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Socioeconomic status and health-care utilisation in Canadians with Asthma

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Socioeconomic status and health-care utilisation in Canadians with asthma

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Thesis submitted to the
Faculty of Graduate and Postdoctoral Studies
In partial fulfillment of the requirements
For the MSc degree in Epidemiology

University of Ottawa

September 30th, 2005

Your file Votre référence
ISBN: 0-494-11258-1
Our file Notre référence
ISBN: 0-494-11258-1

ABSTRACT

Asthma emergency department (ED) visits and hospitalization represent a great burden on the Canadian population in terms of morbidity and health expenditures. This thesis aims to understand the influence of socioeconomic status (SES) on these outcomes.

This cross-sectional analysis of the NPHS 1996 Asthma Supplement was based on data from 1814 respondents with asthma. After controlling for various individual-level factors, measures of low SES (low education, low income and high unemployment) at the community level were strong predictors of increased risks of having at least one ED visit or having at least one hospitalization. At the household level, middle-income was associated with greater likelihood of hospitalization but not ED visits, whereas low education and unemployment were related to greater likelihood of ED visits. The relationship between ED visits or hospitalization and SES was not explained by more contacts with key primary health services. The greater use of ED visits among those with low household income was stronger in respondents reporting rare or no asthma symptoms as opposed to those with frequent or continuous symptoms. They may have altered symptom perception.

The independent association of area-level SES with hospital use among individuals with asthma needs further research to identify the specific factors that could be the basis of community-based interventions to improve asthma control.

ACKNOWLEDGEMENTS

I am grateful to Dr Chen, my supervisor, for sharing his knowledge and wisdom with such generosity and patience during the process of this work.

I would like also to express my profound thanks to my supervisors, Dr Stewart and Dr Dales. I learned a great deal from each of them. Their comments and insight have greatly improved this manuscript.

I would like to acknowledge the Data Access Unit, National Population Health Surveys, Health Statistics Division at Statistics Canada. Special thanks to Mario Bédard, Colette Koeune and François Brisebois for helping me in accessing and using the datasets.

I also would like to thank Dr Wilkins for his help and insightful comments and for providing me with some of data used in this thesis, and Dr McDowell for his thought provoking comments.

Thanks to Ms Fay Draper for her invaluable support and kindness and Sylvie Desrochers for her constant availability.

Thanks to my family for their support and indefectible encouragement throughout this long time.

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ABBREVIATIONS USED

SES: socioeconomic status

NPHS: National Population Health Survey

DEFF: Design effect

ED: Emergency department

HSD: High school diploma

IPPE: Income per person equivalent

HH: household

OR: Odds ratio

95%CI: 95 % confidence intervals

EA: Enumeration area

COPD: (Chronic obstructive pulmonary disease) Chronic bronchitis or emphysema

I. INTRODUCTION

I.1 Access to health care and inequalities in health

Access to health-care services may be defined as "the timely use of affordable personal health-services to achieve the best possible health outcomes" (*1*). Some authors suggest that access to health-care services can be the major reason for differences in health outcomes (*2, 3*). For example, a study found that in children, preventable (ambulatory care sensitive) hospitalization rates were lower in Spain than in the US and that in Spain, contrary to the US, the rate of preventable hospitalizations were not affected by either area-level socioeconomic or primary-care characteristics. The author concluded that the provision of universal financial access to care and the availability of a consistent primary care provider are associated with lower preventable hospitalization rates (*3*). While equitable access to health care services is a goal towards which most industrialized countries are aiming, two main distinctions between equity objectives can be made. On the one hand, equity may be defined in terms of equality and, on the other hand, equity may be defined in terms of minimum standards to be met. In Canada, equity is based on equality, which is built on an egalitarian view of the society that considers that access to health care services should not be influenced by income, wealth or social status (*4*). In other words, equal treatment for equal need. The second vision of equity, the so-called 'libertarian' approach, is defined with respect to minimum standards guaranteed to each member of the society. In the USA, this 'individualistic' vision implies an access to health resources based on the ability and willingness to pay and therefore requires only a minimum standard of care for the poor while others could use their income and wealth to gain more or better health (*5*).

However, it is generally recognized that differential access to health care services is not the only basis for inequality in health: the latter based on socio-economic status (SES) persists and sometimes widens in countries where a universal access to health services has been in place for many years (*6*). The instigation of medical insurance targeted at people with low income such as Medicaid in USA, has to some extent decreased the gap between the rich and poor with respect to access to health-care services (*7*), yet, there is still a differential in health and in access to health care based on SES especially among ethnic minorities, women and young children (*8*). Within countries of the Organization for Economic Cooperation and Development, the United States is the country with the highest health care spending per capita, yet, for most health outcomes measures, it ranked near the bottom (*9*). In addition, as mentioned by Adler, it is estimated that only 10% of overall premature mortality can be attributed to inadequate health care access (*10*). In a review of health insurance coverage policy across countries, the same author concluded that access to care (defined on the sole criterion of health insurance coverage) accounts for "little" in the socioeconomic inequalities in health (*11*). Lack of sufficient insurance coverage seems to mediate only a part of the relationship between SES and access to health-care services. For example, a study found large regional variations in hospitalization in four Nordic countries despite similarities in sociodemographic characteristics, health status, and health-care system (*12*). Lacking a regular physician was found to be a stronger predictor of low use of health care than insurance status after controlling for demographics, SES and health status. Those lacking a regular doctor were more likely to delay seeking care, to report no physician visits and no ED visits in the past year (*13*). Other factors such as social or physical environment, psychological processes, symptom perception, health beliefs and behaviours, represent pathways through which SES may affect health-care services access and use (*14, 15*) and increases socioeconomic inequalities in health (*11*).

These pathways, however, are not identical or equally important for all conditions and all services; also the magnitude of the association between SES and health care services use differs according to the service considered. For instance, dental service and physiotherapy and other forms of preventive care are more strongly related to SES than hospital or emergency department use (*16*); people with high educational level use more specialists whereas people with low SES use more general practitioners (*17*). In addition, some medical conditions (including asthma, diabetes or hypertension) are more "care sensitive" than others, and thus, ED visits or hospitalization rates for these conditions are usually inversely related to the access and effectiveness of primary health care and SES (as measured by the proportion of low income households per area in the United States at the zip-code level and percentage of households without central heating in Great Britain at the electoral ward level) (*18, 19*). In a study by Bindman et al., the preventable hospitalization rate for five conditions (pooled together) measured at the zip-code level in urban California, was found to be independently related with low self-rated access to care (individual-level measure), proportion of poor, low educated and uninsured people. Those associations held even after controlling for proportions of people with a regular source of care, Medicaid coverage, prevalence of the medical conditions, propensity to seek care (individual level), physician admitting style, age, sex and race (*20*).

I.2 Socioeconomic status: definition and measurement

Socioeconomic status can be defined according to two main theoretical concepts of social class. The first refers to social groups defined by the groups' relationship to the means of production and emphasizes economic inequalities as enounced by Marx. The interdependence of social classes implies that members of one social class improve their economic and social welfare at the expense of other social classes. For example, different social classes may have conflicting attitudes towards government expenditures in social programs and its related level of taxation or government regulations of working conditions and legal minimum wages. Social class in this context is not an individual's property but rather a social relationship. The second concept of social class as held by Weber, defines social class as an individual's position in the socioeconomic hierarchy and is subsequent to the social interrelationships described above. It principally reflects two main dimensions: 1) the degree of ownership of resources as appraised by various economic measures such as income, wealth or assets, but also, indirectly, education (as it provides the qualifications for better jobs) and occupation (as it is related to monetary payoffs); 2) status is the second dimension and relates to prestige and individual's rank or status in the community and implies access to goods, services and knowledge. It is usually measured by occupational ranking according to the prestige and honour it confers. However, educational achievement and income are also related to knowledge, lifestyle and social networks, and consequently to prestige. Clearly, each of the three measures do not fall into a single dimension: class (or resources ownership) vs. status (or rank) (*21, 22*). In health research, SES is typically assessed according to the Weberian notions of stratification (income, education, occupation, and ownership of property) than with the Marxist emphasis on relationship to the system of production. (*23*).

Diverse methods can be used to determine SES including measures based on a single indicator, such as income, education or occupation, and those based on composite indices (constructed from several indicators). Any single measure has its own advantages and liabilities. The disadvantage of using income as a single indicator is that it is not always well correlated with education level or occupation status and is unstable over time. Individual or family income should be adjusted for household size to be meaningful; also, the non-response rate may be an issue as income can be a sensitive topic for some respondents. Educational attainment is easy to measure, applicable to those not in the active labour force and is a stable measure over a lifetime; however, any change in SES after completion of formal education will not be detected if education is used as a single measure of SES. In addition, the number of years of formal education attained varies between birth cohorts so that it may represent different social classes for different birth cohorts. Occupation status, which is based on occupational classifications, is more often used in Europe than in North America. It can provide information about job characteristics and working conditions, and reflects the outcome of educational attainment and suggests income level. However, it can be problematic to apply to social groups outside the recognized paid labour force, thus making it difficult to use in general population samples including children and elderly (*21, 22*). The use of a variety of separate measures of SES (e.g., income, education and occupation) instead of a composite index is preferable as the latter can obscure each component's contribution to health outcomes. In addition, measures of SES, although generally related (better education facilitates access to jobs which in turn produces income) could be divergent, for example, high education status in persons with a relatively low or moderate income. In such case, discrepancies could be concealed by the use of a composite index (*21, 22*).

Household-level SES is usually derived from individual SES measures by equating household SES with the most dominant and powerful individual class position in the household, regardless of gender (dominance approach). Another alternative assigns men's, married or not, to the woman living in the same household. Any of the individual-level measures may be used for defining household-level SES. The main advantage is that this approach takes into account the standard of living and resources shared by the household. Neighbourhood-level social class is generally appraised by creating indices of deprivation (mostly in UK) or by using individual- or household-level information, such as the unemployment rate, the average family income, the proportion of households with a certain level wealth, below the poverty line or with low education (*21, 22*).

I.3 Asthma background

The 1999 Canadian guidelines defines asthma as "characterized by paroxysmal or persistent symptoms such as dyspnoea, chest tightness, wheezing, sputum production and cough associated with variable airflow limitation and a variable degree of airway hyper-responsiveness to endogenous or exogenous stimuli. Inflammation and its resultant effects on airway structure are considered the main mechanisms leading to the development and maintenance of asthma" (*24*). The disease is characterized by genetic susceptibility (family history of asthma or allergy) and environmental provocative factors. The latter include, in allergic asthmatics, exposure to aeroallergens such as those related to dust mites, pets, cockroaches, mould spores and pollens. Outdoor and indoor pollution (such as environmental tobacco smoke, ozone and inhaled particulate) can play a role in exacerbating asthma symptoms and may interact with the effect of aeroallergens. Respiratory viral infections can also contribute to asthma symptoms, especially in small children.

The diagnosis of asthma is based on the presence of asthma symptoms such as those mentioned above, objective measurement of variable airflow obstruction (peak expiratory flow, forced expiratory volume in one second (FEV1) or an inhalation challenge test) and if deemed, allergen skin testing. According to national and international guidelines, if asthma is properly managed, asthmatics should not require hospitalizations or ED visits. The management of asthma should be comprehensive and include patient education and a self-management action plan, strategy for avoidance of triggers and, if required, inhaled antiinflammatory medications as the basis of asthma maintenance therapy (*24, 25*).

According to the 1996 National Population Health Survey, over 2.2 million Canadians have been diagnosed with asthma by a physician (12.2% of children and 6.3% of adults). Similar figures were reported by the 2003 Canadian Community Health Survey; an estimated 2,226,770 (8.4%) Canadians reported that they have been diagnosed with asthma (*26*). The age-adjusted mortality rate, although declining since 1985, was about 1.2/100,000 population in 1997 in Canada (*27*). In the US, the mortality rate was estimated at about 2.2/100,000 population in 1998 (*28*).

The prevalence of self-reported asthma in Canadians aged four years and older increased from 7% in 1994 to 9% in 1998 (*29*) . This trend over time is also present when asthmatic status is ascertained using data collected from provincial health insurance plan, (physicians' claims) and potential diagnostic exchange is taken into account (a tendency to label patients with asthma instead of alternative diagnoses such as chronic bronchitis). In Manitoba the number of people seen and treated for asthma by a physician doubled between 1980 and 1990 (*30, 31*). The prevalence of asthma varies geographically across provinces, with higher prevalence in the maritime provinces (*29, 32-34*). The International Study on Asthma and Allergy in Childhood (ISAAC) has documented a worldwide variation in the prevalence of reported asthma symptoms with estimated between-countries differences of 20-fold, ranging from 1.6 to 36.8% (*35*).

In Canada, asthma "explained" 3% of all-cause hospitalizations and the effect of asthma as a risk factor for all-cause hospitalizations was more pronounced in less educated people (*36*). The proportion of Canadians with asthma reporting at least one ED visit and that of those reporting at least one overnight hospitalization in the past 12 months was estimated to be 18% and 5.3%, respectively (*27, 37*). Despite a decrease in asthma hospitalization discharges from 187 discharges per 100,000 population in 1994/1995 to 128 in 1999/2000, asthma is still a leading cause of hospitalization in children (*38-40*). In 1990, the total cost of asthma was between 504 and 648 million Canadian dollars (*37*). In the USA, about 15 million persons were affected in 1995 and 5500 deaths were attributed to asthma (i.e., 2.1/100,000). The total estimated cost (direct and indirect) was 11.3 billion US dollars in 1998 (*41*) .

I.4 Asthma morbidity and SES

Across countries, an inverse relationship between the per capita gross national product and the prevalence of asthma and other allergic symptoms is suggested in young adolescents (*42*) . This geographical heterogeneity and the time-trend of asthma prevalence, suggest that in addition to genetic predisposition to asthma, other factors (for example, environmental exposure, allergic sensitisation, socioeconomic status (SES) may play important roles in the pathogenesis and onset of asthma.

Numerous studies have detected a relationship between low SES and an increased asthma or asthma symptoms prevalence. However, the results are not uniform throughout the literature (*43*) and vary according to the outcome considered (*44-47*). One study suggested that it is severe asthma that is associated with low SES: low family education was found to be associated with higher prevalence of severe but not of mild asthma (*47*). In Canada, exercise-induced bronchospasm was highest in poorer than in better-off school children (as measured by parental occupation status) but wheeze and diagnosed asthma were not (*44*). Using claims databases, a study performed in Winnipeg, Canada, showed an association between increased prevalence of asthma (defined as physician diagnosed) and low average household income measured at the area level in those aged 35 years or more but not in the younger age groups. However, with a more stringent definition of asthma that excluded those who received care for asthma and a related diagnosis (such as acute bronchitis/bronchiolitis or chronic bronchitis, emphysema and chronic airway obstruction) during the year, the relationship disappeared and an opposite income gradient was present in younger age groups (<35 years) (*48*). Low household income adequacy was found to be associated with an increase risk of self reported asthma in Canadians as a whole (*49*). Finally, an 11-year community cohort study conducted in Norway, showed that the cumulative incidence of self reported asthma was significantly higher in those with low educational level as compared to those with a university education (OR = 2.1), after adjusting for hay fever, smoking, and occupational exposure (*50*). In the US, where ethnicity is strongly related to SES, the relationship between morbidity, race and SES is difficult to disentangle. However, even after controlling for educational attainment, and marital history; number of siblings; presence of smokers in the household; and low birth weight or preterm, low family lifetime income was found to be a positive predictor of parent reported diagnosis of asthma in non-African-Americans but not in African-American young children aged 3 years (OR=1.45) (*51*). There is also a higher prevalence as well as more severe asthma among children in schools where African-American are predominant and in areas with low median income of the school's census tract (*52*). Aligne suggests that the higher prevalence of asthma among African-American children is not due to race or income per se, but to the fact that they live in an urban setting (*53*) .

Duran-Tauleria, in Britain, suggests that after controlling for father's occupation class, the prevalence of persistent wheezing in children aged 5–11 years was usually higher in deprived areas as measured by the Townsend deprivation score (an index for area deprivation based on unemployment, home ownership, car ownership and home overcrowding); asthma attacks and occasional wheezing were not associated with the area deprivation score. However, none of the estimates of the relationship between area deprivation and father's social class with any of the three outcomes were actually adjusted for one another (*45*). Cesaroni and colleagues, using data derived from the ISAAC study, found that in Rome (Italy), self-reported diagnosis of asthma in young children was positively but moderately related to both low parental education and low area SES whereas prevalence of severe asthma was strongly associated to low parental education but not with low area SES. Hospitalization was even more strongly related to both parental education and area SES (*46*). Basagana and colleagues used multilevel analysis techniques on the data from the European Community Respiratory Health Survey conducted in 15 European countries, New Zealand, Australia and the United States. They showed that at the residential area level, low education but not occupation class was associated with higher risk of asthma independently from individual SES (*54*).

I.5 Socioeconomic status and health care services use

Despite the widespread distribution of guidelines for asthma pharmacotherapy and availability of efficient treatment, there appears to be an unexplained suboptimal use of health resources by some asthmatics (*43, 55*). A study conducted by Erzen in Winnipeg suggests that asthmatics living in enumeration areas with low income have more physician contacts, more hospitalizations but less physician referrals to a specialist than those in higher income areas, although care continuity seemed similar across income group levels. However, those results are subject to limitations: the author attributed to asthma all health-care utilization ascribed by the treating physician to related diagnosis (such as acute bronchitis/bronchiolitis or chronic bronchitis, emphysema and chronic airway obstruction). Also, when asthma was defined more strictly by excluding those who received care for asthma and any of those related diagnosis during the year, the relationship disappeared. Finally, area-level information about SES may not reflect the true SES of individuals (*48*). Nonetheless, if the results are valid, one could argue that because asthmatics receiving care from asthma specialists may have better health outcomes than those who receive care from generalists (fewer ED visits or hospitalizations) (*56-60*), any difference in referral to specialists based on SES could lead to differences in hospitalization and/or ED visits by SES. Thus, there could still be a differential in the quality of primary care received, or in asthma severity. This hypothesis is supported by the analysis of the utilisation of physicians services by Canadians in general (not only asthmatics) which showed that those with higher income status or higher education level are more likely to use specialized doctors when compared with those with lower education or income level (*61*) . It is also suggested that asthmatic patients depending primarily on ED care for the management of their asthma exacerbations were more likely to have lower income, to be less knowledgeable about asthma and less likely to have a predetermined crisis plan when compared with those seen in an ambulatory asthma care facility (*62*). However, it is suggested that frequent ED users may be more likely to recognise the increased severity of their asthma and perceive a future attack than those with fewer ED visits, so symptom perception might not explain the difference in health-care prevention seeking behaviour (*63*) . A recent Canadian study found that low average area income was associated with higher rate of rehospitalization (Rate ratio = 1.25), but after controlling for area-level education, the relationship was no longer significant (*64*). Another Canadian author found that children with low household income were at higher risk (OR=1.68) of hospital visits for asthma and that the odds ratio for the association increased slightly after controlling for the intensity of medication received (OR=1.76) and was no longer significant when environmental tobacco smoke was accounted for (*65*).

In the US, the association of SES with hospitalization is more salient than in Canada: hospitalization rates have increased significantly more in children living in low-income zip-code areas than in those in high-income areas (*66*). Since 1995, the rates of hospitalization and death decreased, but African-Americans continue to have higher rates of asthma emergency department visits (twice), hospitalizations, and deaths than do whites (*28*). Low median income of the school's census tract in Chicago is inversely related to the number of ED visits and markers of asthma severity even after controlling for race (*52*). Children living in high SES-score areas (as measured by a composite index based on education, income, home ownership and access to services) have significantly fewer ED visits than those living in low SES-score areas (OR= 0.4; 95% confidence interval [95%CI.]: 0.2, 0.8) and the association holds after controlling for race, anti-inflammatory medication prescription and type of physician (*67*). Similarly, the hospitalization rate of asthma among children residing in areas where poverty is greatest, is three times as high as that among those children residing in areas with the lowest poverty (*68*). When SES is assigned at an individual level, low lifetime income in African-American children aged 3 years was related to a higher risk of emergency department use than those non-African-Americans or those with high lifetime income (*51*). African-Americans also have fewer outpatient encounters, primary care visits, and prescription refills and relatively more urgent visits to the emergency department (*69*). The high hospitalization rates in inner-city children, most of whom are from low income families, may in fact signal a greater need due to more frequent severe asthma attacks which could be related to various environmental factors such as exposure to indoor allergens associated with low income dwelling (*70, 71*). Ethnicity has been found to be associated with inadequate therapy which could simply reflect the presence of barriers to health-care quality services for ethnic minority groups such as Medicaid insurance status and Spanish language (*72*). This is supported by a study of a Medicaid enrolled children showing that, as compared to their white counterparts, African-American children had significantly fewer follow-up physician visits (i.e. Family physician, GP, internist, paediatricians) for the six-month period after hospitalization, even after adjusting for potential confounding variables, whereas emergency services utilisation was similar in the two groups (*73*).

In the UK, children of low social class (as defined by the Registrar General's classification of the parent's occupation) had more severe asthma and higher general practice consultation rates (*74*). Asthma hospital admission rates are also significantly higher in poorer districts (as measured by the Townsend index) and this relationship is likely to be in part due to differences in health care received during exacerbations by asthma patients from different economic background (*75*), and not to variations in prevalence (*76*). In Rome (Italy), a cross sectional study among children aged 6 to 7 years reported that living in census tracts with low average income was related to higher risk of hospitalization even when parental education and smoking were taken into account (OR=4.46), and that both low father's education (OR=3.37) and living in low SES index census tracts (OR=2.80) were independently associated to higher risk of hospitalization. (*46*).

Asthma drug consumption varies greatly from country to country and the prevalence of anti-inflammatory medication use in the last 12 months by patients with physician-diagnosed asthma ranged from 17% to 20% (Italy and France) to 49% (UK, New-Zealand) with widespread steroid undertreatment (*77*). A population cohort study in children found evidence that anti-inflammatory (including cromolyn) medication use is negatively associated with ED use and hospitalizations, confirming its clinical effectiveness (*78*). However, SES does not seem linked to anti-inflammatory drug use (*79*) or if so, only in children with mild-moderate asthma (*80*).

In Canada, asthma medication use was above the 75 percentile of that of European countries (*34*); and asthma drugs were among the three classes of drug more commonly used among low-income than among high-income individuals (*81*). There is also evidence that asthmatics do not receive and/or take appropriate ambulatory medication in accordance with established guidelines. The overuse of inhaled short-acting beta-agonists and more importantly the under-use of inhaled steroids is a frequent finding in most studies (*63, 82*). In British Columbia, Anis found that inappropriately treated asthmatics were more likely than appropriately treated to receive more prescriptions, to visit more prescribing physicians and to be admitted to hospital. This suggests that inappropriately treated patients may have poorer outcomes, independently of disease severity or control. However, the studied population included only those receiving social assistance or those exceeding the $600 per year deductible and thus, the results are not generalisable to the entire Canadian asthmatics population (*83*).

I.6 SES, asthma and health care utilisation: possible pathways

The association of SES with health outcomes is well established for various conditions, but the study of pathways that link SES and health, is a continual challenge. Many theories and conceptual frameworks have been proposed with increasing sophistication to take the complexity of the relation into account. Some suggested mechanisms could be thought of as being based on material conditions of living, while others are more related to the psychosocial environment. Asthma is a condition that involves a complex array of health determinants and represents a good example for exploring the role of both community- and household-level SES and related factors. (*84*). It is not always easy to distinguish those pathways as acting at the area or household level as some effects measured by a relationship at the area level may well influence health outcomes through household SES (and vice-versa). This is especially true when the level of SES considered is based on a small area (*85*). For example, an area-level characteristic may be directly related to individual asthma outcomes, or may act as a proxy for other factors not measured at the individual level. In the following section, I will consider studies that are relevant to asthma outcomes and health services utilisation by asthmatics.

1.6.1. Asthma management and medications

Because asthma treatments, principally inhaled medications, are inconvenient to use (*86*), are expensive yet offer no immediate perceivable benefit, adherence could be a major problem in the management of asthma. In the United States, in Medicaid insured children, underuse of controller medications was found to be inversely associated with high education level (OR=0.6), having a primary care physician, having seen a specialist and having received a written asthma management plan (*87*). Those covered by Medicaid are, in general, less likely to have controller medications dispensed (RR= 0.72) but they were equally as likely to have them prescribed as those not under Medicaid (*88*). Furthermore, a study showed that asthmatics with lower education levels (less than 12 years of schooling) were more likely to be non-adherent with inhaled steroids prescription than those with high education even though the medications were given at no charge (OR: 6.7; CI: 1.1 to 41.0). The analysis took into account various covariates and assessed adherence through electronically monitored metered dose inhaler (*89*). In Canada (British Columbia), high education (university diploma), high household income, living in a high income neighbourhood or in a neighbourhood with high proportion of residents with a bachelor's degree, were associates with decreasing short acting beta-agonists prescription, which is a marker of poor adherence to management guidelines. These associations were adjusted for asthma severity (*90*).

1.6.2. Asthma health knowledge

Higher education is usually correlated with better literacy, which confers an individual various skills, such as the ability to process information along with critical thinking, to interact with institutions and health practitioners. The depth of asthma knowledge is generally related to formal education level but not to income level (*91*), and is considered to be a factor mediating the relationship between education level and asthma outcomes. For example, a low reading level has been found to be a strong predictor of lower asthma knowledge (measured by questionnaire) and an inadequate metered-dose inhaler technique (*92*). This may be of importance since the efficacy of different types of asthma education interventions at reducing morbidity including hospitalization and ED visits in adults and children is established (*93, 94*).

1.6.3. Home environment and indoor pollution

Mounting evidence suggests that exposure to indoor allergens and irritants is a major contributor to childhood asthma and the home environment of low income asthmatics may put them at substantial risk of exposure to asthma triggers (*95, 96*). For example, homes of urban low-income households and are much more likely to contain very high concentration of cockroach allergens (*97, 98*), which may increase the risk of asthma in allergic children (*99*), and contribute to increased asthma morbidity as shown by significantly higher rates of hospitalization, unscheduled medical visits, more frequent days of wheezing and sleep disturbances (*100*).

1.6.4. Health services supply and primary care shortage

Shortage of primary care services and subsequent inadequate ambulatory outcomes may be a predictor of poor primary health outcomes such as preventable hospitalizations. A study found that the likelihood for an individual of experiencing a preventable hospitalization (for a wide range of conditions, including asthma) living in primary care shortage areas was 1.7 time that of an individual living in an area with no shortage. The study sample was composed of 4200 Medicare beneficiaries in fair or poor health and various factors including age, sex, race, education, income, marital status and Medicaid recipient were controlled for. Only the primary care shortage indicator for the area and sex were significantly associated with increased risk of preventable hospitalization (*101*).

There could be a differential in availability of health care facilities based on SES. For example, distance from physician can represent a barrier to health care access since the frequency of health services use tends to decrease as distance increases. In Canadian urban centers, physician supply is concentrated in census enumeration areas (EAs) in the highest average income per person equivalent (IPPE) quintile where 40% of physicians are located (193 people/physician) as compared to the lowest quintile EAs (480 people/physician). In less urbanized and rural areas the difference of supply according to IPPE is less salient (around 600 vs. 800 people/physician). However, because in urban areas, 98% of residents of both high and low IPPE quintiles were within 5 km from the nearest physician and public transportation is more available in urban areas, distance is barely related to income (*102*). It is however possible that longer waiting times and waiting lists arise as barriers for those living in low IPPE urban areas. On the other hand, in rural areas, although physician concentration is less related to IPPE, distance to physician is unequal according to IPPE: 55% and 76% of people were less than 5 km from the nearest physician when they lived in lowest and highest IPPE quintile, respectively (*102*). Moreover, lack of public transportation makes car ownership more important in reaching a physician since 24% of rural low income (< \$15,000) and only 2% of rural high income households (≥ \$30,000) did not own a car (*103*). Other barriers could actually further impede low SES people from using them. For example, other competing demands such as inflexible jobs from which it is impossible to leave without some sort of consequence or penalty, unstable family circumstances or difficult living conditions may make it complicated to plan in advance and take preventive health actions, the immediate priorities being to struggle for every day life (*104*).

1.6.5. Environmental hazards

Areas of increased poverty may be associated with risks of exposure that are less amenable to individual risk avoidance than population risk avoidance. For example, areas of poverty tend to have a higher population density with more persons sharing residences, which may result in added risk of viral respiratory infections, which is known to be a provocative factor of asthma morbidity. They may share many exposures such as moulds and cockroach infestations, requiring community based solutions, and are less under the control of any one individual, regardless of individual attitudes or behaviours towards changing these exposures. There is evidence that rich communities have developed healthier environments to improve the local population health as an ecological study conducted in Canada showed that municipal expenditure on environmental protection exerted a negative effect on mortality (*105*).

Atmospheric pollutants have been associated with asthma ED visits and hospitalization, and poor neighbourhoods may present higher levels of those pollutants. It is suggested that living near (within 200 m) roads with heavy traffic contributes to asthma hospitalization (*106, 107*) and repeated medical visits (*108*). Moreover, recent studies show that the negative effects of ambient air pollution may be more deleterious to those living in deprived rather than those in rich areas. A Canadian study found that some air pollutants were significantly and positively associated with asthma hospitalization in areas with low but not high average income (*109*). The effect of carbon monoxide pollution may be larger for low SES asthmatic children who, in addition, are exposed to higher levels of pollution (*110*). A recent study conducted in 10 major Canadian cities found that elevated aeroallergen levels was related to increased hospitalization admissions only in census enumeration areas with low average family education but not in those with high average family education, and suggests that those living in areas with lower education levels are more susceptible to aeroallergens (*111*).

Inadequate home environments, such as substandard or older housing with higher indoor pollution and exposure to allergens and other asthma triggers, is likely to be more prevalent in poor neighbourhoods, which can produce a high sensitisation in those living in deprived areas. For example, after controlling for family income, homes located in higher poverty areas were four times more likely to have high concentrations of cockroach allergens (*97*). A study found that asthma prevalence, mean total IgE levels and specific IgE serum levels for various indoor inhalant allergens such as cockroach and pets, significantly increased as area poverty increased (*112*).

