SOCIOECONOMIC STATUS, ASTHMA, AND EMERGENCY DEPARTMENT USE IN ONTARIO, CANADA

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SOCIOECONOMIC STATUS, ASTHMA, AND EMERGENCY DEPARTMENT USE IN ONTARIO, CANADA

By

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Abstract

Socioeconomic factors are associated with asthma-related emergency department (ED) visits in the USA. This thesis reviewed the literature examining the association between socioeconomic status (SES) and asthma-related ED visits and hospitalizations. Secondly, it investigated if the SES of adult patients with asthma who visit the ED in Ontario, Canada is related to the frequency of ED visits. Using data from the Ontario Asthma Regional Variation Study and Statistics Canada's 2001 Census, the following SES characteristics of asthma-related ED visitors were described: age, sex, household income, marital status, highest level of educational achievement, and employment status. Using additional data from the Canadian National Ambulatory Care Reporting Service, univariate and multivariate Poisson regression analyses of SES characteristics on ED visit counts were conducted and demonstrated that lower household income and lower level of educational attainment were related to an increased risk of ED visits.

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List of Abbreviations and Symbols

CA – State abbreviation for California

ED – Emergency Department

et al.- and others

FSA – The Forward Sortation Area of a Canadian postal code is a geographical region in which all postal codes start with the same three characters

NACRS – National Ambulatory Care Reporting Service

NC – State abbreviation for North Carolina

OARVS – Ontario Asthma Regional Variation Study

ORORN – Ontario Respiratory Outcomes Research Network

RR – Relative Risk

SES – Socioeconomic Status

US – United States

USA – United States of America

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Co-Authorship Statement

Chapter two is a comprehensive review of the literature. It will be revised into a manuscript that will be co-authored with Dr. Diane Lougheed of Queen's University, Kingston, Ontario, Canada. As first author, I was responsible for formulating the research question, designing the research methods, conducting the primary analysis and writing the body of the research paper. Dr. Lougheed served as a supervisor and guide through this process. Additionally, she was involved in the iterative revision process that resulted in the manuscript in its current form.

Chapters three and four represent the analytical and primary research component of this dissertation. These chapters will be revised into independent publications co-authored with Dr. Diane Lougheed, Mr. Andrew Day, Ms. Miao Wang, and Dr. Mui Lam. Dr.'s Lougheed and Lam are associated with Queen's University. Mr. Day and Ms. Wang are associated with the Kingston General Hospital Clinical Research Unit. As first author, I was responsible for formulating the research question, designing the research methods, conducting the primary analysis, and writing the body of the research paper. Dr. Lougheed served as a supervisor and guide through this process. Dr. Lam, Mr. Day and Ms. Wang assisted with decisions regarding the primary research design, choice of analytical methods, and with technical and statistical support for data analyses. In addition, Mr. Day and Ms. Wang assisted in initial dataset linkage and performed the analysis comparing the sub-sample of ORORN data used in this thesis to the sub-sample

of ORORN data that was not used. The primary analyses and coding were conducted and written exclusively by myself.

All co-authors will assist in the preparation and revision of the forthcoming manuscripts but I will be responsible for writing the body of any manuscripts produced.

1 Introduction and Overview

1.1 Introduction

Asthma is a chronic inflammatory disease of the airways affecting 8.4% of Canadian adults and 6.7% of American adults.[1,2] Asthma exacerbations account for 1% of all ambulatory visits in the United States and are associated with a large number of hospitalizations.[2-4] Mortality from asthma continues to remain unacceptably high with as many 15-20 asthma-related deaths per 1,000,000 persons each year in the United States.[3] The World Health Organization has estimated that 15 million disability-adjusted life years (DALYs) are lost annually due to asthma. This represents 1% of the total global disease burden.[5] Clearly, asthma and its exacerbations exact a significant cost to society both financially and in terms of health status.

Many risk factors have been implicated in asthma exacerbations, hospitalizations, and deaths. Genetic factors relating to atopy and bronchial hyperresponsivensess, environmental factors such as occupation, allergen exposure, tobacco smoke and exposure to air pollution and certain sociodemographic and socioeconomic factors have all been identified to be associated with increased asthma cost and morbidity.[6] Socioeconomic factors remain one of the most consistently associated factors with asthma-related ED visits and hospitalizations. Specifically, the most extensively studied SES determinants associated with asthma morbidity include: marital status, sex, race,

household income, education, employment status, and socioeconomic status of the region in which an individual lives.[7-11]

1.2 Epidemiology of asthma and socioeconomic status – A brief review of the literature

Despite being extensively studied there has been no formal review of the body of current literature examining the association of asthma and socioeconomic factors identified after extensive searching. It has therefore been difficult to determine the relative importance and magnitude of the relationships observed. Such a review is complicated by the utilization of markedly different research methodologies between different studies and a lack of a standard set of socioeconomic variables of interest, outcome measures, or inclusion and exclusion criteria for study subjects.[12]

1.3 Literature Review

What is known about the epidemiology of the relationship between socioeconomic status and asthma is briefly summarized below. A comprehensive systematic narrative review of the literature is presented as a separate chapter of this thesis.

Perhaps the most consistently associated socioeconomic determinant associated with increased ED visits and hospitalizations is race/ethnicity. Dozens of articles have been published over the last 30 years that unequivocally demonstrate that members of visible

minorities such as African Americans[9,13], Hispanics[14], Alaskan Natives[15], Canadian Aboriginals[16], and New Zealand Maori Indians[17] have higher ED visits and hospitalizations. In fact, only 2 of 51 articles in the following comprehensive review varied from this trend.

Age and sex differences in the epidemiology of asthma have been recognized for some time. These differences appear to be dependent on age in that females younger than 15 are half as likely to have ED visits and hospitalizations than males, whereas females older than 15 years are twice as likely to have ED visits and hospitalizations than males.[3,4] Additionally, amongst adults with asthma, younger persons fair less well than older persons and there is a clear gradient of decreasing asthma-related ED visits and hospitalizations with increasing age that has been demonstrated in several studies and in epidemiological surveillance data.[3,4]

The epidemiology of income and its relationship to the epidemiology of asthma-related ED visits and hospitalizations has been studied with two basic approaches. In the first, and most straightforward approach, a person's or household's self-reported income is used to form categories which are subsequently analyzed. The second approach, which is far more common, uses aggregated small-area census or administrative data to estimate a person's or household's income. Individuals or households are subsequently assigned an income and analyzed as if they had self-reported actual income. Regardless of how income was derived, the majority of published studies demonstrate an increased risk of an asthma-related ED visit or hospitalization with decreasing index of income.[13,18-20]

Some 20 studies have examined the association of highest level of educational attainment on asthma-related ED visits and/or hospitalizations. The general trend that is identified in these studies is that increasing educational attainment is associated with fewer asthma-related ED visits and hospitalizations.[21,22] However, the literature in this area is less conclusive than the strong association identified for race/ethnicity, income or sex. A significantly higher proportion of studies demonstrate no association or weak association only.[8,23]

Only 10 studies have examined the association of labor force activity and asthma-related ED visits and/or hospitalizations. The quality of this literature is poor. All but one study presented descriptive data only. The single study that presented a statistical analysis of the association found that being unemployed was associated with an odds ratio of 1.57 for an asthma-related ED visit as compared with being employed.[13] The remaining descriptive data suggests that a relationship exists but further work needs to be done to clarify whether unemployment is associated with an increased risk of ED visits or hospitalizations.

Finally, the association between marital status and asthma-related ED visits and/or hospitalizations has been examined in 4 studies.[13,20,24] None have shown any clear association with increased risk for ED visits or hospitalizations.

1.4 Canadian Literature Review

Much of the literature examining this question has been produced in the United States of America, where, unlike Canada, there is no universal health care system. Hence, the true magnitude of the impact of socioeconomic variables on asthma morbidity and mortality in Canada is unknown. Canada has a universal socialized health care system in which socioeconomic variation in care and morbidity patterns should theoretically be minimized. However, despite such a health care system, socioeconomic disparities do exist.[25-27] Table 1-1 summarizes the current Canadian literature that met inclusion criteria for the accompanying literature review regarding the association between socioeconomic status and asthma-related ED visits and hospitalizations.

It is clear from the paucity of high-quality epidemiological research that the true magnitude of the impact of socioeconomic variables on asthma morbidity and mortality in Canada is unknown and has not been well studied. This lack of understanding and literature underlies the motivation for, and the design of, the following thesis.

Table 1-1: Canadian Literature Review

Socioeconomic Determinant	Number of Studies	Description of Findings
Sex[8, 16, 23, 28-33]	9	Seven of 9 studies demonstrated an increased number of ED visits and Hospitalizations for adult females. The majority showed the expected 2:1 ratio. Two of seven studies found no association.
Race[8, 16, 23, 28]	4	Non-white races were associated with increased odds of admission in one study but not in another. In one study there was a higher than expected number of non-white visitors. The majority of these studies were descriptive only.
Small-Area Income[8, 11, 23]	3	Small-area income was not reliably found to be associated with ED visits or Hospitalizations.
Individual Income[29]	1	Middle income Canadians were at higher risk for an admission to hospital when asthma was considered as a risk factor.
Highest Level of Educational Attainment[8, 23, 28, 29]	4	One of four studies suggested that lower education was associated with a higher odds of admission to hospital
Employment Status	0	None available
Marital Status	0	None available

1.5 Thesis Hypothesis and Objectives

The hypotheses of the following thesis are:

1. There is a general trend of increasing asthma-related morbidity with increasing socioeconomic disadvantage.

2. Canadian patients with asthma who visit the Emergency Department (ED) consist of an increased proportion of socioeconomically disadvantaged persons than the general population.

3. Canadians with lower SES have a higher risk of asthma-related morbidity and tend to visit the ED more frequently than those with higher SES.

In order to address the underlying hypothesis of this thesis, three major objectives have been identified. These objectives are addressed sequentially in separate manuscripts and form the chapters of the following thesis. The three objective of this thesis are:

1. To conduct a systematic narrative review of the adult literature examining the relationship between socioeconomic determinants of health and asthma-related emergency department visits and hospitalizations.

2. To determine if adult patients with asthma who visit the ED from a given small geographic area in Ontario, Canada have different SES characteristics than the general population with respect to the following SES determinants: age, sex, household income, marital status, level of educational attainment, and employment status.

3. To determine if the socioeconomic status of adult patients with asthma who visit the ED in Ontario, Canada is related to ED visit rates or the risk of an asthma-related ED visit.

1.6 Description of the following Manuscripts

1.6.1 Manuscript 1

Manuscript 1 addresses thesis objective 1. Manuscript 1 is a systematic narrative review of the available literature addressing the association of selected socioeconomic determinants with asthma-related ED visits and hospitalizations. Abstracted data is presented separately as a series of accompanying appendices. The review included several study types including cohort (prospective and retrospective), ecological, case-control, and surveys or other cross-sectional type studies which included data on one of the following socioeconomic determinants of health: age, sex, race, individual measures of income, regional geographic measures of income, level of educational attainment, labor force

activity, and marital status. The review included adult patients older than 14 years of age with a diagnosis of asthma and excluded other types of obstructive lung disease. The lower limit age of 14 years was chosen to avoid excluding large amounts of adult literature that included patients of this age without exposing the review to significant amounts of pediatric data. The primary endpoints of interest were asthma-related emergency department visits and hospitalizations.

1.6.2 Manuscript 2

Manuscript 2 addresses thesis objective 2. Manuscript 2 uses data from the Ontario Asthma Regional Variation Study (OARVS) (from March 1, 2001 - February 28, 2002) and 2001 Statistics Canada General Population Census Data (20% sample, weighted). Using this data, the following SES characteristics are described: age, sex, household income, single parent households, education, and employment status.[34] After dataset linkage, comparisons between the general population and a sample of asthma-related ED visitors were made using Chi-Square and Mantel-Haenszel tests controlling for geographic area.

1.6.3 Manuscript 3

Manuscript 3 addresses thesis objective 3. Manuscript 3 uses data from the Ontario Asthma Regional Variation Study, the 2001 Statistics Canada General Population Census, and the National Ambulatory Care Reporting System (NACRS). After dataset linkage, socioeconomic stratum specific emergency department visit counts were tabulated.

Subsequently, univariate and multivariate Poisson regression analyses of age category, sex, median household income category, and level of educational attainment category on emergency department visit counts were conducted.

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2 Manuscript I - Socioeconomic status and asthma: A systematic narrative review of the literature

2.1 Manuscript I: Abstract

2.1.1 Rationale

Asthma is a chronic inflammatory disease of the airways affecting 8.4% of Canadian adults and 6.7% of American Adults.[1,2] Mortality from asthma continues to remain unacceptably high with as many as 15-20 asthma-related deaths per 1,000,000 persons each year in the United States.[3] Many risk factors have been implicated in asthma exacerbations. However, socioeconomic factors remain one of the most consistently associated factors with asthma-related emergency department (ED) visits and hospitalizations. Specifically, sex, age, race, personal income, geographic location, educational attainment and marital status have been variously identified.[4-8]

2.1.2 Methods

This review included studies which reported data on one of the following socioeconomic determinants of health: age, sex, race, individual measures of income, regional geographic measures of income, level of educational attainment, labor force activity, and marital status. Selected studies included adult patients older than 14 years of age with a diagnosis of asthma and excluded other types of obstructive lung disease. The primary endpoints of interest were asthma-related ED visits and hospitalizations.

2.1.3 Results

Strong relationships demonstrating increased risk of an asthma-related ED visit or hospitalization were demonstrated for younger adults, females, persons of non-white race, and lower income groups. Having a lower level of educational attainment was also associated with increased asthma-related ED visits and hospitalizations but with significantly less robust supporting literature. Few studies examined the association of marital status or employment status to asthma-related ED visits and hospitalizations. A few studies did suggest that unemployment and being single might represent risk factors for asthma-related morbidity.

2.1.4 Conclusion

Non-white race, age, female sex, low-income, and lower educational attainment, are associated with increased asthma-related ED visits and hospitalizations. Marital status and employment status may be related to increased asthma-related morbidity but require further study.

2.2 Manuscript I: Body

2.2.1 Background

Asthma is a chronic inflammatory disease of the airways affecting 8.4% of Canadian adults and 6.7% of American Adults.[1,2] Asthma exacerbations account for 1% of all

ambulatory visits in the United States and are associated with a large number of hospitalizations.[2,3,9] Mortality from asthma continues to remain unacceptably high with as many 15-20 asthma-related deaths per 1,000,000 population each year in the United States.[3] The World Health Organization has estimated that 15 million disability-adjusted life years (DALYs) are lost each year due to asthma. This represents 1% of the total global disease burden.[10]

Many risk factors have been implicated in asthma exacerbations, hospitalizaions, and deaths. Genetic factors relating to atopy and bronchial hyperresponsivensess, environmental factors such as occupation, allergen exposure, tobacco smoke and exposure to air pollution and certain sociodemographic and socioeconomic factors have all been identified as influencing these outcomes.[11] Socioeconomic status remains one of the most consistently identified associations with asthma-related ED visits and hospitalizations. Specifically, sex, age, race, personal income, geographic location, educational attainment and marital status have been variously identified.[4-8]

Despite being extensively studied, no formal review of the body of current literature examining the association of asthma morbidity and socioeconomic factors was identified in the literature. It has therefore been difficult to determine the relative importance and magnitude of the relationships observed. Such a review is complicated by the utilization of markedly different research methodologies between different studies and a lack of a standard set of socioeconomic variables of interest, outcome measures, or inclusion and exclusion criteria for study subjects.[12]

2.2.2 Objective

The objective of the current study is to conduct a systematic narrative review of the adult literature examining the association between socioeconomic determinants of health and asthma-related emergency department visits and hospitalizations.

