Asthma and the Risk of Hospitalization in Canada*

The Role of Socioeconomic and Demographic Factors

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Objective: **Asthma is an important determinant of hospitalization. The study aims to examine the modifying effects of demographic and socioeconomic factors on the relationship between asthma and the overall number of hospitalizations.**

Methods: **We examined the data on 17,601 Canadians who were ≥ 12 years of age to explore the combined effects of asthma and other factors on hospitalization within the context of a publicly funded health-care system. Asthma was determined by an affirmative response to the question: "Do you have asthma diagnosed by a health professional?" The subjects also were asked whether they had been an overnight patient in a hospital during the past 12 months.**

Results: **Asthma as a risk factor explained 3.7% of all hospitalizations of men and 2.4% of all hospitalizations of women. Overall, hospitalization was positively associated with female gender, old age, and low household income. The odds ratio for asthma as a risk factor for overall hospitalization (*ie*, hospitalization for any reason and all causes, not only for asthma) was greater for younger men than for older men, for less-educated women than for well-educated women, and for men with middle or high incomes than for men with low incomes.**

Conclusions: **These results suggest that demographic and socioeconomic factors play a role in the relationship between asthma and the overall number of hospitalizations, with certain population subgroups being at greater risk of hospitalization in relation to asthma.**

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Key words: asthma; hospitalization; socioeconomic and demographic factors

Abbreviations: CI = confidence interval; DEF = design effect; NPHS = National Population Health Survey; OR = odds ratio

Asthma is a common respiratory disease, reported by approximately 10% of adolescents and young adults, and by 5% of adults in Canada.[1] It represents a heavy burden on the health-care system in all countries studied.[2] In an analysis based on the 1987 US National Medical Expenditure Survey, Smith et al[3] 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.[3] In Canada, total expenditures on asthma were between $504 million and $648 million in 1990.[4] The 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.[5] Studies in the United States have found that low income is associated with an increased prevalence of asthma, as well as with increased hospitalization and mortality rates.[6–8] Low-income Americans are more likely to be uninsured, which may limit the quality of care that they receive. Although Canada has a publicly funded health-care system that may modify the influence of socioeconomic status on hospital admis-

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sions, this issue has not been well-studied in this country. There is some evidence that low income is a risk factor for emergency department utilization. Brown and Goel[9] reported higher emergency department utilization in Ontario, Canada, among low-income individuals, young adults, and children of single parents. Also in Ontario, those people with less education and employment were more likely to make multiple (at least three) emergency department visits for asthma.[10] Although socioeconomic and demographic factors are important determinants of health,[5] the modifying effects of education and income on the influence of asthma on overall hospital admissions have not been well-documented. The purpose of the present analysis is to examine the impact of asthma in conjunction with age, gender, education, and income on overall hospitalization (*ie*, hospitalization for any reason and all causes, not only for asthma) in a large representative sample of the Canadian population.

Materials and Methods

This analysis was based on data from the first cycle of the National Population Health Survey (NPHS), conducted by Statistics Canada from 1994 to 1995. The methodology for this cross-sectional study has been detailed elsewhere.[11] In brief, the target population included household residents in all provinces, with the principal exclusion of populations on Indian reserves, Canadian military bases, and some remote areas in Québec and Ontario. The NPHS used a two-stage stratified sampling design (using the Labor Force Survey sampling frame in all provinces except Québec, where the sample was selected from dwellings participating in the 1992 to 1993 Enquête Sociale et de santé organized by Santé Québec) to draw a representative sample of approximately 19,600 households, with a national response rate of 88%. Within each household, some limited 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. The present analysis used the data from 17,605 subjects who were at least 12 years of age who responded to questions about hospitalization and asthma.

Subjects were asked whether they had been an overnight patient in a hospital during the past 12 months. The cause of the hospitalization was not available. Respondents who answered the following question affirmatively were considered as having asthma: "Do you have asthma diagnosed by a health professional?" Subjects were grouped into two education categories. 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. Subjects were classified into low-income, middle-income, and high-income groups based on total household income adjusted for the number of household members.[1] Current smokers were respondents who reported smoking cigarettes regularly at the time of the survey. Ex-smokers were those who reported smoking cigarettes daily in the past but were not smoking at the time of the survey. Otherwise, subjects were classified as nonsmokers. A positive history of allergy was indicated if an affirmative response was given to either of the following questions: "Do you have any food allergies diagnosed by a health professional?"; or "Do you have other allergies diagnosed by a health professional?" Body mass index was calculated from the equation, weight (kg)/height $(m)^2$, with classifications of < 20.0, 20.0 to 24.9, 25.0 to 27.9, and ≥ 28.0.