1.6.6. Psychological factors and health beliefs

The role played by psychological factors in asthma morbidity is not well established, although, some evidence suggests that they may contribute to asthma outcomes through asthma health knowledge, health attitudes and coping abilities. Meyer et al. showed that psychological variables such as lower self-esteem and poor perceived ability of control over health ("others- and chance-oriented health locus of control") were strongly related to asthma knowledge independent of education level, and were able to explain a large portion of its variance (*91*). A prospective study has shown that personal attitudes such "Less use of avoidance coping style" and "Less dislikes of asthma medication" were associated with lower odds of having a hospitalization or ED visits. Whereas "lower preferences for autonomy in asthma management decisions" was associated with higher odds of hospitalization in the next 12 months (*113*). Lower level of parental confidence in the efficacy of medicines, and a failure to use a criterion for seeking emergency care may decide parents of asthmatic children to turn to the emergency department for help. Among those, a large proportion may rely on the emergency department for treatment of asthma episodes (mild or moderate) while earlier self-management action taken at home would possibly have spared them the ED visit (*114*). It is suggested that social support interacts with psychological distress in their association with physician visit use. A cross sectional study found that the risk of medical visits in people with high distress is even greater if they have low social support (*115*).

1.6.7. Psychosocial factors and community influence

Health related behaviours, which reflect individual choices may also be strongly influenced through social networks by other members of the community. For instance, after taken into account individual SES, area deprivation (for example measured by the Townsend deprivation index) remained associated with higher likelihood for an individual of being smoker (116-118). Hence, chronic exposure to environmental tobacco smoke is likely to be more common in deprived communities and an individual living in such neighbourhood could possibly be influenced by his peers to start smoking and/or keep on his smoking habit. Finally, higher body mass index was also independently associated with low area socioeconomic conditions (*119*), and high BMI was linked to asthma occurrence in women (*120*).

People with higher education and income are more likely to have a stable job and be granted social benefits such as rich social networks, extension of cultural capital and socialisation that encourages health-promoting behaviours. They may live in neighbourhoods where they enjoy not only a healthier physical environment, but also lower crime rates and friendlier relationships with their peers which can translate in more social support. They may also be exposed to less stress at work and have a more rewarding job. All these factors can be of importance in the relationship between health and socioeconomic status as they determine the extent to which people are exposed to stressful events or chronic stress. Additionally, they may have developed better abilities to cope with adverse life-events (121, 122).

Sandberg and colleagues in a prospective study showed that stressful life events and chronic stress significantly increased the risk of new asthma attacks in children, immediately within two days of the life-event occurrence and then latter, 5 to 7 weeks after the event (123). Wright et al. found a relationship between high crime rates and violence in the community and the number of days and nights with asthma symptoms (124). However, a prospective study on 115 previously hospitalised children, after a period of 1-year follow-up, failed to find that family social environment (conflict/cohesion/dialogue), health beliefs or three census tract-level SES measures were associated with prospective hospitalization. Nevertheless, the same study found that lifetime history of hospitalization was associated with greater family strain and conflict, greater financial strain as well as caretaker characteristics (greater personal strain, beliefs about not being able to manage one's child's asthma) (125).

The underlying biological processes for such results are still not clear. Pathways linking psychosocial factors and the resulting psychological stress to asthma could be through an increased susceptibility to viral respiratory infections with agents such as rhinoviruses and respiratory syncytial virus (126), known to be provocative factors of asthma morbidity (*24*). Another pathway could also be through an effect of stress on immune response by the preferential stimulation of type-2 (TH-2) rather than type-1 (TH-1) T-helper cells. The predominance of TH-2 cytokines has a central role in promoting the involvement and activation of other immune cells and the production of diverse pro-inflammatory cytokines, which promote the asthmatic bronchial inflammatory response. However, direct evidence for a clinically meaningful effect of social support as a mediator (by altering the immune response to stress) of the effect of SES in the context of asthma is still not established (127). Similarly, the role of stress and health beliefs as a mediator for the effect of SES, by inducing immunological changes compatible with those seen in asthma, has not yet been elucidated. The above-mentioned changes are limited and do not mirror the main alterations usually encountered in asthma (th-2 cytokines predominance) (128).

Psychological stress may perhaps influence asthma morbidity through behavioural response to stress, such as increased need for cigarette smoking, disruption of adherence to an asthma management plan. More studies are needed to elucidate the mechanism involved in the relationship between psychosocial factors and asthma morbidity.

Summary and limitations of the literature

Asthma prevalence is increasing worldwide and asthma hospitalizations are declining. The decrease of asthma hospitalization has been less than expected with regards to availability and potency of new treatments and could reflect a rise in the severity threshold for admission (*70*). An unexplained sub-optimal use of health resources by some individuals with asthma is frequently reported in the literature despite the widespread distribution of guidelines for asthma management, and the availability of effective medications.

Many studies provide evidence of an association between SES and asthma or health services utilisation by asthmatics. The prevalence of asthma differs substantially between countries and between regions within countries. In Canada, a possible differential may exist in specialist referral based on income, and despite a universal health care system, medications are still funded through a complex mix of public and private insurance and out-of pocket payments. This may contribute to a differential in asthma outcomes based on SES. Low education and low area-educational level and low income were found to be associated with increased hospitalizations and it has been suggested that a subgroup of low-income patients may rely on ED for the management of their asthma exacerbations.

A frequent feature of published studies is that they often use aggregated-level information on SES (e.g. average income per area) as surrogates for individual-level SES whereas the outcome is measured at the individual level. It then becomes difficult to be certain that aggregated measures reflect the true level of exposure (i.e. SES) for individuals. The use of aggregate measure should not be interpreted as if they were micro-level variables (129), because the resulting "cross-level" inferences are prone to bias (130). Furthermore, area-based and individual-based measures of SES are not perfectly correlated and may be complementary instead (131, 132). A study conducted in Montreal revealed that the agreement between area-based SES measures and individual-level SES scores is poor with correlation coefficients ranging from 0.19 to a maximum of 0.39 (133). There is growing evidence that in addition to individual socioeconomic determinants of health, sociological determinants at an area-level should be considered as affecting health independently from individual-level SES. They are to be interpreted at the strict community level for their contextual rather than compositional effect. For instance, low-income people may have worse health outcomes when they live in poor areas than those of same income level living in rich areas. Thus, the effect of macro-level SES may not necessarily reflect the effect of micro-level SES (133-135). Only one study conducted in Rome (Italy) assessed simultaneously the association of parental education and contextual SES with hospitalization (*46*).

Finally, studies conducted outside Canada in different populations may not always be directly applicable within the Canadian health-care system context and population characteristics and no published study assessed the association between health services use by asthmatics and SES measured simultaneously at both individual-and community levels in Canada on a national level.

II. OBJECTIVES AND RESEARCH QUESTIONS

This thesis is exploratory in nature and aims to improve understanding of health care utilisation patterns in a nationally representative sample of Canadians with asthma. I will explore the relationship of SES, measured at both the community and household levels simultaneously, to ED visits and hospitalization. More specific objectives are:

Primary objectives

1a – To examine the differential of asthma hospitalization and ED visits by SES, and explore the extent to which area-level and household-level SES act independently from one another.

1b – To determine whether the effect of SES measured at an individual level is modified by SES measured at an area level.

Secondary objectives

2a – To determine whether income inequality is related to ED visits or hospitalization and may account for or modify the association between household- or area-level income and ED visits or hospitalization.

2b – To investigate whether primary care services utilisation (having a regular doctor, frequency of visits, contact with specialist, treatment prescription or source of medical information), asthma severity or co-morbid conditions account for the association between SES and ED visits or hospitalization.

2-c To investigate whether primary care service utilisation (as mentioned above) is associated with SES.

III. MATERIALS AND METHODS

III.1 Description of the databases

In this thesis, I used information extracted from three databases: The 1996-97 National Population Health (NPHS), the Asthma Supplement to the 1996-97 NPHS and the census of 1996.

III.1.1. The National Population Health Survey 1996-97

The National Population Health Survey (NPHS) is a longitudinal health survey of persons who live in Canada. There are two main components to the NPHS: the institutional component (long-term residents expected to stay longer than six months in health care facilities with $\geq$ 4 beds) and the household component. Only the latter, used in this study, will be described in the following sections.

The first cycle of the NPHS took place in 1994-1995. During this first cycle, a member of each household selected for the survey was selected for the longitudinal panel; all interviews for selected respondents under 12 years old were done by proxy. Those longitudinal respondents were then interviewed two years latter. During the second cycle (1996-97), 17,276 longitudinal respondents (i.e. 86% of the 20,095 respondents of the core first cycle) *and* their current household members were interviewed again. As no new longitudinal respondents were selected during the second cycle, all the longitudinal respondents were two years old or older at the time of the second cycle. The target population of the NPHS household component consists of residents of households in all provinces except for long-term residents of institutions, persons living on Indian reserves, Canadian Forces bases and certain distant regions of Quebec and Ontario. Table III.1 shows the sample size by province.

Table III.1. Cross-sectional core sample size by province

- NPHS 1996/97 - General component
(excluding provincial supplements)

Province	Number of persons
Newfoundland	3,017
Prince Edward Island	2,752
Nova Scotia	2,775
New Brunswick	2,888
Québec	7,838
Ontario	10,899
Manitoba	3,045
Saskatchewan	2,785
Alberta	4,164
British Columbia	4,276
Total	44,439

From 1996-97 NPHS Public Use Microdata Documentation. (136)

In fact, there is no dataset available containing only the core 44,439 respondents excluding the provincial buy-ins. Instead, the cross-sectional sample for the general component includes three provincial buy-in (Ontario, Manitoba, and Alberta) yielding a total of 78,181 new households. Those buy-ins interviews were implemented according to the Statistics Canada Random Digit Dialling (RDD) system, which is not described here because the Asthma Supplement originates solely from those households that were strictly part of the core cross-sectional component.

The attrition of the sample, (deaths, out-of-scope cases, untraceable cases and non-respondents) is relatively small; an analysis of the 1996-97 samples before data collection showed that the sample was not biased with respect to representativity by province, age or sex. The responses rate of the 1996-97 general component was 94.3% for the core sample (and 80% for the RDD buy-ins). The number of respondents for the general component is detailed in Table III.2.

Table III.2. Sample size by province - NPHS 1996/97 -

	Sample size	Population
Newfoundland	3,017	561,586
Prince Edward Island	2,752	135,717
Nova Scotia	2,775	917,152
New Brunswick	2,888	745,464
Québec	7,838	7,221,079
Ontario	110,845	11,131,489
Manitoba	32,399	1,085,634
Saskatchewan	2,785	974,046
Alberta	40,802	2,728,382
British Columbia	4,276	3,780,907
Total	210,377	29,281,456

General component dataset (including provincial supplements)
From 1996-97 NPHS Public Use Microdata Documentation. (136)

Sample selection

The sample selection of the NPHS has been described in detail elsewhere (136, 137) and a only a brief description of the sampling design is given in this section.

The core NPHS household component used a stratified two-stage design with the sample size distributed proportionally to the population size in each province. In all provinces except Québec, the Labour Force Survey (LFS) design which provided general household surveys with clustered samples of dwellings was used. The LFS design is a multi-stage stratified sample of dwellings selected within clusters. A minimum of 1,200 households in each province was needed to ensure a specified reliability by sex and broad age groups. Each province was divided into three types of areas (major urban centres, urban towns and, rural areas) and further into separate geographic and/or socioeconomic strata within each areas (usually census enumeration areas (EA) with probability proportional to size (PPS). The sample of dwellings was then obtained after listing operations in sample clusters were completed. Finally, additional modifications and adjustments were made to meet requirements specific to the NPHS .

In Québec, the NPHS sample was selected from dwellings participating in the 1992-93 *Enquête Sociale et de Santé* (ESS). The latter used a two-stage design similar to that of the LFS. The province was divided by crossing 4 urban density classes (Montréal census metropolitan area, regional capitals, small urban agglomerations and the rural sector) with 15 health areas. In each area, clusters were stratified by socio-economic characteristics and selected using a PPS sample. Random samples of 10 to 30 dwellings in each cluster were drawn while insuring that the four types of household (one-member households; households with children; other households with youths; and the rest) would be proportional to the populations for the four household types.

III.1.2. The Asthma Supplement to the NPHS 1996-97

The Asthma Supplement is the main dataset used in this thesis as it provides additional health information about asthma status and outcomes. The complete methodology of the Asthma Supplement is accessible on request at the Data Access Unit - Health Surveys – Health Statistics Division- Statistics Canada. A brief description is presented here.

Sample design

The Asthma Supplement of the NPHS 1996-97 sample was selected from among respondents to the NPHS. It consists of all individuals who indicated, in the main survey of 1996-1997, that they had asthma diagnosed by a health professional. This question was asked to every individual aged 2 years and over who was selected as longitudinal respondent at the baseline survey in 1994-1995.

During the NPHS of 1996-1997, Statistics Canada received funds from some provincial governments to increase the sample size in their respective provinces to allow for estimates by health region. The additional households selected because of these funds were not included in the sample for the Asthma Supplement. The total number of eligible persons was 2,555, their distribution by provinces is described in Table III.3.

Table III.3. Number of eligible people for the Asthma Supplement

Province	**Number of eligible people** (reporting asthma diagnosed by a health professional during the 2nd cycle of NPHS)
Newfoundland	154
Prince Edward Island	141
Nova Scotia	156
New Brunswick	162
Quebec	442
Ontario	664
Manitoba	194
Saskatchewan	154
Alberta	249
British Columbia	239
Total	**2,555**

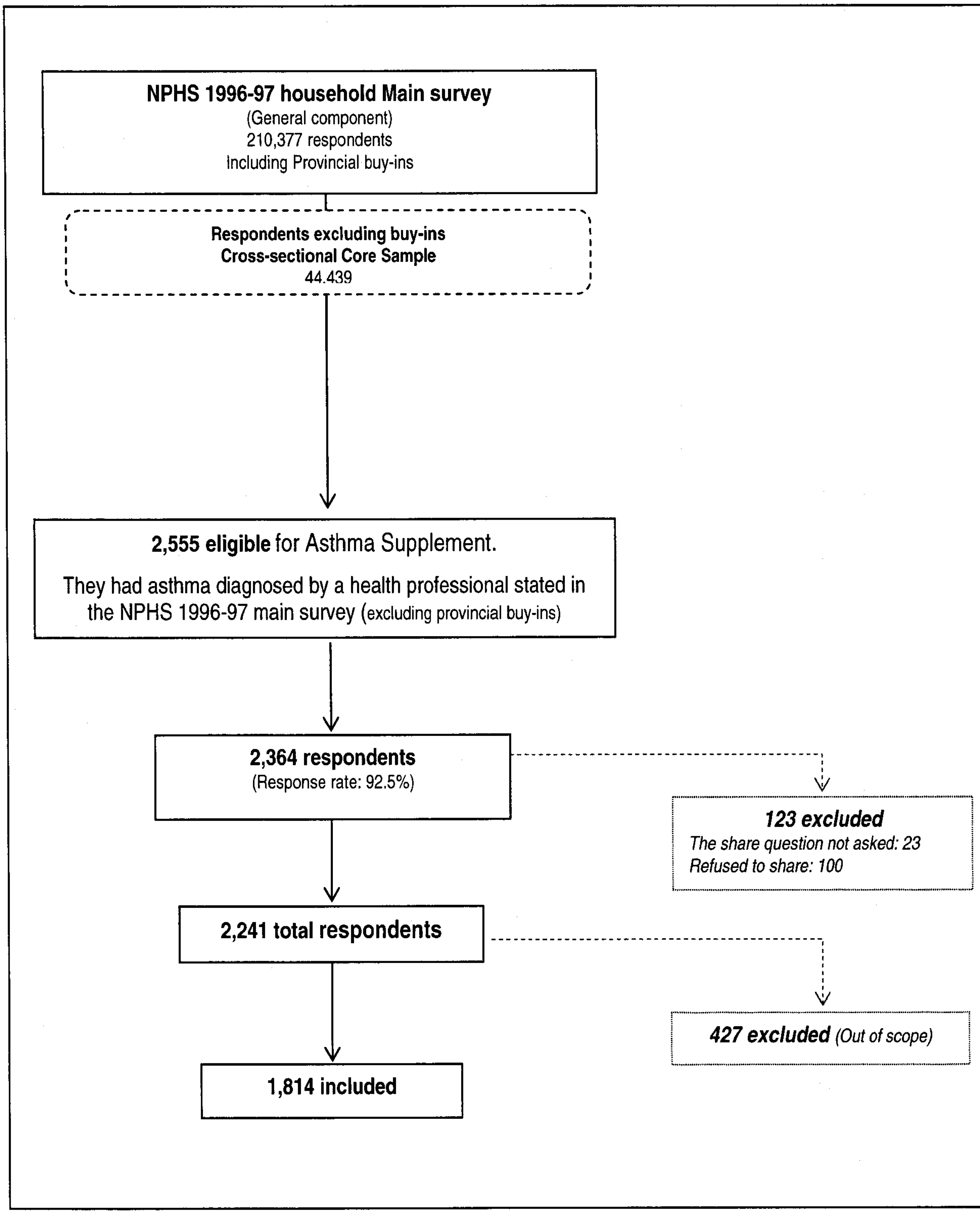
Response rate

All respondents to the NPHS 1996-1997 main survey (excluding provincial buy-in samples) for whom asthma was reported, were selected for the Asthma Supplement. From these 2,555 people, 2,364 were respondents (response rate: 92.5%). Of these cases, 427 respondents were classified as not eligible (or "out of scope") because they were not considered to be "current asthmatic". A current asthmatic patient is defined as a respondent who reported having been diagnosed with asthma by physician and who had had asthma symptoms or attacks or had taken medication for asthma in the last 12 months (Cf. Table III.4). An additional 23 were discarded because they had only partially responded to the questionnaire and were not asked the share question concerning the approval for sharing information from both NPHS general file and the Asthma Supplement file. An additional 100 fully respondents refused to share the information and were considered as non-respondents. The resulting Asthma Supplement (AS) dataset contains 1814 records of Canadian asthmatics who agreed to share the information (Cf. Figure III.1).

Table III.4. Distribution of the 427 out-of-scope cases according to their answers

Response to the **Asthma Supplement**	Response to the **NPHS 1996-97 General file** Respondent h*as physician-diagnosed asthma...* ... and has had asthma symptoms, attacks or medication in the last 12 months	 ... but **NO** asthma symptoms, attacks or medications in the last 12 months
Has asthma but **no** asthma symptoms/ attacks or medication the last 12 months	84	133
Doesn't have asthma but had it the past	34	31
Doesn't have asthma and never had it	91	43
Doesn't have asthma and doesn't know if ever had it	7	4
Total: 427 .	216	211

Figure III.1. Response rate and selection of participants in Asthma Supplement



It is important to note that there are two Asthma Supplement datasets; one containing all 1814 respondents (corresponding to the general component of the NPHS) while the second is restricted only to those persons selected as longitudinal respondents for the NPHS Health component. Both 1996 NPHS datasets contains the same general socio-demographic and general health information but the health component contains more detailed health information. As a result, the two Asthma Supplement datasets present two major differences with respect to sample size and possibilities: The first dataset (n=1814) can be used to retrieve information exclusively from the general component of the NPHS 1996-97 but not from the health component. The second dataset allows the retrieval of the much detailed information from the health component of the NPHS but its small sample size (N=840) makes it difficult if not impossible to be used in the present thesis. In addition, Statistics Canada strongly urges to use the dataset containing all 1814 records whenever possible for deriving valid and stable estimates. Therefore, the Asthma Supplement dataset used here is the one deriving from the NPHS general component and contains 1814 observations (Table III.5).

Table III.5. Asthma Supplement sample size by province

Province	Sample size Eligible	Total Respondents	Out-of-scope	**Completed**
Newfoundland	154	141	23	**118**
Prince Edward Islands	141	124	23	**101**
Nova Scotia	156	133	23	**110**
New Brunswick	162	140	26	**114**
Quebec	442	400	102	**298**
Ontario	664	580	98	**482**
Manitoba	194	170	31	**139**
Saskatchewan	154	135	24	**111**
Alberta	249	213	39	**174**
British Columbia	239	205	38	**167**
Total	2555	2241	427	**1814**

Weighting

A set of analytical weights (specifically calculated for the Asthma Supplement) is necessary to take into account the complex design and to compute meaningful estimate from the survey. The principle behind estimation in a probability sample such as the NPHS is that each person in the sample represents several other persons not in the sample. Two set of weights are necessary for the Asthma Supplement, however, I only describe the set that is used for the variables of both the general and asthma questionnaires (administered to all persons selected for the Asthma Supplement (n=1814)). The second set, only needed when the variables of the health component are to be used, is ignored here. The Asthma Supplement weights are derived from the cross-sectional weights calculated for the NPHS main General survey 1996-97 (excluding any RDD provincial buy-ins). The following section summarises the adjustments made to that weight for the Asthma Supplement.

The base weight is the NPHS 1996-97 cross-sectional household member weight after the household member non-response adjustment. Only those 2 to 11 year olds who were longitudinal respondents were asked the chronic conditions section of the general questionnaire in the main survey. Hence, the base weight for these individuals is the selected respondent cross-sectional weight after the inter-provincial migration adjustment. Post-stratification and non-response adjustments were applied. A data sharing adjustment step is required for the Asthma Supplement to adjust the weight of respondents who agree to share their information in order to compensate for those who have refused; this permission allowed sharing the information with Health Canada. The final weight (or household member weight) is the base weight that is multiplied by each of the adjustments described above. This weight is used for producing valid point estimates for any analysis using variables from both the general and Asthma Supplement questionnaires (section III.5.2 gives additional information about this weight).

Survey non-sampling errors

To reduce non-sampling errors in the survey, quality assurance measures were implemented during data collection and processing. These measures, such as the use of highly skilled interviewers, extensive training of interviewers, observation of interviewers to detect problems with the questionnaire or the understanding of instructions and procedures, ensured that data collection errors were minimized.

In the Asthma Supplement, partial non-response was essentially non-existent (23 cases). Total non-response (168 cases: 6.6%) only occurred when the interviewer was either unable to contact the respondent, no member of the household was able to provide the information, or the respondent refused to participate in the survey. Total non-response was handled by adjusting the weight of households who responded to the survey to compensate for those who did not respond.

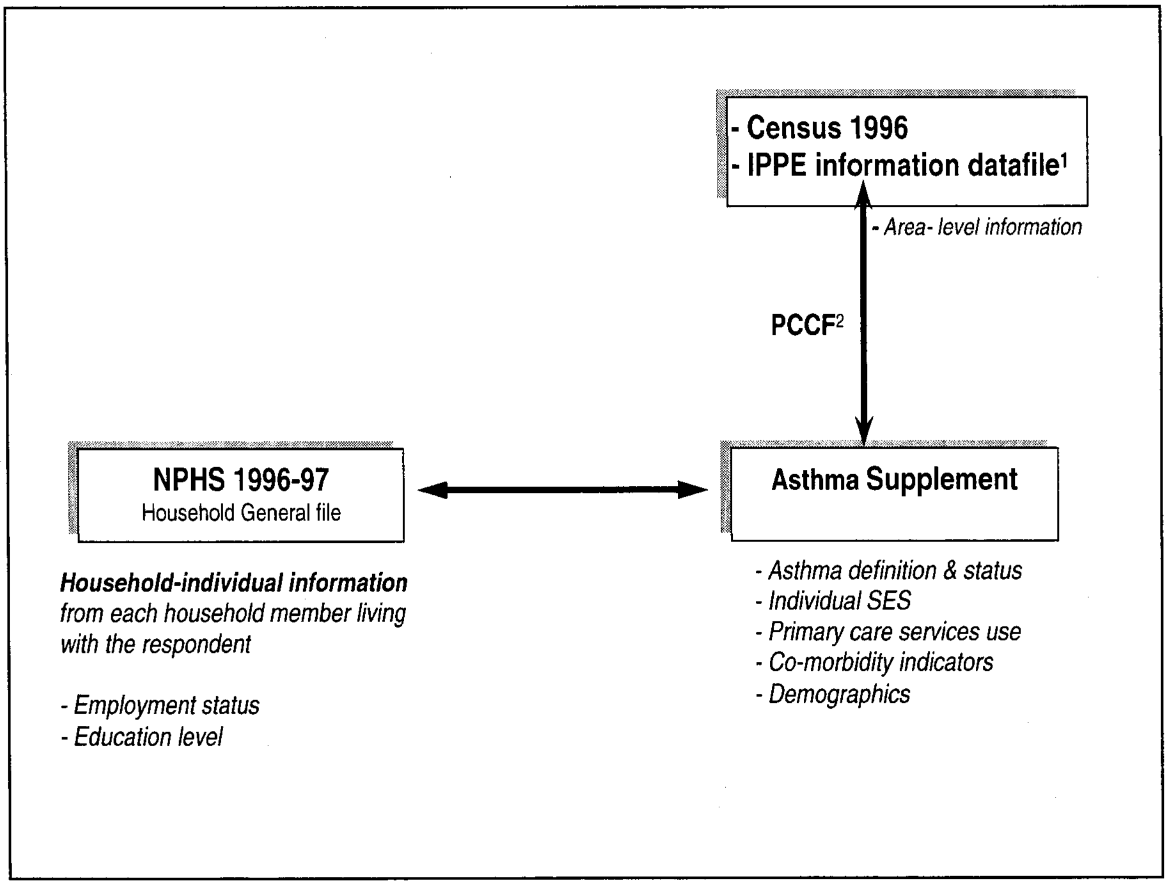
III.1.3. Census 1996

The census is conducted every five years and provides information on the demographic, social and economic characteristics of the Canadian population. The variables used in this study were retrieved from the census 1996, profile series. Various steps were implemented to ensure data quality and preserve confidentiality. A detailed description of the census is available from statistics Canada (138).

III.2 Study design and data

This is an analysis of cross-sectional survey data relating individual and group-level SES with individual health services use. Three databases were used: the NPHS-Asthma Supplement 1996-97 which provided asthma-specific information and a stricter definition of asthma status, the NPHS general file 1996-97 which supplied additional data about household socioeconomic status and the 1996 Census dataset provided area-level information about SES (standard tabulations). The latter dataset was linked to the Asthma Supplement by using the Postal-Code Conversion File programs (139) which produces geographical determination of the enumeration area and census division from the postal code of every Asthma Supplement respondent. The following diagram illustrates the study databases linkage (Figure III.2).

Figure III.2. Study databases



1: Income per person equivalents information from datafile provided by Wilkins R (102)
2: Postal Code Conversion File. (139)

Andersen's behavioural model of utilisation was used for the choice of variables (14, 140, 141). This model is the most commonly used in the literature pertaining to health care services utilisation and emphasises the notion of equitable and inequitable access to services which is defined according to which predictors of health care access/utilisation are predominant. The variables include predisposing, enabling and need variables. '*Predisposing*' variables, which exist prior to the onset of illness, include sociodemographic variables such as age, sex, formal education and describe the propensity of individuals to use health services. `*Enabling*' variables provide the means to use health care services for members of the society. They include structural factors such as income, health insurance (public or private), having a regular source of care and availability of health care facilities. They are considered mutable or subject to change through policy with the objective of influencing access to care. `*Need*' factors are typically considered the most pressing predictors of health care use and include chronic diseases or disability, objective and perceived health status and symptoms experienced. At the community level, all variables are considered to be enabling factors and represent, for example, community *support* which includes resources within the community directly allocated to provide safety net services, community attitudes regarding such services, and the general wealth of the community. Support varies according to the community considered and is influenced by federal legislation and more directly by state and local health policy and financing. It is assumed that greater community wealth and its distribution (unemployment rate, per capita income, and income inequality) would be associated with greater support for services for the low-income population. (142).

Asthma is a good condition indicator for the study of health care use because of the complexity of its pathogenesis, which involves a wide range of environmental and behavioural determinants in addition to genetic susceptibility. The selection of variables for this analysis was based on the conceptual framework, the availability in the dataset as well as on the literature for those (individual) factors classically related to asthma morbidity.

III.3 Selection of variables of interest

III.3.1. ED visits and hospitalization

The main outcomes of interest are the number of ED visits and the number of hospitalizations in the past 12 months. This information was provided by the respondents themselves when asked: "How many times, in the last 12 months, have you visited a hospital emergency room because of asthma?" and, "How many times, in the last 12 months, have you spent a night or longer in hospital because of asthma?". ED visits and hospitalizations visits were expressed as proportion of respondents who have experienced at least one in the last 12 months among the study subjects.

III.3.2. SES variables and other risk factors

Household socioeconomic status

The measurement of SES did not involve any composite indices and instead was appraised through its three most commonly used indicators: Income, educational attainment and employment status because each one of these three could be measuring different aspects of socio-economic position and may have independent pathways linking them to health. Different socioeconomic factors may relate differently to different health outcomes (21, 134).

In the NPHS, *household income adequacy* is available but not individual income. It was derived from the response to the question: "What is your best estimate of the total income, before taxes and deductions, of all household members from all sources in the past 12 months?". It is based on total annual household income and household size with five categories; although, for this analysis, they were grouped into three categories: High household income adequacy (included both high and middle-high categories), middle household income adequacy (included the middle category) and low (included both middle-low and low categories). The reference group was the high household income category. Total annual household income is defined as income exclusive of taxes but inclusive of government transfers. Table III.6 presents the different household income adequacy levels.

Table III.6. Household income adequacy

	Income adequacy group level				
Household size	**Lowest**	**Lower middle**	**Middle**	**Upper middle**	**Highest**
1 or 2 persons	< $10,000	$10,000-$14,999	$15,000-$29,999	$30,000-$59,999	≥ $60,000
3 or 4 persons	< $10,000	$10,000-$19,999	$20,000-$39,999	$40,000-$79,999	≥ $80,000
5 or more persons	< $15,000	$15,000-$29,999	$30,000-$59,999	$60,000-$79,999	≥ $80,000

$: Total annual income earned by all members in the household.
From 1996-97 NPHS Public Use Microdata Documentation. (136)

We consider that, if individuals living in the same household share the familial resources, they must also share some common standard of living, cultural values as well as physical and socio-psychological environment. However individual-level SES may be more adequate if workplace is considered (*21*). Therefore, the highest level of educational attainment and employment status of the household members was used in the analysis. Household education status was ascertained according to the response to the question : "What is the highest level of education that you (or he or she if proxy respondent) attained?". Then, we attributed the highest education level attained by any member of the household to the asthma respondent, so that the reference group (high education) was made up of respondents living in household where at least one member had a high school degree diploma (HSD) or more as opposed to those living in households where no member had a HSD.