2.2.3 Methods

2.2.3.1 Inclusion Criteria

2.2.3.1.1 Types of studies

All studies included in this review were observational in nature. Included study types were cohort (prospective and retrospective), ecological, case-control, and surveys or other cross-sectional studies which included data on one or more of the following socioeconomic determinants of health: age, sex, race, individual measures of income, regional geographic measures of income, level of educational attainment, labor force activity, and marital status.

2.2.3.1.2 Types of participants

This study included patients older than 14 years of age with a diagnosis of asthma. Several studies included data from both patients older than age 14 years and those age 14 years and younger. Data from patients ≤14years of age were included only when a study

contained data from patients older than 14 years. If a study included younger individuals, whenever possible, only data for patients greater than 14 years of age were reported in this review. The lower limit age of 14 years was chosen to avoid excluding large amounts of adult literature that included patients of this age without exposing the review to significant amounts of pediatric data. Patients with other forms of obstructive lung disease were excluded.

2.2.3.1.3 Types of outcome measures

The primary endpoints of interest were asthma-related ED visits and hospitalizations. Studies examining repeat asthma-related ED visits and hospitalizations were excluded. Studies examining only mortality, only other markers of morbidity, or visits to other ambulatory care sites were excluded.

2.2.4 Search Methods for the Identification of Studies

2.2.4.1 Electronic searches

An explicit search strategy was undertaken of the EMBASE and PubMED databases. In addition, a bibliographic review of selected references was undertaken and relevant references not identified by electronic search methods were included. Table 2-1 provides details of the data sources, search strategy, key words and limitations used. Searches were current as of July, 2010.

Table 2-1: Search Strategy Details

Article Database	Key Words [†]	Limits	Articles Identified (n)	Articles Abstracted (n)
PubMed	• "Marital Status"[Mesh] • "Employment"[Mesh] • "Educational Status"[Mesh] OR "Education"[Mesh] • "Sex"[Mesh] • "Ethnic Groups"[Mesh] OR "Ethnology"[Mesh] OR "ethnology "[Subheading] • "Income"[MeSH] or "Poverty"[MeSH] or "Socioeconomic Factors"[MeSH] • "Patient Admission"[Mesh] OR "Patient Readmission"[Mesh] OR "Hospitalization"[Mesh] • "Socioeconomic Factors"[Mesh] OR "Social Class"[Mesh] OR "Health Status Disparities"[Mesh] • "Emergency Medical Services"[Mesh] OR "Emergency Service, Hospital"[Mesh] OR "Emergency Treatment"[Mesh] OR "Emergency Medicine"[Mesh] • "Asthma"[MeSH]	• Humans • English • All Adult: 19+ years • Adolescent: 13-18 years	449	67
EMBASE	• 'asthma'/exp • 'emergency ward'/exp OR 'emergency health service'/exp OR 'emergency care'/exp OR 'emergency treatment'/exp • 'hospitalization'/exp OR 'hospital readmission'/exp OR 'hospital admission'/exp • 'income'/exp OR 'poverty'/exp • 'social class'/exp OR 'social status'/exp OR 'socioeconomics'/exp • 'race'/exp OR 'ethnic difference'/exp OR 'ethnic and racial groups'/exp • 'sex'/exp OR 'sex'/exp OR 'sex difference'/exp • 'education'/exp OR 'educational status'/exp • 'employment'/exp OR 'employment status'/exp • 'marriage'/exp	• Adolescent • Adult • Humans • English	712	82
Selected References	Not Applicable	Not Applicable	4	4

[†] Selected combinations of MeSH and Emtree Terms were combined using Boolean operators to focus search results

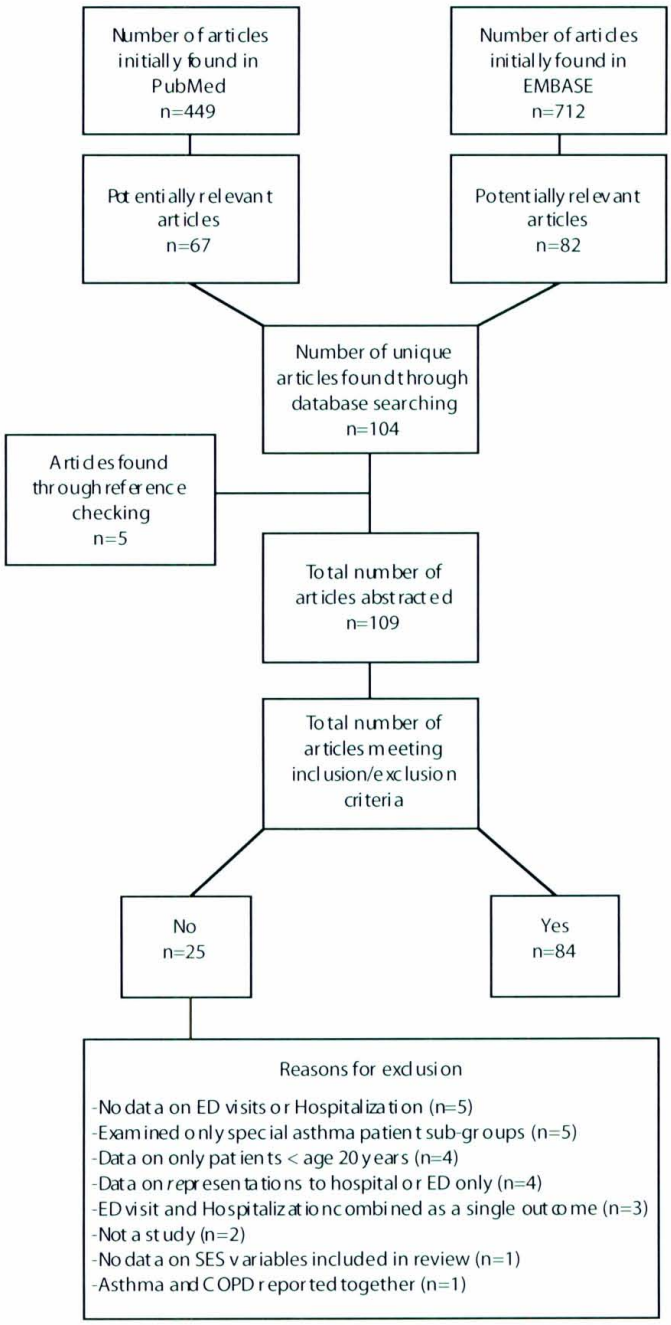

Figure 2-1: Included Studies Flow Diagram

2.2.5 Data collection and analysis

2.2.5.1 Selection of studies

A single reviewer reviewed titles and abstracts of all studies identified in electronic and selected reference searches. Supplementary and online material was reviewed when available. The full text of articles deemed to be relevant were obtained.

2.2.5.2 Data extraction and management

A single reviewer extracted data. A data collection form was utilized and extracted data was stored in an electronic database (FileMaker, FileMaker Inc., Santa Clara, California, USA).

2.2.5.3 Data synthesis

A variety of methods of reporting outcome measures were utilized in the identified studies and included, rates, relative risks, odds ratios, and simple summary statistics. Given the disparate reporting methods, a tabular presentation of the principal findings of the identified studies along with an accompanying narrative review was chosen to synthesize and report the findings.

2.2.6 Results

2.2.6.1 Results of the search / Included and excluded studies

A total of 449 and 712 individual results were returned from searches of PubMED and EMBASE respectively. A total of 104 unique articles were identified from title and abstract review for further evaluation. Five articles were identified through reference checking. One hundred and nine articles were evaluated for inclusion and exclusion criteria. Eighty-four articles met inclusion criteria. A total of 25 articles were excluded. See figure 2-1 for a diagrammatic representation of search results and details for the exclusion of articles.

2.2.6.2 Sex and asthma-related ED visits and hospitalizations

A total of 57 articles contained results detailing patient sex and its relationship with asthma-related ED visits or hospitalizations (see section 7.1.1 of the appendix for full details). Many of the included studies did not rigorously examine for statistical associations with outcomes but rather used sex as a control factor for other analyses though several articles did examine the direct relationship of sex on ED visits and hospitalizations in patients with asthma.

Nearly all included articles demonstrated a 2:1 ratio of female to male sex amongst ED visitors.[4,8,13-28] A small minority of articles demonstrated approximately equal sex ratios or a higher proportion of males amongst asthma-related ED visitors.[29,30] Despite such an

apparent sex disparity, when sex was examined as a risk factor for asthma-related ED visits in controlled statistical analyses the results were less clear. The majority of articles were still suggestive of an increased health care burden borne by females.[20,22,31] However, several articles demonstrated an increased risk for an asthma-related ED visits for men rather than women[32,33], and several other articles demonstrated no sex association at all.[13,34]

Overwhelmingly, asthma-related hospitalizations demonstrated a similar pattern of increased female to male utilization and risk.[15,26,35-57] A small number of articles suggested that males were at higher risk of an asthma-related hospitalization[25,30,32,33] or that the male and female rates of hospitalization for asthma were similar.[13,14,26,31,58-61]

2.2.6.3 Race and asthma-related ED visits and hospitalizations

A total of 51 articles contained results detailing patient race and its relationship with asthma-related ED visits or hospitalizations (see section 7.1.2 of the appendix for full details). Similar to the results reported for sex, many of the included articles did not rigorously examine for statistical associations with outcomes but rather used race as a control factor for other analyses. Generally though, a larger number of articles used statistical rather than purely descriptive methods to examine the relationship between race and asthma-related ED visits and hospitalizations.

The majority of studies demonstrated that visible minorities had higher rates of asthma-related ED visits than the general population. This was true for African Americans and Hispanics[8,16,17,20,25,30,62-66], Canadian and Australian Aboriginal peoples[27], New Zealand Maori and Pacific Islanders[18], and generally for any visible minority[33,34]. Only two of the included articles challenged the trend of higher asthma-related ED visits in minorities or persons of non-white race.[13,37] It should be noted that both articles showed increased raw rates of ED visits by visible minorities that were not considered statistically significant in controlled multivariate analyses.

Asthma-related hospitalizations demonstrated similar associations with race as asthma-related ED visits. Again, the trend of increasing admission amongst visible minorities was true for African Americans and Hispanics[5,16,25,30,41,44-46,49,50,58,62-64,66-73], Canadian and Australian Aboriginal peoples[40,74], New Zealand Maori and Pacific Islanders[75], and generally for any visible minority.[6,26,76-80] Notably, several articles did not show this relationship.[13,54,56,60,81,82] The majority of these studies were conducted at single centers, had small numbers of participants, or examined very specific racial/ethnic groups.

2.2.6.4 Personal income and asthma-related ED visits and hospitalizations

Only 8 of the included articles contained data on the individual or personal income levels of participants (see section 7.1.3 of the appendix for full details). Four of these articles examined the relationship between individual income level and asthma-related ED visits[8,20,34,81] and four at asthma-related hospitalizations.[38,46,60,77]

Two Brazilian and two American articles examined personal income level and the risk of an ED visit.[8,20,34,81] The study by Fernandes *et al.* provides only descriptive data showing that, in a certain region of Brazil, a large number of asthma-related ED visitors earn very little (69% had an average income less than $3000USD). The other Brazilian study by Brandao *et al.* did not find any association between individual income level (referenced to minimum wage) and asthma-related ED visits. The two studies conducted in the United States by Griswold *et al.* and Markovitz *et al.* both demonstrated graduated responses that showing increased asthma-related ED visits with decreasing individual income.

Of the four studies that examined the relationship of personal income level and asthma-related hospitalization one was produced in Canada[38] and three in the United States.[46,60,77] The study by Chen *et al.* in Canada used the large Canadian National Population Health Survey as its primary source of information and concluded that, in Canada, persons in the 'middle income' bracket had more asthma-related hospitalizations than those in lower and higher income groups. The three studies produced in the United States demonstrated that, at least in the US, persons of lower income were more likely to be hospitalized or had had more 'financial difficulties' in the year preceding hospitalization.

2.2.6.5 Geographic area socioeconomic status and asthma-related ED visits and hospitalizations

A total of 25 articles contained data detailing area-based income or area-based measure of SES status and their associations with asthma-related ED visits or hospitalizations (see section 7.1.4 of the appendix for full details). Only 5 of the 25 articles examined ED visits as an outcome and 22 examined hospitalizations.

Without exception, the five articles that examined the relationship between area-based markers of SES or income demonstrated consistent increases in asthma-related ED visits with decreasing socioeconomic status or income.[16,18,26,29,66] The study by Kim *et al.* demonstrated that regions of lower income were more susceptible to changes in aeroallergens and contained persons who were more likely to have an asthma-related ED visit. Bourdreaux *et al.*, Weber *et al.*, and Zoratti *et al.* all demonstrated that lower area-based measures of income, as estimated from zip-code correlated census data, was associated with increasing asthma-related ED visits.[16,26,66] Finally, Garrett *et al.* demonstrated that asthma-related ED visitors were consistently from areas of higher SES deprivation as measured on the Elley-Irving scale.[18]

The majority of the 22 articles that examined the relationship between asthma-related hospitalization and area-based SES and income measures demonstrated increasing hospitalizations with decreasing SES and income.[5,6,37,40,42,45,49,50,52,53,58,61,66,67,71,78,83-86] Only one article provided more than descriptive statistics and this article did not demonstrate a statistically significant increase in hospitalizations with increasing area-

based markers of SES and income. However, this article did show the same general trend of increasing risk of hospitalization with decreasing SES.[26]

2.2.6.6 Educational attainment to asthma-related ED visits and hospitalizations

A total of 20 articles contained results detailing the relationship between educational attainment and asthma-related ED visits or hospitalizations (see section 7.1.5 of the appendix for full details). Only 9 of the 20 articles examined ED visits as an outcome and 12 examined hospitalizations.

The majority of articles that examined educational attainment and the relationship to ED visits demonstrated an increased risk of ED visits with less schooling.[8,16,17,20,21,23,31,34,81] The studies by Brandao *et al.*, Miller *et al.*, Griswold *et al.*, and Adams *et al.* all demonstrated statistically significant increases in ED visits amongst persons having a lower educational attainment. As an example Adams *et al.* studied 293 persons over the age of 15 years in Australia and found that ED visits were significantly more frequent in those with 10 years or less of formal education ($p = 0.0007$). In contrast, the large study by Markovitz *et al.* of 2195 Americans with asthma did not show any increase in the risk for an asthma-related ED visit between college graduates, persons with high school certificates and those without high school certificates.[20]

There were a total of 12 articles that reported on the relationship between asthma-related hospitalizaions and educational attainment.[5,26,31,36,38,43,46,49,67,77,78,87] Virtually all of these

articles found an increase in hospitalizations in persons with lower educational attainment and the majority demonstrated statistical significance.[5,31,36,38,43,46,67,78,87] Notably, there were 3 articles that did not demonstrate any significant associations between educational attainment and asthma-related hospitalizations.[26,49,77]

2.2.6.7 Labor force activity to asthma-related ED visits and hospitalizations

A total of 10 articles contained results detailing the relationship between employment status and asthma-related ED visits or hospitalizations (see section 7.1.6 of the appendix for full details). Only 7 of the studies examined ED visits as an outcome and 3 examined hospitalizations.

