.12 (SAS Institute, Inc., 1996).

Point estimates were weighted according to the demographic profile of the Canadian population, and the Rao-Wu bootstrap method was used to estimate the standard errors of these estimates in order to take into account for the complex survey design. Logistic regression models were used to evaluate the association between income adequacy and the prevalence and incidence of asthma after adjusting for covariates.

3. RESULTS

3.1 Income adequacy and the prevalence of asthma

Of 84,311 males and 88,721 females 12 years of age or more, 5.7% (95% confidence interval(CI): 5.4%, 6.0%) of males and 7.9% (95% CI: 7.5%, 8.3%) of females reported having asthma. The prevalence of asthma was higher for the 12-24 year age group (10.5%) as compared with other age groups (25-39 year: 6.6%, 40-54 year: 5.1%, 55-69 year: 5.6%, 70+ year: 6.0%). The prevalence of asthma increased with decreasing household income in both males and females (Table 1). After adjusting for sex, age, history of allergy, household size and number of bedroom, individuals with low incomes had a higher risk of asthma, while those with high incomes had a lower risk, as compared with those with middle incomes. The results were consistent for males and females.

3.2 Income adequacy and the two-year cumulative incidence of asthma

Table 2 shows the 2-year cumulative incidence of asthma stratified by income adequacy. The difference in asthma incidence was not significantly different among three income groups in both sexes.

Many other factors could be important confounders and/or effect modifiers. The 2-year cumulative incidence of asthma in females was higher than that in males in younger age groups. Male and female subjects 55 years of age or more exhibited similar incidences of asthma. Females who had any pets at home or who were non-immigrants were more likely to develop asthma than females who had no pets at home or who were immigrants. These associations were less pronounced in male subjects. Female but not male smokers had a higher incidence of asthma compared with nonsmokers during the two-year study period. The incidence of asthma was approximately 3-fold high for those who had a history of allergy. In addition, the presence of household pets notably modified the influence of smoking on asthma incidence in females. A significant effect of smoking on asthma incidence was observed among females who had pets at home, while the incidence of asthma showed little variation among female smokers, ex-smokers and nonsmokers who did not have pets at home.

Table 1. Relationship between income adequacy and the prevalence of asthma among Canadians 12 years of age or more, National Population Health Survey General Component 1996-97

Income adequacy	No.	Cases	%	Adjusted OR (95% CI)*
Males				
Low	7586	529	8.0	1.30 (1.00, 1.68)
Middle	19241	1241	6.0	(Reference)
High	38431	2242	5.1	0.74 (0.63, 0.87)
Unknown	19053	1111	5.2	0.89 (0.76, 1.05)
Females				
Low	10761	1178	10.4	1.26 (1.08, 1.47)
Middle	20938	1702	8.0	(Reference)
High	36495	2765	7.1	0.79 (0.70, 0.91)
Unknown	20527	1579	7.4	0.97 (0.83, 1.11)
Total				
Low	18347	1707	9.4	1.27 (1.11, 1.45)
Middle	40179	2943	7.1	(Reference)
High	74926	5007	6.1	0.77 (0.69, 0.86)
Unknown	39580	2690	6.4	0.93 (0.84, 1.04)

* Adjusted odds ratio (95% confidence interval): Adjusted for (sex), age, history of allergy, household size and number of bedroom.

Table 2. The 2-year cumulative incidence of asthma among Canadians 12 years of age or more by income adequacy, longitudinal observations from the National Population Health Survey Health Component 1994-96

Income Adequacy	Males			Females		
	No.	%	95% CI*	No.	%	95% CI
Low	949	1.9	1.0, 2.8	1670	3.6	2.3, 5.0
Middle	1696	1.6	0.9, 2.4	2050	2.3	1.6, 3.0
High	2866	1.5	0.9, 2.0	2885	3.1	2.4, 3.9
Unknown	236	2.6	0.0, 5.4	284	2.5	0.3, 4.7

* 95% CI, 95 % bootstrap confidence interval

We used logistic regression model to adjust for the potential effects of age, smoking, household pets, household size, number of bedrooms, history of allergy, educational level, regular drinking, regular exercise or body mass index at baseline. There was no significant effect of income adequacy on the incidence of asthma in both sexes after the adjustment.