Similarly, household unemployment was determined according to whether the respondent was living in household where at least one of the members had a current job (reference group) as opposed to living in household where no member had a current job. This variable was based on the responses to several questions asked to participants aged 15 to 75.

Area-level socioeconomic status

The smaller the area, the stronger is the association and the more precise is the definition of the area status because of the increased homogeneity (*21, 22*). For all the following area-level variables, data were reported for persons 15 years of age and over, excluding institutional residents, at the enumeration areas (EA) level. EA is the geographic area canvassed by one census representative and is the smallest standard geographic area for which census data are reported. All the territory of Canada is covered by EAs. The number of dwellings in an EA generally varies between 440 in large urban areas to 125 in rural areas. In some instances, geographically very small EAs are formed for large apartment buildings, large townhouse communities and large collective dwellings (143).

Average income of households from the census refers to the average total income per household and takes into account total money income received from the various sources (including government transfers and excluding taxes) during calendar year 1995 by persons 15 years of age, however, instead of using the average total household income, the average total household *income per person equivalent (IPPE)* was used. It takes into account the household size and is more consistent with its household-level counterparts (household income adequacy). Indeed, the IPPE takes into account each additional person in the household in terms of "single person equivalent" and total household income; the IPPE information was extracted from data files supplied by Dr Wilkins R and the method used for the construction of IPPE is described in an article by Ng E, Wilkins R et al. (102). It has been calculated using the low income cut-offs (LICOs) criteria published by Statistics Canada in 1995 (138). The LICOs define a level of income below which a family would be financially strained as expenses on basic necessities (food, shelter and clothing) would represent a large proportion of its total income (20% above the average spent on those necessities by Canadians) . The LICOs are updated according to changes in the consumer price index.

For brief comparison with IPPE, estimation of the association between average household income (not accounting for the household size) and ED visits and hospitalization was carried out.

The average *unemployment rate* and the average *percentage of low educated people* were included in the analysis. The former is the unemployed labour force expressed as a percentage of the total labour force (15 years of age and over) in the week prior to census day whereas the latter is the percentage of people with less than a high school diploma (HSD).

Income inequality

The Lorenz curve displays the cumulative share of total income accruing to successive income intervals (see appendix VII.4). The Gini coefficient is the most commonly used measure of inequality and is strongly correlated to other measures of inequality (144). It is the ratio of the area between the Lorenz curve and the 45-degree line (equal distribution or no inequality) to the area below the latter line. The Gini coefficient reflects the degree of income concentration according to income classes, the higher the coefficient, the more inequality is present. A maximum coefficient of 1 indicates an extreme concentration of income in the wealthiest households (absolute theoretical inequality) whereas 0 indicates absolute theoretical equality.

The Gini coefficient was calculated at the level of census divisions (CD) which are geographic areas between the municipality (census subdivision) and the provincial level. A census division contains larger population and thus would allow for more variation in income distribution than smaller areas would. They represent counties, regional districts, regional municipalities and other types of provincially legislated areas. They have been established in provincial law to facilitate regional planning and the provision of services that can be more effectively delivered on a scale larger than a municipality (Cf. Appendix VII.3). The Gini coefficient was computed across the income range within census divisions (CD). Nevertheless, in order to assess whether the association of income inequality with ED visits and hospitalization was different according to the geographical level considered, the Gini coefficient was also computed at the provincial level and is briefly compared to that computed at the census division level (Cf. appendix VII.4 for more details).

In total, for the modelling process, all three area-level SES variables and the Gini coefficient were expressed as dichotomous variables using the 50th percentile (median) as cut off point. The reference groups were the following categories: "high" IPPE (>$32,534), "high" education (proportion of people with less than a HSD ≤ 32.56%),"low" unemployment rate (≤ 8.40%) and "low" income inequality (Gini coefficient ≤ 0.374).

Covariates: individual-level factors

Other factors were included since they may have an impact on the relationship between socioeconomic status and ED visits or hospitalizations. They involve three main types of variables including, demographics, severity, utilisation of primary health care services and co-morbid conditions and smoking.

<u>Two co-morbid conditions and current smoking status</u>

Allergic status was established if there was a positive response to one of the following questions: "Do you have food allergies diagnosed by a health professional?" or "Do you have any other allergies diagnosed by a health professional?" Those who didn't report a diagnosis of allergy by a health professional were included in the reference category. A diagnosis of *chronic bronchitis or emphysema* (COPD) was ascertained if the respondent answered positively to the question "Do you have chronic bronchitis or emphysema diagnosed by a health professional?" The reference category was "no diagnosis of COPD". *Smoking status* of the respondent was categorised into two categories: "daily smoking" and "non daily smokers", the latter was the reference group and included non-smokers and occasional smokers.

<u>Three asthma symptoms severity indicators</u>

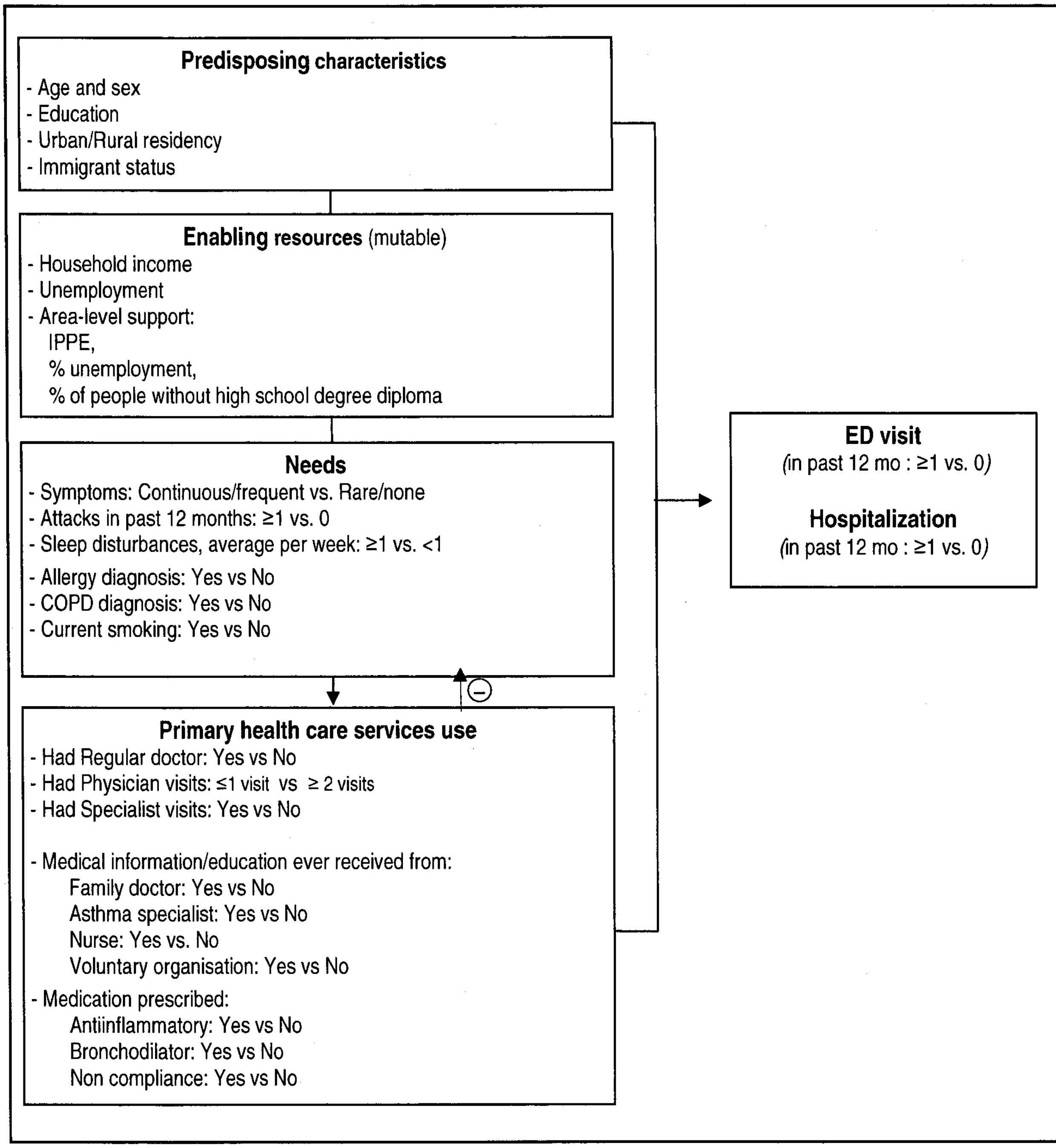
Asthma symptoms severity was appraised using the reported frequency of symptoms, sleep disturbances due to asthma, and asthma attacks. They were categorised according to Canadian guidelines as long as frequency distributions allowed it (Cf. appendix VII.1). The *frequency of attacks* during the past 12 months was grouped into two categories: those with at least one attack as opposed to those with no attacks (the reference category). *Frequency of sleep disturbances per week* due to asthma was also grouped into two categories: those with one sleep disturbance or more per week and those with less than one sleep disturbance per week (the reference group). *Frequency of asthma symptoms* (wheezing or whistling, shortness of breath, difficulty breathing, chest tightness and cough) were also grouped into two categories: "Continuously or often" and "None or rarely", the latter being the reference category.

Ten indicators of utilisation of primary health care services

Asthma antiinflammatory drugs (steroids and other immunomodulating medications) prescription and *bronchodilator* medications prescription were studied. The participants were asked the following question: "In the last month, have you been on any asthma medicine? Remember to include medicine prescribed for asthma even though you may not have actually taken it" (Cf. appendix VII.5 for definition of antiinflammatory and bronchodilator medications). Reported *Non-compliance* to prescribed medication was also considered. Having a *regular doctor* and having a *visit to an allergy specialist or respirologist* in the last 12 months as well as the *number of physician visit* (any type of doctor) for asthma were included in the analysis. Medical information ever received from a *family doctor*; from a *specialist*, from a *nurse* and from a *voluntary organisation* were also accounted for.

Others Age and sex, immigrant status, and living in an urban/rural enumeration area were also considered. Urban enumeration areas are those continuously (i.e. discontinuity $\leq$ 2 kilometres) built-up areas having a population concentration of $\geq$ 1,000 and a population density of $\geq$400/km^2 based on the previous census. The following diagram summarises the variables selected for study (Figure III.3).

Figure III.3. Variable selection



III.4 Power and sample size

Because the NPHS 1996-97 Asthma Supplement used a complex survey design while the sample size is relatively small, it is important that statiscal power be sufficient to detecte any meaningful associations under study. The following section describes calculations and estimation of the projected statistical power.

The Asthma Supplement design incorporates multiple stages of selection, clustering and unequal probabilities of selection of respondents. To reflect those characteristics, Statistics Canada usually computes and publishes a factor called the design effect (DEFF) which inflates the variance estimates. Some simulations were ran while taking into account the DEFF. The power of a statistical test, which is the probability of correctly rejecting the null hypothesis when a study is repeated, can be estimated using the following formula,

$$Z_\beta = \frac{(p_1 - p_2) \times \sqrt{N^*}}{\sqrt{(p_1 q_1 + p_2 q_2)}} - Z_{1-\alpha/2}$$

Where Z_β is the normal deviate corresponding to power and $Z_{1-\alpha/2} = 0.05$ is the normal deviate corresponding to significance level. Also, p_1 is the proportion of asthmatics who experienced at least one ED visit in the exposed group and p_2 is the corresponding proportion in the unexposed group. Thus, the effect size is the difference between these proportions.

$N^* = n/$ DEFF is the effective sample size incorporating the design effect. The latter is the ratio of the sampling variance for an estimated parameter under the complex survey design to the variance obtained under simple random conditions (145). The average DEFF is determined by first calculating design effects for a wide range of characteristics and then choosing from among these a conservative value to be used in the look-up tables. This average DEFF would then apply to the entire set of characteristics; however, because there was no average DEFF specifically computed for the Asthma Supplement file, I used the design effects from the 1994 NPHS (DEFF =1.8) and 1996 NPHS (DEFF=5.26 when including add-ins). Two limitations exist for these power simulations: Firstly, they are computed based on one studied characteristic (crude associations) and the results could be quite different (less power) when multivariate logistic regression is used. Secondly, the average DEFF estimates used here for power estimation may not be suitable for the Asthma Supplement. Please, note that the average DEFF was only used for power simulation not for the actual analysis, which used bootstrap procedures.

III.5 Statistical analysis

In order to allow for potential sex differences in the associations, the descriptive analysis, including frequency distributions and prevalence of outcomes, were stratified by sex as long as the sample size permitted it. Crude estimates of bivariate associations between each risk factor (household SES, area-level SES, Gini coefficient as well as individual covariates) are presented.

Multiple logistic regression models were used to investigate associations between risk factors and outcomes using backward elimination strategies. The latter models were not stratified by sex because of the small sample size and number of cases (especially for hospitalizations). Important individual factors were included in the models if a notable change (≥10%) in odds ratios estimates for the relationship between the main predictors (SES variables) and each of the two outcomes.

Effect-modification was assessed by including two-way interaction product terms in the models. Wald χ^2 test was used to determine the statistical significance of each product term since it was not possible for us to use partial log likelihood ratio test (LRT) along with the bootstrap method.

III.5.1. Modelling strategy

Due to the small sample size (and small number of hospitalized cases) and to avoid multicollinearity among SES variables which are expected to be correlated, especially those measured on the same level (household or area level) (129, 135), each association between an outcome and a single main exposure was modelled separately (while adjusting for other 20 individual-level covariates). Since there were two outcomes, six SES measures and the Gini coefficient, seven models for each outcome were considered. This produced a total of 14 final models adjusted for the same set of covariates that noticeably altered the odds ratio estimate (≥10% change in OR) for any association of interest.

In a second stage, when the final adjusted models were established, I assessed the presence of cross-level effect-modification between the effects of income, education or job status at the household level by that of the corresponding SES measure at the area level. Modification of the association of ED visits or hospitalization with household level SES by age and sex were tested, as well as the modification of the association of ED visits or hospitalization with area or household income by income inequality.

In a third stage, I considered confounding of the association of household level SES (with ED visits or hospitalization) by its area-level counterparts and vice versa (e.g. does the association of average area income with ED visits or hospitalization holds when household income is included in the model?). Confounding effect among SES measures within one level was also considered, although it was expected that collinearity might be present to some extent.

As stated as objectives-2, I assessed whether utilisation of primary heath care services was related to SES, income inequality, asthma severity or co-morbid conditions and smoking factors. To do so, one model was fitted for each one of the ten primary health services (as an outcome) and each one of the main exposures (three household and three area level SES variables and income inequality) while adjusting for asthma severity indicators and co-morbid conditions and smoking in addition to sex and age.

Finally, to assess potential association of asthma severity with SES or income inequality, one model was fitted for each one of the three severity indicators (as outcome) and each one of the main exposures (three household and three area level SES variables and income inequality) while adjusting for primary care utilisation variables and co-morbidity factors in addition to sex and age. Similarly, to appraise potential association of co-morbidity factors with SES or income inequality, one model was fitted for each one of the three co-morbidity factors (as an outcome) and each one of the main exposures (three household and three area level SES variables and income inequality) while adjusting for primary care utilisation variables and severity indicators in addition to sex and age.

III.5.2. Variance estimation using the bootstrap resampling method

Following Statistics-Canada recommendations to compute a parameter P, an analytic weight is to be used which represents the unequal probability of selection for each record. This weight incorporates the population weight from the survey, missing responses and population stratification. It will provide unbiased point estimates but incorrect variance estimation because it does not account for further features of the complex survey design such as multistage sampling design and clustering. Statistics Canada urges researchers to use a resampling technique using bootstrap replicates by Rao (146) and adapted for the NPHS by Yeo (147). Multiple simulated datasets (similar size and structure as the original dataset) are produced by resampling the primary sampling units (PSU) in each stratum; that is, within each stratum h simple random sample with replacement of $m_h = n_h - 1$ of the N_h clusters is taken and a first bootstrap weight is then calculated for each record in that stratum (See Appendix VII.6). The replication process was repeated a number of times that must be large enough to produce a precise bootstrap variance estimator (less variable or more consistent). For the Asthma Supplement, the process must be run 1000 times for any variance estimation. In comparison, the NPHS general file requires "only" 500 replications.

All point estimates presented in this thesis were carried out using the population final weights for point estimates and bootstrap weights for variance estimation and 95% confidence intervals calculations. To calculate 95% confidence intervals for ORs where interaction is present, covariance matrices based on bootstrap weights were produced using a customized SAS macro. The software program SAS for Windows v 8.01 has been used to conduct all analyses *(SAS Institute Inc., Cary, NC, USA)*.

III.6 Ethical considerations

The Ottawa Hospital Research Ethics Board has approved the study protocol and this thesis received a financial support from CPHI. There were no costs for acquiring the data, also both the NPHS-1996 master-file and the Asthma Supplement master-file were accessed on-site at Statistics-Canada facilities. The research project was submitted to Statistics-Canada and the access to the master data file was granted. The already available standard tabulations from the census were free of charge for use. No customized tabulations for fees were asked. Also, there were no costs for the linkages between census, IPPE datafile and both NPHS datasets since we implemented it ourselves.

IV. RESULTS

IV.1 Preliminary results

IV.1.1. Comparison of samples in the Asthma Supplement and the NPHS Household Component general file

Compared to the NPHS general file sample, in the Asthma Supplement sample, females and children/adolescents were slightly more represented. There also were three times more respondents reporting having an allergy diagnosed by a health professional in the Asthma Supplement than in the NPHS general file. Study subjects from the Asthma Supplement were four times more likely to report having COPD and were twice less likely to be an immigrant than the general population (appendix VII.7).

IV.1.2. Correlations among SES measures

Correlations among SES measures from the same level, for instance household income with household job status, or area unemployment rate with area education level) were generally stronger (Pearson correlation coefficient $|r|$ ranging from 0.42 to 0.63) than correlations between SES measures from different levels, for example, area education rate with household education status ($|r|$ ranging from 0.20 to 0.34). The only exception is that of area IPPE with household income (r=0.44). In addition, those living in household where no member is employed are 20 times and 13 times more likely to be from low income and low education households, respectively. For more details, please see table in appendix VII.8.

IV.1.3. Handling of missing values and sensitivity analysis

Because there were a substantial number of variables to consider, even a moderate number of missing values in some of them could amount to a large number of observations with one missing value in at least one variable. In addition, giving that the sample size is quite small and the use of bootstrap resampling technique, which tends to produce large variances estimates, it was crucial to give a careful consideration to any missing values. Therefore, in order to keep as much information as possible, the following practical steps were implemented:

Step-1: When possible and reasonable to do so, information was retrieved from other variables and used to recode the missing value, as follows. There were three variables for which 132 respondents (younger than 12 years old) were not asked the related question. Those children had no information about their allergic status. Among them, 65 were not prescribed anti-allergic medication and did not see an immunologist (in the last 12 months) and as a result, they were recoded as being non-allergic. Two children had a prescription for anti-allergic medications and saw an immunologist; therefore, they were recoded as being allergic. In addition, all 132 children had no information about their smoking status and about whether they were diagnosed with COPD. Because it seemed reasonable to expect that most children less than 12 years old were not daily smokers and did not have COPD, they were recoded as being non-daily smokers and having no COPD.

Bronchodilator medication prescription was missing for four respondents who did not supply information about the name of the medication prescribed. They were recoded as having bronchodilator prescription because they had answered affirmatively to two other questions: first, that they had been prescribed a medication for asthma and second that they had a medicine to relieve asthma attacks.

After the first step was implemented, the number of missing values was as summarised in the Table IV.1.

Table IV.1. Missing values: number and percentage of total sample

	Missing values	
	Number	%
Outcomes		
ED visits	5	0.3
Hospitalization	3	0.2
Household SES		
Household income adequacy	129	7.1
Household highest job status	25	1.4
Household highest educational attainment	2	0.1
Area-level variables		
Income per person equivalent	8	0.4
% people with less than HSD	7	0.4
% unemployment	7	0.4
Covariates		
Allergic status	66	3.6
Sleep disturbance	64	3.5
Asthma attacks	38	2.1
Visit to specialist	36	2.0
Medical information ever received from a voluntary organization	21	1.2
Asthma symptoms	19	1.0
Number of physician visits	18	1.0
Medical information ever received from a family doctor	14	0.8
Non-Compliance	10	0.6
Medical information ever received from a specialist	9	0.5
Medical information ever received from a nurse	5	0.3
Antiinflammatory medications	4	0.2
Bronchodilators drugs	4	0.2
Visit to specialist	4	0.2
Smoking status	1	0.1
Has regular doctor	1	0.1

HSD: High school diploma

Step-2. Separate categories were created for unknown values of two household SES variables: Income adequacy and job status.

Step-3. Missing values for the three area-level SES variables were recoded as mean values.

Step-4. Missing values for covariates were recoded as "zero" (unexposed) then as "one"(exposed).

-4a. Fourteen backward modeling processes were run to obtain 14 final adjusted models when missing values for covariates were recoded as "zero".

-4b. Fourteen backward modeling processes were run to obtain 14 final adjusted models when missing values for covariates were recoded as "one".

Step-5. After comparison of the ORs for the main exposures (household- and area-level SES measures) from the 14 final models from step-4a to those obtained from step-4b, the zero recoding was kept as the differences in ORs were negligible (≤10%); If they had not been negligible, the recoding with the most conservative ORs would have been kept. Indeed, the adjusted ORs for the effect of SES measures (final models) had the same direction and were of quasi-identical magnitude (difference ranging from -3.0% to +3.4% for hospitalization and -4.3% to +2.7% for ED visits. The results are summarized in appendix VII.9.

Step-6. Missing values for household education (two observations) were recoded as zero and its adjusted ORs compared with that of step-5 (when missing values were kept). The zero recoding was kept since there was no meaningful difference (0.4% for ED visits and -2.0% for hospitalization). If they had not been similar, the original missing values would have been kept. In addition, the recoding of missing values as "one" also gives comparable OR values (results not shown).

Step-7. Missing values for the two outcomes (hospitalization and ED visits) were recoded as zero. The ORs obtained were virtually identical to those before the recoding, with difference ranging from -2.42% to +0.30%.

All further results that are presented in this thesis used the whole sample of 1814 respondents: no observation was discarded because of missing values.

IV.1.4. Attribution of household-level SES

The attribution of the highest household SES to individual asthma respondents raised the number of high school diploma (HSD) holders by 572. The number of respondents with no HSD decreased by 442 and that of those with missing values decreased by 130 (children <12 year old). Of these 572, mentioned earlier, 457 did not have HSD by themselves and 115 were originally coded as missing. In addition, 15 missing responses were set to "No current job" status. Similarly, the "has current job" status was attributed to 621 additional respondents: the number of respondents with no current job diminished by 317 and those with missing values by 304. Beside that, 55 missing responses were set to "No current job" status whereas among the 621 previously mentioned, 372 were originally classified as "No current job" and 249 as missing values.

Table IV.2 and Table IV.3 show the distribution of those respondents, who were "promoted" to match their household member with the highest status, according to their household income level (which is originally presented as such in the NPHS databases). It appears that most of them came from households with high (49%-50%) and middle (34%-35%) income. The distributions were roughly comparable to that of the entire sample except for those 621 respondents to whom "has a current job" was attributed since they were less likely to be from low income household (8.54 %) than were the respondents from the entire sample (17.74%).

Table IV.2. Household job status and education level attribution

	(a) Respondents to whom "Has a HSD" was attributed		(b) Respondents to whom "has a current job" was attributed	
Household income	Number	% (95% CI)	Number	% (95% CI)
High	255	48.9 (41.6, 56.2)	284	50.5 (43.9, 57.1)
Middle	207	34.3 (27.6, 41.0)	218	35.1 (28.9, 41.2)
Low	71	11.7 (7.1, 16.3)	68	8.5 (4.9, 12.2)
Unknown	39	5.11	51	5.9
total	**572**	100.0	**621**	100.0

Column (a): Household income characteristics of those 572 respondents who were attributed a higher level of education.
Column (b): Household income characteristics of those 621 respondents who were attributed a "higher" employment status.
HSD: High school diploma

Table IV.3.Household income characteristics for the entire sample

	Respondents of the Entire sample	
Household income adequacy	number	% (95% CI)
High	808	46.0 (42.2, 49.8)
Middle	560	30.6 (27.3, 33.9)
Low	317	17.7 (14.6, 20.8)
Unknown	129	5.6
total	**1814**	100.0

IV.2 Descriptive results

There were 1814 respondents in our sample (729 females and 1085 males) from 1633 households. Only 344 respondents (19% of the sample) shared the same household with another respondent; the majority (81%) came from different households.

Table IV.4. Number of respondents per household

Number of respondents per household	Number of households	Total number of respondents	% respondents
1	1470	1470	81.1
2	146	292	16.1
3	16	48	2.6
4	1	4	0.2
Total	1633	1814	100.0

The linkage of the Asthma Supplement file to the NPHS general file retrieved SES information from 5,360 records of the latter file representing the 1,633 households.

IV.2.1. ED visits and hospitalizations

A total of 350 respondents (18.2%) reported having had at least one ED visit in the last 12 months, while 99 (5.3%) reported at least one hospitalization during the same period. Table IV.5 and Table

IV.6 summarise the distributions where "Number in population" refers to the number of people in the population corresponding to (or represented by) the number of respondents in the Asthma Supplement sample when using the final weights as described in section III.1.2.

Table IV.5. Number of ED visits in last 12 months

Number of **ED visits**	Number in sample	Number in population	% population
None	1,461	1,400,526	81.6%
1	194	178,934	10.4%
2 - 3	110	97,296	5.7%
4 - 6	33	22,996	1.3%
7 - 12	9	8,381	0.5%
15 - 20	4	4,418	0.3%
unknown	3	3,356	0.2%
	1,814	1,715,907	100.0%

Table IV.6. Number of stays in hospital in last 12 months

Number of **Hospitalizations**	Number in sample	Number in population	% population
None	1,710	1,621,585	94.5%
1	61	55,290	3.2%
2 - 3	21	21,369	1.2%
4 - 6	8	5,893	0.3%
7 - 12	5	3,254	0.2%
30 - 42	4	5,318	0.3%
unknown	5	3,199	0.2%
	1,814	1,715,907	100.0%

The 1-year period prevalence of having at least one hospitalization as well as that of having at least one ED visit in the last 12 months were quite similar in males and females as shown in Table IV.7.

Table IV.7. Distribution of respondents who had at least one ED visit or one hospitalization in the previous year

	MALES				FEMALES			
	Sample: 729				*Sample: 1,085*			
	Population: 775,710				*Population: 940,197*			
	n	N	%	95%CI	*n*	N	%	95% CI
Hospitalization								
respondents who had ≥1 hospitalization in the last 12 months								
No	*687*	726,032	**93.6**	90.8 96.4	*1,028*	898,752	**95.6**	94.2 97.1
Yes	*42*	49,679	**6.4**	3.6 9.2	*57*	41,445	**4.4**	3.0 5.9
ED visits								
respondents who had ≥1 ED visit in the last 12 months								
No	*597*	633,026	**81.6**	77.1 86.2	*867*	770,856	**82.0**	79.0 85.0
Yes	*132*	142,685	**18.4**	13.9 22.9	*218*	169,340	**18.0**	15.0 21.0

n: number with the attribute in the sample
N: number with the attribute in the population
95% CI: 95% confidence interval

IV.2.2. Household-level SES

The distribution of the sample according to household SES showed no marked differences between males and females as shown in Table IV.8.

Table IV.8. Distribution of household socioeconomic characteristics

	MALES					FEMALES				
	Total sample: 729					*Total sample1085*				
	Total population: 775,710					*Total population: 940,197*				
	n	N	%	95% CI		*n*	N	%	95% CI	
Income adequacy										
High	*338*	358,543	**46.2**	40.3	52.2	*470*	430,820	**45.8**	41.4	50.2
Middle	*239*	243,784	**31.4**	26.1	36.8	*321*	281,426	**29.9**	26.0	33.9
Low	*107*	135,728	**17.5**	12.0	23.1	*210*	168,616	**17.9**	14.8	21.1
Unknown	45	37,656	**4.9**	2.7	7.1	84	59,334	**6.3**	4.5	8.2
Education										
High (at least one household member has a HSD)	*648*	684,565	**88.3**	83.4	93.4	*956*	819,367	**87.2**	84.1	90.2
Low (no household member has a HSD)	*81*	91,146	**11.8**	6.9	16.6	*129*	120,830	**12.9**	9.8	15.9
Employment status										
Employed (At least one household member is employed)	*592*	610,986	**78.8**	73.2	84.3	*871*	726,721	**77.3**	73.8	80.8
Unemployed (no household member is employed)	*130*	155,411	**20.1**	14.5	25.6	*196*	190,949	**20.3**	16.8	23.8
Unknown	7	9,314	**1.2**	0.2	2.2	18	22,526	**2.4**	1.1	3.7

n: number in the sample
N: number in the population
95% CI : 95% confidence interval
HSD : high school diploma

IV.2.3. Area-level SES

There were 1,551 different census enumeration areas (EA) from which area-level information were extracted. The large majority of those areas (1,250 or 83.3%) contained only one individual, and only one EA contained five individuals. We can reasonably assume that the intra-group correlation was very small if it existed and therefore the variance estimation is not prone to underestimation caused by this. Table IV.9 summarises the distribution of respondents according to enumeration areas.

Table IV.9. Number of respondents per enumeration area

Number of respondent per enumeration area	Number of enumeration Areas	%
1	1250	83.3
2	195	12.9
3	51	3.4
4	4	0.3
5	1	0.1
Total	1501	100

The sample distribution for area level SES characteristics was similar in males and females (Table IV.10).