The majority of the articles containing data on the relationship between asthma-related ED visits and employment status presented descriptive data without comparative analysis with a single exception.[8,17,19-21,88,89] In general, the observation was made that the level of unemployment or joblessness was higher in the cohort of patients with asthma that visited EDs. For example the study by Partridge *et al.* demonstrated that, of adult asthma-related ED visitors, 17.7% self-reported as being unemployed. In contrast, the population unemployment at the time of the study averaged 8.3%.[89] The only article with comparative analysis of employment status and asthma-related ED visits was by Markovitz *et al*. This study demonstrated that being unemployed was associated with an odds ratio of 1.57 (95% CI: 1.24-1.97) for an ED visit when compared with those who were employed.[20]

The three articles that reported on the relationship between asthma-related hospitalizations and employment status all reported a significantly higher number of hospitalizations amongst the unemployed. However, in two of the three articles the measure of employment was an area-based measure of employment (proportion of population unemployed in a given small geographic area) and the remaining article presented descriptive data only.[5,60,67]

2.2.6.8 Marital status to asthma-related ED visits and hospitalizations

Only 4 articles contained results detailing the relationship between marital status and asthma-related ED visits or hospitalizations (see section 7.1.7 of the appendix for full details). Three of the studies examined ED visits as an outcome and 1 examined hospitalization.

Of the three articles that included data on marital status and asthma-related ED visits, all showed that approximately 55% of asthma-related ED visitors were single.[8,17,20] The study by Markovitz *et al.* did not demonstrate any differences in marital status between ED visitors and non-visitors in a group of 2195 persons with asthma in the USA.[20] The single article that looked at the relationship between asthma-related hospitalizations and marital status did not find any difference between those hospitalized and those not.[77]

2.2.7 Discussion

This comprehensive narrative review demonstrates that there are clear and strong relationships between asthma-related ED visits and hospitalizations and markers of socioeconomic status. Specifically, the relationships between race, sex, area-based income and personal income and asthma-related ED visits and hospitalizations are convincing and have been durable across multiple countries, study types, and through time. Similarly, there is substantial data suggesting an inverse relationship between educational attainment and asthma-related ED visits and hospitalizations. Unfortunately, there is significantly less data available which examines the relationship of marital status and employment status on asthma-related ED visits and hospitalizations. Further, the data that does exist is not robust enough to draw definite conclusions but is also suggestive of an important inverse relationship.

Several important observations may be made from this review. Firstly, there is a racial and ethnic inequality in the risk for ED visits and hospitalizations amongst persons with asthma. Interestingly though, this inequality appears to apply to groups who are visible minorities rather than specific groups of genetically homogeneous groups. For example, in the US, Alaskan Natives, Hispanics and African Americans are all at increased risk for asthma-related ED visits and Hospitalizations. Certainly, these groups are genetically dissimilar though, in the US context, socioeconomically similar. This does raise the question of whether known genetic differences between ethnicities are important in asthma morbidity or whether socioeconomic status and the barriers to care and environmental changes that it implies are responsible.

Secondly, socioeconomic differences were observed in many different countries. Many of these countries purport to have universal access health care systems but continue to demonstrate a socioeconomic gradient with respect to asthma-related ED visits and hospitalizations. Again, similar to ethnic differences, this too suggests that lower socioeconomic status is associated with barriers to care or other environmental differences not easily explained by geography or genetics.

Finally, as demonstrated by this review, socioeconomic gradients in asthma-related health resource utilization unquestionably exist. The recognition of this permits us to both investigate the nature and strength of these relationships further and to better characterize the reasons why they exist. In particular, the identification of exactly how decreased socioeconomic status affects an individual's microenvironment or an individual's ability to access care and benefit from asthma care needs to be studied. The challenge now to understand how and why these relationships exist and how we can modify those factors to improve the health of patients with asthma.

The current review has several strengths. It is currently one of the only comprehensive attempts to evaluate the current literature covering this topic. Also, it has identified strong and consistent trends showing an inverse relationship between decreased socioeconomic status and increased asthma morbidity. Finally, although a narrative review, it was conducted using rigorous inclusion/exclusion and review criteria and represents a comprehensive and authoritative review of the literature. The principal weakness of the

current review is the protean number of study designs, socioeconomic comparators, socioeconomic classification systems, and inhomogeneous populations that prevented statistical pooling of results in a more formal meta-analytic format. In addition, the utilization of a single reviewer also raises the possibility of reviewer bias in article selection and data collection.

2.2.8 Conclusion

The systematic narrative review of the adult literature examining the association between socioeconomic determinants of health and asthma-related emergency department visits and hospitalizations clearly demonstrates that non-white race, female sex, decreasing area-level income and SES measures, and decreasing personal income are associated with increased ED visits and hospitalizations. Current data suggest that decreasing levels of education, being unemployed or being single are also associated with an increased risk of ED visits and hospitalizations, though the relationships are not as strong.

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3 Socioeconomic Status of Adult Patients with Asthma Utilizing the Emergency Departments in Ontario: An Analysis of Differences from the General Population

3.1 Manuscript II: Abstract

3.1.1 Rationale

Literature from the United States shows that socioeconomic status (SES) influences asthma-related resource utilization and asthma severity. Canadian literature examining this topic has generally been limited to small studies of individuals or larger ecologic studies. Enhanced understanding of the relationship between SES and asthma-related resource utilization in Canada could lead to improved allocation of treatment and educational resources. The purpose of this study is to identify differences in markers of SES between the geographically matched general population and adults with asthma who visit the emergency department (ED) in Ontario, Canada.

3.1.2 Methods

Using data from the Ontario Asthma Regional Variation Study (from March 1, 2001 - February 28, 2002; Lougheed *et al.*, 2009) and Statistics Canada 2001 Census Data (20% sample, weighted), the following SES characteristics are described: age, sex, household income, single parent households, education, and employment status. Comparisons between groups were made using Chi-Square and Mantel-Haenszel tests controlling for geographic area.

3.1.3 Results

A total of 1018 individual patients were studied. Compared with the geographically matched general population, adult patients with asthma visiting the ED were more frequently female (66.2% vs. 33.8%, $p<0.001$), were younger (53.3% vs. 40% 20-40yrs, 33.6 vs. 38.0% 40-60yrs, 13.1 vs. 21.9% >60yrs, $p<0.001$), had lower incomes (34.7% vs. 16.3% <$25,000, 38.7% vs. 23.4% $25,000 - $49,000, and 26.6% vs. 60.3% ≥ $50,000, $p<0.001$), were more frequently single (27.5% vs. 19.7% single, 55.2% vs. 65.0% married, $p<0.001$), were more frequently unemployed (15.4% vs. 4.3% unemployed, 67.4% vs. 63.9% employed, $p<0.001$, 17.2% vs. 31.8% not in labor force) and were less educated (20.0 vs. 26.4% without high school, 24.6% vs. 14.7% high school only, 39.2% vs. 33.3% some or completed trade or college, 16.2% vs. 25.6% some or completed university degrees, $p<0.001$.

3.1.4 Conclusion

There is a statistically significant and clinically important difference in the SES of adult patients with asthma who visit the ED in Ontario, Canada and the general population in which they reside.

3.2 Manuscript II: Body

3.2.1 Introduction

Eight percent of Canadian adults have asthma.[1] Many factors influence the development and severity of asthma. Socioeconomic status (SES) is of notable importance.[2-4] The most extensively studied SES determinants associated with asthma morbidity include: marital status, sex, race, household income, education, employment status, and socioeconomic status of the region in which an individual lives.[4-8] Much of the literature examining this question has been produced in the United States of America, where, unlike Canada, there is no universal health care system. Hence, the impact of socioeconomic status on asthma morbidity and mortality in Canada is unknown.

The Ontario Asthma Regional Variation Study (OARVS) investigated the regional variation in asthma morbidity seen in the province of Ontario, Canada.[9] Information about factors contributing to observed regional variation in asthma practice patterns, emergency room visits, and hospitalizations was collected. Excluding race, participant level data on the above listed SES determinants are available in the OARVS study database.

Combining region-specific, individual participant-level data from the OARVS database with region-specific population-level long-form Statistics Canada Census data affords an excellent opportunity to examine the relationship between these SES determinants of adult patients with asthma who utilize the health care system in Ontario, Canada.

In the present study, we hypothesize that patients with asthma who visit the Emergency Department (ED) are different from the general population and consist of an increased proportion of persons with lower SES than the general population. The purpose of the current study is to determine if adult patients with asthma who visit the ED from a given small geographic area in Ontario, Canada have different and lower SES than the general population with respect to the following SES determinants: age, sex, household income, marital status, level of educational attainment, and employment status.

3.2.2 Materials and Methods

The OARVS study was conducted using a stratified sample of 16 Ontario hospitals from March 1, 2001 to February 28, 2002. The details of sampling and data acquisition have been reported previously.[9,10] The study sample consisted of OARVS data from adult (age $\geq$ 20 years) ED visitors with fully completed questionnaires from the subsample of Forward Sortation Areas (FSA) for which the OARVS study had $\geq$50% market share of ED visits based on data from the National Ambulatory Care Reporting System Database 2002-2003 (NACRS). The NACRS database is a reporting system and database of Canadian ambulatory care utilization, including ED usage, maintained by the Canadian

Institute for Heath Information. The NACRS database was assumed to have 100% capture of asthma-related ED visits. Asthma-related visits were ED visits that were coded to include the following International Classification of Diseases, 10th Revision codes: J45.0, J45.00, J45.01, J45.1, J45.10, J45.11, J45.8, J45.80, J45.81, J45.9, J45.90, J44, and J44.8. The subset of FSA's with a market share ≥50% was chosen to maximize the accuracy and representativeness of the OARVS sample. NACRS market share was estimated using an analytical tool that has been previously described (Inform.Rx AdapCS Canada, Kingston, Ontario, Canada.)[11] Generally though, market share represents the proportion of ED visits to participating study centers from a given FSA.

Data on the following variables were collected: FSA, age (20-39 years, 40-59 years, ≥60 years), sex (male, female), median household income category (<$25,000, $25,000-$49,999, ≥$50,000), level of educational attainment category (less than high school, some or completed university or college, some or completed trade), marital status category (single never married, single previously married, married), employment status category (employed, unemployed).

Data were cross-tabulated and stratified by all variables except marital status and employment status. There were a number of non-unique responses (5 in total) to questions regarding marital status and employment status in the OARVS dataset. Non-unique values resulted in removal of these subjects from the analysis. SES strata-specific ED visit counts were obtained separately for the OARVS samples consisting of FSA's with ≥50% market share of ED visits and for FSA's with < 50% market share of ED visits. The

OARVS samples were then compared directly using Chi-Squares to ensure that there were no clinically or statistically significant differences between patients in FSA's with ≥50% market share of ED visits and those with <50% market share of ED visits. Corresponding general population data for the selected FSAs were obtained from the Statistics Canada 2001 Long Form Census (weighted 20% sample) and were cross-tabulated and stratified in a similar way. The OARVS sample of FSA's with ≥50% market share of ED visits and the Statistics Canada Census data were then compared directly by Chi-Squares and subsequently by Mantel-Hanzel tests for general association controlling for geographic area (FSA). A sensitivity analysis was undertaken accounting for sample weighting and the complex survey design of Statistics Canada Long Form Census Data. All statistical analyses were conducted using the SAS statistical software package (SAS, Version 9.2; SAS Institute; Cary, NC, USA). All tests were two-sided, and a p value of ≤ 0.05 was considered to be statistically significant.

3.2.3 Results

3.2.3.1 Patient Selection

In FSA's with market shares ≥50% a total of 1018 first-time adult ED visitors with asthma with fully completed questionnaires for all cross-tabulated variables were identified and subsequently evaluated in this study. This is detailed in figure 3-1. Because non-unique values resulted in removal of subjects from the analysis the total number of subjects in the OARVS sample FSA's with ≥50% market share of ED visits for marital

status and employment status is 1013. A total of 589 subjects were identified in FSA's with < 50% market share of ED visit and were excluded from the analysis. A map of included FSA's is shown in figure 3-2 (Microsoft MapPoint , Version 10.0; Microsoft Corporation; Redmond, CA, USA). This map shows that the majority of the sampled OARVS patients live in-and-around major urban centers.

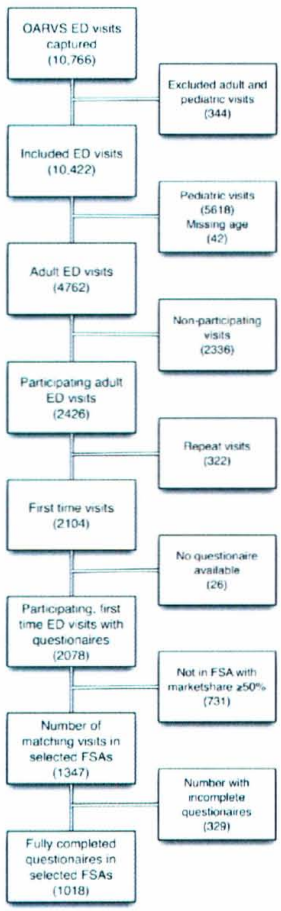

Figure 3-1: Patient Selection Flow Diagram

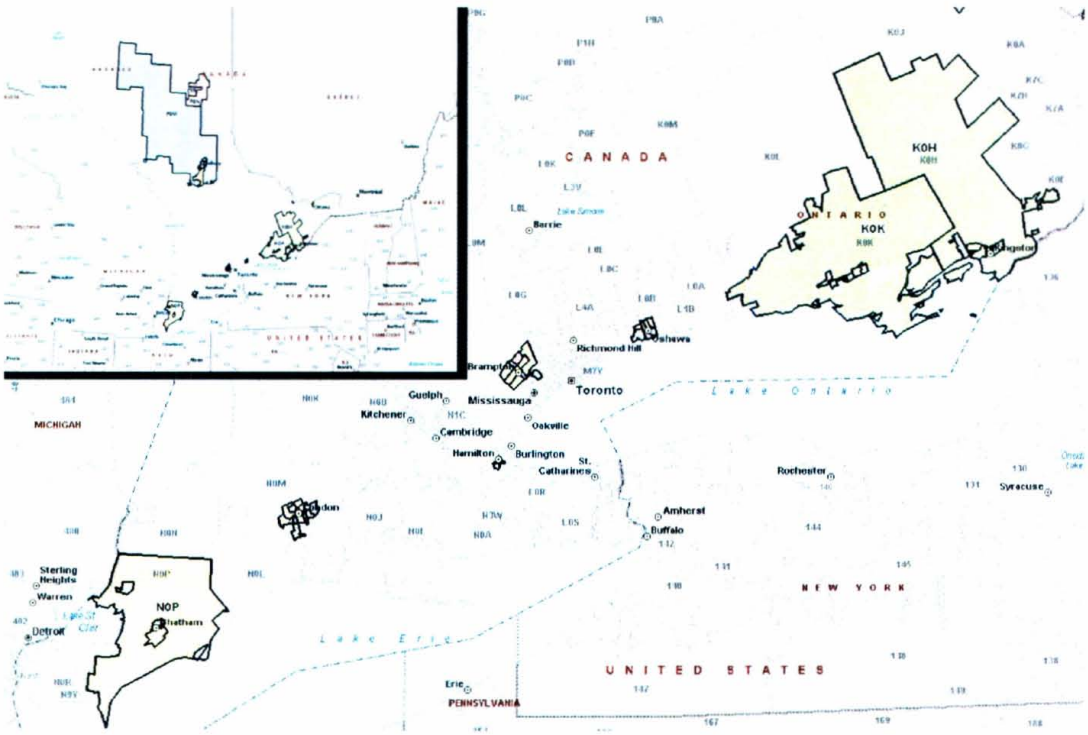

Figure 3-2: Map of Included Forward Sortation Areas (≥ 50% Market Share)

3.2.3.1.1 Comparison of FSA's with ≥50% market share of ED visits and those with < 50% market share of ED visits

Table 3-1 shows the results of the comparison of FSA's with ≥50% market share of ED visits and those with <50% market share of ED visits. While the Chi-Square analysis shows that there are statistically significant differences between the groups for the income category and educational attainment category the absolute differences are small. Hence, the two groups are appropriately considered to have similar characteristics.