Other variables included in the analysis were age (age categories, 12 to 24 years, 25 to 39 years, 40 to 54 years, 55 to 69 years, or ≥ 70 years), immigrant status (yes or no), size of household (1, 2, 3, or ≥ 4 people), number of bedrooms (< 3, ≥ 3), any pets at home (yes or no), regular drinking (yes or no), and regular exercise (yes or no).

The relationship between asthma and overall hospitalization was examined among men and women separately. We calculated the 1-year cumulative incidence of overall hospitalization and the corresponding 95% confidence intervals (CIs) according to various risk factors. Weighted logistic regression models were constructed to evaluate the association between asthma and the cumulative incidence of overall hospitalization after adjustment for relevant covariates. Model parameters were estimated by the method of maximum likelihood, and the Wald statistic was used to test the significance of individual variables or interaction terms in relation to overall hospitalization.

Because the data from the NPHS from 1994 to 1995 were based on a complex survey design incorporating stratification, multiple stages of selection, and unequal probabilities of selection for respondents, standard statistical methods may not be appropriate for the analysis of these data. The NPHS microdata documentation provides guidelines stating that the population sample weights (expansion weights) must be used to produce correct population estimates.[1,11] This weighting takes into account patterns of missing data and oversampling of some strata.

The effect of the complex survey design on variance estimates is summarized as a design effect (DEF). This DEF is 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.[12,13] In the present analysis, SEs were inflated by the average DEF in order to take into account the complexities of the survey design.

We used an approximate method for incorporating the DEF.[1] First, the individual weights were divided by the average weight for all subjects in the survey. The sum of these relative weights is the effective sample size. Next, we divided the relative weights by the square root of an average DEF based on the average sampling variability for the survey variables of interest. These analytic weights take into account both the survey design and the imputation of missing responses.

The population attributable risk (or attributable fraction)[14] was estimated for the cumulative incidence of overall hospitalization in relation to asthma, weighted to the demographic characteristics of the Canadian population. All statistical analyses were performed using computer software (SAS, version 6.12 for Unix; SAS Institute; Cary, NC).[15]

Results

Table 1 shows the crude 1-year cumulative incidence of overall hospitalization in relation to various characteristics of the study participants. The hospitalization incidence was higher among asthmatics (10.1% in men and 16.4% in women) than among nonasthmatic patients (6.9% in men and 11.3% in women). The incidence was higher for less-educated subjects (8.4%) than for well-educated subjects (5.3%) in men, with similar results for women. Those

Table 1—*The 1-Year Cumulative Incidence and 95% CIs for Hospital Admissions According to Various Characteristics (NPHS, 1994 to 1995)*