Table IV.10. Distribution of area-level socioeconomic characteristics

	MALES *Total sample: 729* *Total population: 775,710*					**FEMALES** *Total sample1085* *Total population: 940,197*				
	n	N	%	*95% CI*		*n*	N	%	95%CI	
Area level SES										
IPPE ($)										
High > $32,534 (reference)	339	380,482	**49.1**	43.1	55.1	463	480,728	**51.1**	46.4	55.9
Low ≤ $32,534	390	395,229	**50.9**	44.9	57.0	622	459,469	**48.9**	44.1	53.6
Education % with no HSD										
Low: ≤ 32.56 (reference)	325	378,513	**48.8**	43.1	54.6	453	483,027	**51.4**	46.7	56.1
High: > 32.56	404	397,197	**51.2**	45.4	57.0	632	457,169	**48.6**	43.9	53.3
Unemployment %										
Low: ≤ 8.40 (reference)	364	412,597	**53.2**	46.9	59.4	468	444,834	**47.3**	42.6	52.1
High: > 8.40	365	363,114	**46.8**	40.6	53.1	617	495,363	**52.7**	48.0	57.4

IPPE: Income per person equivalent
n: number of cases in the sample; N: number of cases in the population
HSD: high school diploma

IV.2.4. Gini coefficient

The Gini coefficient was computed for 226 different census divisions represented in the sample. The Gini coefficient ranged from 0.29 to 0.45 with a mean and a median of 0.38. Contrary to enumeration areas, many census divisions contained multiple respondents, which could lead to autocorrelation within census divisions and underestimated variances. For example, only 40 (17.8%) census divisions contained one respondent and as many as 79 (35.1%) contained more than five respondents. As for provincial level distribution, the number for each province is even higher; eight provinces contained 100 to 200 respondents, one included 298 and the remaining province held 482 of them (Table IV.11). Therefore, we must exercise extreme caution when interpreting variance and statistical significance associated with any Gini coefficient point estimate. The proportions of males and females living in areas with low income inequality were similar (Table IV.12).

Table IV.11. Number of respondents per census division

Number of respondent per census division	Number of census division	%
1	40	17.8
2-5	147	65.3
6-10	39	17.3
11-75	40	17.8
Total	225	100

Table IV.12. Distribution of Gini coefficient at the census division level

	MALES *Total sample: 729* *Total population: 775,710*					**FEMALES** *Total sample 1085* *Total population: 940,197*				
	n	N	%	*95% CI*		*n*	N	%	95% CI	
Gini coefficient (Census division)										
Low: ≤ 0.374 (reference)	460	381,924	**49.2**	43.2	55.3	679	471,657	**50.2**	45.6	54.7
High: > 0.374	269	393,786	**50.8**	44.7	56.8	406	468,539	**49.8**	45.3	54.4

IV.2.5. Individual-level covariates

All frequency distributions for covariates according to sex can be found in appendix VII.11. There were no significant sex differences except for allergic status which was more frequently reported in females (57.1%; 95% CI: 52.5, 61.6) than in males (42.4%; 95% CI: 37.2, 47.6). Women also reported more frequently having more than one episode of sleep disturbance (13.6%; 95% CI: 11.0, 16.1) than did men (8.3%; 95% CI: 5.8, 10.7).

IV.3 Prevalence and bivariate analysis

IV.3.1. Household SES and area level measures

Because of the small sample size, many prevalence estimates of ED visits and hospitalization varied greatly as revealed by wide 95% confidence intervals, especially for hospitalizations. However, females tended to show greater disparity in prevalence of ED visits and hospitalization according to SES as shown in Table IV.13 and Table IV.14. For example, in females, there was a clear gradient towards increased prevalence of ED visits as household income level decreased.

Table IV.13. Prevalence of ED visits according to SES and income inequality

	MALES *n=729*					FEMALES *n=1085*				
	Total	*Cases*	%	95% C. I.		*Total*	*Cases*	%	95% C. I.	
Household SES										
Income adequacy										
High	*338*	*41*	**14.1**	7.6	20.5	*470*	*65*	**11.6**	8.0	15.2
Middle	*239*	*55*	**24.2**	16.2	32.1	*321*	*70*	**17.3**	11.7	22.8
Low	*107*	*34*	**24.0**	9.1	38.9	*210*	*62*	**34.5**	25.1	43.9
Unknown.	**45**	**2**	-	-	-	**84**	**21**	**21.3**	**10.6**	**31.9**
Education status										
High: ≥ HSD	*648*	*104*	**17.0**	12.4	21.6	*956*	*180*	**15.8**	12.7	18.8
Low: < HSD	*81*	*28*	**28.8**	11.2	46.5	*129*	*38*	**33.4**	22.5	44.2
Employment Status										
High: ≥ 1 member employed	*592*	*92*	**15.7**	11.0	20.4	*871*	*157*	**14.8**	11.7	17.9
Low: No member employed	*130*	*38*	**27.4**	15.2	39.7	*196*	*58*	**29.2**	20.9	37.5
Unknown	7	2	-	-	-	18	3	-	-	-
Area-level SES (EA)										
IPPE										
High > $32,534	*339*	*42*	**15.3**	8.8	21.7	*463*	*53*	**10.1**	6.9	13.4
Low ≤ $32,534	*390*	*90*	**21.4**	15.0	27.9	*622*	*165*	**26.3**	21.4	31.1
Education % with no HSD										
Low: ≤ 32.56	*325*	*44*	**16.2**	9.9	22.6	*453*	*59*	**11.7**	8.1	15.4
High: > 32.56	404	88	**20.5**	14.1	26.8	632	159	**24.7**	19.8	29.6
Unemployment %										
Low: ≤ 8.40	364	50	**16.8**	10.3	23.2	468	58	**10.8**	7.1	14.4
High: > 8.40	365	82	**20.3**	13.9	26.6	617	160	**24.5**	19.4	29.6
Other area measure										
Gini coefficient (CD)										
Low: ≤ 0.374	359	65	**20.2**	12.9	27.5	534	116	**18.1**	13.2	23.0
High: > 0.374	370	67	**16.6**	10.9	22.3	551	102	**17.9**	13.6	22.2

IPPE: Income per person equivalent
EA: enumeration area; CD: census division
Prevalence is the proportion of respondents who reported at least one ED visit in the previous year.
HSD: high school diploma

Table IV.14. Prevalence of hospitalization according to SES and income inequality

	MALES *n=729*					**FEMALES** *n=1085*				
	Total	Cases	%	95% C. I		Total	Cases	%	95% C. I	
Household SES										
Income adequacy										
High	338	7	**2.3**	0.3	4.3	470	13	**2.3**	0.8	3.9
Middle	239	20	**10.0**	4.2	15.8	321	18	**5.6**	2.1	9.0
Low	107	14	**12.6**	1.6	23.5	210	17	**6.1**	2.2	10.0
Unknown.	45	1	-	-	-	84	9	**9.2**	2.6	15.8
Education status										
High: ≥ HSD	648	30	**5.1**	2.5	7.8	956	45	**3.5**	2.3	4.7
Low: < HSD	81	12	**16.2**	1.4	30.9	129	12	**10.4**	3.3	17.5
Employment Status										
High: ≥ 1 member employed	592	22	**4.1**	1.6	6.5	871	41	**4.1**	2.5	5.7
Low: No member employed	130	20	**16.1**	6.5	25.8	196	15	**5.9**	2.2	9.6
Unknown	7	0	-	-	-	18	1	-	-	-
Area-level SES (EA)	Total	Cases	%	95% C. I		Total	Cases	%	95% C. I	
IPPE										
High > $32,534	339	10	**2.9**	0.7	5.1	463	12	**2.4**	0.8	4.1
Low ≤ $32,534	390	32	**9.8**	4.9	14.7	622	45	**6.5**	4.0	8.9
Education % with no HSD										
Low: ≤ 32.56	325	11	**3.9**	1.2	6.6	453	10	**2.1**	0.6	3.6
High: > 32.56	404	31	**8.8**	4.1	13.6	632	47	**6.9**	4.3	9.4
Unemployment %										
Low: ≤ 8.40	364	13	**5.2**	1.4	8.9	468	14	**2.0**	0.6	3.3
High: > 8.40	365	29	**7.8**	3.5	12.2	617	43	**6.6**	3.9	9.3
Other area measure										
Gini coefficient (CD)										
Low: ≤ 0.374	359	18	**6.1**	2.4	9.8	534	30	**4.5**	2.1	6.9
High: > 0.374	370	24	**6.7**	2.6	10.7	551	27	**4.3**	2.4	6.1

IPPE: Income per person equivalent
EA: enumeration area; CD: census division
Prevalence is the proportion of respondents who reported at least one overnight hospitalization in the previous year.
HSD: high school diploma

Crude ORs according to various risk factors are not presented by sex because of the small sample size. In addition, the prevalence presented earlier showed that, based on the 95% confidence intervals that were quite wide (especially for hospitalization) and always overlapping, there were no noticeable dissimilarity between males and females. In fact, crude ORs stratified by sex were carried out but, as anticipated, no significant differences by sex were found based on the 95% confidence intervals (results not shown). Therefore, crude ORs are presented for the entire sample in Table IV.15.

In an effort to improve readability of the manuscript, unless stated otherwise, ORs for the association of "ED visits" with any other variable refers to reporting at least one ED visit in the previous year. Similarly, ORs for the association of "hospitalization" any other refers to reporting at least one "overnight hospitalization" in the previous year.

Table IV.15. Crude odds ratios for SES measures with ED visits and hospitalization

	ED visits			Hospitalization		
Household SES	**OR**	95% C. I.		**OR**	95% C. I.	
Income adequacy						
High	1.00			1.00		
Middle	**1.77**	1.14	2.73	**3.48**	1.68	7.18
Low	**2.92**	1.75	4.87	**4.15**	1.77	9.73
Unknown.	‡:	-	-	2.57	0.85	7.77
Education status						
High: ≥ HSD	1.00			1.00		
Low: < HSD	**2.35**	1.43	3.84	**3.33**	1.54	7.19
Employment Status						
High: ≥ 1 member employed	1.00			1.00		
Low: No member employed	**2.21**	1.45	3.37	**2.76**	1.46	5.24
Unknown	‡:	-	-	‡:	-	-
Area-level SES (EA)						
IPPE						
High > $32,534	1.00			1.00		
Low ≤ $32,534	**2.24**	1.51	3.3	**3.20**	1.73	5.92
Education % with no HSD						
Low: ≤ 32.56	1.00			1.00		
High: > 32.56	**1.85**	1.25	2.74	**2.86**	1.46	5.60
Unemployment %						
Low: ≤ 8.40	1.00			1.00		
High: > 8.40	**1.86**	1.25	2.77	2.09	0.97	4.48
Other area measure						
Gini coefficient (CD)						
Low: ≤ 0.374	1.00			1.00		
High: > 0.374	0.89	0.59	1.34	1.02 ‡	0.55	1.90

OR: odds ratio; 95%CI: 95% confidence intervals
IPPE: Income per person equivalent
HSD: high school diploma
Bold ORs are significant at α = 5%
‡: Very high variability
Odds ratios are for reporting at least one ED visit or at least one overnight hospitalization in the previous year.

There was a significantly increased risk of hospitalization as household income adequacy decreased: as compared to those with the highest household income, those in the middle segment were more than three times more likely to report hospitalization (OR=3.48) and twice as likely to report ED visits (OR=2.92). People with the lowest household income were four times more likely to report hospitalization (OR = 4.15). In addition, compared to their better-off counterparts, those living in low education households were more likely to report at least one hospitalization (OR=3.33) and one or more ED visit (OR=2.35). Likewise, respondents living in a household where no member had a current job were more prone to report being hospitalised at least once (OR = 2.76) and having had at least one ED visit (OR=2.21) in the past year.

Area-level SES showed fairly strong and statistically significant associations with hospitalization and, to a lesser extent, with ED visits; those living in low IPPE area were three times more likely to report a hospitalization (OR=3.20) and twice more likely to have one or more ED visit (OR=2.24). Similarly, asthma patient living in communities with low education levels were more likely to report a hospitalization (OR=2.86) and a ED visit (OR=1.85).

IV.3.2. Individual-level covariates

Based on the 95% confidence intervals, there was no significant dissimilarity in the prevalence of ED visits or that of hospitalization between males and females. Please see appendices VII.12 and VII.13 for more information.

Based on the crude ORs estimates, nine covariates were significantly associated with increased risk of ED visits (appendix VII.14). The larger OR estimates were for physician visits ($\geq$2 vs $\leq$1 visits, OR=6.33), at least one asthma attack (OR=4.10), a visit to a specialist (OR=3.66) and weekly sleep disturbances due to asthma (OR=3.05). The other five risk factors were having received medical information from a nurse, having been prescribed antiinflammatory and bronchodilators medications, having asthma symptoms at least once a month and finally having been diagnosed with COPD. Among these nine factors mentioned above, eight were also associated with higher risk of hospitalization (except asthma symptoms). The strength and direction of the associations were roughly comparable to those described earlier. Please refer to appendix VII.14 for all crude ORs.

IV.4 Adjusted associations of ED visits and hospitalizations with SES and income inequality

The full models, which included 20 covariates in addition to one measure of SES or income inequality, clearly showed that all six measures of low SES at both levels were significantly associated with higher risk of ED visits after adjustment for all the covariates. A higher risk of hospitalization was also associated with all three measures of low area-level SES and only one measure at the household level, that is, low and middle household income adequacy. Fully adjusted ORs for the association between hospitalization and SES measures showed much wider 95% confidence intervals than those involving ED visits; they also showed larger differences between crude and fully adjusted ORs. The magnitude of ORs for household-level SES decreased more noticeably (maximum decrease of -27% for hospitalization and -21% for ED visits) than that of area-level associations (see tables in appendix 0). Among the 20 covariates, eight were significantly associated with ED visits, whereas only four covariates were significantly associated with hospitalization. The strength and direction of associations of a covariate with a given outcome (ED visits or hospitalization) were quite comparable regardless of the main exposure (SES measure or income inequality) in the model involved (Cf. appendix VII.16).

Rather than the full models, the following sections present a more detailed description of final adjusted associations, that is, the association estimates from the most parsimonious models adjusted for 10 covariates after backward elimination processes. These 10 covariates induced a change greater than 10% (compared with fully adjusted ORs) in at least one of the main studied associations when dropped from the models. They are age, sex, number of attacks, allergy, COPD, smoking status, specialist visits, physician visits, urban/rural residency and medical information received from a specialist. Results of the most parsimonious models (final models) are reported for the association of each of the two outcomes with each of the six measures of SES as well as income inequality (i.e., 14 final models). Fully adjusted ORs, final adjusted ORs were of similar magnitude and precision except for the association between hospitalization and unemployment rate, which reached the critical point of statistical significance.

Asthmatics from households with middle income, low income, low educational or low employment status (no member employed) had an increased risk of reporting an ED visit as compared with their better-off counterparts. Those living in an area with low IPPE, a high percentage of poorly educated people or a high unemployment rate, were at higher risk of ED visits than those living in less deprived areas. Asthmatics living in households with middle income or low income were at higher risk of hospitalization than their better-off counterparts. They were also at higher risk of hospitalization if they lived in areas with low IPPE, high percentage of poorly educated people or high unemployment rate. Please note that low household education and low job status were possibly associated with higher risk of hospitalization; however, the conventional 5% level of statistical significance was not reached (*p-value*=0.07).

As shown by wider 95% confidence intervals, the ORs estimates for the associations between hospitalization and SES were of lesser precision than those involving ED visits. Finally, income inequality was not associated with hospitalization or ED visits but, the association with hospitalization may still not be correctly assessed (high variability). In summary, all SES measures at both household and area levels were significantly associated with a higher risk of ED visits, and while all three measures of area-level deprivation were significant predictors of an increased risk of hospitalizations, only low and middle household income was associated with higher risk of hospitalization. The following tables show ORs for the final adjusted associations.

Table IV.16. Adjusted odds ratios for SES or income inequality with ED visits and hospitalization

	ED visits	Hospitalization
Household SES	**OR** (95% CI)	**OR** (95%CI)
Income adequacy		
High	1.00	1.00
Middle	**1.75** (1.08, 2.84)	**3.52** (1.63, 7.60)
Low	**2.39** (1.27, 4.52)	**3.25** (1.20, 8.85)
Unknown.	1.36 (0.64, 2.90)	**3.69** (1.01, 13.41)
Education status		
High: ≥ HSD	1.00	1.00
Low: < HSD	**2.62** (1.33, 5.17)	2.88 (0.90, 9.20) ‡
Employment Status		
High: ≥ 1 member employed	1.00	1.00
Low: No member employed	**2.39 (1.31, 4.36)**	2.14 (0.94, 4.85) ‡
Unknown	†	†
Area-level SES (EA)		
IPPE		
High > $32,534	1.00	1.00
Low ≤ $32,534	**2.36** (1.49, 3.73)	**3.71** (1.84, 7.47)
Education % with no HSD		
Low: ≤ 32.56	1.00	1.00
High: > 32.56	**2.10** (1.32, 3.35)	**3.59** (1.67, 7.70)
Unemployment %		
Low: ≤ 8.40	1.00	1.00
High: > 8.40	**2 .00**(1.29, 3.11)	**2.36** (1.04, 5.32)
Other area measure		
Gini coefficient (CD)		
Low: ≤ 0.374	1.00	1.00
High: > 0.374	0.76 (0.47, 1.24)	0.89 (0.45, 1.77) †

ORs from final models are adjusted for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, and physician visits, urban/rural residency and medical information received from a specialist

IPPE: Income per person equivalent

HSD high school diploma

EA: enumeration area

CD: Census division

†: very high variability; ‡: *p-values* are 0.07

Odds ratios are for reporting at least one ED visit or at least one overnight hospitalization in the previous year.

For employment status, 139 were students or retirees who lived in households where no member had a job. Unemployment was significantly associated with increased risk of ED visit and the results were similar when these 139 respondents were either grouped into the 'employed' or 'unemployed' categories An elevated likelihood of hospitalization was also observed in the unemployed group; however, the association was not statistically significant (Table IV.17).

Table IV.17. Adjusted odds ratios for unemployment with ED visits and hospitalization

	OR for ED visits	OR for hospitalization
When 139 unemployed students & retirees were recoded as employed	**OR** (95% CI)	**OR** (95% CI)
High: ≥ 1 member employed	1.00	1.00
Low: No member employed	2.26 (1.08, 4.75)	2.40 (0.92, 6.28)
When 139 unemployed students & retirees were recoded as unemployed		
High: ≥ 1 member employed	1.00	1.00
Low: No member employed	2.39 (1.31, 4.36)	2.14 (0.94, 4.85)

ORs from final models are adjusted for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, and physician visits, urban/rural residency and medical information received from a specialist
95% CI: 95% confidence intervals
Odds ratios are for reporting at least one ED visit or at least one overnight hospitalization in the previous year.

Among the 10 covariates included in final adjusted models, only five were significantly associated with hospitalization and/or ED visits: having at least one asthma attack, having a specialist visit and having at least two physician visits was associated with a higher risk of hospitalization and ED visits. On the contrary, as compared to non-allergic, people with allergies were at lesser risk of hospitalization and ED visits; however, allergic status was significant predictor at $p \leq 0.05$ in 5 instances. Table IV.18 summarises the main results and presents the maximum value and minimum value among the seven ORs obtained from each one of the seven final models (each of those models included one main exposure and 10 covariates). More details are available in appendices VII.17 and VII.18.

Table IV.18. Adjusted odds ratios for significant covariates associated with ED visits and hospitalization

	ED visits		Hospitalization	
	OR Minimum	OR maximum	OR Minimum	OR maximum
Asthma attacks				
None	1	1	1	1
≥ 1 attack	3.49	3.88	4.51	5.26
Allergy				
No	1	1	1	1
Yes	0.59	0.63	0.47	0.50
Visit to specialist				
No	1	1	1	1
Yes	2.55	2.83	2.28	2.74
Physician visits				
≤1 visit	1	1	1	1
≥ 2 visits	4.43	4.88	2.91	3.32

ORs from final models are adjusted for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visits, urban/rural residency and medical information received from a specialist.
The maximum OR is the value of the larger OR estimate among 7 final models.
The minimum OR is the value of the smaller OR estimate among 7 final models.

IV.4.1. Change of the association estimates for ED visits or hospitalization with SES due to covariates

The results from the literature may diverge from ours partly because of difference in covariates adjustment. Therefore, it was important to determine which covariates induced changes in the estimated ORs for the main associations under study. Although change in ORs occurred for household SES and (less often) for area SES measures, only the changes induced by covariates in the ORs for household-level SES were compatible with possible confounding or intermediate variable. The change was measured as the percentage difference between the OR value when the potential confounding or intermediate variable was dropped from the *final* model and the OR value from the corresponding *full* models. Possible confounding or intermediate variable was considered if the three following criteria are met; 1) When dropped from the final model, the covariate should induce a >10% change for the main studied association; 2) the covariate had to be associated with the outcome

(ED visits and/or hospitalization); and 3) the covariate had to be associated with the main exposure (one of the SES measures) in question.

The relationships between ED visits and SES measures were generally more consistent and less prone to change than those between hospitalization and SES when covariates were withdrawn from the models. All 10 covariates (except age and sex) induced more than 10% change in the associations of SES with hospitalization whereas three of them induced such a change in the association of SES with ED visits. However, only two covariates met the three criteria mentioned earlier for the association of SES and ED visits (asthma attacks and physician visits) and four covariates (asthma attacks, COPD, specialist visits and physician visits) had a confounding effect on the relationships between SES and hospitalization. Crude ORs for the associations between those four covariates and hospitalization or ED visits are presented in appendices VII.14 and the following Table IV.19 shows the crude ORs of the associations between SES and those four covariates.

Table IV.19. Crude odds ratios for the association between SES measures and individual covariates

	Asthma attacks	**COPD**	**Visit to specialist**	**Number of physician visits**
	≥1 vs. None	*Yes vs. No*	*≥1 vs. None*	*≥2 vs. ≤1*
Household income				
High		1		1
Middle	nc	**1.84** (1.13, 2.97)	nc	1.27 (0.91, 1.78)
Low	nc	**2.83** (1.69, 4.75)	nc	**2.18** (1.40, 2.39)
Household education				
High	1	1	1	1
Low	**0.56** (0.34,0.91)	**5.25** (3.09, 8.90)	**1.99** (1.21, 3.28)	**1.79** (1.09, 2.92)
Household job status				
Employed				1
Unemployed	nc	nc	nc	**1.69** (1.17, 2.46)

95% Confidence intervals are enclosed in brackets
nc: Not compatible with confounding or intermediate variable (according to the 3 criteria mentioned in the text)
Bold ORs are significant at α = 5%
COPD: Chronic bronchitis or emphysema

Changes in the odds ratios of the association between household SES and ED visits, by confounding or intermediate covariates

When the variable asthma attacks was dropped from the final models, the magnitude of the association of ED visits with household education level fell by 23.6% below the corresponding fully adjusted OR. Respondents with lower household education level were less likely to report asthma attacks than those with higher education level (OR=0.56), even though they did report an ED visit 4.10 times more often (see crude ORs of the association between covariates and ED visits in appendix VII.14).

When number of physician visits was no longer accounted for, the association of ED visits with low household income and low household job status were reinforced (+22.3% and +10.3%, respectively). Respondents from households with low income or no employment were, respectively, 2.18 and 1.69 more likely to report two or more physician visits than those from more privileged households. Also, those who had two or more physician visits were 6.33 times more likely to report an ED visit than those who had less than one visit (see appendix VII.14). The changes in ORs (compatible with confounding or intermediate variable) of the association of SES with ED visits that were described in this section are summarized in the following Table IV.20. For complete table of change in ORs, please refer to appendix VII.19.

Table IV.20. Changes in the odds ratios for household SES and ED visits, by confounding or intermediate covariates

	ORs for the association between household SES and ED visits		
	Household income	**Household education**	**Household Employment**
	Low vs. high	Low vs. high	Unemployed vs. employed
Full models: ORs for SES	**2.31**	**2.61**	**2.34**
Final models: ORs for SES	**2.39**	**2.62**	**2.39**
ORs (% change) **when a covariate was removed from the final models**			
Asthma attacks (yes vs. no)	nc	**1.99** (-23.6%)	nc
Physician visits (≥2 vs. ≤1)	**2.82** (+22.3%)	nc	**2.58** (+10.3%)

Final models are adjusted for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visits, urban/rural residency and medical information received from a specialist.

ORs from full models are adjusted for all 20 covariates

(%): change in adjusted OR when one covariate was removed, compared to full model

nc: Not compatible with confounding or intermediate variable (according to the 3 criteria mentioned in the text)

Changes in the odds ratios of the association between household SES and hospitalization, by confounding or intermediate covariates

When the variable "asthma attacks" was not adjusted for, the OR for the association of education with hospitalization drop by 13.8%. Asthma attacks was positively related to hospitalization and was negatively related to low household education (asthmatics with low education reported less frequently asthma attacks than those with higher education level).

When "having a specialist visit" was not accounted for, the OR for the association between household education level and hospitalization increased by 16.6%. Respondents with low education level were twice more likely to have a visit to a specialist than those from households with high education level and "visit to a specialist" was associated with higher risk of hospitalization. When "physician visits" was not taken into account, the OR for the associations of hospitalization with low household income and low household education, increased by 24.2% and 20.0%, respectively. Those with low household income and education were more likely to report ≥2 physician visits.

Similarly, when diagnosis of COPD was not accounted for, the ORs for the association of hospitalization with low household income and with low household education, increased by 14.2%, and 19.9% respectively.

The changes in ORs of the association of SES with hospitalization that were described in this section are summarized in the following Table IV.21. For complete table of change in ORs, please refer to appendix VII.20. Crude ORs for the associations of covariates and hospitalization are presented in appendix VII.14.

Table IV.21. Changes in the odds ratios for household SES and hospitalization, by confounding or intermediate covariates

	ORs for the association between household SES and hospitalization	
	Household income Low vs.high	**Household education** Low vs. high
Full models	**3.03**	**2.64**
Final models	**3.25**	**2.88**
ORs (% change) **when a covariate was removed from the final models**		
Asthma attacks (yes vs. no)	nc	**2.28** (-13.8%)
COPD (yes vs. no)	**3.46** (+14.2%)	**3.16** (+19.9%)
Visit to specialist (yes vs. no)	nc	**3.08** (+16.6%)
Physician visits (≥2 vs. ≤1)	**3.76** (+24.2%)	**3.17** (+20.0%)

Final models are adjusted for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visits, urban/rural residency and medical information received from a specialist.

ORs from full models are adjusted for all 20 covariates

(%): change in adjusted OR when one covariate was removed, compared to full model

nc: Not compatible with confounding effect by covariate

COPD: Chronic bronchitis oe emphysema

IV.5 Adjustment for other SES measures

IV.5.1. Cross-level adjustment for SES measure of comparable nature

This section describes the changes in the ORs of household-level SES when the corresponding area-level measure was accounted for, and vice versa. The OR estimates for the association of ED visits with middle and low household income decreased and became statistically non-significant when area IPPE was taken into account, whereas that for area IPPE remained significant. While remaining significant, the OR for household education diminished by 15% if area-level education was accounted for. The OR estimates of the associations between ED visits or hospitalization with household unemployment and high area unemployment rate were remarkably stable and no substantial changes were observed when they were put in the presence of one another. The results are summarized and presented in Table IV.24.

Finally, adjustment for income inequality did not change the ORs of the association of either area-level IPPE or household income with ED visits or hospitalizations (results not shown).

Table IV.22. Change in the odds ration for SES when the corresponding cross level SES measure was accounted for

Table IV.22-A Change in odds ratios for the association of SES with ED visits

	Models with two SES measures			*Change*	*Change*	Models with one SES measure		
Model-1	**OR**	95% CI		*in OR †*	*in VAR.†*	**OR**	95% CI	
Household income								
High	1.00					1.00		
Middle	1.51	0.93	2.47	*-14%*	*3%*	**1.75**	1.08	2.84
Low	1.88	0.95	3.72	*-21%*	*14%*	**2.39**	1.27	4.52
Area IPPE $								
High: > 32,534	1.00					1.00		
Low: ≤ 32,534	**2.07**	1.28	3.35	*-12%*	*11%*	**2.36**	1.49	3.73
Model-2								
Household education								
≥ 1 member has HSD	1.00					1.00		
No member has HSD	**2.22**	1.13	4.36	*-15%*	*0%*	**2.62**	1.33	5.17
Area education (% without HSD)								
High: ≤ 32.56	1.00					1.00		
Low: > 32.56	**1.92**	1.21	3.05	*-9%*	*-1%*	**2.10**	1.32	3.35
Model-3								
Household job status								
≥ 1 member employed	1.00					1.00		
No member employed	**2.30**	1.23	4.29	*-4%*	*7%*	**2.39**	1.31	4.36
Area unemployment %								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	**2.06**	1.32	3.24	*3%*	*5%*	**2.00**	1.29	3.11

Table IV.22-B Change in odds ratios for the association of SES with hospitalization

	Models with two SES measures			*CHANGE*	*CHANGE*	Models with one SES measure		
Model-1	**OR**	95% CI		*IN OR †*	*IN VAR.†*	**OR**	95% CI	
Household income								
High	1.00					1.00		
Middle	**2.91**	1.29	6.58	*-17%*	*12%*	**3.52**	1.63	7.60
Low	2.46	0.88	6.88	*-24%*	*6%*	**3.25**	1.20	8.85
Area IPPE $								
High: > 32,534	1.00					1.00		
Low: ≤ 32,534	**3.12**	1.50	6.50	*-16%*	*10%*	**3.71**	1.84	7.47
Model-2								
Household education								
≥ 1 member has HSD	1.00					1.00		
No member has HSD	2.26	0.73	6.97	*-22%*	*-6%*	2.88	0.90	9.20
Area education (% without HSD)								
High: ≤ 32.56	1.00					1.00		
Low: > 32.56	**3.32**	1.55	7.13	*-7%*	*0%*	**3.59**	1.67	7.70
Model-3								
Household job status								
≥ 1 member employed	1.00					1.00		
No member employed	2.12	0.92	4.85	*-1%*	*3%*	2.14	0.94	4.85
Area unemployment %								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	**2.30**	1.01	5.25	*-2%*	*2%*	**2.36**	1.04	5.32

*: All ORs are from final models that include 10 covariates: age, sex, attacks, allergy, COPD, smoking, specialist visits, physician visits, urban/rural residency and medical information received from a specialist

† compare final model including two SES measures at once with final model including one SES measure.