3.2.3.1.2 Comparison of FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data

Table 3-2 shows the results of the comparison of OARVS FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data. For all variables examined there are statistically significant differences that persist when controlling for small geographic area.

3.2.3.2 Age

This analysis showed that adult asthma ED visitors tended to be younger than the general population with 87% of adult ED visitors between the ages of 20 and 60 years in contrast to 78% of the general population.

3.2.3.3 Sex

Almost twice as many adult females as males with asthma visit the emergency department whereas the ratio of males to females in the general population is closer to one-to-one.

Table 3-1: Comparison of FSA's with ≥50% market share of ED visits and those with < 50%

SES Determinant	Majority Market Share	Percent	Minority Market Share	Percent	χ^2, p-value
	(n)	(%)	(n)	(%)	
Age (Years)					4.1, 0.13
20-39	543	53.3	328	55.7	
40-59	342	33.6	171	29.0	
>=60	133	13.1	90	15.3	
Sex					0.005, 0.94
Male	344	33.8	198	33.6	
Female	674	66.2	391	66.4	
Income Category					7.4, 0.02
<=$24,999	353	34.7	192	32.6	
$25,000-$49,999	394	38.7	203	34.5	
>=50,000	271	26.6	194	32.9	
Educational Attainment					14.4, 0.002
Without high school graduation certificate	204	20.0	129	21.9	
High school graduation certificate	250	24.6	171	29.0	
Some or completed trade or college	399	39.2	176	29.9	
Some or completed university certificate or degree	165	16.2	113	19.2	
Employment Status[¶]					2.3, 0.32
Employed	683	67.8	371	64.1	
Not employed	156	15.0	95	16.4	
Not in the labour force	174	17.3	113	19.5	
Marital Status[¶]					4.4, 0.11
Married	559	55.2	293	49.8	
Single	279	27.5	183	31.1	
Previously married	175	17.3	113	19.2	

[§] Statistics Canada Strata Counts are reported as the population weighted value. The long form census is a complex survey design with cell weights that vary between 1 and 25. A sensitivity analysis dividing the Statistics Canada cell count sequentially from 1 to 25 to account for this design was conducted. No loss of statistical significance was detected.

[¶] Employment Status and Marital Status were not cross-tabulated. There were a number of non-unique responses to these questions in the OARVS dataset. Non-unique values resulted in removal of these subjects from the analysis. Hence, the total number of subjects in the OARVS sample FSA's with ≥50% market share of ED visits for Marital status and Employment status is 1013.

Table 3-2: Comparison of FSA's with ≥ 50% market share of ED visits and Statistics Canada Census Data

SES Determinant	OARVS	Percent	Statistics Canada [§]	Percent	χ^2, p-value MH χ^2, p-value
	(n)	(%)	(n)	(%)	
Age (Years)					87.5, <0.0001 104.4, <0.0001
20-39	543	53.3	483180	40.0	
40-59	342	33.6	458695	38.0	
>=60	133	13.1	266555	22.0	
Sex					82.1, <0.0001 80.6, <0.0001
Male	344	33.8	580190	48.0	
Female	674	66.2	628240	52.0	
Income Category					501.9, <0.0001 396.9, <0.0001
<=$24,999	353	34.7	197120	16.3	
$25,000-$49,999	394	38.7	282255	23.4	
>=50,000	271	26.6	729055	60.3	
Educational Attainment					128.2, <0.0001 113.6, <0.0001
Without high school graduation certificate	204	20.0	319440	26.4	
High school graduation certificate	250	24.6	177635	14.7	
Some or completed trade or college	399	39.2	401965	33.3	
Some or completed university certificate or degree	165	16.2	309390	25.6	
Employment Status[¶]					353.1, <0.0001 345.6, <0.0001
Employed	683	67.8	774705	63.9	
Not employed	156	15.0	52365	4.3	
Not in the labour force	174	17.3	384855	31.8	
Marital Status[¶]					49.1, <0.0001 48.8, <0.0001
Married	559	55.2	787720	65.0	
Single	279	27.5	238485	19.7	
Previously married	175	17.3	185715	15.3	

[§] Statistics Canada Strata Counts are reported as the population weighted value. The long form census is a complex survey design with cell weights that vary between 1 and 25. A sensitivity analysis dividing the Statistics Canada cell count sequentially from 1 to 25 to account for this design was conducted. No loss of statistical significance was detected.

[¶] Employment Status and Marital Status were not cross-tabulated. There were a number of non-unique responses to these questions in the OARVS dataset. Non-unique values resulted in removal of these subjects from the analysis. Hence, the total number of subjects in the OARVS sample FSA's with ≥50% market share of ED visits for Marital status and Employment status is 1013.

3.2.3.4 Income Category

There are a strikingly high proportion of adult ED visitors from low-income strata as compared to the general population. Fully 73.4% of ED visitors with asthma made less than $50,000 compared with 39.7% of the general population.

3.2.3.5 Educational Attainment

ED visitors were more likely to have graduated high school, had similar proportions having completed a trade or college certificate, but were almost half as likely to have obtained a university degree than the general population.

3.2.3.6 Employment Status

The number of employed persons in each group is similar. A slightly higher proportion of asthma-related ED visitors were employed. However, almost three times as many asthma-related ED visitors reported being unemployed compared to the general population. The number of persons identified as not-in-the-labor-force was approximately twice as high in the general population.

3.2.3.7 Marital Status

The number of single persons in the general population was less than amongst ED visitors and, correspondingly, there were a higher number of persons identified as being married in the general population.

3.2.4 Discussion

This study demonstrates clear and marked differences in the SES of adult patients with asthma who utilize the emergency department in Ontario, Canada compared to the geographically matched general population with whom they reside. Amongst ED visitors, differences in age, sex, income, and educational attainment categories were both clinically and statistically discrepant from that of the general population. The distribution of marital status and employment status, while still different between ED visitors and the general population, is less strikingly different.

Traditionally, composite or derived regional markers of socioeconomic status identified by Postal/ZIP code or census block are utilized to infer the socioeconomic status of individuals in studies of this kind. This is primarily because individual level data is often expensive and difficult to obtain.[4,12,13] This leads to confounding (ecological bias) in which ecological associations, or lack thereof, fail to predict or represent individual level associations. The present study utilizes an analysis of the individual characteristics of ED visitors compared to a geographically matched reference population. Utilization of individual level data in an analysis of this type effectively reduces or nullifies the effect of ecologic bias and is one of the major strengths of this study.

The findings of this study are consistent with previous studies conducted in other jurisdictions that demonstrate that younger age, female sex, lower educational attainment,

unemployment, and poverty are all associated with increased ED visits and hospitalizations.[13-18] However, there is less agreement about this association in the Canadian literature. For example, in an ecological study by Chen *et al.* there was no association between the proportion of a census enumeration area who were university graduates and readmission for asthma.[4] In the same study, average personal income of a small geographic region was not associated with asthma readmissions when accounting for covariates. Weber *et al.* also failed to identify a relationship between geographic markers of income and either ED visits or hospitalizations.[8] In contrast, Bacon showed that educational attainment was associated with higher ED visits and hospitalizations in Canada.[19] Also, Erzen *et al.* showed that children and older adults in 'lower-income quintiles' were more likely to be hospitalized for asthma.[6] However, to date, the current study is one of the largest Canadian studies to examine the relationship between markers of SES and ED visits. With data from over 1000 patients it provides convincing evidence that Canadians from lower income and SES strata place a disproportionate burden on ED utilization for asthma.

There are several potential reasons why such a difference exists in a country that purportedly has universal health care. Firstly, universal access to healthcare does not exist. Economic barriers are ubiquitous in the current system and include difficulties obtaining transportation, inability to forgo the economic benefits of employment for healthcare, and the inability of the "working poor" to afford prescription controller medications, comprehensive drug plans, and appropriate environmental modifications.[20] Secondly, there are educational barriers to effective asthma care.[21] Poor and uneducated

persons may have little education or knowledge of asthma's control and management and may not possess knowledge of how to access such resources. It has been definitively shown that asthma management education improves asthma related health outcomes.[22] Finally, poorer and impoverished persons often live in a microenvironment that is not conducive to asthma control.[23-26]

The current study has several strengths. In particular, the utilization of a large sample of individual level data seemed to minimize ecological bias in the analysis. In addition, the consistency with previous observations of asthma epidemiology, the use of well-validated data sources, and the magnitude of the observed differences also support the findings of the current study.

There are a number of limitations to the current study. Firstly, data from the OARVS, NACRS, and Statistics Canada Census data are not entirely contemporaneous and this may have introduced errors in the estimation of reference populations and market shares. Secondly, the Statistics Canada Long Form Census is a complex survey design and the provided dataset represents a weighted 20% sample of the total population. While sensitivity analysis accounting for the weighting of this data was undertaken, the true weights and variance of the population sample are not known. Finally, only FSA's with $\geq$ 50% market share were chosen for inclusion in this study. For this reason, and because the majority of study centers were urban hospitals, persons in rural areas may be underrepresented and the results skewed to reflect this. Finally, the sample of ED visitors chosen did not include patients that were seen in walk-in clinics, urgent care clinics not

based in a hospital setting, patients with incomplete data, or those who declined to participate in the study. These patients may be fundamentally different from those included in the analysis and this may give rise to participation bias.

3.2.5 Conclusion

There is a statistically important difference in the socioeconomic characteristics of adult patients with asthma who visit the ED in Ontario, Canada. Further, these differences highlight specific groups of people who may be more susceptible to asthma morbidity and mortality and for whom targeted interventions such as asthma education, prescription drug subsidies, and environmental modification subsidies may decrease the overall human and absolute cost of asthma.

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4 Socioeconomic deprivation and emergency department use in Ontario, Canada: A poisson regression analysis

4.1 Manuscript III: Abstract

4.1.1 Rationale

Asthma exacerbations account for 1% of all ambulatory care visits in the United States and almost half a million hospitalizations annually.[1-4] Socioeconomic factors are one of the most consistently associated factors with asthma-related morbidity and resource utilization.[5-9] The purpose of the current study is to determine if asthma-related ED visits are associated with the socioeconomic status of adult patients with asthma who visit the ED in Ontario, Canada.

4.1.2 Methods

Using data from the Ontario Asthma Regional Variation Study (OARVS), the 2001 Statistics Canada Population Census Long Form Census of the Population, and the National Ambulatory Care Reporting System, socioeconomic stratum-specific univariate and multivariate Poisson regression analyses of age category, sex, median household income category, and level of educational attainment category on emergency department visit counts were conducted.

4.1.3 Results

Univariate poisson regression analysis demonstrated that age and sex were related to an increased risk for ED visits: age (20-39 years [RR: 2.26, p<.0001], 40-59 years [RR: 1.49, p=0.0084], 60 years and over [RR: 1.00, p=Reference]) and sex (Female [RR: 1.82, p<.0001], Male [RR: 1.00, p=Reference]). Age- and sex-adjusted poisson regression analysis demonstrated that low household income and lowest level of educational attainment were related to an increased risk of ED visits: household income (persons in households with household income $50,000 and over [RR: 1.00, p=Reference], persons in households with household income $25,000 to 49,999 [RR: 4.13, p=<0.0001], persons in households with household income <= $24,999 [RR: 5.38, p=<0.0001]), highest level of educational attainment (some or completed university certificates or degrees [RR: 1.00, p=Reference], without high school graduation certificate [RR: 1.51, p=0.0078], some or completed trade or college [RR: 1.91, p=<0.0001], high school graduation certificate only [RR: 2.74 , p=<0.0001]). Similar findings were demonstrated in a multivariate poisson regression analysis.

4.1.4 Conclusion

This study demonstrated strong and graduated increases in the risk of an emergency department visit with decreasing markers of socioeconomic status. Additionally, these differences highlight specific groups of people who may be more susceptible to asthma morbidity and mortality and for whom targeted interventions such as asthma education,

prescription drug subsidies, and environmental modification subsidies may decrease the overall human and absolute cost of asthma.

4.2 Manuscript III: Body

4.2.1 Introduction

Asthma exacerbations account for 1% of all ambulatory visits in the United States.[1-3] In addition, asthma exacerbations account for almost half a million hospitalizations annually in the USA.[4] Mortality from asthma continues to remain unacceptably high with as many 15-20 per 1,000,000 asthma-related deaths each year in the United States.[1] The World Health Organization has estimated that 15 million disability-adjusted life years (DALYs) are lost annually due to asthma which represents 1% of the total global disease burden.[10]

Multiple studies have sought to identify risk factors for emergency department visits for asthma including genetic factors relating to atopy and bronchial hyperresponsivensess, environmental factors such as occupation, allergen exposure, tobacco smoke and exposure to air pollution, and socioeconomic status (SES).[11] Socioeconomic status remains one of the most consistently associated factors with asthma-related ED visits. Specifically, the SES markers sex, age, race, personal income, geographic location, educational attainment and marital status have been variously identified.[5-9]

Canada has a universal socialized health care system in which socioeconomic variation in care and morbidity patterns should theoretically be minimized. However, despite such a

health care system, disparities do exist.[12-14] In the current study, it is hypothesized that persons with asthma-related ED visitors are of lower SES and have a higher risk for asthma-related morbidity and tend to visit the emergency department more frequently than people with higher SES. Hence, the purpose of the current study is to determine if the socioeconomic status of adult patients with asthma who visit the ED in Ontario, Canada is related to ED visit rates or the risk of an emergency department visit.

4.2.2 Materials and methods

4.2.2.1 Data Sources

The Ontario Asthma Regional Variation Study (OARVS) study was conducted in a stratified sample of 16 Ontario Hospitals during the year comprising March 1, 2001 to February 28, 2002. The details of sampling and data acquisition have been reported previously.[15,16] The study sample consisted of OARVS data from individual adult (age ≥ 20 years) ED visitors with fully completed questionnaires from the subsample of Forward Sortation Areas (FSA) for which the OARVS study had ≥50% market share of ED visits based on data from the National Ambulatory Care Reporting System Database (NACRS) 2002-2003. The NACRS database is a reporting system and database of Canadian ambulatory care utilization, including ED usage, maintained by the Canadian Institute for Heath Information. The NACRS database was assumed to have 100% capture of asthma-related ED visits. Asthma-related visits were ED visits that were coded to include the following International Classification of Diseases, 10th Revision codes: J45.0, J45.00,

J45.01, J45.1, J45.10, J45.11, J45.8, J45.80, J45.81, J45.9, J45.90, J44, and J44.8. The subset of FSA's with a market share ≥50% was chosen to maximize the accuracy and representativeness of the OARVS sample. NACRS market share was estimated using an analytical tool that has been previously described (Inform.Rx AdapCS Canada, Kingston, Ontario, Canada.)[17] Generally though, market share represents the proportion of ED visits to participating study centers from a given forward sortation area (FSA).