Characteristic	Men			Women		
	No.	%	95% CI	No.	%	95% CI
Asthma						
Yes	443	10.1	7.0–13.3	675	16.4	12.8–20.1
No	7,604	6.9	6.2–7.5	8,879	11.3	10.5–12.2
Age, yr						
12–24	1,579	4.9	3.7–6.1	1,660	9.1	7.4–10.7
25–39	2,410	4.6	3.7–5.7	2,873	15.4	13.7–17.1
40–54	1,945	5.8	4.6–7.0	2,053	6.1	4.9–7.4
55–69	1,306	12.3	10.0–14.6	1,599	12.1	10.0–14.2
≥ 70	807	18.0	14.3–21.7	1,369	17.8	14.7–20.8
Size of household						
1	1,541	9.6	7.2–12.1	2,160	14.2	11.7–16.8
2	2,610	10.2	8.7–11.7	3,008	10.6	9.1–12.0
3	1,520	6.3	4.9–7.7	1,760	13.7	11.7–15.7
≥ 4	2,376	4.6	3.7–5.5	2,626	10.7	9.4–12.0
Bedrooms						
< 3	2,669	8.8	7.4–10.2	3,424	14.9	13.3–16.6
≥ 3	5,374	6.4	5.6–7.1	6,124	10.3	9.4–11.2
Unknown	4			6		
Any allergy						
Yes	1,353	7.4	5.8–9.0	2,213	15.0	13.0–16.9
No	6,694	7.0	6.3–7.7	7,341	10.7	9.8–11.6
Immigrant						
Yes	1,077	6.7	5.2–8.2	1,319	11.8	10.8–12.7
No	6,970	7.2	6.4–7.9	8,235	11.7	9.8–13.5
Educational level						
Low	4,858	8.4	7.4–9.3	5,528	11.7	10.6–12.8
High	3,178	5.3	4.4–6.2	4,016	11.6	10.4–12.9
Unknown	11			10		
Income adequacy						
Low	1,407	10.3	8.2–12.4	2,410	17.1	14.9–19.2
Middle	2,345	8.1	6.7–9.4	2,802	11.2	9.7–12.7
High	3,970	5.8	5.0–6.6	3,941	9.5	8.4–10.6
Unknown	325	5.3	2.8–8.1	401	14.3	10.1–18.5
Body mass index, kg/m^2						
< 20.0	172	11.2	6.2–16.3	768	10.0	7.4–12.5
20.0–24.9	2,202	5.5	4.4–6.6	3,124	11.5	10.1–12.9
25.0–27.9	1,876	5.0	3.8–6.2	1,065	12.5	10.0–15.1
≥ 28.0	1,600	6.9	5.4–8.4	1,498	12.0	9.9–14.2
Unknown	2,197	10.2	8.6–11.7	3,099	11.9	10.4–13.4
Smoking status						
Nonsmoker	3,386	5.4	4.5–6.2	5,015	9.8	8.8–10.8
Ex-smoker	2,381	9.6	8.1–11.0	2,161	14.0	12.1–16.0
Smoker	2,279	7.5	6.1–8.8	2,374	13.9	12.0–15.7
Unknown	1			4		
Regular drinking						
Yes	5,210	6.4	5.6–7.2	4,226	9.6	8.5–10.7
No	2,824	8.4	7.2–9.7	5,325	13.3	12.1–14.5
Unknown	13			3		
Regular exercise						
Yes	2,245	8.2	6.8–9.5	2,645	9.4	8.0–10.9
No	5,254	6.9	6.0–7.7	6,665	12.4	11.4–13.4
Unknown	548	4.8	2.8–6.8	244	14.4	9.7–19.0

from low-income families were twice as likely to be hospitalized as those from high-income families. Being an immigrant in Canada did not influence overall hospitalization. Age was strongly associated with overall hospitalization. The incidence was similar for men and women who were ≥ 40 years of age, but was greater for women than for men in the younger age groups. Ex-smokers and smokers demonstrated increased hospitalization compared with nonsmokers for both genders. Overall hospitalization was positively associated with a history of allergy in women.

Other variables that may be potential confounders or effect modifiers for the relationship between asthma and overall hospitalization are included in Table 1. The incidence of overall hospitalization tended to be lower for those living in larger households and for women who were regular drinkers and exercisers.

A multiple logistic regression model was used to assess the effect of asthma on overall hospitalization after controlling for the effects of other variables. In addition to asthma, the logistic regression models included age, size of household, number of bedrooms, income, education, smoking, and alcohol drinking. The adjusted odds ratio (OR) for asthma as a risk factor for overall hospitalization was 1.73 for men (95% CI, 1.19 to 2.51) and 1.52 for women (95% CI, 1.14 to 2.02). The population-attributable risk was estimated to be 3.7% for men and 2.4% for women.

Table 2 shows the unadjusted 1-year cumulative incidence of overall hospitalization by asthmatic status and other subject characteristics including age, education, and household income. Asthma seemed to have a greater effect on hospitalization in male children and young adults compared with male adults ≥ 25 years of age, in less-educated subjects compared with well- educated subjects, and in male subjects from middle-income families and female subjects from low-income families compared with their counterparts from high-income families.

A logistic regression model was used to evaluate possible interactions between asthma and other characteristics on a multiplicative risk scale. Although the interaction terms for asthma with age, education, and household income were all not significant ($p > 0.10$), this does not rule out the possibility of departures from additivity for the effect of asthma combined with other factors on overall hospitalization.