IPPE: income per person equivalent

IV.5.2. Adjustment for same level SES measures

Contrary to the preceding section, the changes in the associations were more considerable when all three SES measures from the same level were in same models (change ranging from -11% to -42%). Indeed, while each one of the three household-level SES measures were significantly associated with ED visits when they were included alone in the models, they were not anymore so when all three were included in the same model. However, the relationships of hospitalization with middle household income remained significant (OR=3.12, 95% CI: 1.41, 6.89) despite an 11% drop in magnitude. Similarly, the magnitude of the OR estimates for the associations of area-level SES with ED visits or hospitalization dropped substantially when all three area-level SES measures were included in the model. All corresponding ORs, became non-significant with the exception of area-level education which remained significantly associated with hospitalization (OR=3.12, 95% CI: 1.41, 6.89) despite a 33% drop in OR's magnitude. Please see appendix VII.21 and appendix VII.22for detailed results.

In an attempt to determine whether two same level SES variables may be measuring some shared characteristics, six models, which included any combination of two same level SES variables, were run for each outcome (ED visits or hospitalization). When ED visits was the outcome, both household education and low income remained significant when introduced in the same model. Household employment status remained significant when either household income or education were accounted for; whereas education was no more significant when in the presence of employment status. When hospitalization was the outcome, only household income remained significant whether education or unemployment status was adjusted for (see appendix VII.23).

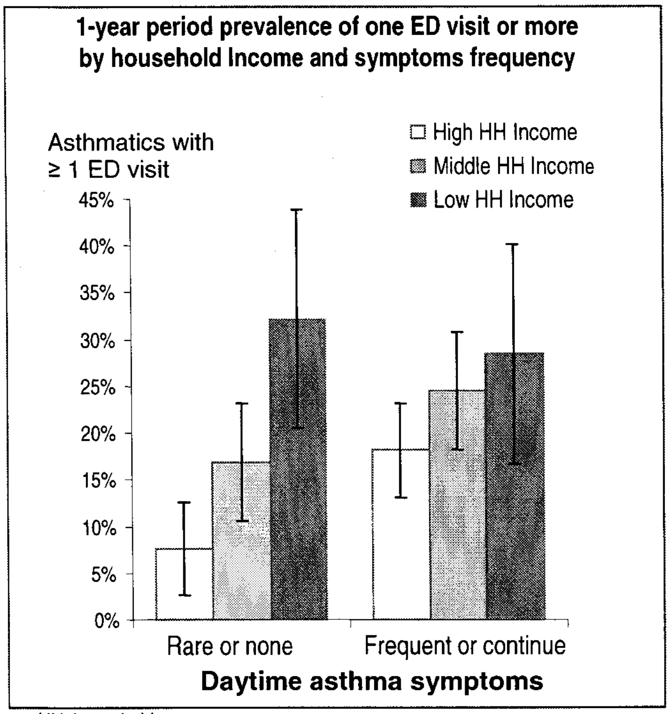
As for area-level SES, when ED visits was the outcome, the effect of area IPPE remained significant when any of unemployment rate or area education was taken into account. On the contrary, the two latter variables became non-significant when in presence of IPPE. The alterations obtained with hospitalization as outcome were of the same direction and pattern excepting the following: the decrease in magnitude of associations was more pronounced, area unemployment rate was never significant if another same level SES variable was in the model and finally, area education remained significant despite the presence of area IPPE in the model (please see appendix VII.24

In summary, with the noticeable exception of income, the OR for an SES measure at one level was moderately or not altered when its area level counterpart was taken into account and vice versa: their effects were quite independent. On the contrary, household level SES measures interfere quite extensively with one another. Similarly, area SES measures also interfere with one another although less markedly. This reveals that our approach of multiple separate modeling strategies using one SES measure at a time has the advantage of circumventing the possible multiple collinearity that may have arisen.

IV.6 Modification of the effect of household income by asthma symptoms

At the 10% error level there was no effect modification on a multiplicative scale, between household- and area-level SES measures of the same nature. Similarly, no effect modification was detected between income inequality (at both census division and provincial levels) and household income adequacy or area IPPE. Age, sex, asthma attacks and sleep disturbance due to asthma did not modify the relationships between any of the SES measures and hospitalization or ED visits. However, asthma symptoms frequency may interact with household income adequacy in its relationship with ED visits. The regression coefficient of the interaction term for the product of low income adequacy with more frequent asthma symptoms was -1.14 and the p-value for the Wald $\chi 2$ test was 0.04; however, its complimentary product term (middle income with frequent asthma symptoms) was not significant (p-value = 0.29). The association of low household income adequacy (vs. high) with ED visits was three times larger in asthmatics with no or rare symptoms (OR=4.87, 95%CI: 1.92, 12.33) than in those with more frequent symptoms (OR=1.55, 95%CI: 0.72, 3.34).

Figure IV.1. Prevalence of ED visits according to household income and symptom frequency



HH: household

Figure IV.2. Odds ratios for asthma daily symptoms and ED visits according to household income

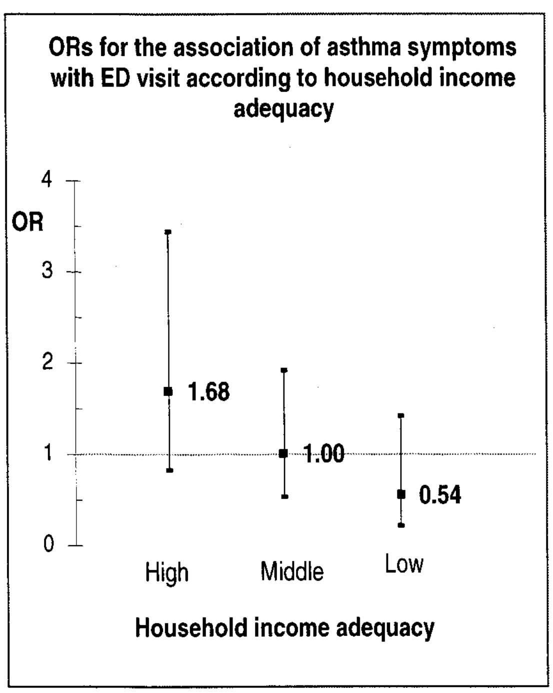
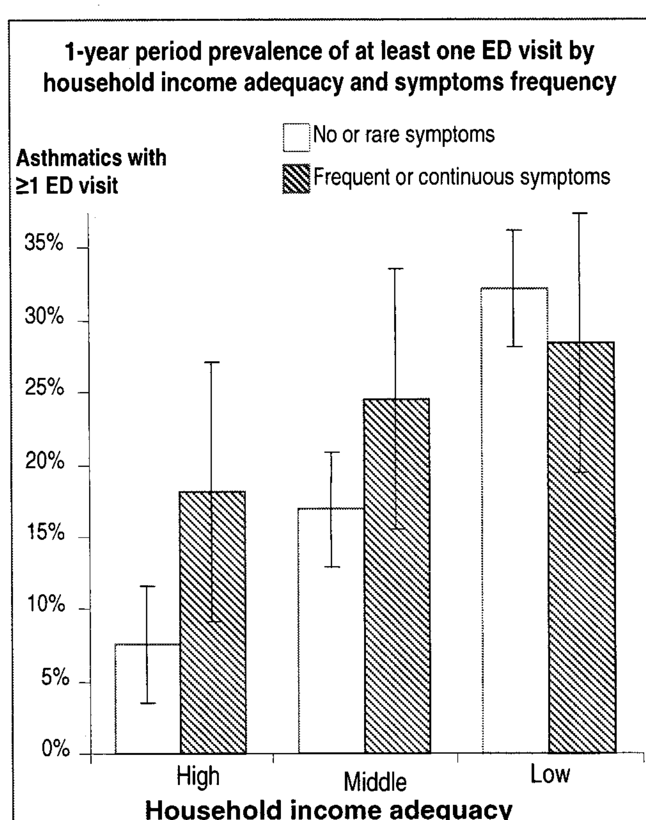


Figure IV.3. ED visits prevalence according to household income and asthma symptoms frequency



The association of more frequent asthma symptoms (vs. rare/no symptoms) with ED visits was negative in asthmatics with low household income adequacy (OR=0.54, 95%CI: 0.21, 0.41), nil in those with middle household income adequacy (OR: 1.00) and positive in those with high income adequacy (OR: 1.68, 95%CI: 0.82, 3.43). In other words, the effect of symptoms frequency became less strong as household income increased (Table IV.23).

Table IV.23. Adjusted odds ratios for the association of household income and ED visits modified by symptoms frequency

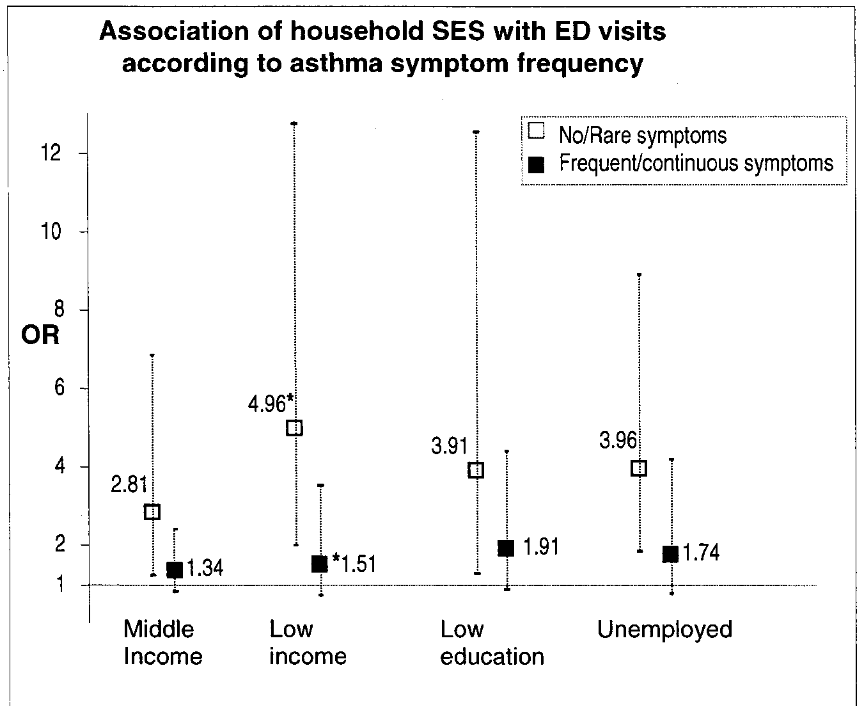
		In asthmatics with rare or no symptoms	In asthmatics with frequent or continuous symptoms
Household income adequacy		OR (95% CI.)	OR (95% CI.)
	High	1.00	1.00
	Middle	2.38 (1.01, 5.6)	1.42 (0.84, 2.4)
	Low	**4.87** (1.92, 12.33)	**1.55** (0.72, 3.34)

Asthma symptoms (Frequent/continuous vs. rare/none)	OR (95% CI.)
in high household income respondents	**1.68 (**0.82, 3.43)
in middle household income respondents	1.00 (0.52, 1.92)
in **low** household income respondents	**0.54 (**0.20, 1.41)

All ORs are from final models that include 10 covariates: age, sex, attacks, allergy, COPD, smoking, specialist visits, physician visits, urban/rural residency and medical information received from a specialist

Although no statistically significant interaction between household education or employment status and symptom frequency in their relation with ED visits, the ORs for the association of household-level SES measures with ED visits tended to be always larger in those with less frequent symptoms (none or rarely) than in those with more frequent symptoms (continuously or often). Figure IV.4 illustrates the change of association between the three measures of household-level SES and ED visits according to the frequency of symptoms.

Figure IV.4. Odds ratios for household SES and ED visits according to asthma symptoms



The reference categories for income, education and employment status are,
high income, high education and currently employed, respectively.
*: significant interaction on a multiplicative scale as shown by the product interaction term

IV.7 Relation between primary care services use and SES

This section will address questions included in objective-2c and is devoted to the description of any differential use of primary-care services (having a regular doctor, specialist visits, physician visits, asthma treatment prescription and source of medical information received) according to SES. To do so, one model was fitted for each one of the nine primary health services (as outcome) and each one of the main exposures (three household- and three area-level SES variables as well as income inequality) while adjusting for asthma severity indicators, co-morbidity factors, sex and age.

We found no significant association between any of the six measures of SES and having a regular doctor, having visited a specialist, having been prescribed asthma treatment (antiinflammatory and bronchodilators drugs) and having ever received information from a specialist, a nurse or a voluntary organisation. However, those with low household income reported more frequently two or more physician visits than those from high household income (OR=2.15 (95% CI: 1.20, 3.85), and those from households with low education were less likely than their better-off counterparts to report non-compliance to prescribed medication(OR=0.39, 95% CI: 0.16, 0.97). Finally, low household education was related to lesser likelihood of receiving information from a family doctor (OR=0.43 and 95% CI: 0.25, 0.77). The OR was identical when also accounting for having a regular doctor, a specialist visit and received information from a specialist.

Neighbourhood -level SES measures were not associated with health service use, although asthmatics living in areas with high income inequality were more likely to have received medical information from a specialist (OR=1.46, 95% CI: 1.07, 1.99) or from a voluntary organisation (OR=1.75, 95% CI: 1.20, 2.56) than those living in low income inequality areas.

IV.7.1. Utilisation of primary care services and severity

Respondents who reported asthma attacks, compared to those who did not, were more likely to have been prescribed antiinflammatory medications (ORs ranging from 1.51 to 1.54), bronchodilators medications (ORs, from 1.93 to 2.01), to report two or more physician visits (ORs, from 2.05 to 2.13) and to have received medical information from a nurse (ORs, from 1.46 to 1.50). Also, respondents with at least one sleep disturbance per week were more likely to report two or more physician visits than those with less frequent sleep disturbance (ORs, from 2.21 to 2.37). They may also have received more information from a nurse (ORs ranged from 1.53 to 1.54), statistical significance was marginal. As compared with participants with less frequent asthma symptoms, those stating more frequent symptoms, reported more often having been prescribed antiinflammatory medications (ORs ranging from 1.53 to 1.54) or bronchodilators (ORs ranging from 1.67 to 1.71) and to have had two or more physician visits (ORs ranging from 2.32 to 2.38). Contrary to those reporting more asthma symptoms or asthma attacks, those who experienced more sleep disturbance, were not more likely to have been prescribed antiinflammatory therapy.

IV.7.2. Utilisation of primary care services and co-morbidity factors

As compared to occasional or non-smokers, daily smokers were less likely to report antiinflammatory medications prescription (ORs ranging from 0.57 to 0.60), to have a regular doctor (ORs ranging from 0.51 to 0.57) and to have received information from a specialist (ORs ranging from 0.50 to 0.53) or from a voluntary organization (ORs ranging from 0.57 to 0.61). They were also more likely to report treatment non-compliance (ORs ranging from 2.12 to 2.23). Also, compared to asthmatics without a diagnosis of COPD, those with such diagnosis were more likely to have been prescribed bronchodilators drugs (ORs ranging from 1.78 to 1.89) to report two or more physician visits (ORs ranging from 1.66 to 1.85) and possibly to have had a specialist visit (however, only one out of seven associations was significant, OR=1.75). Still, they were less likely to report that they had received information from a specialist (ORs ranging from 0.58 to 0.64). Allergy was not associated with primary care services utilisation.

In summary, there was no evidence that respondents with low SES were less likely to have a regular doctor, to have used at least once in the past year primary services such as a specialist visit or a treatment prescription, or to have had two or more physician visits. However, low household education was negatively associated with information ever received from a specialist and treatment non-compliance in the last month. Asthma severity was positively related to having used at least some primary health services, such as treatment prescription (antiinflammatory drugs and bronchodilators), at least two physician visits and information ever received from a nurse. Although, contrary to asthma attacks or asthma symptoms, the frequency of sleep disturbances was not associated with higher prevalence of treatment prescription. Finally, current daily smokers were less likely to report at least some use of service in the past year and more likely to be non-compliant to treatment.

IV.8 Other findings

IV.8.1. Individual vs. household SES

As indicated by the magnitude of the odds ratios, education measured at the individual level was less strongly associated with ED visits than education measured at the household level (as shown by a -32.9% differences in magnitude in odds ratios of final models). Individual job status was less strongly associated with ED visits than its household level equivalent, though the difference in strength (-16.9%) was not as large as that found for education status. The association of individual education with hospitalization was also less strong (-34.2%) than that of household-level education with hospitalization. However, the association of hospitalization with job status, measured at the individual level were almost identical to that measured at the household level (Table IV.24).

Table IV.24. Adjusted odds ratios for SES with ED visits and hospitalization: Individual vs. household-level SES

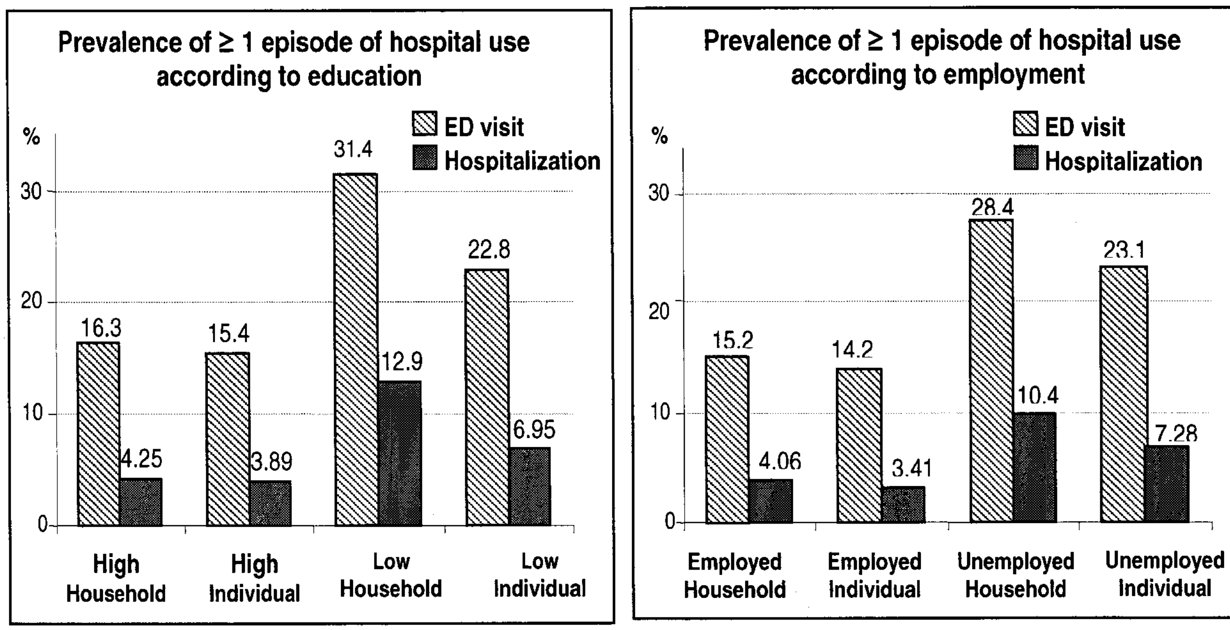
Odds ratios for ED visits	Individual level			Household level		
	OR	95%	CI	OR	95%	CI
Education status						
High	1.00			1.00		
Low	**1.76**	1.10	2.82	**2.62**	1.33	5.17
Job status						
Employed	1.00			1.00		
No current job	**1.99**	1.25	3.16	**2.39**	1.31	4.36

Odds ratios for hospitalization	Individual level			Household level		
	OR	95%	CI	OR	95%	CI
Education status						
High	1.00			1.00		
Low	1.89	0.78	4.60	2.88	0.90	9.20
Job status						
Employed	1.00			1.00		
No current job	2.14	0.99	4.61	2.14	0.94	4.85

All ORs are from final models and are adjusted for 10 covariates: age, sex, asthma attacks, COPD diagnosis, smoking status, specialist visit, physician visits, urban/rural residency status and medical information ever received from a specialist.
Household level SES: Highest SES level achieved by any member of the household
Individual-level SES: SES level achieved by the respondent himself

Closer inspection showed that prevalence of hospital uses was similar in those with high SES whether SES was ascertained using individual- or household-level information. On the contrary, low SES respondents had higher prevalence of hospital use when SES was based on household information than when SES was ascertained based on individual information (Figure IV.5). Those differences were present in women, men, adults and children, although they were slightly more noticeable for education level than for employment status, and in women than in men (results not shown).

Figure IV.5. Prevalence of one or more episode of hospital use by SES according to level of measurement (household vs. individual)



IV.8.2. Average area household income or average area IPPE associated with ED visits or hospitalization

The ORs for the association between ED visits and average area household income (i.e. when household size was not taken into account) were somewhat larger than those for the association between ED visits and IPPE: +8.9% for ORs from final models. There were virtually no differences between the association of hospitalization with average area household income and that of hospitalization and IPPE.

Table IV.25. Adjusted odds ratios for ED visits and hospitalization associated with SES: Average area household income vs. IPPE

ORs for ED visits Area IPPE $	OR	95% CI		Area household income $	OR	95% CI	
High (> 32,534)	1.00			High (> 47,491)	1.00		
Low (≤ 32,534)	**2.36**	1.49	3.73	Low (≤ 47,491)	**2.57**	1.60	4.13

ORs for hospitalization Area IPPE $	OR	95% CI		Area household income $	OR	95% CI	
High (> 32,534)	1.00			High (> 47,491)	1.00		
Low (≤ 32,534)	**3.71**	1.84	7.47	Low (≤ 47,491)	**3.68**	1.86	7.28

IPPE: Household income per person equivalent
All ORs are adjusted for 10 covariates: age, sex, asthma attacks, COPD diagnosis, smoking status, specialist visit, physician visits, urban/rural residency status and medical information ever received from a specialist.

Summary of key findings

After controlling for various individual-level factors, each measure of low SES (education, income or unemployment) at the area level was found to be a strong predictor for increased risk of ED visits and hospitalization. Living in a middle-income household, compared with living in a high-income household, was a risk factor for hospitalization but not for ED visits. Low household education and having no job were positively related to ED visits. Our results also suggest that the relationship between low household income and ED visits may be stronger in respondents reporting rare or no symptoms as opposed to those reporting frequent or continuous symptoms.

We unexpectedly found that respondents with low household education were less likely to report one or more asthma attack than those with higher household education despite the fact that they reported more often at least one ED visit in the previous year.

Finally, the relationship between ED visits or hospitalization and SES was not explained by more contacts with key primary health services use in favour of high household SES respondents and there was no differential use of those services in favour of high SES respondents.

After controlling for age, sex, asthma severity and comorbidity factors, we found that primary health services use such as having a regular doctor, treatment prescription, and specialist visit was similar among different SES.

V. DISCUSSION

The Andersen model served as a basis for the selection of variables to be studied in this research project. It was initially developed in the late 1960s to assist the understanding of how and why health services were used and to define, measure and promote equitable access to health care, especially in disadvantaged people. However, in this study, we focused on SES as the main exposure and considered other variables as covariates in order to obtain valid estimates of the relation between SES and hospital use. This approach has been used by others (115).

The first part of this section compares our results to other studies on the difference in hospital use (at least one ED visit or at least one hospitalization in the past 12 months) by socioeconomic factors. The second part considers the different use of primary health services according to SES. The third part explores the significance and interpretations of those results.

V.1 SES and hospital use

V.1.1. Household education level

In a community-based sample (San Diego - USA-) of 193 Latino children aged 3 to 17 years, those whose parent had less than a high school education, had a higher risk of ED visits but not hospitalization in the past year (OR=2.2) even after controlling for a wide range of factors including asthma severity, insurance status, bedroom triggers and having a controller medication (148). In spite of the different target populations, our results are in line with the results above-mentioned. The estimated OR in our study for the association of ED visits with household income adequacy was of the same magnitude and hospitalization was not associated with low household income as well (except the crude association, which was significant). Lack of power was not likely the cause given the estimate of power that we calculated (~90%), however the latter was based on a crude (rather than adjusted) OR of 3.33.

An unexpected finding in our analysis was that low household education was associated with less reported asthma attacks and more ED visits. The reason for this is not known; A selective recall bias might have taken place with underestimation of past occurrence of attacks, due for example to health attitudes involving a certain degree of symptom denial in those with low education. It is also possible that a differential in symptom perception by household educational attainment could lead to an underestimation of asthma attacks in those living in household with low education.

Three other studies assessed the risk of repeated ED visits (not just ED visits) using clinic- or hospital-based samples. A clinic-based sample study, found a two-fold risk of reporting a repeated ($\geq$2 in the past year) ED visits in children whose parent education was less than a high school degree (149). Similarly, in Ottawa (Canada), in a hospital based sample of 339 adults, post-secondary education was found to be marginally associated with a 60% increased risk of repeated ED visits in the past year ($\geq$3 vs. 1); however, no other factor was accounted for (*63*). In another hospital based sample of adults in Harlem, low education was not related to an increased risk of repeated ED visits ($\geq$2 vs. 1) in adults (150) even when the crude estimate was considered.

Better education may confer values and beliefs that promote healthier lifestyles, more preventive health behaviours and better health knowledge and resources to cope with stressful events (22, 151). Some proposed pathways are presented in the first section of the thesis.

V.1.2. Household-level income

A prospective longitudinal study found that low lifetime family income in African-American children aged 3 years was related to a higher risk of emergency department use (*51*). Obviously, the age range targeted makes the study not comparable with ours.

A cross sectional analysis of a Canadian population based sample of 2987 school children found that asthmatic children with low household income were at higher risk (OR=1.68) of hospital visits for asthma and that the odds ratio was no longer significant when highest parental education or environmental tobacco smoke was accounted for (*65*). Our results indicate a stronger relationship between household income and ED visits, which disappeared when area-level IPPE was taken into account. We found that the OR for the effect of middle household income (vs. high) was larger in asthmatics with no or rare symptoms compared to those with frequent or continuous symptoms. A Canadian study conducted in Manitoba found an association between low area-level income and a decreased likelihood of inhaled corticosteroids prescription only in asthmatics children with mild to moderate asthma and not in those with severe asthma (*80*). The reasons for the effect modification are not clear. When asthma is severe enough, low and high-income patients may resort to the same actions (similar decision-making process and outcomes) regardless of patient's SES. Conversely, when asthma is less severe, any difference, for example in health care seeking behaviour or self-management skills based on SES, may be important enough to result in a stronger relationship between SES and ED visits favouring asthmatics with high SES. Another explanation would be that when asthma symptoms are frequent or continuous, the perception of acute bronchoconstriction by the patient is reduced or altered regardless of SES or level of health knowledge and self-management skills. An evaluation of symptom perception in asthmatics found that patients with low baseline FEV1 (forced expiratory volume in one second), a marker of more severe asthma, have a reduced perception of dyspnoea or bronchoconstriction (152).

Even more striking was the reversal of the effect of more frequent asthma symptoms (vs. rare/no symptoms) on ED visits. Indeed, the association of asthma symptoms with ED visits is negative in asthmatics with low household income (OR: 0.51), becomes slightly positive in those with middle household income (OR: 1.03) and is markedly positive in those with high household income (OR: 1.73). Only speculative explanations can be proposed. Are people living in high income households more prone to go to the emergency room (make the decision quicker) or more sensitive to their symptoms or do they report more easily having more frequent symptoms than those who are from household with less income? Do respondents from households with less education lack asthma knowledge or self-management skills, which makes them tolerate more frequent asthma symptoms before seeking help? They may also be biased in recalling or reporting the frequency of symptoms, that is, tendency to underreport it, which may result in an exposure misclassification. An explanation for these potential interactions calls for further investigation.

V.1.3. Household-level unemployment

The rare studies that report unemployment in their results (usually as a variable to control for) did not find any significant relationship with asthma health services utilisation such as repeat ED visits (63, 150). Adams reported that the self-reported prevalence of current anti-inflammatory use was approximately doubled in employed persons compared to unemployed asthmatics for all severity groups (153). In our sample, self-reported anti-inflammatory drugs prescription did not differ by unemployment status (result not shown). However, we found that unemployment was a strong independent predictor of higher likelihood of ED visits. This association persisted even when controlling for household educational achievement or controlling for household income level. There is no definitive explanation for such findings, it is however possible that living in a household were all members are unemployed is a marker of further disadvantage (given that no other source of income is available). Unemployment is thought to affect health in various ways: it reduces people's ability to purchase goods and services, such as adequate housing and nutrition. In addition, employment is a primary source of status and provides social support, structure to life and a mean of participating in society. In this sense, unemployment can represent marginalization and social exclusion that adds up to financial strains and could promote unhealthy behaviours (121).

The relationships between health and each of the three distinct measures of household SES overlap and are likely to reflect the influences of both dimensions of SES (resources and rank) on health.

Income or wealth gives access to more social amenities, preventive health care resources and health-promoting activities and lifestyle; it may give an individual more control over harmful environmental exposures and more flexibility to cope with unexpected stressful events. Low occupational status can be related in the work place to exposure to harmful agents, physical strain or psychologically stressful environment in addition to job insecurity and lack of personal control (*22*). Better education may confer values and beliefs that promote healthier lifestyles, more preventive health behaviours and better health knowledge (22, 151).

Adjusting for three household measures in the same model yielded non-significant associations except for household income and hospitalization. No household-level SES indicator was related to ED visits. Given the probable collinearity between same-level measures (as indicated by correlations), it was not possible to disentangle their respective independent effect.

V.1.4. Area-level education

There are few reports about the relation between education measured at the area level and ED visits or hospitalization. In the US, asthma hospitalization rate was inversely correlated with educational attainment as measured by the proportion of people holding a bachelor's degree at the borough level (5 boroughs in New York city) (154). Chen and colleagues find that rehospitalization was not related to the proportion of people with a university degree (measured at the EA level) (*64*). On the contrary, we found that living in EA with low education (i.e. high proportion of people with less than a high school diploma) was associated with a higher risk of ED visits and hospitalization even when its household level counterpart was accounted for. This suggests an independent "area effect" of living in neighbourhoods with low education that operates at the area level and is not the mere result of the compositional effect of having more people with low education ("aggregated") in the same areas. Area-level SES may also captures unmeasured aspects of individual SES (see section V.3).