Data on the following variables were utilized: FSA, age (20-39 years, 40-59 years, ≥60 years), sex (male, female), median household income category (<$25,000, $25,000-$49,999, ≥$50,000), and level of educational attainment category (less than high school, high school graduation certificate, some or completed university or college, some or completed trade). All variables were cross-tabulated and socioeconomic status strata-specific emergency department visit counts were obtained for the OARVS sample consisting of FSA's with ≥50% market share of ED Visits.

Corresponding general population data for the selected FSAs were obtained from the Statistics Canada 2001 Long Form Census (weighted 20% sample) and were cross-tabulated in a similar way to provide an estimate of the population at risk in a given stratum. In addition, the total number of emergency departments visits for asthma for an FSA was obtained from the NACRS database. The ratio of the number of OARVS participants in FSA's with greater than 50% market share with fully completed questionnaires to the total number of visits identified in an FSA in the NACRS database was used to weight the population at risk from a given socioeconomic stratum.

4.2.2.2 Statistical Analysis

Using socioeconomic stratum-specifc visit counts and weighted at-risk population estimates, univariate poissson regression analyses of age, gender, median household income, level of educational attainment category on emergency department visit counts were conducted. Next, a multivariate poisson regression analysis of the same variables on emergency department visit rates was conducted. Poisson regression was used as the outcome data consisted of ED visit counts in which an ED visit was a rare occurrence relative to the population at risk and the data followed a Poisson distribution. For the poisson regression, each included FSA by SES strata represented an observation where the dependent variable was the strata specific ED visit count from the OARVS sample. The corresponding offset was the natural log of the strata specific census population prorated by the proportion of NACRS emergency department visits captured in the OARVS sample. All poisson regression scale parameters were adjusted for sample overdispersion using the Pearson scaling option of SAS's *proc genmod* function. For univariate and multivariate models, socioeconomic variable category-specific visit rates were calculated by the least squared means method. For all models, likelihood ratio statistics for a type III analysis were used to assess the significance of model effects. All statistical analyses were conducted using the SAS statistical software package (SAS, Version 9.2; SAS Institute; Cary, NC, USA). All tests were two-sided, and a p-value of $\leq$ 0.05 was considered to be statistically significant.

4.2.3 Results

4.2.3.1 Patient selection

In FSA's with market shares ≥50% a total of 1018 first-time adult ED visitors with asthma with fully completed questionnaires were identified and subsequently evaluated in this study (see Figure 3-1). A total of 589 subjects were identified in FSA's with < 50% market share of ED visit and were excluded from the analysis. A map of included FSA's is shown in figure 3-2 (Microsoft MapPoint, Version 10.0; Microsoft Corporation; Redmond, CA, USA). This map shows that the majority of the sampled OARVS patients live in-and-around major urban centers.

4.2.3.2 Univariate Analyses

Each univariate poisson regression model was tested for significance of model effects and was statistically significant with $p<0.0001$. Table 4-1 shows the relative risk of an asthma ED visit for each level of the variables investigated. In keeping with studies from other jurisdictions, younger age, female gender, and lower household income show clear statistically and clinically important increases in the risk of an emergency room visit.[6,18-22] Females and the youngest age category (age 20-39 years) had approximately twice the risk of males and the oldest age category (>=60 years) respectively. Persons in the lowest median household income category (<= $24,999) had a five-fold increase in the risk of an ED visit when compared to the highest income category (>=$50, 000).

The 'some or completed university degrees' category had a slightly lower relative risk of an ED visit than 'without high school graduation certificate' which was statistically significant. In addition, while education generally followed a trend of increasing social disadvantage having a higher risk of ED visits the 'without high school graduation certificate' category was an exception.

Table 4-1: Relative risk of emergency department visits - Univariate

Variable	Category	Relative risk	95% Confidence limits		p-value
			Lower CL	Upper CL	
Age	20-39 years	2.26	1.71	3.00	<.0001
	40-59 years	1.49	1.11	2.00	0.0084
	60 years and over	1.00	1.00	1.00	Reference
Gender	Female	1.82	1.50	2.19	<.0001
	Male	1.00	1.00	1.00	Reference
Income [§]	Persons in households with household income <= $24,999	5.38	4.36	6.64	<0.001
	Persons in households with household income $25,000 to 49,999	4.13	3.37	5.06	<0.001
	Persons in households with household income $50,000 and over	1.00	1.00	1.00	Reference
Educational attainment [§]	High school graduation certificate	2.74	2.06	3.64	<0.001
	Some or completed trade or college	1.91	1.47	2.48	<0.001
	Without high school graduation certificate	1.51	1.11	2.05	<0.0078
	Some or completed university certificates or degrees	1.00	1.00	1.00	Reference

[§] Income and Educational attainment are age and sex adjusted.
For all analyses n=1018.

Table 4-2 shows the estimated rate of an asthma ED visit for each level of the variables investigated using univariate poisson regression. The highest observed rate was in the

lowest income category with a rate of 13.43 visits per 1000 persons per year. The age, gender, and education category results show similar trends with increasing SES disadvantage. Again, the 'without high school graduation certificate' category is an exception to the general trend.

Table 4-2: Rate of emergency department visits - Univariate

Variable	Category	Visit Rate per 1000 patient per year	95% Confidence limits	
			Lower CL	Upper CL
Age	20-39 years	9.97	8.81	11.29
	40-59 years	6.56	5.61	7.67
	60 years and over	4.40	3.42	5.66
Gender	Female	9.50	8.51	10.60
	Male	5.23	4.49	6.10
Income[§]	Persons in households with household income <= $24,999	13.43	11.58	15.58
	Persons in households with household income $25,000 to 49,999	10.30	8.94	11.87
	Persons in households with household income $50,000 and over	2.49	2.10	2.96
Educational attainment[§]	High school graduation certificate	10.03	8.28	12.14
	Some or completed trade or college	6.98	5.94	8.20
	Without high school graduation certificate	5.53	4.53	6.75
	Some or completed university certificates or degrees	3.66	2.89	4.64

[§] Income and Educational attainment are age and sex adjusted.
For all analyses n=1018.

4.2.3.3 Multivariate Analysis

The multivariate regression model was tested for significance and all model effects were found to be significant with $p<0.0001$. The multivariate model showed similar

relationships as the univariate analysis. The results of the multivariate analysis are found in table 4-3 (relative risks) and table 4-4 (rate estimates). It is worth noting the increase in the relative risk of an emergency visit for each of the youngest age category, females, and the lowest income category when other covariates are included in the model. As with the univariate poisson analysis the 'without high school graduation certificate' remains the only exception to the trend of increasing asthma related ED visits with increasing SES disadvantage and was the only statistically insignificant relationship observed.

Table 4-3: Relative risk of emergency department visits - Multivariate

Variable	Category	Relative Risk	95% Confidence limits		p-value
			Lower CL	Upper CL	
Age	20-39 years	2.88	2.26	3.67	<.0001
	40-59 years	2.10	1.64	2.70	<.0001
	60 years and over	1.00	1.00	1.00	Reference
Gender	Female	1.68	1.43	1.97	<.0001
	Male	1.00	1.00	1.00	Reference
Income	Persons in households with household income <= $24,999	5.52	4.53	6.72	<0.0001
	Persons in households with household income $25,000 to 49,999	4.06	3.36	4.91	<0.0001
	Persons in households with household income $50,000 and over	1.00	1.00	1.00	Reference
Educational Attainment	High school graduation certificate	2.30	1.81	2.94	<0.001
	Some or completed trade or college	1.66	1.32	2.07	<0.001
	Without high school graduation certificate	1.04	0.80	1.35	0.7913
	Some or completed university certificates or degrees	1.00	1.00	1.00	Reference

For all analyses n=1018.

Table 4-4: Rate of emergency department visits - Multivariate

Variable	Category	Rate	95% Confidence Limits	
			Lower CL	Upper CL
Age	20-39 years	11.16	9.99	12.47
	40-59 years	8.14	7.12	9.32
	60 years and over	3.87	3.11	4.82
Gender	Female	9.15	8.22	10.18
	Male	5.45	4.73	6.28
Income	Persons in households with household income $50,000 and over	2.51	2.13	2.94
	Persons in households with household income $25,000 to 49,999	10.17	8.89	11.64
	Persons in households with household income <= $24,999	13.82	11.99	15.92
Educational Attainment	High school graduation certificate	11.53	9.79	13.59
	Some or completed trade or college	8.30	7.23	9.52
	Without high school graduation certificate	5.19	4.37	6.16
	Some or completed university certificates or degrees	5.01	4.09	6.13

For all analyses n=1018.

4.2.4 Discussion

The principal finding of this study was a well-defined gradient of increasing risk of an ED visit with increasing socioeconomic disadvantage in a Canadian cohort of patients with asthma. This study is, to our knowledge, the largest study of an adult Canadian cohort to assess the relationship of individual versus area-level socioeconomic position on the frequency of asthma-related ED visits. Further, the direction and magnitude of the

findings are somewhat surprising in the context of a socialized healthcare system that purports to have universal access and availability. This study corroborates the presence of a link between socioeconomic position and asthma morbidity found in previous studies conducted in other jurisdictions.[6,18-22]

The observed relationship between socioeconomic status and ED visits for asthma may have several theoretical explanations. Firstly, socioeconomically disadvantaged persons, even in a socialized health system, may continue to suffer from barriers to access of care including monetary (lack of prescription drug coverage, lack of a regular primary care provider, inability to pay for transportation, inability to defer benefits of work for medical care), physical (rural patients need to travel farther, poor access to/utilization of specialist providers), and informational (reduced general literacy, reduced health literacy, poor access to disease specific education regarding chronic diseases.)[19,20,23-25]

Secondly, the socioeconomically disadvantaged are exposed to microenvironments that are often not conducive to good asthma care. Specifically, persons of low socioeconomic status more frequently reside in areas exposed to high pollen counts, have increased exposure to household smoking, were less frequently breast fed as children, and are more likely to be obese.[26-32]

Lastly, the socioeconomically disadvantaged are frequently from minority populations. A significant body of literature has confirmed the link between non-white race and

increasing morbidity from asthma.[7,33-37] Unfortunately, this relationship could not be controlled in this analysis as no data on race were collected.

The findings of this study are notable in their consistency regarding gradients of risk with increasing social adversity. The finding that people with the highest and lowest educational attainment have similar ED visit rates was unexpected. However, the lowest risk of an ED visit was in those with a university education compared to other groups. This suggests a protective effect of a university education compared to other types of post-secondary education. This is consistent with the general trend of decreasing morbidity with increasing socioeconomic status. The explanation for the similar risk of an asthma-related ED visit amongst those with the highest and lowest educational attainment is not clear. However, in Canada, prescription drugs are provided for persons greater than age 65 via a government funded prescription drug benefit program. Educational attainment 'less than high school' is more frequent in older age groups. The simultaneous occurrence of older age and provision of prescription drugs may have rendered this age group more immune to certain economic barriers to adequate care. Alternatively, it may have been a result of the limitations of the current study's design particularly with respect to recruiting largely urban versus rural participants and the modifying effect this might have on the influence of socioeconomic factors on access to care. In addition, as with all survey designs, the effect of voluntary response or social desirability bias may play a factor in this observation.

The present study has several strengths. The utilization of a large amount of individual level data and the subsequent minimization of ecological bias in the analysis affords a high level of confidence in the quality of the data. In addition, the consistency with previous observations of asthma epidemiology, the use of well-validated data sources, and the magnitude of the observed differences also support the soundness of the findings of the current study.

The principle weaknesses of the current study arise from the fact that data from the OARVS, NACRS, and Statistics Canada Census data are not entirely contemporaneous and this may have introduced errors in the estimation of reference populations and market shares. In addition, the Statistics Canada Long Form Census is a complex survey design and the provided dataset represents a weighted 20% sample of the total population. No attempt was made to account for the complex weighting of the census data in the present analysis. It should be noted that only FSA's with $\geq$ 50% market share were chosen for inclusion in this study. For this reason, and because the majority of study centers were urban hospitals, persons in rural areas may be underrepresented and the results skewed to reflect this. Finally, this study compares asthma-related ED visitors with the general population. This comparison does provide give any information regarding the SES status of asthma-related ED visitors compared to the population of asthmatics who do not use the emergency room or the SES status of asthma-related ED visitors compared to ED visitors in general. This potentially limits the strength of the findings that asthma-related ED visitors generally have lower SES status.

4.2.5 Conclusion

Statistically and clinically important differences in the socioeconomic characteristics of adult patients with asthma who visit the ED in Ontario, Canada exist despite the presence of a 'universal' health care delivery system. Specifically, this study demonstrated strong and graduated increases in the risk of an emergency department visit with increasing markers of socioeconomic deprivation. Further, these differences highlight specific groups of people who may be more susceptible to asthma morbidity and mortality and for whom targeted interventions such as asthma education, prescription drug subsidies, and environmental modification subsidies may decrease the overall human and absolute cost of asthma.

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5 Summary and Conclusion

5.1 Introduction

This thesis presented a hypothesis for which three primary research objectives were derived. These objectives were addressed sequentially in the three manuscripts of this thesis. Following is a discussion uniting each manuscript and relating the information gleaned from each individually and as a whole to the underlying hypotheses:

1. There is a general trend of increasing asthma-related morbidity with increasing socioeconomic disadvantage.

2. Canadians with asthma who visit the ED consist of an increased proportion of socioeconomically disadvantaged persons than the general population.

3. Canadians with lower SES have a higher risk of asthma-related morbidity and tend to visit the ED more frequently than those with higher SES.

5.2 Review of literature

This comprehensive narrative literature review identified clear and strong relationships between asthma-related ED visits and hospitalizations and markers of socioeconomic status. The relationships between race, gender, area-based income and personal income and asthma-related ED visits and hospitalizations are convincing and have been durable

across multiple countries, study types, and through time. Similarly, there was substantial data suggesting an inverse relationship between educational attainment and asthma-related ED visits and hospitalizations. Significantly less data is available examining the relationship of marital status and employment status on asthma-related ED visits and hospitalizations. Further, the data that does exist were not robust enough to draw definite conclusions but were also suggestive of an important inverse relationship.

Canada has a universal socialized healthcare system in which socioeconomic variation in care and morbidity patterns should theoretically be minimized. However, despite such a universal healthcare system, disparities do exist.[1-3] Much of the literature examining the relationship between asthma-related ED visits and hospitalizations and socioeconomic status has been produced in the United States of America, where, unlike Canada, there is no universal healthcare system. The paucity of Canadian literature that does exist consisted of markedly varied and difficult-to-compare methodologies with inhomogenous outcome measures and definitions of socioeconomic status. While the bulk of Canadian literature tends to confirm similar trends as found in other jurisdictions, it is less conclusive and less methodologically robust than the remaining literature. This was demonstrated in the mini-review of the Canadian-only literature contained in the introduction to this thesis.

The systematic literature review confirmed the first thesis hypothesis that there was a general trend of increasing asthma-related morbidity with decreasing SES. Further, review of the Canadian literature demonstrated that the variation in asthma-related ED

visits and hospitalizations, as they relate to one's socioeconomic status, had not been well studied in Canada and was largely unknown.