Table 3 presents the OR for asthma by age, education, and household income. The OR was greater for younger subjects than for older subjects among men, but no such age effect was seen in women. Less-educated subjects tended to have a higher OR than did well-educated individuals. (This may be partly because of the age effect, because children would not yet have had an opportunity for higher education.) When we excluded subjects < 20 years of age, the OR for asthma as a risk factor for total hospitalization was 1.43 (95% CI, 0.81 to 2.53) for less-educated men compared with 1.37 (95% CI, 0.67 to 2.83) for well-educated men. For women, the corresponding ORs were 1.61 (95% CI, 1.06 to 2.46) and 1.17 (95% CI, 0.70 to 1.94), respectively. A significant association between asthma and overall hospitalization was noted in men from middle-income or high-income families, but not in men from low-income families. The ORs were similar across the income strata in women.

Table 2—*The 1-Year Cumulative Incidence and 95% CIs for Hospital Admissions Related to Asthma by Age, Education, and Income (NPHS, 1994–1995)*

Characteristic	Asthmatics		Nonasthmatics	
	%	95% CI	%	95% CI
Men				
Age, yr				
< 25	10.0	4.8–15.1	4.3	3.1–5.5
≥ 25	10.2	6.2–14.2	7.6	6.8–8.4
Education				
Low	12.5	8.1–16.9	8.1	7.1–9.1
High	6.4	2.3–10.6	5.3	4.4–6.2
Income adequacy				
Low	10.2	2.8–17.7	10.3	8.2–12.5
Middle	13.5	6.7–20.3	7.7	6.4–9.1
High	8.5	4.3–12.7	5.6	4.8–6.5
Unknown	—	—	5.3	2.6–8.0
Women				
Age, yr				
< 25	14.0	8.1–19.8	8.4	6.8–10.1
≥ 25	17.7	13.1–22.4	12.0	11.1–13.0
Education				
Low	18.1	13.2–23.0	11.2	10.1–12.3
High	13.9	8.4–19.3	11.5	10.2–12.8
Income adequacy				
Low	23.2	14.7–31.7	16.5	14.3–18.8
Middle	14.0	7.6–20.5	11.0	9.4–12.5
High	13.8	8.7–18.8	9.2	8.1–10.3
Unknown	—	—	13.9	9.7–18.1

Discussion

Asthma as a risk factor explains approximately 3% of overall hospitalization among Canadians ≥ 12 years of age. It is comparable to an estimate based on > 11 million hospital morbidity records during a 3-year period (1994 to 1997; unpublished data) that 2.7% of total hospital admissions were because of asthma and related conditions. The following individual indicators of socioeconomic and demographic status increased the risk of overall hospitalization: older age; female gender; and income. It seems obvious that pregnancy is a major reason for hospitalization for young women. We considered these variables as potential effect modifiers or confounders for the influence of asthma on overall hospitalization in this analysis.

In the present analysis, we found that men < 25 years of age had a higher OR for asthma as a risk factor for overall hospitalization than did men ≥ 25 years of age. The OR in women was similar in these two age groups. A previous study demonstrated that

Table 3—*Unadjusted and Adjusted ORs for Asthma as a Risk Factor for Hospitalization by Age, Education, and Income (NPHS, 1994–1995)

Characteristic	Men		Women	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age, yr				
< 25	2.46 (1.29–4.66)	2.77 (1.43–5.34)	1.76 (1.04–3.00)	1.54 (0.87–2.75)
≥ 25	1.40 (0.89–2.19)	1.44 (0.90–2.29)	1.57 (1.13–1.19)	1.49 (1.06–2.09)
Education				
Low	1.63 (1.06–2.49)	2.02 (1.29–3.15)	1.75 (1.23–2.47)	1.77 (1.24–2.53)
High	1.24 (0.61–2.51)	1.22 (0.59–2.50)	1.24 (0.77–1.99)	1.17 (0.73–1.90)
Income adequacy				
Low	0.99 (0.43–2.31)	1.05 (0.44–2.50)	1.53 (0.92–2.53)	1.50 (0.90–2.52)
Middle	1.86 (1.01–3.44)	2.06 (1.08–3.90)	1.32 (0.76–2.31)	1.31 (0.75–2.30)
High	1.56 (0.89–2.73)	1.93 (1.09–3.41)	1.58 (1.01–2.47)	1.59 (1.01–2.51)
Unknown	1.43 (0.44–9.54)	1.34 (0.19–10.01)	2.26 (0.52–9.81)	2.47 (0.53–11.45)

*Variables in each model included age (as a continuous variable), education, income adequacy, size of household, No. of bedrooms, smoking, and alcohol drinking.

adult women were twice as likely to be hospitalized as men, despite having 12% better peak flow rates when expressed as a percentage of normal reference values.[16] In this study, however, the population-attributable risk was lower for women than for men.