V.1.5. Area-level income

Most studies found a relationship between low income measured at the area level and a higher risk of ED visits or hospitalization (individually measured). For example, in the US (Chicago), low median income of school's census tracts and self reported ED visits in school children (*52*). Percentage of households in the ZIP code area with incomes below $15,000 was strongly and positively related to hospitalization rates calculated at the same area level (*19*). In New York city, median household income measured at the borough level was related to asthma hospitalization rates (155). In Boston, asthma hospitalization rate was positively correlated with poverty rate and inversely correlated with average per-capita income (154). In a longitudinal analysis of hospital discharges data, increased asthma hospitalization rates were noted in children residing in zip codes with lower median household incomes (*66*).

In Canada, no such relationship was found for rehospitalization incidence rates and average personal income measured at the EA level (*64*). Possible explanations evoked by the author are that rehospitalization may not be sensitive enough in detecting subtle but clinically relevant effects of area-based SES, and that the follow-up was only for within fiscal year and thus some individuals could have had a very short follow-up period.

On the contrary, the association detected in our study between average IPPE measured at the EA level and ED visits and hospitalization was strong and did not fade away when household income was controlled for. An independent effect of low income operating at the area level indicates that using a contextual measure can unveil SES inequalities in health that are not observable by individual- or household-level measures alone. For example, the same level of household income may confer a different available purchasing power if there are disparities in prices of goods and services or even taxation levels according to the neighbourhood of residency (*21*).

V.1.6. Area unemployment rate

Even though strong relationships emerged in the analysis between high unemployment rate and increased risk of ED visits and hospitalization independent of household-level employment, we could not find any study that specifically assessed those relationships.

Living in an high unemployment area, even though one is not unemployed, could on its own be psychologically stressful as job insecurity and threat of job loss may be exacerbated (121).

V.1.7. Other measures of area deprivation or SES

Children living in high SES-score zip-codes (as measured by a composite index based on education, income, home ownership and access to services) had significantly fewer ED visits than those living in low SES-score areas (OR= 0.4; 95% CI.: 0.2, 0.8) and the association persisted after controlling for race, anti-inflammatory medication prescription and type of physician (*67*).

A study by Cesaroni and colleagues specifically evaluated the association of both area- and individual/household-level SES concomitantly as predictors of hospitalization in asthmatics. This cross sectional study in Rome (Italy), among children aged 6 to 7 years, reported a higher risk of hospitalization associated both with living in census tracts with the lowest SES index (based on various indicators including education, occupational class and unemployment rate) and low father's education (primary school), respective ORs were 2.80 and 3.37. However, when income area index, which was a strong predictor of hospitalization (OR=4.46), was in the model, none of the parents education or area SES index was anymore significant; also, passive smoking was the only factor adjusted for in the analysis (*46*).

V.1.8. ED visits versus hospitalizations

SES was associated with both hospitalization and ED visits, but the odds ratios were generally larger for hospitalization. However, the wide confidence intervals (especially for hospitalization) were always overlapping; this may suggest a large variability instead of a true dissimilarity between ED visits and hospitalization.

ED visits and hospitalization usually are both considered markers of poorly controlled asthma. The decision to hospitalise a patient presenting at the ED is based on objective measures of respiratory distress and non-response to therapy administered in the emergency room. The need for hospitalization is a sign of further severity in the acute episode. The increased risk of hospitalization for individuals with lower SES could be because the attacks are more severe or are more difficult to treat in the ED (e.g. if a concomitant respiratory or cardiovascular co-morbid condition is present). Another explanation could be that during symptom exacerbations, higher SES patients may evaluate quicker and decide sooner to go to the ED. Finally, it is also possible that for the same degree of severity, the attending ED physician could be more inclined to admit a patient with low rather than high SES; that is, if there are manifest signs of social isolations, lack of health knowledge or low confidence in self-management skills. Also, physicians who practice in deprived areas could have a greater predisposition to hospitalize patients, based on their clinical status or on social factors associated with patients with low SES.

V.2 Utilisation of primary health care services and SES

There was no evidence that asthmatics of low SES or those in most need (severe or frequent asthma symptoms) experienced or reported barriers to use medical attention through key health care services, such as less treatment prescriptions, lacking a regular doctor or no access to specialist visit. This is, in accordance with a cohort study performed in Manitoba showing that children living in enumeration areas with the highest income quintile were more likely to have inhaled corticosteroids prescription than those in the lowest income quintile (49.1% vs. 39.4%), although after controlling for asthma severity, the relationship disappeared (*80*).

The argument that inequality in access to primary health care service is an important explanation for higher risk of ED visits/hospitalization for individuals with low as compared with high SES was not supported by our findings in a Canadian context of universal access to health care. Low SES was often associated with more reporting of at least some use of key primary health-care services. Our results indicate that access to primary care, such as having a regular doctor, was not the predominant reason driving ED use since 90% of the respondents had a regular doctor for the management of their asthma. Furthermore, having a regular doctor was not significantly related to ED visits or to SES as suggested by another study (156). We did not find that those with higher SES were more likely to have one or more specialist visit as described by a Canadian study using the Ontario Health Survey which did not focused on asthma only (157).

Thus, our findings are not consistent with those studies reporting that asthmatics with low SES more often depend principally on ED visits for the management of their asthma and use less ambulatory primary health-care services (*43, 62*) In our sample, asthmatics with low SES did not rely on the emergency department as a replacement to ambulatory care in the management of their asthma while under-using primary health care services, which corroborate those of other studies (63, 150). Asthmatics with low SES may present difficult to control asthma that is not completely easily amenable to treatment despite more contact with physician including specialists. In addition, the relationship of increasing number of physician visits with elevated risks of ED visits and hospitalization suggests that these people were not substituting emergency care for regular primary care (*113*), but rather looking for assistance in as many ways as possible (See appendix VII.25).

It has been reported that asthmatics receiving care from allergologists have a significant reduction in ED use for asthma (possibly due to the increased use of inhaled corticosteroids) and specialists appear to better follow clinical guidelines (*59, 60*). Indeed, after controlling for SES, age, sex, symptom severity and co-morbidity factors, we found that those with a specialist visit were more likely to report antiinflammatory therapy prescription than those with no specialist visits. However, this did not translate into fewer ED visits or hospitalization, which may reflect the fact that specialists may be in charge of more severe cases of asthma that more often require antiinflammatory prescription to achieve the same degree of symptoms control as those with less severe asthma followed by non-specialists.

V.3 Level of measurement of SES variables and inferences

The presence of multiple levels of measurement used in this thesis imposes different constructs (158). Group-level variables as defined by Morgenstern and others (130, 159) might be used as proxies for unavailable individual-level variables or as a measure of group-level constructs themselves. We considered that they refer to a group level construct rather than being just proxies for individual information. The three main measures of neighbourhood-level socioeconomic characteristics we used are derived group-level variables as they have an analogue at the individual/household-level. At the household-level, we used education and employment status in part because individual-SES information was unavailable for some respondents, but also because we believe that the household (or family) environment can be important on its own (160).

V.3.1. Area-level effects

After controlling for individual/household level SES, we were able to detect significant and rather large estimates of associations between neighbourhood level variables and hospital use. Our results suggest that the places in which the studied respondents live appear to contribute something unique to their reported risk of hospital use. Various plausible neighbourhood factors related to asthma were described by Wright & Fisher (84): (1) environmental exposure, (2) stress, (3) health behaviours and psychological factors, and (4) access to health care.

Environmental outdoor pollution may be more prominent in less affluent neighbourhoods. It could affect the individual differently according to individual or household SES and coping abilities. For example, an individual could reduce his/her actual exposure or he/she may have a higher biological susceptibility resulting from the concomitant presence of other factors (e.g. higher exposure to indoor allergens).

Both physical and social factors can be a source of environmental stress for people living in a particular area. The presence of chronic stress, labelled "neighbourhood disadvantage" characterized by different community-level stressors such as high unemployment, poverty and violence rates can be associated with the erosion of social cohesion and social capital (160). There is support for a link between stress and asthma through increased susceptibility to upper respiratory viral infections (126), and a recent study established a relation between community violence and occurrence of upper respiratory infections (161). Moreover, a prospective investigation also reported that more frequent life events were related to cold induced exacerbations of asthma and that the relation might be buffered by high level of social support (162).

Affluent neighbourhoods may have more local primary health services (doctor clinics, dispensaries and after-hours facilities) or better access to them than do less privileged areas (see section I.6). This in turn could translate into better asthma follow-up and asthma education received by those living in advantaged areas (84).

High environmental stress may contribute to increased smoking by individuals who use it to cope with stress (84). An individual may also be more inclined to smoke in areas where smoking is more prevalent (and more socially acceptable) independently of his/her individual SES (163). In addition, living in disadvantaged areas could lead to increased risk of exposure to environmental tobacco smoke.

Patient self-management skills and active participation are related to perceived control of asthma and possibly to other individual characteristics such as learned helplessness, which might be influenced by the social environment (violence, high unemployment with low prospect and opportunities to a better future).

Further evidence for an effect at the neighbourhood level comes from a community-based intervention, the Neighbourhood Asthma Coalition (NAC), which was implemented in low-income, predominantly African-American neighbourhoods of St. Louis in the United States. It was developed as a peer-based approach (neighbour to neighbour) to promote community support, reach those individuals with asthma, and convey key messages related to asthma education. Findings from the study highlighted that children of socially isolated parents (those below the median on both support from family and from friends) reported more frequent asthma symptoms and ED visits, and poorer asthma management practices, than non-isolated care givers (164). The NAC intervention had positive results in reaching those socially isolated asthmatics/care-givers, induced changes in management practices, and to a lesser extent, some decrease in hospital use (ED visits or hospitalization) among active participants in the program (165).

V.3.2. Use of household-based measures for SES

Household measures variables were considered better suited than individual information to capture the socioeconomic status of individuals with asthma. Many individual measures of SES were missing as the sample included children for whom formal education achievement and employment status was not yet measurable. We also considered that household-level socioeconomic characteristics might be both a close proxy for individual data and capture additional information pertaining to the household. In doing so, we may consider the household's respondent as an immediate or proximal social environment that conveys information relevant to the study of health outcomes. This assumption is in fact often implicitly made when children with asthma are studied. As well, there was no individual income information available in the NPHS datasets; rather data was collected on household income and the number of people supported by this income in order to obtain more valid and meaningful estimates.

In our study, we selected the highest education level achieved by one of the household member (i.e. the one who had the highest education in the household regardless of gender) to represent "household education". Underlying this assumption is that health related knowledge, values and beliefs may be shaped or at least altered by the interactions occurring between household members. Similarly, financial hardship and unemployment (no household member unemployed) could affect the whole household or family functioning, according to the degree of cohesiveness or adaptability, the level of mutual support or conflict between the members. From this perspective, the household may be a source of stress (life events and chronic stress) or support, and contribute to determining coping abilities of the members (160). In the case of asthmatics, the household/family environment can be influential on their sense of perceived control, self-confidence and efficacy and ultimately their capacity of asthma self-management. This has been mainly studied in children (166) and adolescent (167) for whom family was an important source of information about asthma.

For this thesis, we assumed that in practice household-based SES should perform at least as well as individual information. Our results confirmed this assumption, as the former were in general able to detect larger health differences according to SES than the latter (more so for education than unemployment). We used the approach described by Krieger et al. who compared in women the magnitude of the association between four different SES measures (based on occupational class) and a wide range of health outcomes (some of which were derived from physical examination or laboratory analysis). They found class inequalities in health, comparing women categorised as working class with non-working class, generally were stronger using the gender-neutral household class measure (highest in the household), compared with the individual class measure. Women with high status had similar health outcomes regardless of which measure was used. By contrast, women classified as "working class" by the household measure were generally more likely to have a poorer health profile than those classified as "working class" by the individual level measure (168). Our results are in line with those findings.

V.3.3. Area-level versus household-level magnitude of associations

In studies of other health problems, area-based measures of SES are generally less strongly associated with individual health outcomes than individual or household-based measures. In our sample, we detected quite large ORs estimates for the associations of area-level SES with hospital use. The ORs were roughly on the same scale as those measured at the household-level even after adjustment for one another. The only published study assessing the association of both area- and individual-based SES with hospitalization (lifetime) in children obtained even larger ORs estimates of increased risk of hospitalization with lower area SES (adjusted for father's SES) than we did (46). However, the same study was unable to detect strong associations between area-level SES and the prevalence of reported physician diagnosed asthma or the prevalence of severe asthma (see section V.1.7 for more details on the study by Cesaroni et al.).

This suggests that some morbidity outcomes might be more sensitive to the place's socioeconomic characteristics than others. It is also possible that neighbourhood variables capture in part SES differences that may not be measured at the household level (e.g., enumeration area IPPE reflects long-standing income levels and differences in wealth while household income fluctuates from year to year).

Area characteristics appear to have a truly deep effect on asthma outcomes due to the combined effect of multiple factors. Their influences may be through common avenues with factors measured at the individual/household-level, and may interact with each other. Clearly, more research is needed to understand this relationship.

V.4 Difficulties and limitations

The strengths of this study include use of a population-based sample (rather than a hospital- or clinic-based sample) representative of the Canadian population with asthma. The resulting external validity allows for a better generalization of the results. In a population-based setting, persons with possibly milder asthma and higher SES characteristics are less likely to be excluded, as it may be the case in studies using samples relying on health service settings, which are more representative of a higher risk population with asthma (*113*). This thesis included detailed SES information with multiple measures at both household and area level; IPPE was used to take into account household size at the area level. We used information from a wide range of variables that included not only ED visits and hospitalization but also primary care contacts, medication use, asthma symptoms and comorbidity factors. The non-response rate was quite low (2.5 %) with a harmonious distribution across provinces. Detected associations for covariates were generally consistent across different models and sensitivity analysis for the handling of missing values added to the internal validity of the study. Finally, the association of SES and health care services utilisation was estimated at both levels. However, beside those strengths, there were also limitations and criticisms that can be made which are described in the following subsections.

V.4.1. Geographical area and sense of "community"

The analysis presented in this thesis used postal code for geocoding of small communities at the area level. EA were used as proxy for immediate community or "neighbourhood" because of the small geographical size and population. The subsequent homogeneity regarding economic and socio-demographic conditions and environment of living should agree with the resident's sense of belonging to a specific community sharing the same physical and social context. For example, census tracts in Montreal followed rather closely natural boundaries (169). However, there is no certainty that indeed each enumeration area defines a local community or a neighbourhood since it is theoretically possible, but unlikely, that one postal code encompasses more than one community. Furthermore, even if homogeneity is high within an EA, some characteristics may be shared more directly within a geographical area while others may not be as easily defined based on physical proximity. Examples of the former would be, for instance, exposure to environmental hazards and the measures taken to reduce their impact on the population, economic opportunities, availability of local services such as those depending on municipality policies and resources and even the availability of a variety of local services. However, the psychosocial environment within which an individual is embedded may rely on social networks that go beyond any geographically defined community. Clearly, restricting the definition of a community according to geographical boundaries may fail to capture more complex influences that engage the individual or a family in social activities and build social capital and social support outside the limits of the neighbourhood. A broad and more adequate definition of a community in this sense would characterize a community according to the following:

- *Its membership has a sense of identity and belonging.*
- *It has common symbol systems: similar language, rituals, and ceremonies.*
- *It has shared values and norms.*
- *It offers mutual influence—community members have influence and are influenced by one another.*
- *It has shared needs and a shared commitment to meeting them.*
- *It has a shared emotional connection—members share common history, experiences, and support.*

Israel et al. 1994, cited in Health and Behavior (170)

In that regard, if exposure misclassification occurred, assuming that it was random and non-differential, any bias would be towards underestimating the association of area-level SES with ED visits and hospitalization.

V.4.2. Cross sectional data and self reported information

There were no objective measures in any of the variables used, hence the accuracy of the data is likely to be affected by recall bias and we have no mean to verify to what extent it could have affected the validity of our results. However, a study comparing patient self-reported health services use with corresponding fee service claims in the Ontario health insurance plan administrator database, showed a substantial agreement for hospital admission and visit to a specialist (ED visits use was impossible to assess properly) (171).

In cross-sectional studies, there is no indication as to the temporality of the associations of interest; therefore, the interpretation of any detected association does not permit us to draw definitive conclusions as to its causal nature. However, except occupational asthma and its consequences on employment status (172), asthma does not seem to impede employment substantially as shown by a prospective cohort study (173). Also, a 17-year follow-up study found no significant associations between a diagnosis of asthma in childhood and the educational achievement or adult SES at age 26, even after adjusting for childhood SES (174). Therefore, it is reasonable to envisage that health services use and health outcomes are the result of SES, not the other way around.

Residents move from one area to another so that they may not have been exposed to the same type of environment for the same duration. In addition, a neighbourhood's socio-economic characteristics may also change over time, which could possibly result in change in health outcomes (175). Our analysis did not include any information on the respondent's duration of residence in the same EA, therefore, it is not possible to determine whether the effect of area-level SES depends on length of exposure.

The same limitations apply for household-level SES and its effect on health. Furthermore, beyond the duration of exposure and independently of income level, financial instability and/or lack of job security may have direct or indirect effects on health on its own independent of current income or job status (121).

V.4.3. Asthma definition and sample size

The very strict definition criteria of asthma may have discarded some genuine asthmatics (see Table III.4, page 37). Indeed, 217 respondents had answered that they had physician diagnosed asthma but also that they did not have any symptoms, attacks, or asthma medications in the last 12 months. We cannot infer the direction or magnitude of any bias, if any has taken place. This is due to the fact that the NPHS 1996-97 data file available to us does not allow for retrieving the information about those out-of-scope respondents (for example, the information about asthma diagnosis in children less than 12 yrs old is not available). However, on the other side, we could be reasonably confident that our sample was composed of true asthmatics due to the high specificity of the main question related to "physician diagnosed asthma" (176), especially when combined to the additional criteria previously mentioned.

Because of the moderate sample size and complex design effect, we had to limit some categorical variables to the minimum meaningful number of categories (grouping). Stratified analyses produced estimates with large variability and lack of statistical power might have been an issue for the appraisal of association between income inequality and any of the outcomes studied.

V.4.4. Categorisation & dichotomization of ED visits and hospitalization

We dichotomized the outcomes variables (number of ED visits and number of hospitalizations in the past year) into none vs. one or more, for two reasons. First, the distributions were not normal (extremely skewed) since the majority of the respondents reported no ED visits or hospitalizations, and the sample size being small, only few observations would remain included in each combination of exposure-outcome category. The loss of power and precision would have made our analyses often impractical. Clearly, a trade-off had to be made. As for area-based SES, after categorisation into quartiles, we did make sure that the ORs using the median values were appropriate cut-off points. Also, using those area SES quartiles, OR estimates for hospitalization proved to be impractical due to high variability and small number of observations in each categories.

The second reason is that we were not interested in measuring the volume of care used or in quantifying the morbidity burden. Rather, the focus was on evaluating in Canadians with asthma the added risk or likelihood of hospital use (ED visits or overnight admission) for those living in low SES household or areas as compared with their better-off counterparts.

Finally, we acknowledge that by dichotomizing some variables, we may have lost some information in the process but this did not affect the overall findings and their interpretation within our research questions.

V.4.5. Interaction testing

A drawback in using bootstrap programs such as those provided by statistics Canada is that the computation of a partial likelihood ratio test could not be done this time. The current approach does not allow us to test the statistical significance for more than one interaction term for same variables at a time. In other words, any interaction terms that involved household income (three levels, i.e., two indicator variables for a set of two interaction terms) was tested separately. As a result, we could not estimate the statistical significance of the entire set of (two or more) interaction terms. In our case, one interaction term was found significant for an indicator variable (low household income by asthma symptom frequency) while the other complementary interaction term was not (middle income by asthma symptom frequency). This limitation is of minimal importance regarding interpretations of the results and does not affect the overall conclusions.

V.4.6. Multilevel design and multilevel analysis

The individuals within a same area may have some characteristics in common and be correlated, which could jeopardise the independence of observations, leading to a variance underestimation. However, it is reasonable to believe that such dependence is likely to be minimized if not null for the characteristics measured at the EA level (smallest census geographic area) because there was only 1 or very few respondent per area. Furthermore the design of NPHS used the census enumeration area as the principal primary sampling unit and the bootstrap weights produced by Statistics Canada are intended to account for the resulting clustering (in addition to other sampling frame and design features) and hence probably intra-group dependencies.

When analysing variables at both individual and group level simultaneously, it is preferable to rely on specific statistical tools. Multilevel analysis is a technique that allows the simultaneous examination of the effects of the predictors on both levels and the possible cross-level interactions effects while accounting for correlation of observations within group. The model specification in multilevel analysis takes into account the fact that the individual level variation can be different in each group so that instead of having only one regression coefficient for individual level variation (fixed effect), the model lets the regression coefficients vary from one group to another (random effects) and hence treats the groups as sampled from a broader population of groups about which inferences can be made (177).

I was unable to implement such technique for two reasons. Firstly, there were no statistical tools available to us to integrate both multilevel analysis techniques and bootstrap resampling methods. Secondly, and most importantly, the size of the Asthma Supplement would not have met the requirements to conduct such analysis without jeopardizing the validity of parameter estimates (178). For example, Kreft recommends 30 groups with at least 30 individuals per group (179) and Hox et al. suggests 10 observations per group and 100 groups as a general minimum if the random part of the model is of interest (177). In the case of the thesis, multilevel techniques may not be adequate as 85% of the groups (EAs) contained only one individual.

V.4.7. *Medication insurance coverage*

This information was only available in the health component (selected household member) of the Asthma Supplement, therefore, it was not considered in this thesis. However, there are a few reasons that let us believe that such information about medication coverage and barriers due to cost were not needed.

Firstly, in Canada, essential prescription medications (such as those for asthma) are generally accessible to people who are not covered by insurance medications coverage, through special provincial access programs (ex: Ontario Drug Benefit for very low household income people and Trillium program for those with middle income). In such case, an exposure misclassification bias could be introduced in the analysis since those people may report having no insurance medications coverage despite benefiting from programs described earlier. In fact, the validity of the prescription drug insurance data reported in the NPHS 1996-1997 is threatened by substantial underreporting (180). For example, 61% all NPHS respondents reported having drug insurance (181) whereas using other data sources, the proportion could be in fact as high as 90% (182). Also, results from the NPHS 1996-97 shows that despite a positive relationship between high income and having insurance, use of medications was less likely as income increased, in particular asthma drugs (*81*). Secondly, the cost as a barrier to medication use was actually imbedded in the "Compliance to prescribed medication" question, to which only six respondents stated that they took less medicine than prescribed because of the cost (0.3% out of 1814); among them, only one had ED visits whereas none had hospitalizations. In conclusion, it is reasonable to assume that barrier due to costs would not have a significant impact on the study results.

V.4.8. *Taxes and transfer payments*

The datasets used here did not contain information about income after taxes and other transfer payments which could have an impact on income redistribution and therefore on the association between income inequality and health outcomes. It can be argued that in an egalitarian setting or society, the impact of income redistribution would weaken the association of income (and income inequality) with health outcomes. However, a study by Kawachi and Kennedy (1997) showed that the association is not significantly altered by taxes and transfer payments (183).

V.5 Implication for policy and future research

V.5.1. Implication for policy

The purpose of this thesis was to gain greater understanding of the relationships of health services utilisation with individual as well as community socioeconomic characteristics. Our results support the concept of independent associations of SES in relation to health services use. Use of emergency services and hospital resources in general is closely related to socioeconomic status. The variable use of primary health services for asthma is not the primary cause for the observed inequalities. Clearly, policies aimed at promoting equal access to quality health services, should always be a necessary part of the overall objective of improving the well-being and health of all Canadians.

Nevertheless, excessive focus on the mediating effect of any of the risk factors that are related to socioeconomic differences (e.g., environmental and behavioural risk factors and access to primary health care services) can lead policy makers to overlook the central role of socioeconomic position as a fundamental cause of health while targeting exclusively those factors (134). Also, as low household socioeconomic status is related to adverse health outcomes irrespective of the characteristics of the areas of residence and the individual use of primary health services, improving the socioeconomic conditions of individuals most in need through policies committed to favour social equality may lead to a reduction of health morbidity. This can be achieved through health and social policies that are determined at higher levels of political authority to reflect more broad and fundamental societal choices made by all members of the society. Indeed, there are grounds for believing that, in general, policies that rely on more socially progressive political models achieve better health outcomes than those more economically (neo)-liberal systems (184). This all the more important as in low-income neighbourhoods, the level of earned income in constant dollars fell and unemployment rate is rose substantially between 1980 and 1995 (185).

V.5.2. Further consideration

Studies that contribute to the knowledge of specific issues such those related to the impact of asthma management compliance and symptoms perception/reporting on the relationship of SES with asthma hospital use, should hopefully guide more focused interventions based on improving access and enhancing all those enabling factors such as education and health knowledge. More specifically, exploring the differential effect of household SES according to asthma symptoms reporting could lead to better education intervention focused or tailored to benefit those with higher needs. Further research is needed to confirm the effect modification between symptoms frequency and household income in their relationship with hospital use.

While studies incorporating health care access or utilisation indices are abundant, there are only few empirical studies that provide evidence of the pathways through which SES determine asthma hospital services use, and demonstrate quantitatively the effect of any mediating factors.

Research on community- or aggregate-level factors is mostly directed towards structural and organizational aspects of the health-care delivery system. There is lack of studies that evaluate the impact of psychosocial factors as opposed to the physical environment on health outcomes or services utilisation by asthmatics in Canada. Longitudinal studies would answer more adequately questions pertaining to causes and determinants of health outcomes in asthmatics.

V.6 Conclusion

Canadians with asthma living in households with low education or in households where no member has a current job face a higher risk of ED visits; living in middle-income household was related to increased hospitalization after adjusting for the area-level SES of the area of residence. Each one of the three measures of low area-level SES (education, income and unemployment) were related to substantially higher prevalence of at least one hospitalization and ED visit in the past 12 months, independent of household-level SES. This underlines the additional need for an ecologic approach with the implementation of community-based interventions involving local populations to improve health focused on asthma education (186).

By embracing three key components from Aday's framework, namely needs, primary health care service use and co-morbidity indicators to circumvent any confounding factors, this study suggests that in Canada, the differential in ED or hospitalization is not explained by a differential in access to primary services. Furthermore, we found no evidence of such differential in use of key primary health services favouring respondents with high SES. However, in spite of this, socially disadvantaged people with asthma are at higher risk of ED visits and hospitalization than their more privileged counterparts are.

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VII. APPENDICES

VII.1 Asthma control criteria

Symptoms: *coughing, wheezing, breathlessness*	Asthma symptoms < 4 days/ week Night-time symptoms < 1/ week
Exacerbations	Mild, infrequent
Activity	Normal; No Absenteeism
Short Acting β_2 agonist *(as required)*	≤ 3 doses/ week

Adapted from the Canadian Asthma Guidelines (24)

VII.2 Variables definition and labelling

Household-level SES	**Area-level SES** (according to the median values)
Household income adequacy High: Highest and upper middle groups (reference) Middle: Middle group Low: Lowest and lower middle groups	**Area IPPE**: Average income per person equivalent High: > \$32,534 (reference) Low: ≤ \$32,534
Household education High: At least one member has a HSD or more (reference) Low: No member has a HSD or more	**Area education** - % of people with no HSD - High: ≤ 32.56 (reference) Low: > 32.56
Household job status High: At least one member has a current job (reference) Low: No member has a current job	**Area unemployment** (%) Low: ≤ 8.40 (reference) High: > 8.40
	Gini coefficient Low: ≤ 0.374 (reference) High: > 0.374

HSD: High school diploma
Reference: reference categories
For household income adequacy, please see the following

	Income adequacy group level				
Household size	**Lowest**	**Lower middle**	**Middle**	**Upper middle**	**Highest**
1 or 2 persons	< \$10,000	\$10,000-\$14,999	\$15,000-\$29,999	\$30,000-\$59,999	> \$60,000
3 or 4 persons	< \$10,000	\$10,000-\$19,999	\$20,000-\$39,999	\$40,000-\$79,999	> \$80,000
5 or more persons	< \$15,000	\$15,000-\$29,999	\$30,000-\$59,999	\$60,000-\$79,999	> \$80,000

\$: Total annual income earned by all members in the household.
From 1996-97 NPHS Public Use Microdata Documentation. (136)

VII.3 Census geographical areas

	CANADA	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	BC	YT	NWT
Census division	**288**	10	3	18	15	99	49	23	18	19	28	1	5
Census subdivision	**5,984**	381	113	110	283	1,599	947	298	970	467	713	35	68
Enumeration area	**49,361**	1,236	267	1,511	1,393	11,684	16,469	2,050	2,844	4,746	6,880	111	170

From Statistics Canada. 1996 Census Dictionary, *Cat.No.92-351-UIE.* 1999. (143)

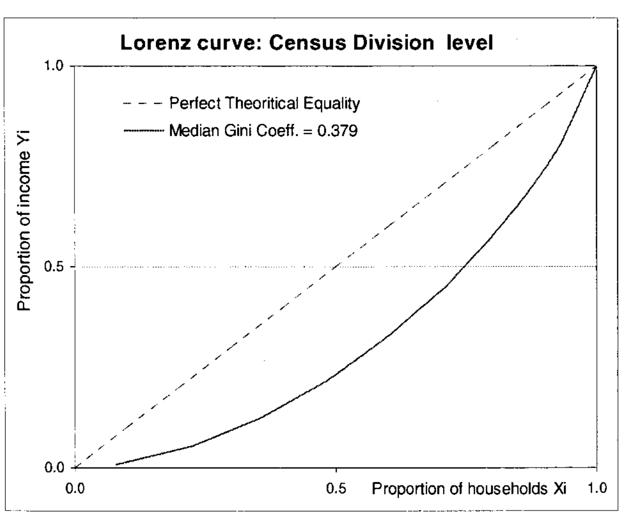
VII.4 Gini coefficient calculations and Lorenz curves

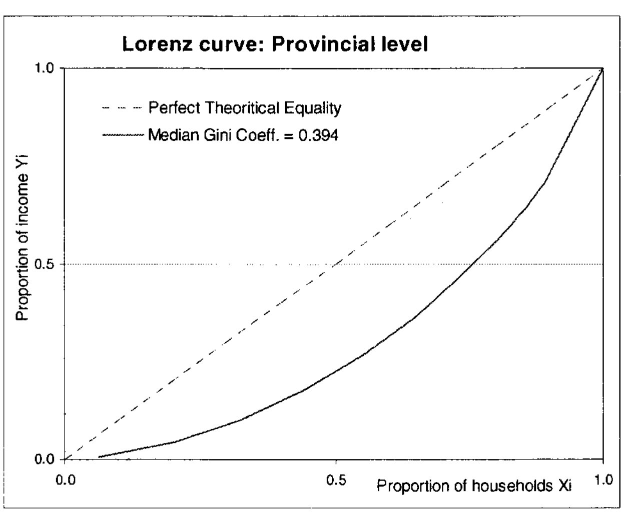
The variables needed were retrieved from the census 1996 profile series (138). The variables needed were the number of households by income class (11 income classes) and the average household income within each area. The total household income per class *i* was obtained by multiplying the mid-point value of each income class by the number of households in that class (except for the last income class (≥100,000) which was obtained by subtracting the sum of household income in all 10 other intervals from the total household income in the area. Finally, the Gini coefficient is computed according to the following formula (187).

$$Gini\ coefficient = \sum_{i=1}^{n}(X_i Y_{i+1}) - \sum_{i=1}^{n}(Y_i X_{i+1})$$

Below is an example for an area (CD) where the average household income was $47,674 (NS – Halifax)
Gini coefficient = 3.41342 - 3.79246 = 0.37904

Household income class $	Number of households	Income	Proportion of households	Proportion of income	Cumulative proportion of households X	Cumulative proportion of income Y	X_iY_{i+1}	Y_iX_{i+1}
< 10,000	10,440	52,200,000	0.07939	0.00833	0.07939	0.00833		
10,000 19,999	19,310	289,650,000	0.14683	0.04620	0.22622	0.05452	0.00433	0.00188
20,000 29,999	16,820	420,500,000	0.12790	0.06707	0.35412	0.12159	0.02751	0.01931
30,000 39,999	17,045	596,575,000	0.12961	0.09515	0.48373	0.21675	0.07675	0.05882
40,000 49,999	15,760	709,200,000	0.11984	0.11312	0.60357	0.32987	0.15956	0.13082
50,000 59,999	13,880	763,400,000	0.10554	0.12176	0.70911	0.45163	0.27259	0.23391
60,000 69,999	11,520	748,800,000	0.08760	0.11943	0.79671	0.57106	0.40494	0.35981
70,000 79,999	8,515	638,625,000	0.06475	0.10186	0.86146	0.67292	0.53612	0.49194
8,000,089,999	5,715	485,775,000	0.04346	0.07748	0.90491	0.75040	0.64644	0.60893
90,000 99,999	3,765	357,675,000	0.02863	0.05705	0.93354	0.80745	0.73067	0.70053
>=100,000	8,740	1,207,207,740	0.06646	0.19255	1	1	0.93354	0.80745
Total	131,510	6,269,607,740	1	1			3.79246	3.41342





VII.5 Asthma medications

Asthma antiinflammatory drugs (including other immunomodulating medications) prescription and bronchodilator medications prescription
"In the last month, have you been prescribed any medication for asthma...?"