The literature review suffered due to the protean number of study designs, socioeconomic comparators, socioeconomic classification systems, and inhomogeneous populations that prevented statistical pooling of results in a more formal meta-analytic format. There was also a dearth of analytic studies with much of the literature consisting of observational data only. This was particularly true for the Canadian studies.

The literature overwhelmingly supported an inverse relationship in which decreasing socioeconomic status was associated with increasing asthma-related morbidity. This is particularly true of the United States, the country in which the majority of research on this topic has been conducted. Having demonstrated this fact, the second manuscript attempted to address the question of whether or not asthma-related ED visitors were socioeconomically similar to the general population with whom they reside in Ontario, Canada.

5.3 Asthma ED visitors are different from the general population with whom they reside

Manuscript II addressed objective 2 of this thesis and demonstrated clear and marked differences in the SES of adult patients with asthma who utilize the ED compared to the geographically matched general population with whom they reside. Amongst ED visitors,

differences in age, gender, income, and educational attainment categories were both clinically and statistically discrepant from that of the general population. The distribution of marital status and employment status, while still different between ED visitors and the general population, was less strikingly different. Overall, this suggested that SES and markers traditionally associated with socioeconomic deprivation were associated with increased ED visits in Ontario, Canada and confirmed the second tenet of the hypothesis underlying this thesis.

The study conducted an analysis to compare the individual characteristics of ED visitors to a geographically and SES matched reference population. Traditionally, composite or derived regional markers of SES identified by postal/ZIP code or census block are utilized to infer the socioeconomic status of individuals in studies of this kind. This is primarily because individual level data is often expensive and difficult to obtain.[4-6] This leads to confounding ecological bias in which ecological associations, or lack thereof, fail to predict or represent individual level associations. Utilization of individual level data in an analysis of this type effectively reduces or nullifies the effect of ecologic bias and was one of the major methodological strengths of this study. The principal limitation of this study derives from difficulties with database linkage. Specifically, data from the OARVS, NACRS, and Statistics Canada Census data are not entirely contemporaneous and this may have introduced errors in the estimation of reference populations and market shares. In addition, the Statistics Canada Long Form Census is a complex survey design and the dataset utilized represented a weighted 20% sample of the total population. Attempting to account for this weighting was complex and several assumptions regarding the dataset

were made when doing so. Specifically, the increased sample variance of the Statistics Canada 20% 2001 Census sample data was not directly accounted for and was assumed to be homogeneous for all data. Instead, a sensitivity analysis was conducted to attempt to account for any loss of statistical robustness. These assumptions regarding observation weights and variances may not be valid. Finally, rural patients with asthma were underrepresented due to the selection criteria employed.

Acknowledging these limitations, the analysis confirmed the second major tenet of the thesis hypothesis that Canadian patients with asthma who visit the ED are different from the general population and consist of an increased proportion of SES disadvantaged persons than the general population. The nature and magnitude of the relationship of these differences were addressed in the third manuscript.

5.4 SES characteristics are associated in a predictable way with ED visits

Manuscript III addressed the final objective of this thesis. The principal finding of this study was a well-defined gradient of increasing risk of an ED visit with increasing socioeconomic disadvantage in a Canadian cohort of patients with asthma. The direction and, more pointedly, the magnitude of the findings are somewhat surprising in the context of a socialized healthcare system that purports to have universal access and availability. Younger age, and female sex were both associated with a higher risk of an asthma-related ED visit. Lower household income and lower level of educational attainment were also

associated with increased asthma-related ED visits in age-sex adjusted univariate and multivariate models. The utilization of a large amount of individual level data allowed minimization of ecological bias in the analysis and afforded a high level of confidence in the quality of the data.

From a methodological standpoint, the analysis presented in the third thesis manuscript suffers from similar weaknesses as outlined regarding the second manuscript. Principally, these were in the same three broad categories: complexities of dataset linkage, assumptions regarding statistical weighting, and rural underrepresentation.

The analysis did, however, support the third and final tenet of the thesis hypothesis that socially disadvantaged Canadian patients have a higher risk for asthma related morbidity and tend to visit the emergency department more frequently than the less socially disadvantaged.

5.5 Clinical Implications

The role of socioeconomic determinants on asthma-related morbidity, both generally and in the Canadian context, has been clearly demonstrated in the three manuscripts that comprise the body of this dissertation. While it is possible that age, sex and racial genetic differences explain some of the observed variation attributed to socioeconomic factors the more probable explanation is more complicated.

Firstly, socioeconomically disadvantaged persons more frequently reside in areas exposed to high pollen counts, have increased exposure to household smoking, were less frequently breast fed as children, and are more likely to be obese.[7-13] Hence, socioeconomically disadvantaged persons are probably exposed more frequently to microenvironments that are often not conducive to good asthma care.

Secondly, socioeconomically disadvantaged persons, even in a socialized health system, may continue to suffer from barriers to access to care including monetary (lack of prescription drug coverage, lack of a regular primary care provider, inability to pay for transportation, inability to defer benefits of work for medical care), physical (rural patients need to travel farther, poor access to/utilization of specialist providers), and informational (reduced general literacy, reduced health literacy, poor access to disease specific education regarding chronic diseases.)[14-18]

Fundamentally, individual microenvironment and barriers to access to care are modifiable risk factors. Microenvironment change is possible and current guideline statements are replete with statements regarding both their usefulness and supporting literature.[19] Microenvironment change may be difficult for persons of limited socioeconomic means and may require significant personal, healthcare, and financial resources to implement. Barriers to access to care are removable if the resources are provided to identify them and do so. In fact, a number of evaluative frameworks are available the sole function of which is to identify modifiable health care access barriers.[20,21] These could be employed in the

study of asthma epidemiology and the findings implemented as part of a chronic health care model for asthma.

The analyses presented in the manuscripts of this thesis identify that socioeconomic differences in asthma morbidity exist in Canada. More importantly, this body of work helps to identify the populations at highest or increased risk for asthma-related morbidity in Canada. Using this information to target further study of health care access barriers and subsequent interventions and also to aid in the implementation of microenvironmental change is the ultimate contribution of this work.

5.6 Conclusion

Asthma morbidity is related to socioeconomic status regardless of country, race/ethnicity, or sex. This is true for the Canadian experience as well. This is demonstrated by the findings of this study which showed that there are statistically and clinically important differences in the socioeconomic characteristics of adult patients with asthma who visit the ED in Ontario, Canada and the general population in which they reside and that these differences are characterized by strong and graduated increases in the risk of an emergency department visit amongst asthma-related ED visitors in Canada that increases with increasing markers of socioeconomic deprivation. These differences highlight specific groups of people who may be more susceptible to asthma morbidity and mortality and for whom targeted interventions such as asthma education, prescription

drug subsidies, and environmental modification subsidies may decrease the overall human and absolute cost of asthma.

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7 Appendices

7.1 Appendix I: Literature Review Tables

7.1.1 Asthma-related ED visits and Hospitalizations: Sex

Author, Year	Data Sources	Results
Roy et al., 2010[1]	Mississippi Asthma Surveillance System 2003-2005 United States Census Data	*Hospitalization Results:* Asthma hospitalization rates were higher among females.
Lambertino et al., 2009[2]	Individual patients	*ED Visit Results:* The odds of a male having an ED visit in the last year was 1.13 when compared with women (95% CI: 0.38-3.29). *Hospitalization Results:* The odds of a male having a hospitalization in the last year was 0.89 when compared with women (95% CI: 0.29-2.74).
Rowe et al., 2009[3]	Alberta Ambulatory Care Classification System Database 1999-2005	*ED Visit Results:* ED visits were predominantly female (61.2%; 64,741 of 105,813 visits).
Smith et al., 2009[4]	Arizona Healthcare Cost Containment System Medicaid administrative claims database 2002-2003	*Hospitalization Results:* Males were 45% less likely than females to have an exacerbation (OR 0.55, 95% CI 0.32-0.95).
Ginde et al., 2008[5]	United States National Hospital and Ambulatory Care Survey 1993-2005 United States Census Bureau Population Estimates 1993-2005	*ED Visit Results:* Overall, asthma ED visit rates were higher among women (7.2 per 1000 population, 95% CI: 6.6-7.7) than men (6.1 per 1000 population, 95% CI 5.6-6.6).
Correll et al., 2007[6]	New South Wales Inpatient Statistics Collection 2000-2003 Victorian Admitted Episodes dataset 2000-2003 New South Wales Emergency Department Data Collection 2000-2003 Victorian Emergency Minimum Dataset 2000-2003 Australian Census 1996	*Hospitalization Results:* Females had a higher odds of admission compared to males (OR: 1.09, 95% CI: 1.03-1.14).
Kim et al., 2007[7]	Seoul Air Pollution Monitoring Stations, Seoul, Korea 2002 Data Korean National Health Insurance Records 2002	*ED Visit Results:* 50.1% of ED visitors were male and 49.9% of ED visitors were female.
Rowe et al., 2007[8]	Individual patients - Multicenter Asthma Research Collaboration Data 1996-1998 Canadian Census Data United States Census Data	*ED Visit Results:* Females accounted for 57% of Canadian ED visits and 55% of US ED Visits.

Author, Year	Data Sources	Results
Al Marri et al., 2006[9]	Human Information Systems at the Hamad Medical Cooperation United States National Hospital Discharge Survey	*Hospitalization Results:* The rate of hospitalization was almost three times higher in women than men (78 versus 36 per hundred thousand population).
Baibergenova et al., 2006[10]	Canadian National Ambulatory Care Reporting System Visit Data	*ED Visit Results:* 62% of visitors to the ED were Female versus 38% males. *Hospitalization Results:* 73% of patients hospitalized with asthma were females versus 27% males. Women consistently had higher hospitalization rates than men within each category of age group, Canadian Triage and Acuity Score, and ED volume with an overall odds ration in a multivariate model of 1.64, (95% CI 1.41-1.90).
Markovitz et al., 2006[11]	Individual Patients	*ED Visit Results:* 77% of ED visitors or urgent resource users were female. Male gender was associated with a reduced risk of needing urgent or emergent care (OR 0.59, 95% CI 0.48, 0.72).
Meng et al., 2006[12]	Individual patients - California Health Interview Survey data 2000-2001 United States Census 2000	*ED Visit Results:* No significant association found.
Miller et al., 2006[13]	Individual patients - Data from the 'The Epidemiology and Natural History of Asthma: Outcomes and Treatment Regimes' study	*ED Visit Results:* 71.6% of ED visitors for asthma were females.
Ng et al., 2006[14]	Individual patients	*ED Visit Results:* Male sex was associated with a greater hazard of having an ED visit (HR: 1.58, 95% CI: 1.15-2.17).
Pines et al., 2006[15]	Individual Patients	*ED Visit Results:* 66% of ED visitors were female.
Ramos et al., 2006[16]	United States Census 2000 Pennsylvania Department of Transportation Traffic Data Pennsylvania Health Care Cost Containment Council Hospitalization data	*Hospitalization Results:* Females had a higher relative risk of hospitalization for asthma when compared to males (RR = 3.34, p = .0001).
Singleton et al., 2006[17]	Indian Health Services Direct and Contract Health Service Inpatient Data set for AI/AN populations 1998-2002 United States National Hospital Discharge Survey 1988-2002	*Hospitalization Results:* Females had higher hospitalization rates in all adult age groups (>20 yrs.).
Baibergenova et al., 2005[18]	Canadian National Ambulatory Care Reporting System 2001-2004 Statistics Canada Population Data Files	*ED Visit Results:* 61.93% of visitors to the ED for asthma were female.
Getahun et al., 2005[19]	National Hospital Discharge Survey Public Use Data Files 1995-2002 Centers for Disease Control Mortality Database	*Hospitalization Results:* Adult females had a higher rate of hospital admission than males for all years studied.
Griswold et al., 2005[20]	Individual Patients The Sourcebook of ZIP code demographics, 12th ed.	*ED Visit Results:* In a multivariate model, female sex was not a significant predictor of less frequent ER visits (OR 0.81, P=0.06).

Author, Year	Data Sources	Results
Lyratzopoulos et al., 2005[21]	United Kingdom Hospital Episode Statistics Data 1997-2001 United Kingdom Census 1991	*Hospitalization Results:* 53.5% of persons admitted for asthma were female. However, male sex was significantly associated with increased readmission risk, independently of length of follow-up in a multivariate regression analysis.
Smith et al., 2005[22]	Texas Medicaid Administrative Claims Data 2000	*ED Visit Results:* The rate of ED visits per 10,000 persons on Medicaid for females was 37.2 and 12.8 for males. This suggested that males utilized the ED more frequently. *Hospitalization Results:* The rate of hospitalization per 10,000 persons on Medicaid was 10.3 for females and 12.8 for males.
Dalcin et al., 2004[23]	Individual patients	*ED Visit Results:* 70.9% of ED visitors were female.
Goeman et al., 2004[24]	Individual patients	*ED Visit Results:* females accounted for 69% of all adult ED visitors.
Baybek et al., 2003[25]	Individual patients	*Hospitalization Results:* The ratio of females to males amongst hospitalized patients was 5.7:1 versus 4:1 in community controls.
Boudreaux et al., 2003[26]	Individual Patients - Multicenter Asthma Research Collaboration Data 1996-1998 United States Census	*ED Visit Results:* 62%, 66% and 71% of African American, Hispanic, and Caucasian ED visitors, respectively, were female.
Chen et al., 2003[27]	Canadian Institute for Health Information Hospital Discharge Database 1994-1997 Canadian Census 1996	*Hospitalization Results:* Females accounted for 55.7% of 'broadly defined' asthma hospitalization, and 51.4% of 'narrowly defined' episodes. The proportion of hospitalizations for females was lower than that for males before the age of 14 years, and it was reversed after the age of 14 years.
Fernandes et al., 2003[28]	Individual patients	*ED Visit Results:* 70.9% of ED visitors were females and 29.1% were males. There were no significant differences between infrequent and frequent visitors.
Ng et al., 2003[29]	Singapore Ministry of Health National Database of the Central Claims Processing System 1991-1998 Singapore Census Data	*Hospitalization Results:* Overall the rate ratio for asthma admission was higher for males (1.21, 95% CI: 1.14-1.28) compared with females. However, this was driven by the large proportion of persons <15 years of age. The rate ratio for persons >= 15 was higher for females.
Salamzadeh et al., 2003[30]	Individual patients - Chart review data Local Hospital Administrative/Discharge Databases 1994-1998 United Kingdom Census Data	*Hospitalization Results:* 59.5% of patients admitted to hospital for asthma for asthma were female versus 40.5% male.
Schatz et al., 2003[31]	Southern California Kaiser Permanente Asthma Case Identification Database 1998-1999 United States Census 1990	*Hospitalization Results:* Sixty-two percent of asthmatic children were male, while 63% of asthmatic adults were female.
Deprez et al., 2002[32]	Individual Patients 1994/1995 Data from the Maine Uniform Hospital Discharge Database 1994 Data the Maine Health Care Finance Commission	*Hospitalization Results:* The rate of hospitalization for females of all ages was 1.64 (95% CI: 1.34-1.93) per 1000 population versus 0.86 (95% CI: 0.64-1.07) per 1000 population for males.
Diette et al., 2002[33]	Individual patients - Managed Health Care Association Outcomes Management System Asthma Project	*Hospitalization Results:* Women were twice as likely to be hospitalized in the follow-up year than men (10.2% versus 5.4%, p <0.001).
Montealegre et al., 2002[34]	Individual patients - Data from chart reviews	*ED Visit Results:* Females were almost twice as likely to visit the ED for asthma.