4. DISCUSSION

This analysis indicated that the risk of asthma increased with decreasing income adequacy in both sexes. Income is a common measure of the resources and prestige that individuals possess in their social environment, and is related to many other factors. In this analysis, income adequacy measured at the household level is considered an indicator of familial resources and standard of living (Krieger et al, 1997). Our results are consistent with those from the United States, where low income is associated with increased prevalence of asthma, as well as with increased hospitalization and mortality rates (Persky et al, 1998; Ray et al, 1998; McConnochie et al, 1999). Although low income Americans are more likely to be uninsured, this may not be a major reason for the association between income and asthma. Although Canada has a publicly funded health care system that may modify the influence of socioeconomic status on hospital admissions, there is some evidence, in addition to ours, that low income is a risk factor for emergency department utilization. Brown and Goel (1993) reported higher emergency department utilization in Ontario, Canada among low-income individuals, young adults, and children of single parents. Also in Ontario, those with less education and employment were more likely to make multiple (at least three) emergency department visits for asthma (Dales et al, 1995). Chen et al (2001) studied the modifying effects of education and income on the influence of asthma on overall hospital admissions, and found that asthma as a risk factor explained approximately 3% of all hospitalizations. Overall hospitalization was positively associated with female gender, old age, and low household income in adults. The odds ratio for asthma as a risk factor for overall hospitalization was greater for younger males than older males, for less-educated females than well-educated females. These results suggest that demographic and socioeconomic factors play a role in the relationship between asthma and overall hospitalization, with certain population subgroups being at greater risk of hospitalization in relation to asthma (Chen et al, 2001a).

There exist several mechanisms whereby income adequacy may influence asthma. Poor inner city housing may increase exposure to cockroach and mouse antigens. The prevalence of cigarette smoking is inversely related to income. Other unexplored possibilities include living in more polluted neighborhoods, and differences in dietary habits. Socioeconomically disadvantaged individuals may be more likely to live and work under hazardous conditions. In a recent analysis, (Lin et al., unpublished data), results showed significant associations between exposure to CO, SO_2, and NO_2 and asthma hospitalization in females with low SES, but not in those with high SES. Our results support that asthma control and prevention programs should target lower income families to a greater extent than higher income families.

Income is likely a determinant of asthma exacerbation; however, there is still lack of evidence if income is related to new development of asthma. Incidence data on asthma are scarce. In addition, a large sample size is needed for

such an association since the incidence of asthma is relatively low. The 1994-96 longitudinal NPHS data provide insufficient statistical power to detect the association of our interest not only because relatively small sample size but also because of a short follow-up period. The impact of income adequacy on the incidence of asthma needs to be further explored.

The diagnosis of asthma is always a concern in population-based studies. Although a universally accepted definition of asthma remains to be established, there is no question that the presence of bronchial hyperresponsiveness and reversible airway narrowing are key features of the disease. Unfortunately, it is not practical to measure these characteristics in large-scale epidemiological studies. As in most epidemiological studies, the asthma definition employed here was based on self-reported physician-diagnosed asthma. The individuals who reported having no asthma at baseline but reported having asthma at follow-up were considered as incident cases during the two-year study period, without additional verification. Identification of incident cases of asthma in this manner may be crude; however, we could not find reasons to believe that this would have an important impact on our conclusions. Secondly, the disease definition we used contains the components essential to the definition used in the original American Thoracic Society Standardization Project questionnaire which inquired; "Have you ever had asthma?", and "Was it confirmed by a doctor?". These questions have been used in various epidemiological studies, and have been validated. In the present study, our definition was based on self-reported asthma and diagnosis by a health care professional.

An additional consideration may be taken in future analyses of the NPHS general component. Asthma is a complex disorder, and there is abundant evidence indicating that asthma is both environmental and genetic. A number of genetic mechanisms may be involved although the mode of inheritance is still unclear (Sandford et al, 1996). Some population-based family studies have suggested major gene control of asthma (Lawrence et al, 1994; The European Community Respiratory Health Survey Group, 1997; Chen et al, 1998; 2001b), whereas the major gene effect is less convincing in other studies (Holberg et al, 1996; Jenkins 1997). However, all the studies showed a familial resemblance of the condition, to which genes, exposure to common environment or both may contribute. Not like the NPHS health component, the NPHS general component includes all household members, and therefore, the observations are not totally independent. If we are able build family linkages (spouse, parent-child, sib-sib etc.), we can further examine the impact of family factor, which can be an important confounder or effect modifier, on the association between income and asthma. Logistic regressive models for family data developed by Bonney (1986) can be used in such analyses.

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