	Asthma antiinflammatory drugs (including other immunomodulating)		**Bronchodilator medications**
1	Beclodisk	80	Apo-Salvent
2	Becloforte	81	Novo-Salmol
3	Beclovent	82	Sabulin
4	Vanceril	83	Ventolin (including Ventodisk)
5	Beclomethasone, dipropionate	84	Volmax
6	Beclomethasone	85	Salbutamol
7	Pulmicort	86	Asmavent
8	Budesonide	87	Gen-Salbutamol
9	Bronalide	88	Med-salbutamol pf
10	Syn-Flunisolide	90	PMS-Salbutamol
11	Flunisolide	91	Rho-Salbutamol
12	Flovent	92	Salbutamol sulfate
13	Cutivate	93	Albutérol sulfate de
14	Fluticasone proprionate	93	Albuterol sulfate
15	Azmacort	94	Berotec (Forte)
17	Triamcinolone	95	Fenoterol hydrobromide
18	Betn.esol	96	Bricanyl
19	Celestone	97	Terbutaline sulfate
20	Betamethasone	98	Alupent
21	Cortone	99	Metaproterenol sulfate
22	Cortisone acetate	100	Orciprenaline sulfate
23	Decadron	101	Maxair
24	Dexasone	102	Pirbuterol (acetate)
25	Hexadrol Phosphate	103	Pro-Air
26	PMS-Dexamethasone (Na phoshat)	104	Procaterol hydrochloride hemihydrate
27	R.O.-Dexsone	105	Isuprel
28	Dexamethasone (sodium phosphate)	106	Kenral-ipratropium
29	Capcort	107	Isoproterenol hydrochloride
30	Cortef	108	Isoprenaline
31	Novo-Hydrocort	109	Isopropylarterenol
32	Vehicle HC	110	Isopropylnoradrenaline
33	Cortisol / Hydrocortisone	111	Serevent
34	A-Hydrocort	112	Salmeterol Xinafoate
35	Solu-Cortef	113	Formoterol
36	Hydrocortisone sodium succinate	114	Bronkaid (Mistometer)
37	Medrol	115	EpiPen (Jr)
38	Depo-Medrol	116	Epinephrine
39	Solu-Medrol	117	Medihaler-Epi
40	Methylprednisolone	118	Epinephrine bitartrate
41	Apo-Prednisone	119	Adrenalin
42	Deltasone	120	Vaponefrin
43	Jaa Prednisone	121	Epinephrine hydrochloride
44	Metreton	122	Jaa Aminophylline
45	Novo-Prednisone	123	Phyllocontin
46	Winpred	124	Aminophylline
47	Deltacortisone	125	Theophylline ethylenediamine
48	Metacortandracin	126	Apo-Oxtriphylline

Asthma antiinflammatory drugs (including other immunomodulating)		Bronchodilator medications	
49	Prednisone	127	Choledyl (SA)
50	Novo-Prednisolone	128	Novo-Triphyl
51	Prednisolone	129	PMS-Oxytriphylline
52	Aristocort	130	Rouphylline
53	Triamcinolone	131	Choline Theophyllinate
54	Zaditen	131	Oxtriphylline
55	Ketotifen fumarate	132	Apo-Theo LA
56	Intal	133	PMS-theophylline
57	Novo-Cromolyn	134	Pulmophylline
58	PMS-Sodium Cromoglycate	135	Quibron-T/SR
59	Cromolyn sodium	136	Slo-Bid
60	Sodium cromoglycate	137	Somophyllin-12
61	Tilade	138	Tedral
62	Nedocromil sodium	139	Theo-Dur
63	Rheumatrex	140	Theo-SR
64	Methotrexate sodium	141	Theochron
65	Amethopterin	142	Theolair (SR)
66	Sandimmune (Neoral)	143	Theo-Bronc
67	Cyclosporin	144	Theolixir
68	Ciclosporine	145	Uniphyl
69	Imuran	146	Theophylline
70	Azathioprine	147	Atrovent
71	Purinethol	148	Apo-Ipravent
72	Mercaptopurine	149	Ipratropium bromide
73	Colchicine	149	Ipratropium, bromure d'
74	Gamimune N.	150	Duovent UDV
75	Immune Globulin (Human)	151	Combivent
76	Myochrysine		
77	Sodium aurothiomalate	175	Other
78	Gold compound	998	Refused
79	Gold sodium thiomalate	999	Don't know
		996	Not applicable

Complementary information from the following question was used if the above was 175 or 998 or 999:

- "Do you have medicine to RELIEVE an asthma attack?":

As a result, four observations were considered as having been prescribed bronchodilators drugs

VII.6 Bootstrap formulae

Bootstrap weight: $\mathbf{W^{\circ}_{hik} = n_h / (n_h\text{-}1)\ m_{hi}\ w_{hik}}$

W°_{hik}	Bootstrap weight for each record
n_h	total number of clusters in stratum *h*
$n_{h\text{-}1}$	number of clusters resampled in each stratum
w_{hik}	original design weight
m_{hi}	Number of times the $_i$ cluster is selected.

Bootstrap variance

$$\operatorname{var}^{\circ}(\theta) = \frac{1}{B}\sum_{b}^{B}\left(\hat{\theta}^{\circ}_{b} - \hat{\theta}^{\circ}\right)^{2}$$

Var(θ): Bootstrap variance (used in this analysis)

B: Total number of replication

θ°: parameter estimate using bootstrap weights. $\hat{\theta} = \frac{1}{B}\sum_{b}^{B}\hat{\theta}^{\circ}_{b}$ . . . . Not used in this analysis.

θ: parameter estimate using design weights (used in this analysis).

VII.7 Comparison of the NPHS with the Asthma Supplement

	NPHS general file	Asthma Supplement
	Sample = 210,377 Population = 29,281,455	Sample = 1814 Population = 1,715,907
	%	%
Household income adequacy		
Highest & Upper-middle	46.0	43.7
Middle	30.6	26.1
Lowest & low-middle	17.7	13.7
Not stated	5.7	16.5
Individual-level education		
Low (has lees than a HSD)	27.5	25.9
High (has ≥ HSD)	51.2	57.2
Not applicable	21.3	16.0
Not stated	0.0	1.0
Individual level job status		
Has a current job	40.2	46.5
Unemployed	30.3	29.0
Not applicable	29.5	24.0
Not stated	0.0	0.6
Sex		
Males	49.5	45.2
Females	50.5	54.8
Age (years)		
0 - 19	27.2	38.3
20 -39	30.8	31.6
40 - 59	26.2	18.5
60 +	15.7	11.7
Allergic status *		
Has food allergy	5.3	15.7
Has any other allergy	16.8	47.0
COPD *		
Yes	2.2	9.8
No	81.7	68.9
Smoker type *		
Daily	20.2	15.9
Not at all or occasional	65.4	62.7
Has a regular doctor*		
Yes	88.6	91.4
No	11.4	8.6
Immigrant status		
Non immigrant	82.9	91.8
Immigrant	16.9	8.3

*: Variables for which percentages do not add up to 100% because of missing values.
COPD: Chronic bronchitis or emphysema
HSD: High school degree diploma

VII.8 Correlations among SES measures

	Household income	Household education	Area IPPE	Area proportion of low educated individuals	Area unemployment
Household income adequacy	1	**0.44**	**0.40**	-0.33	-0.27
Household education		1	0.30	-0.34	-0.20
Area IPPE			1	**-0.63**	**-0.46**
Area proportion of low educated people				1	**0.42**

All Pearson correlation coefficients are significant at $p \leq 0.001$

VII.9 Missing values: sensitivity analysis

Step-5 recoding of covariates

Odds ratios for the association of SES or inequality with ED visits and hospitalization

	Models A. Models when missing values of **covariates** are recoded as "**0**"		**Models B.** Models when missing values **covariates** are recoded as "**1**"
Outcome is ED visits	Odds ratios	% difference	Odds ratios
Household income (middle vs high)	1.75	-4.35	1.67
Household income (low vs high)	2.40	2.67	2.46
Household education (≥ 1 member has a HSD: No vs. Yes)	2.68	-2.90	2.61
Household employment (≥ 1 member employed: No vs. Yes)	2.40	-3.60	2.31
Area IPPE (low vs high)	2.36	0.13	2.36
Area education (low vs high)	2.10	-1.68	2.07
Area unemployment (high vs. low)	2.00	1.36	2.03
Area income inequality (high vs. low)	0.76	0.20	0.76
Outcome is hospitalization	Odds ratios	% difference	Odds ratios
Household income (middle vs high)	3.52	-1.81	3.46
Household income (low vs high	3.26	1.13	3.30
Household education (≥ 1 member has a HSD: No vs. Yes)	2.88	4.38	3.01
Household employment (≥ 1 member employed: No vs. Yes)	2.14	-3.01	2.08
Area IPPE (low vs high)	3.71	-2.32	3.62
Area education (low vs high)	3.60	-0.78	3.57
Area unemployment (high vs. low)	2.35	-0.61	2.34
Area income inequality (high vs. low)	0.89	-0.08	0.89

Step-6 recoding of missing values for household education as zero (2 observations)

Odds ratios for the association of household education with ED visits and hospitalization

	Missing values of household education recoded as 0		Original missing values of household education not recoded
Outcome is ED visits	Odds ratio	*% Difference*	Odds ratio
Household education (≥ 1 member has a HSD: No vs. Yes)	**2.63**	-2.03	**2.68**
Outcome is hospitalization	Odds ratio	*% Difference*	Odds ratio
Household education (≥ 1 member has a HSD: No vs. Yes)	**2.89**	0.41	**2.88**

Missing values – sensitivity analysis – cont'

Final adjusted odds ratios according to missing values of outcomes
(covariates and household education are still recoded as "0" from previous step)

Outcome is ED visits	when missing values of ED visits are recoded as "0" OR	% difference	when original missing values of ED visits are kept OR
Household income (middle vs. high)	**1.75**	-0.13	**1.75**
Household income (low vs. high)	**2.39**	-0.27	**2.40**
Household education (≥ 1 member has a HSD: No vs. Yes)	**2.62**	-0.06	**2.68**
Household employment (≥ 1 member employed: No vs. Yes)	**2.39**	-0.30	**2.40**
Area IPPE (low vs. high)	**2.36**	-0.01	**2.36**
Area poor education % (high vs. low)	**2.10**	-0.31	**2.10**
Area unemployment (high vs. low)	**2.00**	0.30	**2.00**
Area income inequality (high vs. low)	**0.76**	0.07	**0.76**

Outcome is hospitalization	when missing values of hospitalization are recoded as "0" OR	% difference	when original missing values of hospitalization are kept OR
Household income (low vs. high)	**3.52**	-0.04	**3.52**
Household income (low vs. high)	**3.26**	-0.18	**3.26**
Household education (≥ 1 member has a HSD: No vs. Yes)	**2.88**	-2.42	**2.88**
Household employment (≥ 1 member employed: No vs. Yes)	**2.14**	-0.24	**2.14**
Area IPPE (low vs high)	**3.71**	-0.01	**3.71**
Area poor education % (high vs. low)	**3.60**	-0.07	**3.60**
Area unemployment (high vs. low)	**2.35**	-0.02	**2.35**
Area income inequality (high vs. low)	**0.89**	-0.02	**0.89**

IPPE: income per person equivalent
HSD: High school degree diploma

VII.10 Statistical power estimation

When α=5%		Power for ED visits				Power for hospitalization			
		Odds ratios*	Effect* size %	Design effect	**Power %**	Odds ratios*	Effect* size %	Design effect	**Power %**
Household level									
Income adequacy	Middle	1.77	7.8	3.19	**58.4**	3.47	5.3	3.19	**72.1**
	Low	2.92	17.1	3.89	**95.3**	4.14	6.6	3.89	**69.6**
Education		2.35	15.1	3.89	**97.3**	3.33	8.6	3.89	**92.1**
Employment		2.21	13.2	3.95	**93.1**	2.76	6.4	3.95	**75.6**
Area level									
IPPE		2.24	11.6	5.08	**82.1**	3.19	5.4	5.08	**62.1**
Education		1.85	9.0	4.75	**63.1**	2.85	4.9	4.75	**57.4**
Unemployment		1.86	9.1	4.71	**64.3**	2.09	3.6	4.71	**34.6**
Gini coefficient		0.89	1.7	4.23	**6.7**	1.02	0.1	4.23	**2.8**

IPPE: income per person equivalent
* Crude odds ratios and effect sizes may overestimate the power when applied to multiple regression.
NB: The average design effect is 4.81 (average for the 27 variables used in the thesis)

VII.11 Frequency distribution of various individual characteristics

		MALES Total sample: 729 population: 775,710				FEMALES Total sample1,085 Population: 940,197			
		n	%	95% CI		n	%	95% CI	
Age	0 - 20	292	**48.0**	42.4	53.5	318	**32.6**	28.4	36.8
	21-38	205	**26.7**	22.3	31.0	383	**31.4**	28.0	34.8
	>38	232	**25.4**	21.4	29.3	384	**36.0**	32.2	39.9
Asthma Attacks	None	359	**47.2**	41.1	53.3	475	**46.2**	41.9	50.4
	≥ 1 attack	370	**52.8**	46.7	58.9	610	**53.8**	49.6	58.1
Sleep disturbances	< 1 / week	651	**91.8**	89.3	94.2	927	**86.5**	83.9	89.0
	≥ 1 / week	78	**8.3**	5.8	10.7	158	**13.6**	11.0	16.1
Asthma symptoms	None/rare (<1/mo)	396	**54.2**	47.7	60.6	506	**46.2**	41.9	50.5
	Often/continue (≥1/ mo)	333	**45.9**	39.4	52.3	579	**53.8**	49.5	58.1
Allergy	No	360	**57.6**	52.4	62.8	420	**43.0**	38.4	47.5
	Yes	369	**42.4**	37.2	47.6	665	**57.1**	52.5	61.6
COPD	No	664	**91.8**	89.4	94.3	958	**88.9**	86.5	91.4
	Yes	65	**8.2**	5.7	10.7	127	**11.1**	8.6	13.6
Daily smoker	Non	616	**87.2**	83.9	90.5	859	**81.4**	78.6	84.3
	Yes	113	**12.8**	9.5	16.1	226	**18.6**	15.7	21.5
Antiinflammatory drugs	No	405	**51.8**	46.0	57.6	615	**57.0**	52.8	61.2
	Yes	324	**48.2**	42.4	54.0	470	**43.0**	38.8	47.2
Bronchodilators drugs	No	179	**21.5**	17.2	25.9	265	**24.3**	20.9	27.7
	Yes	550	**78.5**	74.2	82.8	820	**75.7**	72.3	79.1
Non-compliance to therapy	No	613	**85.4**	81.3	89.5	913	**81.9**	77.4	86.4
	Yes (Non-Compliant)	116	**14.6**	10.5	18.7	172	**18.1**	13.6	22.6
Having a regular doctor	No	77	**10.9**	7.4	14.4	72	**6.8**	4.8	8.8
	Yes	652	**89.1**	85.7	92.6	1013	**93.2**	91.3	95.2
Visit to a specialist	No visit	623	**87.1**	84.0	90.3	895	**81.3**	78.0	84.7
	Had visit	106	**12.9**	9.7	16.0	190	**18.7**	15.3	22.0
Physician visits	≤1 visit	468	**62.9**	56.9	68.8	631	**59.1**	54.6	63.6
	≥ 2 visits	261	**37.2**	31.2	43.1	454	**40.9**	36.4	45.4
Med. info. from a family doctor	No	175	**25.3**	19.8	30.9	287	**29.6**	25.0	34.3
	Yes	554	**74.7**	69.2	80.2	798	**70.4**	65.8	75.0
Med. info. from a specialist	No	429	**50.7**	44.7	56.7	663	**56.2**	51.6	60.8
	Yes	300	**49.3**	43.3	55.3	422	**43.8**	39.2	48.4
Med. info. from a nurse	No	515	**75.8**	71.2	80.3	785	**69.9**	65.5	74.4
	Yes	214	**24.3**	19.7	28.8	300	**30.1**	25.7	34.5
Med. info. from a vol. org.	No	561	**71.2**	64.9	77.5	846	**78.8**	75.2	82.3
	Yes	168	**28.8**	22.5	35.1	239	**21.2**	17.7	24.8
Immigrant status	Non-immigrant	684	**92.5**	90.1	94.9	1005	**91.1**	89.0	93.3
	Immigrant	45	**7.5**	5.1	9.9	80	**8.9**	6.7	11.0
Urban / rural	Urban	575	**84.6**	80.0	89.3	867	**86.1**	83.4	88.8
	Rural	154	**15.4**	10.7	20.1	218	**13.9**	11.2	16.6

Med info : Medical information ever received.
Vol. org.: voluntary organisation
COPD: Chronic bronchitis or emphysema

VII.12 Prevalence of ED visits according to various individual characteristics

		MALES Total sample: 729 Total population: 775,710					FEMALES Total sample 1,085 Total population: 940,197				
		Total	Cases	%	95% CI		Total	Cases	%	95% CI	
Age	0 - 20	*292*	*48*	**18.5**	11.1	25.8	*318*	*74*	**18.3**	12.4	24.3
	21-38	*205*	*47*	**21.4**	12.9	29.9	*383*	*78*	**19.9**	14.6	25.1
	>38	*232*	*37*	**15.1**	9.3	21.0	*384*	*66*	**16.1**	11.2	21.1
Asthma Attacks	None	*359*	*29*	**8.2**	4.7	11.7	*475*	*42*	**8.2**	4.7	11.8
	≥ 1 attack	*370*	*103*	**27.5**	19.9	35.1	*610*	*176*	**26.4**	21.6	31.2
Sleep disturbances	< 1 / week	*651*	*94*	**15.9**	11.3	20.6	*927*	*159*	**15.8**	12.7	19.0
	≥ 1 / week	*78*	*38*	**45.7**	30.8	60.6	*158*	*59*	**31.9**	22.2	41.7
Asthma symptoms	None/rare (<1/mo)	*396*	*48*	**13.8**	8.2	19.3	*506*	*84*	**14.7**	10.6	18.7
	Often/contin (≥1/ mo)	*333*	*84*	**23.9**	16.5	31.2	*579*	*134*	**20.9**	16.6	25.2
Allergy	No	*360*	*75*	**20.9**	14.4	27.4	*420*	*94*	**19.8**	14.4	25.2
	Yes	*369*	*57*	**15.0**	9.7	20.2	*665*	*124*	**16.7**	13.2	20.2
COPD	No	*664*	*109*	**17.4**	12.6	22.2	*958*	*181*	**16.8**	13.6	20.0
	Yes	*65*	*23*	**29.6**	15.0	44.1	*127*	*37*	**27.6**	17.3	37.9
Daily smoker	Non	*616*	*107*	**17.6**	12.9	22.3	*859*	*169*	**16.9**	13.7	20.1
	Yes	*113*	*25*	**23.7**	10.5	36.9	*226*	*49*	**22.8**	15.7	30.0
Antiinflammatory drugs	No	*405*	*49*	**12.1**	7.6	16.6	*615*	*87*	**13.2**	9.5	16.8
	Yes	*324*	*83*	**25.2**	16.9	33.4	*470*	*131*	**24.5**	19.3	29.7
Bronchodilators drugs	No	*179*	*22*	**12.0**	4.0	20.1	*265*	*36*	**10.9**	5.9	16.0
	Yes	*550*	*110*	**20.1**	14.9	25.4	*820*	*182*	**20.3**	16.6	24.0
Non-compliance to therapy	No	*613*	*106*	**18.1**	13.3	22.9	*913*	*194*	**19.5**	16.1	22.8
	Yes (Non-Compliant)	*116*	*26*	**20.1**	9.5	30.7	*172*	*24*	**11.4**	4.6	18.2
Having a regular doctor	No	*77*	*17*	**17.9**	5.3	30.6	*72*	*16*	**30.9**	14.2	47.6
	Yes	*652*	*115*	**18.5**	13.7	23.2	*1013*	*202*	**17.1**	14.1	20.1
Visit to a specialist	No visit	*623*	*90*	**15.6**	10.9	20.3	*895*	*140*	**13.3**	10.4	16.2
	Had visit	*106*	*42*	**37.4**	24.6	50.2	*190*	*78*	**38.5**	29.3	47.7
Physician visits	≤1 visit	*468*	*32*	**7.9**	4.1	11.7	*631*	*46*	**7.5**	4.5	10.4
	≥ 2 visits	*261*	*100*	**36.1**	25.9	46.3	*454*	*172*	**33.2**	27.3	39.2
Med. info. from a family doctor	No	*175*	*33*	**17.0**	8.9	25.1	*287*	*52*	**13.5**	8.0	19.0
	Yes	*554*	*99*	**18.9**	13.6	24.1	*798*	*166*	**19.9**	16.3	23.6
Med. info. from a specialist	No	*429*	*76*	**17.3**	11.9	22.7	*663*	*123*	**16.6**	12.9	20.2
	Yes	*300*	*56*	**19.6**	12.4	26.8	*422*	*95*	**19.9**	14.3	25.4
Med. info. From a nurse	No	*515*	*68*	**13.1**	8.7	17.6	*785*	*136*	**14.4**	11.3	17.4
	Yes	*214*	*64*	**34.8**	24.3	45.4	*300*	*82*	**26.5**	19.1	33.9
Med. info. from a vol. org.	No	*561*	*102*	**19.3**	13.9	24.7	*846*	*167*	**18.2**	14.6	21.7
	Yes	*168*	*30*	**16.2**	7.4	24.9	*239*	*51*	**17.5**	11.2	23.8
Immigrant status	Non-immigrant	*684*	*125*	**18.6**	13.8	23.4	*1005*	*209*	**19.1**	15.8	22.3
	Immigrant	*45*	*7*	**15.8**	3.9	27.8	*80*	*9*	**7.4**	1.7	13.1
Urban / rural	Urban	*575*	*101*	**18.7**	13.6	23.8	*867*	*164*	**16.7**	13.5	19.9
	Rural	*154*	*31*	**16.6**	7.0	26.3	*218*	*54*	**26.2**	16.8	35.7

Prevalence of ED visits is the proportion of respondents with at least one ED visit in the 12 months prior to interview.
Med info: Medical information ever received.
Vol. org.: voluntary organisation
COPD: Chronic bronchitis or emphysema

VII.13 Prevalence of hospitalization according to various individual characteristics

		MALES					FEMALES				
		Total	Cases	%	95% CI		Total	Cases	%	95% CI	
Age	0 - 20	*292*	*11*	**5.9**	1.4	10.4	318	16	**4.1**	1.2	7.0
	21-38	*205*	*11*	**6.5**	1.2	11.9	383	19	**4.8**	2.3	7.4
	>38	*232*	*42*	**7.3**	3.1	11.5	384	22	**4.3**	2.3	6.3
Asthma Attacks	None	*359*	*7*	**2.1**	0.2	4.1	475	9	**1.4**	0.4	2.4
	≥ 1 attack	*370*	*35*	**10.2**	5.3	15.2	610	48	**7.0**	4.6	9.4
Sleep disturbance	< 1 / week	*651*	*30*	**5.8**	2.9	8.7	927	38	**3.5**	2.2	4.9
	≥ 1 / week	*78*	*12*	**13.0**	3.5	22.4	158	19	**10.0**	4.3	15.8
Asthma symptoms	None/rare (<1/mo)	*396*	*14*	**6.0**	1.9	10.1	506	19	**3.1**	1.6	4.6
	Often/contin (≥1/ mo)	*333*	*28*	**6.9**	3.3	10.6	579	38	**5.6**	3.3	7.8
Has Allergy	No	*360*	*31*	**8.6**	4.0	13.2	420	22	**4.3**	1.8	6.8
	Yes	*369*	*11*	**3.4**	1.1	5.8	665	35	**4.5**	2.8	6.2
COPD	No	*664*	*34*	**5.8**	2.9	8.7	958	44	**3.7**	2.3	5.1
	Yes	*65*	*8*	**13.2**	2.2	24.3	127	13	**10.1**	3.4	16.7
Daily smoker	Non	*616*	*31*	**5.4**	2.7	8.1	859	49	**4.7**	3.0	6.4
	Yes	*113*	*11*	**13.3**	2.2	24.3	226	8	**3.1**	0.7	5.4
Antiinflammatory drugs	No	*405*	*12*	**3.6**	0.9	6.3	615	21	**2.8**	1.5	4.2
	Yes	*324*	*30*	**9.4**	4.4	14.5	470	36	**6.5**	3.6	9.5
Bronchodilators drugs	No	*179*	*8*	**5.0**	--	--	265	8	**2.2**	0.2	4.1
	Yes	*550*	*34*	**6.8**	3.6	10.1	820	49	**5.1**	3.4	6.9
Non-Compliance to therapy	No	*613*	*36*	**6.1**	3.3	9.0	913	51	**5.0**	3.3	6.6
	Yes (Non-Compliant)	*116*	*6*	**8.1**	--	--	172	6	**1.9**	--	--
Having a regular doctor	No	*77*	*7*	**14.9**	--	--	72	4	**5.3**	--	--
	Yes	*652*	*35*	**5.4**	2.9	7.9	1013	53	**4.3**	2.8	5.8
Visit to a specialist	No visit	*623*	*22*	**5.1**	2.2	7.9	895	27	**2.8**	1.3	4.4
	Had visit	*106*	*20*	**15.6**	6.6	24.6	190	30	**11.3**	6.1	16.4
Physician visits	≤1 visit	*468*	*10*	**3.2**	0.4	5.9	631	10	**1.3**	0.4	2.2
	≥ 2 visits	*261*	*32*	**11.9**	5.8	18.0	454	47	**8.9**	5.8	12.0
Med. info. from a family doctor	No	*175*	*11*	**9.2**	2.3	16.1	287	13	**4.5**	1.3	7.8
	Yes	*554*	*31*	**5.5**	2.7	8.3	798	44	**4.4**	2.8	5.9
Med. info. from a specialist	No	*429*	*17*	**4.7**	1.7	7.7	663	33	**4.5**	2.6	6.4
	Yes	*300*	*25*	**8.2**	3.6	12.7	422	24	**4.3**	2.2	6.4
Med. info. From a nurse	No	*515*	*16*	**4.9**	1.6	8.1	785	35	**3.9**	2.3	5.6
	Yes	*214*	*26*	**11.3**	5.4	17.1	300	22	**5.5**	2.5	8.5
Med. info. from a vol. org.	No	*561*	*32*	**6.5**	3.3	9.6	846	42	**4.5**	2.7	6.3
	Yes	*168*	*10*	**6.3**	0.7	11.9	239	15	**4.2**	1.5	6.9
Immigrant status	Non-immigrant	*684*	*41*	**6.7**	3.7	9.7	1005	56	**4.7**	3.1	6.3
	Immigrant	*45*	*1*	**3.1**	--	--	80	1	**1.3**	--	--
Urban / rural	Urban	*575*	*34*	**7.1**	3.9	10.3	867	47	**4.6**	3.0	6.2
	Rural	*154*	*8*	**2.6**	--	--	218	10	**3.2**	0.4	5.9

Prevalence of hospitalization is the proportion of respondents with at least one hospitalization in the 12 months prior to interview.
Med info: Medical information ever received.
Vol. org.: voluntary organisation
COPD: Chronic bronchitis or emphysema

VII.14 Crude odds ratios for the association of various individual characteristics with ED visits and hospitalization