Author, Year	Data Sources	Results
Weber et al., 2002[35]	Individual patients - Multi- center Airway Research Collaboration Data 1996-1998	*ED Visit Results:* Amongst acute ED visitors with asthma 65% were female. *Hospitalization Results:* Female sex was associated with an increased odds of admission (OR: 2.1, p<0.005) in asthma ED visitors.
Brokaw et al., 2001[36]	Missouri State Information for Community Assessment Database 1990-1997 University of Missouri Office of Social and Economic Data Analysis Population and SES Data	*Hospitalization Results:* Women had age adjusted hospitalization rates similar to males (57.3 versus 56.0 per 10,000 population).
Chen et al., 2001[37]	Individual patients - Canadian National Population Health Survey 1994-1995	*Hospitalization Results:* The incidence of hospitalization was similar for men and women who were >= 40 years of age, but was greater for women than for men in the younger age groups.
Adams et al., 2000[38]	Individual patients - Western Region Asthma Pilot Project data 1995-1997	*ED Visit Results:* Men were significantly less likely to have an emergency department visit than women (p = 0.048). *Hospitalization Results:* There were no significant differences in hospitalization between men and women.
Blixen et al., 1999[39]	Computer administrative/discharge database of a "large Midwestern health system" 1993-1995 United States Census 1990	*Hospitalization Results:* 77.2% of patients admitted to hospital for asthma were female versus 22.8% male.
Singh et al., 1999[40]	Individual patients - Multicenter Asthma Research Collaboration study Data	*ED Visit Results:* 64.3% of visitors to the ED were female versus 35.7 male.
Gilthorpe et al., 1998[41]	United Kingdom Hospital Episodes Database 1995-1996 United Kingdom Census 1991	*Hospitalization Results:* Males had higher standardized admission ratios (SAR) in the 0-4 year old age group and similar SAR's for the 5-14 year old age group. However, females had higher SAR's for all other age groups.
Ray et al., 1998[42]	California Hospital Discharge file 1993 United States Census 1990 (Tape 3B)	*Hospitalization Results:* The rate of admissions amongst females was 12.5 per 10,000 population versus 8.2 for males.
Apter et al., 1997[43]	University of Connecticut Health Center Billing Data 1993-1995 United States Census 1990 (Tape 3A)	*ED Visit Results:* Of patients treated in the ED for asthma 69% were female versus 31% male. However, in a logistic regression analysis, gender was not a predictor of ED visits for asthma. *Hospitalization Results:* Of patients admitted for asthma 63% were female versus 37% male. However, in a logistic regression analysis, gender was not a predictor of admission for asthma.
Heard et al., 1997[44]	Modbury and Queens Elizabeth Hospital Patient Records 1989-1991	*Hospitalization Results:* Of patients admitted to hospital for asthma, 68% were female versus 32% male.
Kolbe et al., 1997[45]	Individual patients	*Hospitalization Results:* Of patients admitted for asthma, 75% were female versus 25% male.
Murray et al., 1997[46]	Regenstrief Medical Record System of the Wishard Memorial Hospital, Indianapolis, Indiana 1985-1992 Indiana State Department of Health Death Tapes	*ED Visit Results:* Asthma specific ED visits were similar for males and females (11.4 per 100 patient years for white females compared with 13.4 per 100 patient years for African American males). *Hospitalization Results:* Asthma-specific hospitalizations were highest amongst African American males compared with other race and gender strata (14.6 versus 7.8 per 100 patient years). Asthma hospitalizations were similar between Caucasian males and females.
Partridge et al.,	Individual patients	*ED Visit Results:* 44.9% of ED visits for asthma were females

Author, Year	Data Sources	Results
1997[47]		versus 55.1% males.
Prescott et al., 1997[48]	The Copenhagen City Heart Study data (Individual patient baseline demographics) Denmark National Hospital Discharge Register	*Hospitalization Results:* Of those admitted for asthma, 62.5% were female versus 37.5% male. After controlling for self-reported asthma and smoking, women had a higher risk of being admitted to hospital than men (relative risk 1.7, 95% confidence interval 1.2 to 2.4).
Awadh et al., 1996[49]	Individual Patients	*ED Visit Results:* 88 Females versus 47 males visited the ED during the study period (a ratio 0f 1.9:1). *Hospitalization Results:* There were no significant differences in the percentage of males and females admitted to hospital (13% and 12.1% respectively).
Harju et al., 1996[50]	National Research and Development Centre for Welfare and Health Administrative/Discharge Databases	*Hospitalization Results:* There were 100,972 hospitalizations for females versus 91223 hospitalizations for males over the 10-year period in the study. Admissions were higher in males in childhood, and in the elderly, but were higher in females between ages 30 to 50 years.
Watson et al., 1996[51]	United Kingdom Census 1991 West Midlands Health Information System - Finished Consultant Episodes Data 1991-1994	*Hospitalization Results:* Admission rates were higher in male children aged 0-14 but higher in females aged > =15 years.
Targonski et al., 1995[52]	Illinois Health Care Cost Containment Council Administrative/Discharge Databases United States Census 1980 population data Chicago Department of Planning 1987-1989 population data Medicaid population data 1988	*Hospitalization Results:* Of patients admitted for asthma, 47.5% were female versus 52.5% male.
De Palo et al., 1994[53]	New York State wide Planning and Research Co-operative System (SPARCS) data 1989-1991 United States Census 1990	*Hospitalization Results:* Females had statistically significantly more admissions than males for all years studied ($p<0.01$).
Haas et al., 1994[54]	Individual Patients	*Hospitalization Results:* 71% of patients with asthma admitted to hospital were female versus 29% male.
Carr et al., 1992[55]	New York State Department of Health Administrative/Discharge Databases 1982-1987 New York City Department of Health Vital Statistics Data United States Census 1980 (STF-3B Data file)	*Hospitalization Results:* The rate of admission for asthma was similar for males and females at 40.6 and 37.8 per 10,000 populations respectively.
Skobeloff et al., 1992[56]	Delaware Valley Hospital Council Administrative/Discharge Database Pennsylvania State Data Center provided "1990 Census of Population: Housing Profile I"	*Hospitalization Results:* In the 0-10 years old age groups, statistically significantly more males were admitted than females. However, from age 10 to 70, statistically significantly more females were admitted than males with a ratio of almost 3:1 through the majority of the range.
Garrett et al., 1988[57]	Individual Patients New Zealand Census of the Population 1981 Middlemore Hospital Administrative/Discharge Databases	*ED Visit Results:* Males had higher visit rates in the 5-14 year old group ($p>0.01$). However, females had higher or equal rates for all others.

7.1.2 Asthma-related ED visits and Hospitalizations: Race

Author, Year	Data Sources	Results
Roy et al., 2010[4]	Mississippi Asthma Surveillance System 2003-2005 United States Census Data	*Hospitalization Results:* Asthma hospitalization rates were higher among African Americans. African Americans were >2 times as likely as whites to have multiple hospitalizations in the JMSA and 1.7 times as likely in the Delta regions of Mississippi.
Studnicki et al., 2010[58]	Florida Vital Statistics for 2000 –2005 Florida Inpatient Hospital Discharge data 2000-2005	*Hospitalization Results:* African American hospitalization rates are more than twice the Caucasian rates for asthma.
Lang et al., 2009[59]	Pennsylvania Health Care Cost Containment Council Hospitalization Data 1995-1999 United States Census 1990	*Hospitalization Results:* Median annualized rates of hospitalizations were higher in African American individuals (45.7 per 10,000) compared with Caucasian individuals (7.6 per 10,000.) African American race as an individual-level variable was an independent risk factor for asthma hospitalization in a Poisson regression model (relative risk RR = 4.31, $P < 0.001$).
Rowe et al., 2009[3]	Alberta Ambulatory Care Classification System Database 1999-2005	*ED Visit Results:* Combined, the aboriginal, welfare, and government-sponsored groups represented 3.3% of the study population; however, they had disproportionately more ED visits: 7.1%, 9.1%, and 13.6%, respectively.
Smith et al., 2009[4]	Arizona Healthcare Cost Containment System Medicaid administrative claims database 2002-2003	*Hospitalization Results:* No significant association found.
Ginde et al., 2008[5]	United States National Hospital and Ambulatory Care Survey 1993-2005 United States Census Bureau Population Estimates 1993-2005	*ED Visit Results:* Overall, asthma ED visit rates were higher among African Americans and Hispanics (19 per 1000 population, 95% CI: 17-21 and 7.1 per 1000 population, 95% CI: 6.0-8.2 respectively) than Caucasians (5.0 per 1000 population, 95% CI 4.5-5.4).
Correll et al., 2007[6]	New South Wales Inpatient Statistics Collection 2000-2003 Victorian Admitted Episodes dataset 2000-2003 New South Wales Emergency Department Data Collection 2000-2003 Victorian Emergency Minimum Dataset 2000-2003 Australian Census 1996	*Hospitalization Results:* Indigenous peoples had a higher odds of admission compared to non-indigenous peoples (OR: 1.15, 95% CI: 1.00-1.32).
Erickson et al., 2007[60]	Individual Patients Kaiser Permanente of Northern California Administrative/Discharge Databases	*ED Visit Results:* After adjusting for SES and differences in asthma therapy African American race was associated with a higher risk of ED visits (OR 1.73; 95% CI: 1.07-2.81). *Hospitalization Results:* After adjusting for SES and differences in asthma therapy African American race was associated with a higher risk of hospitalizations (OR 2.01; 95% CI: 1.33-3.02).
Howard et al., 2007[61]	Centers for Medicare and Medicaid Services (CMS) Denominator Database 1999-2002 Medicare Provider Analysis and Review Record (MEDPAR) Databases 1999-2002 United States Census 2000	*Hospitalization Results:* African Americans had a higher odds of admission for asthma compared to Caucasians (OR: 51.51; 95% CI: 1.43 - 1.61).
Rowe et al., 2007[8]	Individual patients - Multicenter Asthma Research Collaboration Data 1996-1998 Canadian Census Data United States Census Data	*ED Visit Results:* Caucasians accounted for 88% of Canadian ED visits and 19% of US ED Visits.

Author, Year	Data Sources	Results
El-Ekiaby et al., 2006[62]	Individual Patients	*Hospitalization Results:* The admission rates were identical for both populations African Americans and Caucasians (African Americans 21.3%, Caucasians 24.6%; p=0.60).
Gupta et al., 2006[63]	National Hospital Discharge Survey Public Access Files 1980-2002 Centers for Disease Control and Prevention United States Vital Statistics System	*Hospitalization Results:* The African American:Caucasian rate ratio for asthma hospitalizations increased from 2.8 to 4 from 1980 through 2002, and the African American:Caucasian rate difference increased from 16.3 to 18.5 discharges per 10,000 population for the same time periods.
Laditka et al., 2006[64]	Health Care Cost and Utilization Project Nationwide Independent Sample 1997 United States Current Population Survey 1997	*Hospitalization Results:* African Americans and Hispanics had higher rates of hospitalization for asthma than Caucasians.
Markovitz et al., 2006[11]	Individual Patients	*ED Visit Results:* 12% of ED visitors or urgent resource users were African American. The OR an ER visit was 2.24 (95% CI: 1.63, 3.0) for African Americans.
Meng et al., 2006[12]	Individual patients - California Health Interview Survey data 2000-2001 United States Census 2000	*ED Visit Results:* Hispanics (13%) and African Americans (14%) had higher rates of ED visits than Caucasians (8%, P <= 0.05).
Ng et al., 2006[14]	Individual patients	*ED Visit Results:* Ethnic Malay and Indian persons had a higher hazard of having and ED visit when compared to ethnic Chinese persons (HR: 1.55, 95% CI: 1.09-2.19, and HR: 1.61, 95% CI: 1.12-2.32 respectively).
Singleton et al., 2006[17]	Indian Health Services Direct and Contract Health Service Inpatient Data set for AI/AN populations 1998-2002 United States National Hospital Discharge Survey 1988-2002	*Hospitalization Results:* There was a lower rate of hospitalization for all American Indian and Alaskan natives than the general population for all age groups studied.
Getahun et al., 2005[19]	National Hospital Discharge Survey Public Use Data Files 1995-2002 Centers for Disease Control Mortality Database	*Hospitalization Results:* The average annual hospitalization rate was 3.4 times higher for African Americans (32.7 per 10,000 population) than Caucasians (9.5 per 10,000 population).
Griswold et al., 2005[20]	Individual Patients The Sourcebook of ZIP code demographics, 12th ed.	*ED Visit Results:* In a multivariate model, Caucasian race was a significant predictor of less frequent ER visits (OR 0.6, P<0.001).
Smith et al., 2005[22]	Texas Medicaid Administrative Claims Data 2000	*ED Visit Results:* The rate of ED visits per 10,000 persons on Medicaid was 33.2 for Caucasians, 72.4 for African Americans, and 31.4 for Hispanics. *Hospitalization Results:* The rate of hospitalization per 10,000 persons on Medicaid was 9.3, 17.2, and 9.6 respectively for Caucasians, African Americans, and Hispanics.
Dalcin et al., 2004[23]	Individual patients	*ED Visit Results:* 70.9% of ED visitors were Caucasian, 19.8% were Black and 9.3% were other ethnicity.
Ellison-Loschmann et al., 2004[65]	New Zealand Health Information Service Mortality and Hospital Discharge Data 1994-2000	*Hospitalization Results:* The rate of asthma hospitalization was higher in Maori than non-Maori in each age group: 0–4 years relative risk (RR) = 1.43; 5–14 years RR = 1.08; 15–34 years