Our current results suggest that income is a risk factor for overall hospitalization, despite the fact that in Canada there is a publicly funded health-care system. This system, however, does not include medications for those < 65 years of age who are not on disability or receiving welfare benefits. Other studies have demonstrated that low income is related to the occurrence of asthma[1] and to asthma hospitalization and mortality.[6,8,17–19] The present analysis suggests that income modifies the effect of a diagnosis of asthma on overall hospitalization in men. The relationship tended to be more pronounced in the middle-income and high-income groups than in the low-income group. This difference may be because of a relatively high incidence of overall hospitalization in low-income men who were not asthmatic.

Although the socially disadvantaged experience higher morbidity from asthma, there is little information on the independent effect of education. Less education is strongly associated with both lower income and ethnicity, and these independent effects are not often isolated. The cumulative incidence of overall hospitalizations was higher in less-educated men than in well-educated men but was not associated with educational attainment in women. However, educational status modified the impact of asthma on overall hospitalization. In men, the modifying effect of education may be because of the age effect. When we excluded youths < 20 years of age, the OR for asthma as a risk factor for overall hospitalization was similar for less-educated men and well-educated men. For women, however, the OR was significantly elevated for less-educated individuals but not for well-educated ones.

Although a low level of education may be related to an increased asthma hospitalization rate,[17] such an increase may or may not be explained by an increased risk of asthma. Our previous analysis has indicated that a low level of education is not associated with an increased prevalence of asthma among the Canadian population,[1] although it is not known whether a low level of education increases the incidence rate or severity of asthma attacks. Education may affect the quality of both primary prevention (*eg*, environmental conditions) and secondary prevention (*eg*, primary care such as medication use). Apter et al[20] reported that < 12 years of education was associated with poor adherence to asthma medication, as measured by an electronic dose counter on the corticosteroid inhaler, that was independent of income and minority status. This suggests that less education may increase overall hospitalization in subjects with asthma through inadequate control of asthma by medication.

The modifying effect of education on the relationship between asthma and overall hospitalization in women cannot be explained by household income. Socioeconomically disadvantaged individuals may have a relatively poor living environment, which may increase the incidence of asthma and the occurrence of acute severe asthma exacerbation. Unlike education, however, low household income did not increase the influence of asthma on overall hospitalization in this population. The relationship between asthma and overall hospitalization was consistent across the income strata in women. These findings

suggest that the modification of education on the relationship between asthma and overall hospitalization in women is not income-related.

Although the present analysis was based on the data from a cross-sectional survey, the causal linkage between asthma and overall hospitalization seems unquestionable. Hospitalization can be a consequence of asthma, while the converse has a minimal possibility, such as by increased medical contact because of a hospitalization leading to a diagnosis of asthma. Admission to a hospital is a major event, and recall bias would be minimal for questioning such an event during a 12-month period. Asthma may be underdiagnosed, but the reporting bias of ever having asthma is small.[21] The major limitation of this study is lack of information on the reasons for hospitalization. It would be interesting to know the differences in relation to social factors for asthma as a primary cause and a secondary cause in the prediction of hospitalization.

In summary, asthma as a risk factor explained approximately 3% of overall hospitalization among the Canadian population. The impact of asthma on hospitalization tended to be stronger in younger men than in older men but was similar in women. Asthma was significantly associated with an increased incidence of overall hospitalization in less-educated women only. We speculate that asthmatics with low educational attainment may have a compromised quality of primary and secondary prevention of asthma attacks. Understanding how specific socioeconomic and demographic factors influence diseases such as asthma is a necessary first step toward designing social programs to reduce morbidity. Our results, together with those from previous studies, suggest that demographic and socioeconomic factors influence the impact of asthma on overall hospitalization, which varies apparently among different population subgroups. Because Canadians are provided relatively equal access to health care, these differences related to social factors are less likely to be caused by the quality of health care.

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