	ED visits			Hospitalizations		
	OR	95% CI		OR	95% CI	
Sex						
Females	1.00			1.00		
Males	**1.03**	0.73	1.45	**1.48**	0.82	2.70
Age						
0 - 20	1.00			1.00		
21 - 38	**1.14**	0.76	1.73	**1.10**	0.51	2.39
>38	**0.83**	0.52	1.31	**1.08**	0.50	2.30
Asthma Attacks						
None	1.00			1.00		
≥ 1 attack	**4.10**	2.69	6.27	**5.22**	2.31	11.81
Sleep disturbance						
< 1/week	1.00			1.00		
≥ 1/week	**3.05**	2.02	4.60	**2.57**	1.36	4.87
Daytime symptoms						
< 1/mo	1.00			1.00		
≥ 1/mo	**1.71**	1.20	2.45	**1.38**	0.75	2.55
Allergy						
No	1.00			1.00		
Yes	**0.75**	0.53	1.04	**0.61**	0.34	1.10
COPD						
No	1.00			1.00		
Yes	**1.92**	1.16	3.17	**2.59**	1.20	5.60
Daily smoker						
No	1.00			1.00		
Yes	**1.44**	0.97	2.15	**1.37**	0.61	3.07
Antiinflammatory drugs						
No	1.00			1.00		
Yes	**2.27**	1.57	3.28	**2.63**	1.41	4.90
Bronchodilators drugs						
No	1.00			1.00		
Yes	**1.97**	1.20	3.22	**1.82**	0.72	4.61
Non-compliance to therapy						
No	1.00			1.00		
Yes	**0.75**	0.45	1.26	**0.79**	0.25	2.47
Has a regular doctor						
No	1.00			1.00		
Yes	**0.70**	0.37	1.31	**0.42**	0.09	1.93
Visit to specialist						
No	1.00			1.00		
Yes	**3.66**	2.52	5.31	**3.65**	1.98	6.94
Physician visits						
≤1 visits	1.00			1.00		
≥ 2 visits	**6.33**	4.14	9.68	**5.12**	2.36	11.08
Med. info. from a family doctor						
No	1.00			1.00		
Yes	**1.38**	0.91	2.08	**0.74**	0.38	1.44
Med. info. from a specialist						
No	1.00			1.00		
Yes	**1.21**	0.82	1.78	**1.37**	0.75	2.48
Med. info. from a nurse						
No	1.00			1.00		
Yes	**2.66**	1.80	3.93	**1.85**	1.05	3.26
Med. info. from a vol.						
No	1.00			1.00		
Yes	**0.88**	0.57	1.36	**0.98**	0.46	2.14
Immigrant status						
No	1.00			1.00		
Yes	**0.52**	0.26	1.04	**0.35**	-	-
Urban / rural						
Urban	1.00			1.00		
Rural	**1.29**	0.82	2.05	**0.49**	0.17	1.41

Med info : Medical information ever received.
Vol. org.: voluntary organisation

VII.15 Fully adjusted odds ratios for the association of SES and income inequality with ED visits and hospitalization

	ED visits OR (95% CI)	Hospitalization OR (95% CI)
Household-level SES		
Income adequacy		
High	1.00	1.00
Middle	**1.73** (1.04, 2.86)	**3.59** (1.56, 8.25)
Low	**2.31** (1.23, 4.34)	**3.03** (1.06, 8.66)
Unknown	1.33 (0.61, 2.93)	**4.23** (1.09, 16.45)
Education status		
≥1 member has HSD	1.00	1.00
No member has HSD	**2.61** (1.35, 5.04)	2.64 (0.78, 8.92)
Employment status		
≥1 member is employed	1.00	1.00
No member is employed	**2.34** (1.27, 4.31)	2.28 (0.90, 5.79)
Unknown	†	†
Area-level SES		
IPPE		
High > $32,534	1.00	1.00
Low ≤ $32,534	**2.33** (1.45, 3.73)	**3.62** (1.70, 7.69)
Education % with no HSD		
Low: ≤ 32.56	1.00	1.00
High: > 32.56	**2.12** (1.32, 3.4)	**3.51** (1.56, 7.88)
Unemployment %		
Low: ≤ 8.40	1.00	1.00
High: > 8.40	**1.90** (1.22, 2.97)	2.15 (0.91, 5.02)
Other area measure		
Gini coefficient (CD)		
Low: ≤ 0.374	1.00	1.00
High: > 0.374	0.81 (0.50, 1.30)	0.92 (0.48, 1.77)

All ORs are adjusted for all 20 individual covariates : Age, sex, attacks, sleep disturbance, asthma symptoms, allergy, COPD, smoking status, antiinflammatory drugs, bronchodilators drugs, non-compliance to therapy, regular doctor, specialist visit, physician visits, source of medical information (Family doctor, specialist, nurse, and voluntary organisation), immigrant status and urban/rural residency area.

All area variables were measured at the census enumeration area level except for the Gini coefficient which was measured at the census division level

IPPE: Income per person equivalent. HSD: High school degree diploma

Bold ORs are significant at α = 5%.. †: high variability (CV ≥ 200%)

VII.16 Fully adjusted odds ratios for covariates associated with ED visits or hospitalization

A. Fully adjusted odds ratios for covariates significantly associated with ED visits

	OR minimum	OR maximum
Asthma Attacks (in last 12 mo)		
No	1.00	1.00
Yes	**3.26**	**3.55**
Sleep disturbance		
< 1/week	1.00	1.00
≥ 1/week	**1.83**	**2.06**
Allergy		
No	1.00	1.00
Yes	**0.57**	**0.63**
Daily smoker		
No	1.00	1.00
Yes	**1.74**	**1.75**
Antiinflammatory drugs		
No	1.00	1.00
Yes	**1.67**	**1.84**
Visit to specialist		
No	1.00	1.00
Yes	**2.23**	**2.51**
Number of physician visits		
≤1	1.00	1.00
≥2	**4.17**	**4.59**
Info ever received from nurse		
No	1.00	1.00
Yes	**2.78**	**2.94**

B. Fully adjusted odds ratios for covariates significantly associated with hospitalization

	OR minimum	OR maximum
Asthma Attacks		
No	1.00	1.00
Yes	**3.99**	**4.68**
Allergy		
No	1.00	1.00
Yes	**0.50**	**0.50**
Visit to specialist		
None	1.00	1.00
≥ 1	**2.25**	**2.36**
Number of physician visits		
≤1	1.00	1.00
≥2	**3.11**	**3.50**

All ORs are adjusted for 1 SES measure (or income inequality) + all 20 individual covariates

NS: Not significant at $p \leq 0.05$

The maximum ORs are the value of the larger OR estimate among the seven associations.
The minimum ORs are the value of the smaller OR estimate among the seven associations.

VII.17 Adjusted odds ratios for covariates significantly associated with ED visits

Household level SES		**OR**	95%CI	
Model-1				
Household income adequacy	Middle vs. high	**1.75**	1.08	2.84
	Low vs. high	**2.39**	1.27	4.52
	Unknown vs. high	1.36	0.64	2.90
Asthma attacks	≥1 vs. None	**3.61**	2.24	5.84
Allergy diagnosed	Yes vs. No	**0.63**	0.41	0.96
Visit to specialist	Yes vs. No	**2.80**	1.62	4.83
Number of physician visits	≥2 vs. ≤1	**4.43**	2.69	7.31
Model-2				
Household education	Low vs. high †	**2.62**	1.33	5.17
Asthma attacks	≥1 vs. None	**3.88**	2.38	6.31
Allergy diagnosed	Yes vs. No	**0.61**	0.40	0.93
Visit to specialist	Yes vs. No	**2.56**	1.50	4.37
Number of physician visits	≥2 vs. ≤1	**4.64**	2.87	7.50
Model-3				
Household job status (≥1 member is employed)	No vs. Yes	**2.39**	1.31	4.36
Asthma attacks	≥1 vs. None	**3.69**	2.31	5.91
Allergy diagnosed	Yes vs. No	**0.61**	0.40	0.93
Visit to specialist	Yes vs. No	**2.55**	1.48	4.40
Number of physician visits	≥2 vs. ≤1	**4.63**	2.84	7.57
Area level measures		**OR**	95%CI	
Model-1				
Area average IPPE	Low vs. high	**2.36**	1.49	3.73
Asthma attacks	≥1 vs. None	**3.77**	2.35	6.04
Allergy diagnosed	Yes vs. No	**0.61**	0.40	0.93
Visit to specialist	Yes vs. No	**2.83**	1.63	4.90
Number of physician visits	≥2 vs. ≤1	**4.59**	2.83	7.46
Model-2				
Area education	High vs. Low	**2.10**	1.32	3.35
Asthma attacks	≥1 vs. None	**3.71**	2.30	6.00
Allergy diagnosed	Yes vs. No	**0.60**	0.39	0.91
Visit to specialist	Yes vs. No	**2.83**	1.61	4.97
Number of physician visits	≥2 vs. ≤1	**4.78**	2.96	7.72
Model-3				
Area unemployment	High vs. Low	**2.00**	1.29	3.11
Asthma attacks	≥1 vs. None	**3.62**	2.25	5.81
Allergy diagnosed	Yes vs. No	**0.59**	0.39	0.91
Visit to specialist	Yes vs. No	**2.70**	1.56	4.65
Number of physician visits	≥2 vs. ≤1	**4.71**	2.90	7.65
Model-4				
Gini coefficient	High vs. Low	**0.76**	0.47	1.24
Asthma attacks	≥1 vs. None	**3.49**	2.21	5.51
Allergy diagnosed	Yes vs. No	**0.60**	0.39	0.92
Visit to specialist	Yes vs. No	**2.65**	1.55	4.52
Number of physician visits	≥2 vs. ≤1	**4.88**	3.01	7.91

All ORs from final models are adjusted for 1 SES measure (or income inequality) + 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visit, urban/rural residency and medical information received from a specialist.

The table shows only ORs for significant covariates

† : Low household education level is less than high school diploma, high household education level is high school diploma or more

COPD: Chronic bronchitis or emphysema

VII.18 Adjusted odds ratios for covariates significantly associated with hospitalization

Household SES as main exposure		OR	95%CI	
Model-1				
Household income adequacy	Middle vs. high	**3.52**	1.63	7.60
	Low vs. high	**3.25**	1.20	8.85
	Unknown vs. high	**3.69**	1.01	13.41
Asthma attacks	≥1 vs. None	**4.98**	2.05	12.10
Visit to specialist	Yes vs. No	**2.68**	1.32	5.45
Physician visit	≥2 vs. ≤1	**2.91**	1.28	6.60
Model-2				
Household education	Low vs. high †	**2.88**	0.90	9.20
Asthma attacks	≥1 vs. None	**5.07**	2.01	12.79
Visit to specialist	Yes vs. No	**2.28**	1.10	4.73
Number of physician visits	≥2 vs. ≤1	**3.14**	1.40	7.07
Model-3				
Household job status (≥1 member is employed)	No vs. Yes	**2.14**	0.94	4.85
Asthma attacks	≥1 vs. None	**4.54**	1.88	11.01
Allergy diagnosed	Yes vs. No	**0.50**	0.25	1.00
Visit to specialist	Yes vs. No	**2.54**	1.26	5.12
Number of physician visits	≥2 vs. ≤1	**3.03**	1.35	6.79

AREA level SES as main exposure		OR	95%CI	
Model-1				
Area average IPPE	Low vs. high	**3.71**	1.84	7.47
Asthma attacks	≥1 vs. None	**5.26**	2.14	12.93
Allergy diagnosed	Yes vs. No	**0.47**	0.24	0.93
COPD	Yes vs. No	**2.28**	1.01	5.15
Visit to specialist	Yes vs. No	**2.72**	1.39	5.32
Number of physician visits	≥2 vs. ≤1	**2.95**	1.32	6.58
Model-2				
Area % of people with low education	High vs. Low	**3.59**	1.67	7.70
Asthma attacks	≥1 vs. None	**5.21**	2.08	13.05
Allergy diagnosed	Yes vs. No	**0.49**	0.25	0.95
Visit to specialist	Yes vs. No	**2.74**	1.37	5.46
Number of physician visits	≥2 vs. ≤1	**3.26**	1.48	7.19
Model-3				
Area unemployment %	High vs. Low	**2.36**	1.04	5.32
Asthma attacks	≥1 vs. None	**4.85**	1.97	11.95
Allergy diagnosed	Yes vs. No	**0.47**	0.24	0.93
Visit to specialist	Yes vs. No	**2.49**	1.23	5.06
Number of physician visits	≥2 vs. ≤1	**3.15**	1.39	7.17
Model-4				
Gini coefficient	High vs. Low	**0.89**	0.45	1.77
Asthma attacks	≥1 vs. None	**4.51**	1.93	10.56
Allergy diagnosed	Yes vs. No	**0.50**	0.25	0.97
Visit to specialist	Yes vs. No	**2.47**	1.24	4.92
Number of physician visits	≥2 vs. ≤1	**3.32**	1.52	7.26

All ORs from final models are adjusted for 1 SES measure + 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visit, urban/rural residency and medical information received from a specialist.

The table shows only ORs for significant covariates

† : Low household education level is less than high school diploma, high household education level is high school diploma or more

COPD: Chronic bronchitis or emphysema

VII.19 Change in odds ratios for the association of SES or income inequality with ED visits

	Household Income (middle vs. high)	(Low vs. high)	Household education (Low vs. high)	Household job status (no job vs Has a current job)	Area average IPPE (Low vs. high)	Area education (Low vs. high)	Area unemployment (high vs. Low)	Gini coefficient (high vs. low)
ORs for SES or income inequality from full models	**1.73**	**2.31**	**2.61**	**2.34**	**2.33**	**2.12**	**1.90**	**0.81**
ORs for SES or income inequality from final models	**1.75**	**2.39**	**2.62**	**2.39**	**2.36**	**2.10**	**2.00**	**0.76**
ORs for SES or income inequality from final models when one of the following covariates is removed								
Age (old vs. younger)	1.73	2.41	2.35	1.93	2.44	2.10	2.02	0.76
Sex (male vs. female)	1.75	2.40	2.64	2.41	2.37	2.10	1.97	0.76
Asthma attacks (yes vs. none)	1.67	2.21	**1.99***	2.23	2.13	1.90	1.88	0.77
Allergy (yes vs. no)	1.81	2.46	2.86	2.47	2.38	2.09	2.00	0.76
COPD (yes vs. no)	1.77	2.45	2.71	2.43	2.37	2.12	2.00	0.76
Smoking (Daily vs. Non)	1.77	2.48	2.68	2.46	2.40	2.14	2.04	0.79
Visit to specialist (yes vs. no)	1.68	2.24	2.74	2.39	2.25	1.98	1.98	0.76
Physician visits (≥2 vs. ≤1)	1.93	**2.82***	2.86	**2.58***	2.49	2.09	2.07	0.87
Urban vs. Rural	1.77	2.40	2.55	2.33	2.38	2.14	1.99	0.75
Medical info. from specialist (yes vs. none)	1.77	2.40	2.65	2.36	2.37	2.10	2.01	0.75
% change in OR comparing the ORs for SES or income inequality from full models to the ORs of the final models when one covariate is removed								
Age (old vs. younger)	0.1	4.3	-10.1	-17.9	4.6	-1.2	6.1	-6.7
Sex (male vs. female)	1.4	4.1	1.0	3.0	1.8	-0.9	3.6	-5.7
Asthma attacks (yes vs. none)	-3.2	-4.2	**-23.6***	-4.8	-8.5	-10.3	-1.1	-4.6
Allergy (yes vs. no)	4.4	6.7	9.5	5.5	2.3	-1.4	5.0	-6.6
COPD (yes vs. no)	2.6	6.3	3.6	3.6	1.6	-0.1	4.8	-6.4
Smoking (Daily vs. Non)	2.4	7.4	2.6	4.8	3.2	1.1	7.3	-3.2
Visit to specialist (yes vs. no)	-2.8	-3.0	4.9	2.1	-3.6	-6.7	4.1	-5.8
Physician visits (≥2 vs. ≤1)	11.4	**22.3***	9.7	**10.3***	7.0	-1.4	8.5	7.3
Urban vs. Rural	2.2	4.2	-2.3	-0.5	2.3	0.9	4.7	-7.4
Medical info. from specialist (yes vs. none)	2.2	3.8	1.4	0.7	1.5	-1.1	5.7	-7.0

All ORs from final models are adjusted for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visit, urban/rural residency and medical information received from a specialist.

All ORs from full models are adjusted for 20 covariates

% change = (final adjusted OR when one covariate is dropped - fully adjusted OR) ÷ fully adjusted OR

*: compatible confounding/intermediate covariate in the association between SES and ED visits

COPD: Chronic bronchitis or emphysema

VII.20 Change in odds ratios for the associations of SES or income inequality with hospitalization

	Household Income (middle vs. high)	(Low vs. high)	**Household education** (Low vs. high)	**Household job status** (no job vs Has a current job)	**Area average IPPE** (Low vs. high)	**Area education** (Low vs. high)	**Area unemployment** (high vs. Low)	**Gini coefficient** (high vs. low)
ORs for SES or income inequality from full models	**3.59**	**3.03**	**2.64**	**2.28**	**3.62**	**3.51**	**2.15**	**0.92**
ORs for SES or income inequality from final models	**3.52**	**3.25**	**2.88**	**2.14**	**3.71**	**3.59**	**2.36**	**0.89**
ORs for SES or income inequality from final models when one of the following covariates is removed								
Age (old vs. younger)	3.49	3.27	2.72	1.96	3.70	3.60	2.36	0.88
Sex (male vs. female)	3.55	3.28	2.96	2.23	3.79	3.51	2.18	0.89
Asthma attacks (yes vs. none)	3.26	3.03	**2.28***	2.06	3.18	3.14	2.15	0.86
Allergy (yes vs. no)	3.72	3.34	3.22	2.23	3.56	3.54	2.27	0.89
COPD (yes vs. no)	3.63	**3.46***	**3.16***	2.28	3.57	3.60	2.30	0.88
Smoking (Daily smoker vs. Non daily smoker)	3.53	3.32	2.91	2.16	3.72	3.61	2.38	0.90
Visit to specialist (yes vs. no)	3.39	3.13	**3.08***	2.16	3.46	3.36	2.34	0.89
Physician visits (≥2 vs. ≤1)	3.79	**3.76***	**3.17***	2.39	4.03	3.61	2.51	0.96
Urban vs. Rural	3.38	3.20	3.02	2.22	3.56	3.28	2.34	0.90
Medical info. from specialist (yes vs. none)	3.51	3.26	2.87	2.14	3.70	3.59	2.36	0.89
% change in OR comparing the ORs for SES or income inequality from full models to the ORs of the final models when one covariate is removed								
Age	-2.7	8.0	3.1	-14.3	2.2	2.5	10.1	-3.7
Sex (male vs. female)	-1.2	8.4	12.0	-2.2	4.7	0.0	1.8	-3.1
Asthma attacks (yes vs. none)	-9.2	0.0	**-13.8***	-9.8	-12.1	-10.6	0.0	-6.7
Allergy (yes vs. no)	3.7	10.4	21.9	-2.2	-1.6	0.8	5.7	-3.0
COPD (yes vs. no)	1.1	**14.2***	**19.9***	0.0	-1.4	2.7	7.2	-4.2
Smoking (Daily vs. Non)	-1.7	9.5	10.4	-5.2	2.9	2.9	10.7	-1.4
Visit to specialist (yes vs. no)	-5.5	3.3	**16.6***	-5.1	-4.3	-4.2	9.3	-3.3
Physician visits (≥2 vs. ≤1)	5.5	**24.2***	**20.0***	4.6	11.3	3.0	16.8	4.4
Urban vs. Rural	-5.8	5.7	14.4	-2.8	-1.6	-6.6	9.2	-1.6
Medical info. from specialist (yes vs. none)	-2.2	7.7	8.6	-6.2	2.3	2.3	10.1	-2.5

All ORs from final models are adjusted for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visit, urban/rural residency and medical information received from a specialist.

All ORs from full models are adjusted for all 20 covariates

% change = (final adjusted OR when one covariate is dropped - fully adjusted OR) ÷ fully adjusted OR

*: compatible confounding/intermediate covariate in the association between SES and ED visits

COPD: Chronic bronchitis or emphysema

VII.21 Adjusted odds ratios for household SES when all three household SES measures are adjusted for

A. Change in odds ratios for the association of household SES and ED visits

	Models with 3 SES measures adjusted for at once					Models with one SES measure adjusted for at once		
	OR	95% CI		*Change in OR †*	*Change in VAR.†*	OR	95% CI	
Household income adequacy								
High	1.00					1.00		
Middle	1.48	0.89	2.46	*-16%*	*9%*	**1.75**	1.08	2.84
Low	1.53	0.80	2.91	*-36%*	*3%*	**2.39**	1.27	4.52
Household education								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	1.78	0.82	3.84	*-32%*	*29%*	**2.62**	1.33	5.17
Household job status								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	1.68	0.88	3.22	*-30%*	*17%*	**2.39**	1.31	4.36

B. Change in odds ratios for the association of household SES and hospitalization

	Models with 3 SES measures adjusted for at once					Models with one SES measure adjusted for at once		
	OR	95% CI		*Change in OR †*	*Change in VAR.†*	OR	95% CI	
Household income adequacy								
High	1.00					1.00		
Middle	**3.12**	1.41	6.89	*-11%*	*6%*	**3.52**	1.63	7.60
Low	2.25	0.65	7.88	*-31%*	*56%*	**3.25**	1.20	8.85
Household education								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	2.06	0.57	7.47	*-28%*	*23%*	2.88	0.90	9.20
Household job status								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	1.29	0.37	4.56	*-40%*	*137%*	2.14	0.94	4.85

All ORs are from final models and are adjusted for 3 SES measures and 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visits, urban/rural residency and medical information received from a specialist

† compare final model which included 3 SES measures at once with final model which included one SES measure
HSD: High school degree diploma

VII.22 Adjusted odds ratios for area SES when all three area SES measures are adjusted for

A. Change in odds ratios for ED visits with area SES when all three area-level SES measures are adjusted for

	3 SES measures in the same model					1 SES measure in the same model		
	OR	95% CI		Change in OR †	Change *in VAR.†*	OR	95% CI	
Area IPPE								
High > $32,534	1.00					1.00		
Low ≤ $32,534	1.66	0.97	2.85	-30%	8%	**2.36**	1.49	3.73
Area education % with no HSD								
Low: ≤ 32.56	1.00					1.00		
High: > 32.56	1.51	0.88	2.58	-28%	8%	**2.10**	1.32	3.35
Area unemployment %								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	1.46	0.91	2.33	-27%	6%	**2.00**	1.29	3.11

B. Change in odds ratios for hospitalization with area SES when all three area-level SES measures are adjusted for

	3 SES measures in the same model					1 SES measure in the same model		
	OR	95% CI		Change in OR †	Change *in VAR.†*	OR	95% CI	
Area IPPE								
High > $32,534	1.00					1.00		
Low ≤ $32,534	2.15	0.91	5.08	*-42%*	*50%*	**3.71**	1.84	7.47
Area education % with no HSD								
Low: ≤ 32.56	1.00					1.00		
High: > 32.56	**2.42**	1.10	5.32	*-33%*	*31%*	**3.59**	1.67	7.70
Area unemployment %								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	1.48	0.58	3.78	*-37%*	*51%*	**2.36**	1.04	5.32

All ORs are from final models and are adjusted for 3 SES measures and 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visits, urban/rural residency and medical information received from a specialist

† compare OR or variance from final adjusted model which included 3 SES measures at once with final adjusted model which included one SES measure

HSD: High school degree diploma

VII.23 Adjusted odds ratios for household SES when another household SES variable is adjusted for

ORs for ED visits	2 SES measures in the same model			% change in OR	% change in var.	1 SES measure in the same mode		
	OR	95%	CI			OR	95%	CI
Model-1								
Household income								
High	1.00					1.00		
Middle	1.61	0.98	2.67	*-8%*	*7%*	1.75	1.08	2.84
Low	**1.98**	1.02	3.81	*-17%*	*7%*	**2.39**	1.27	4.52
Household education								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	**2.06**	1.02	4.16	*-21%*	*7%*	**2.62**	1.33	5.17
Model-2								
Household income								
High	1.00					1.00		
Middle	1.54	0.94	2.54	*-12%*	*6%*	**1.75**	1.08	2.84
Low	1.67	0.87	3.21	*-30%*	*5%*	**2.39**	1.27	4.52
Household job status								
≥ 1 member is employed	1.00					1.00		
No member is employed	**1.88**	1.03	3.44	*-21%*	*1%*	**2.39**	1.31	4.36
Model-3								
Household education								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	1.92	0.89	4.14	*-27%*	*28%*	**2.62**	1.33	5.17
Household job status								
≥ 1 member is employed	1.00					1.00		
No member is employed	**2.01**	1.04	3.88	*-16%*	*20%*	**2.39**	1.31	4.36

ORs for hospitalization	2 SES measures in the same model			% change in OR	% change in var.	1 SES measure in the same mode		
	OR	95%	CI			OR	95%	CI
Model-1								
Household income								
High	1.00					1.00		
Middle	**3.17**	1.40	7.15	*-10%*	*12%*	**3.52**	1.63	7.60
Low	**2.61**	1.01	6.73	*-20%*	*-10%*	**3.25**	1.20	8.85
Household education								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	2.13	0.68	6.69	*-26%*	*-3%*	2.88	0.90	9.20
Model-2								
Household income								
High	1.00					1.00		
Middle	**3.33**	1.53	7.23	*-5%*	*1%*	**3.52**	1.63	7.60
Low	2.52	0.67	9.57	*-22%*	*77%*	**3.25**	1.20	8.85
Household job status								
≥ 1 member is employed	1.00					1.00		
No member is employed	1.51	0.50	4.58	*-29%*	*83%*	2.14	0.94	4.85
Model-3								
Household education								
High: ≥ 1 member has HSD	1.00					1.00		
Low: No member has HSD	2.40	0.62	9.32	*-17%*	*36%*	2.88	0.90	9.20
Household job status								
≥ 1 member is employed	1.00					1.00		
No member is employed	1.65	0.60	4.52	*-23%*	*51%*	2.14	0.94	4.85

All ORs are from final models and are for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visits, urban/rural residency and medical information received from a specialist

HSD: High school degree diploma.

VII.24 Adjusted odds ratios for area-level SES when another area-level SES variable is adjusted for

ORs for ED visits	2 SES measures in the same model			% change	% change	1 SES measure in the same mode		
	OR	95%	CI	in OR	in var.	OR	95%	CI
Model-1								
Area IPPE								
High > $32,534	1.00					1.00		
Low ≤ $32,534	**1.93**	1.15	3.24	*-18%*	*7%*	**2.36**	1.49	3.73
Area education % with no HSD								
Low: ≤ 32.56	1.00						1.00	
High: > 32.56	1.55	0.91	2.65	*-26%*	*7%*	**2.10**	1.32	3.35
Model-2								
Area IPPE								
High > $32,534	1.00					1.00		
Low ≤ $32,534	**1.98**	1.23	3.20	*-16%*	*6%*	**2.36**	1.49	3.73
Area unemployment								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	1.50	0.94	2.40	*-25%*	*6%*	**2.00**	1.29	3.11
Model-3								
Area education % with no HSD								
Low: ≤ 32.56	1.00					1.00		
High: > 32.56	**1.82**	1.13	2.95	*-13%*	*6%*	**2.10**	1.32	3.35
Area unemployment								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	**1.72**	1.10	2.70	*-14%*	*5%*	**2.00**	1.29	3.11

ORs for hospitalization	2 SES measures in the same model			% change	% change	1 SES measure in the same mode		
	OR	95%	CI	in OR	in var.	OR	95%	CI
Model-1								
Area IPPE								
High > $32,534	1.00					1.00		
Low ≤ $32,534	**2.50**	1.23	5.06	*-33%*	*1%*	**3.71**	1.84	7.47
Area education % with no HSD								
Low: ≤ 32.56	1.00					1.00		
High: > 32.56	**2.44**	1.11	5.36	*-32%*	*6%*	**3.59**	1.67	7.70
Model-2								
Area IPPE								
High > $32,534	1.00					1.00		
Low ≤ $32,534	**3.13**	1.32	7.43	*-16%*	*52%*	**3.71**	1.84	7.47
Area unemployment								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	1.52	0.59	3.92	*-36%*	*36%*	**2.36**	1.04	5.32
Model-3								
Area education % with no HSD								
Low: ≤ 32.56	1.00					1.00		
High: > 32.56	**3.16**	1.44	6.97	*-12%*	*7%*	**3.59**	1.67	7.70
Area unemployment								
Low: ≤ 8.40	1.00					1.00		
High: > 8.40	1.87	0.82	4.25	*-21%*	*2%*	**2.36**	1.04	5.32

All ORs are from final models and are for 10 covariates: age, sex, attacks, allergy, COPD, smoking status, specialist visit, physician visits, urban/rural residency and medical information received from a specialist.

VII.25 Prevalence of hospitalization and ED visits according to the number of physician visits

Figure V.1. Prevalence of hospitalization according to the number of physician visits

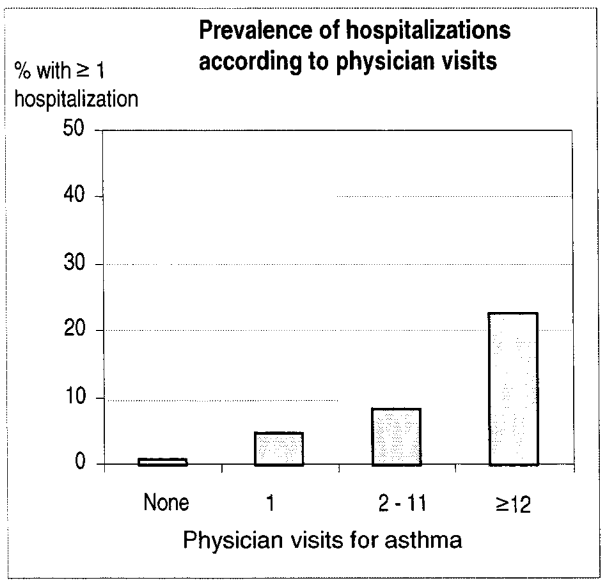


Figure V.2. Prevalence of ED visits according to the number of physician visits