Author, Year	Data Sources	Results
	New Zealand Census data	RR = 1.31; 35–74 years RR = 2.97. The differences were higher in rural areas (RR 1.65, 1.17, 1.34 and 3.13 respectively) than in urban areas (RR 1.25, 1.00, 1.22, 2.79 respectively).
Boudreaux et al., 2003[26]	Individual Patients - Multicenter Asthma Research Collaboration Data 1996-1998 United States Census	*ED Visit Results:* 51.9%, 22.8%, and 25.2% of ED visitors were African American, Hispanic, or Caucasian, respectively. *Hospitalization Results:* Raw rates of admission were similar between African American, Hispanic and Caucasian asthma ED visitors. However, when SES and other demographic and confounding variables were controlled for, African Americans and Hispanics were nearly twice as likely to be admitted to hospital compared to Caucasians ED visitors with asthma (African American OR: 2.1, p=0.005, Hispanic OR: 2.6, p=0.002).
Fernandes et al., 2003[28]	Individual patients	*ED Visit Results:* 70.9% of ED visitors were Caucasian and 19.8% were African American. There were no significant differences between infrequent and frequent visitors.
Ng et al., 2003[29]	Singapore Ministry of Health National Database of the Central Claims Processing System 1991-1998 Singapore Census Data	*Hospitalization Results:* The rates of asthma hospital admissions were higher in ethnic Malays (32.8 per 10,000/year) and Indians (40.8 per 10,000/year) than Chinese (11.9 per 10,000/year).
Diette et al., 2002[33]	Individual patients - Managed Health Care Association Outcomes Management System Asthma Project	*Hospitalization Results:* Nonwhites were twice as likely to be hospitalized in the follow-up year than whites (13.8% versus 7.8%, p <0.001).
Ellison-Loschmann et al., 2002[66]	New Zealand Health Information Service Mortality and Hospital Discharge Data 1962-1998 New Zealand Census Data	*Hospitalization Results:* Historically, hospitalization rates amongst the New Zealand Maori were higher than non-Maori. However, the rates reported in this study show that the rates were similar at the time of the study.
Weber et al., 2002[35]	Individual patients - Multi- center Airway Research Collaboration Data 1996-1998	*ED Visit Results:* Amongst acute ED visitors with asthma, 23% were Hispanic, 51% were African American, and 25% were Caucasian. *Hospitalization Results:* Nonwhite race was associated with an increased odds of admission to hospital (African American: OR 2.0, p=0.03, Hispanic: OR 1.9, p=0.08) in asthma ED visitors.
Brokaw et al., 2001[36]	Missouri State Information for Community Assessment Database 1990-1997 University of Missouri Office of Social and Economic Data Analysis Population and SES Data	*ED Visit Results:* The proportion of African Americans was the largest predictor of ED visits. *Hospitalization Results:* African Americans had age adjusted hospitalization rates nearly three times Caucasians (198 versus 33.3 per 10,000 population). The proportion of African Americans was the largest predictor of hospitalization rates.
Castro et al., 2001[67]	Hospital Industry Data Institute database for 1995 United States Census 1940,1995 Death certificate information from the Bureau of Vital Statistics at the Missouri Department of Health	*Hospitalization Results:* The risk ratio for an adult in an area with > 40% African Americans as compared to those in an area with <10% African Americans to be admitted to the hospital was 2.72 (95% CI: 2.5-2.9).
Eisner et al., 2001[68]	Individual patients	*Hospitalization Results:* Multiple logistic regression analysis showed that nonwhite race had a higher odds of admission (OR: 3.1; 95% CI: 1.1–8.8.) Though, in a controlled multivariate analysis, this relationship was not statistically significant.
Blixen et al., 1999[39]	Computer administrative/discharge database of a "large Midwestern health system" 1993-1995	*ED Visit Results:* African Americans were more likely to visit the emergency room for asthma (45.2% versus 22.4%, p<0.001). However, in models controlling for age, gender, and median

Author, Year	Data Sources	Results
	United States Census 1990	geographic household income quartile, race no longer statistically significantly predicted ED visits. *Hospitalization Results:* 65.3% of patients admitted to hospital for asthma were African American versus 34.7% Caucasian.
Claudio et al., 1999[69]	New York State Department of Health Statewide Planning and Research Cooperative System Database 1994 INFOSHARE Software (Community Studies of New York, Inc., New York) - Based on United States Census 1990	*Hospitalization Results:* A significant correlation between increasing small area proportion of minorities and increasing admissions was observed.
Lin et al., 1999[70]	New York State Department of Health Statewide Planning and Research Cooperative System Database 1987-1993 United States Census 1990	*Hospitalization Results:* A higher proportion of the population of a geographical region consisting of African American and Hispanic ethnicity was associated with a higher risk of admission for asthma in univariate and multivariate analysis for both rural and urban zip codes.
Nauenberg et al., 1999[71]	California Office of Statewide Health Planning and Development Hospital Discharge Records 1991-1994 California Air Resources Board Data United States Census 1990	*Hospitalization Results:* Of patients admitted for asthma, 47.1% were African American, and 32.2% were Hispanic.
Gilthorpe et al., 1998[41]	United Kingdom Hospital Episodes Database 1995-1996 United Kingdom Census 1991	*Hospitalization Results:* Standardized admission ratios were higher in all Black and ethnic groups irrespective of gender.
Ray et al., 1998[42]	California Hospital Discharge file 1993 United States Census 1990 (Tape 3B)	*Hospitalization Results:* In each income-age strata, African Americans consistently exhibited the highest asthma rates of hospitalization compared with the other race/ethnic groups. The age adjusted hospitalization rate for African Americans was almost four times that of any other ethnicity. In a multivariate regression the percentage of the population that was African American was an independent predictor of admission.
Zoratti et al., 1998[72]	Large Detroit based HMO administrative/Discharge/Billing databases United States Census 1990	*ED Visit Results:* African Americans were more frequently seen in the emergency department than Caucasians (0.71 +/- 1.33 encounters per subject versus 0.28 +/- 0.64 encounters per subject, p=0.001 respectively). *Hospitalization Results:* African Americans were more frequently admitted than Caucasians (0.08 +/- 0.31 hospitalizations per subject versus 0.03 +/- 0.28, p=0.002 hospitalizations per subject).
Apter et al., 1997[43]	University of Connecticut Health Center Billing Data 1993-1995 United States Census 1990 (Tape 3A)	*ED Visit Results:* Of patients treated in the ED for asthma 10% were African Americans, 65% were Caucasian, 25% were Hispanic, and >1% were other ethnicity. However, in a logistic regression analysis, race was not a predictor of ED visits for asthma. *Hospitalization Results:* Of patients admitted for asthma 10% were African Americans, 60% were Caucasian, 30% were Hispanic, and 2% were other ethnicity. Hispanics were particularly over represented in hospital admissions. However, in a logistic regression analysis, race was not a predictor of admission for asthma.
Kolbe et al., 1997[45]	Individual patients	*Hospitalization Results:* Of patients admitted for asthma 75% were Caucasian, 18% were Maori, 18% were Pacific islanders and 1% were other. This was similar to the regional ethnic mix at the time of the study.
Murray et al.,	Regenstrief Medical Record System of the	*ED Visit Results:* The unadjusted emergency department visit rate

Author, Year	Data Sources	Results
1997[46]	Wishard Memorial Hospital, Indianapolis, Indiana 1985-1992 Indiana State Department of Health Death Tapes	was slightly higher for African American patients (13 visits per 100 patient years) compared with Caucasian patients (12 visits per 100 patient years). Emergency department visit rates for asthma were highest for African American females and males from 5 to 19 years of age, but were lower in the 20-29 years age group. *Hospitalization Results:* Asthma-specific hospitalizations were highest for African American males compared with other race and gender strata.
Williams et al., 1997[73]	Health Department of Western Australia's Hospital Morbidity Data System 1988-1993 Australian Census	*Hospitalization Results:* In all age groups, being of aboriginal ethnicity was associated with an increased relative risk of admission to hospital for asthma relative to non-aboriginals. All were statistically significant. The relative risks varied from 1.4 to 5.3 across different age groups. Age standardized rates were 3.1 times larger for aboriginals.
Gottlieb et al., 1995[74]	PANDORA (a product of the Codman Research Group, Lebanon, NH) 1992 Massachusetts Data Massachusetts Health Data Consortium Records United States Census 1990 (Tape 3B) IMS America Medication Dispensing Records	*Hospitalization Results:* Asthma hospitalization rate in the 22 small areas studied was strongly correlated with the percentage of the population that was nonwhite ($r=0.84$, $p<0.001$).
Ormerod et al., 1995[75]	Blackburn, Hyndburn and Ribble Valley District Health Authority Administrative/Discharge Records 1991-1992 United Kingdom Census 1991	*Hospitalization Results:* Admission rates amongst the Asian ethnic group were significantly higher than matched Caucasian peers over all age groups.
Walters et al., 1995[76]	West Midlands Regional Health Authority Information Department Administrative/Discharge Databases 1988-1990 United Kingdom Census 1991 Environmental Health Departments of local authorities of the West Midlands, UK	*Hospitalization Results:* In patients greater than age 5, race was not a predictor of hospital admission.
De Palo et al., 1994[53]	New York State wide Planning and Research Co-operative System (SPARCS) data 1989-1991 United States Census 1990	*Hospitalization Results:* Average asthma admission rates per 100,000 population were 1003 for Hispanics, 810 for African Americans, and 242 for Caucasians. A multivariate analysis indicated that this was a 4.91:1 ratio for Hispanics and 4.16:1 for African Americans compared to whites ($p<0.0001$).
Haas et al., 1994[54]	Individual Patients	*Hospitalization Results:* 50% of patients admitted to hospital for asthma were African American versus 38% white, 11% Hispanic and 3% other.
Carr et al., 1992[55]	New York State Department of Health Administrative/Discharge Databases 1982-1987 New York City Department of Health Vital Statistics Data United States Census 1980 (STF-3B Data file)	*Hospitalization Results:* African Americans and Hispanic ethnicities accounted for 81.8% of all admissions. The average rate per 10,000 population was 12.2 for Caucasians, 59.9 or African Americans and 62.9 for Hispanics. Neighborhood asthma hospitalization rates showed a high positive correlation with neighborhood percent African American population ($r=0.74$). In a regression analysis percentage population of African American of the region accounted for 18% of the variability in admission rates ($p<0.0001$) between regions.
Myers et al., 1992[77]	United Kingdom Census 1981 Hospital Admission and Discharge Records United Kingdom Hospital Activity Analysis Data	*Hospitalization Results:* Hospitalizations were increased in Asians from age groups 1-4 years, and 15-29 years but non-significantly. There was a statistically significantly higher hospitalization rate in age groups 5-14 years and 30-44 years

Author, Year	Data Sources	Results
	Office of Population Censuses and Surveys Revision 1987	(OR: 2.03, 95% CI: 1.32-3.12 and OR: 5.85, 95% CI: 3.66-9.35 respectively).
Garrett et al., 1988[57]	Individual Patients New Zealand Census of the Population 1981 Middlemore Hospital Administrative/Discharge Databases	*ED Visit Results:* 36.7% were Caucasian, 24.9% were Maori, and 38.4% pacific Islanders. Logistic regression analysis indicated that race was an independent predictor of ED visits ($p<0.0001$).
Ayres et al., 1986[78]	United Kingdom Hospital Activity Analysis Data 1972-1882 United Kingdom Census 1981	*Hospitalization Results:* Asians were more frequently admitted to hospital than non-Asians. The relative risk of admission for an Asian compared to a non-Asian was 2.5.

7.1.3 Asthma-related ED visits and Hospitalizations: Personal Income

Author, Year	Data Sources	Results
Brandão et al., 2009[79]	Individual patients	*ED Visit Results:* No association found. Having an income more than or equal to the national minimum wage was not associated with a higher odds of an ED visit for asthma (OR = 1.08; 95% CI: 0.89-1.30).
Markovitz et al., 2006[11]	Individual Patients	*ED Visit Results:* Patients with income of $10–50,000USD had an OR of 0.82 (95% CI: 0.60-1.13) for an ER visit. Patients with income of > $50,000USD had an OR of 0.64 (95% CI: 0.45-0.92) for an ER visit.
Griswold et al., 2005[70]	Individual Patients The Sourcebook of ZIP code demographics, 12th ed.	*ED Visit Results:* In a univariate analysis of median income on ED visit rate, increasing income was inversely proportional to the number of ED visits ($p<0.001$).
Fernandes et al., 2003[38]	Individual patients	*ED Visit Results:* 26.7% of ED visitors had an annual income less than $1000USD, 41.9% between $1000USD and $3000USD and 29.1% higher than $3000USD. There were no significant differences between infrequent and frequent visitors.
Chen et al., 2001[37]	Individual patients - Canadian National Population Health Survey 1994-1995	*Hospitalization Results:* Asthma as a 'risk factor' for admission demonstrated a higher odds of admission in 'middle' income Canadians.
Eisner et al., 2001[68]	Individual patients	*Hospitalization Results:* In a bivariate analysis, lower income was associated with an increased risk of admission (OR, 1.3 per $10,000 decrement; 95% CI, 01.1–1.5). Though, in a controlled multivariate analysis this relationship was not statistically significant.
Kolbe et al., 1997[45]	Individual patients	*Hospitalization Results:* Of patients admitted for asthma, 52% responded that they had experienced 'financial difficulties' in the past year.
Haas et al., 1994[54]	Individual Patients	*Hospitalization Results:* 30% of patients with asthma admitted to hospital had a household income <$15,999USD versus 32% with household income $16,000USD-29,000USD versus 38% with household income >= $30,000USD.

7.1.4 Asthma-related ED visits and Hospitalizations: Small Geographic Area

Author, Year	Data Sources	Results
Lang et al., 2009[59]	Pennsylvania Health Care Cost Containment Council Hospitalization Data 1995-1999 United States Census 1990	*Hospitalization Results:* In African American and Caucasian individuals, asthma hospitalization rates increased directly in association with rates of poverty in zip codes of residence and at all levels of poverty. Poverty-area of residence as an individual-level variable was an independent risk factor for asthma hospitalization in a Poisson regression model (relative risk 2.29, $P < 0.001$).
Correll et al., 2007[6]	New South Wales Inpatient Statistics Collection 2000-2003 Victorian Admitted Episodes dataset 2000-2003 New South Wales Emergency Department Data Collection 2000-2003 Victorian Emergency Minimum Dataset 2000-2003 Australian Census 1996	*Hospitalization Results:* People in areas of higher SES disadvantage had a higher odds of admission compared to those living in more advantaged areas for each strata of the 'Socio-Economic Indexes for Areas' score.
Kim et al., 2007[7]	Seoul Air Pollution Monitoring Stations, Seoul, Korea 2002 Data Korean National Health Insurance Records 2002	*ED Visit Results:* Regions of higher income appeared to be less sensitive to the effects of air pollution on asthma ED visits and that residence in more deprived areas increased asthma ED visits.
Ramos et al., 2006[16]	United States Census 2000 Pennsylvania Department of Transportation Traffic Data Pennsylvania Health Care Cost Containment Council Hospitalization data	*Hospitalization Results:* An inverse relationship was observed for hospitalization and both median income and median property value.
Lyratzopoulos et al., 2005[21]	United Kingdom Hospital Episode Statistics Data 1997-2001 United Kingdom Census 1991	*Hospitalization Results:* Amongst persons admitted for asthma, SES status indicated by Townsend Index showed that approximately 25% of persons fell into each quartile of deprivation. In univariate and multivariate analysis higher deprivation status was significantly associated with increased readmission rates in follow-up periods longer than three months, but not at 28 days.
Boudreaux et al., 2003[26]	Individual Patients - Multicenter Asthma Research Collaboration Data 1996-1998 United States Census	*ED Visit Results:* Median household income, as estimated using patients ZIP codes, was significantly different across ethnicity. Trends suggest lower incomes in minority populations and higher income in Caucasians.
Salamzadeh et al., 2003[30]	Individual patients - Chart review data Local Hospital Administrative/Discharge Databases 1994-1998 United Kingdom Census Data	*Hospitalization Results:* 38.6% of patients admitted to hospital for asthma were deprived, 32.5% affluent, and 28.9% unknown when the area-based Townsend Index was utilized to estimate individual SES status.
Schatz et al., 2003[31]	Southern California Kaiser Permanente Asthma Case Identification Database 1998-1999 United States Census 1990	*Hospitalization Results:* Both hospitalized children and adults lived in zip codes with lower mean household incomes than patients who were not hospitalized.
Deprez et al., 2002[32]	Individual Patients 1994/1995 Data from the Maine Uniform Hospital Discharge Database 1994 Data the Maine Health Care Finance Commission	*Hospitalization Results:* Rates of asthma hospitalizations were elevated among males in the rural/low-SES health service areas relative to rates among males in the urban/high-SES health service areas (1.32 vs. 0.67, $p<0.10$). Asthma admissions among females aged 0 to 64 years in the rural/low-SES health service areas were also high in relation to those in the urban/high-SES health service areas (2.11 vs. 1.29, $p<0.10$).
Weber et al., 2002[35]	Individual patients - Multi- center Airway Research Collaboration Data 1996-1998	*ED Visit Results:* Amongst acute ED visitors with asthma estimated household income was similar.

Author, Year	Data Sources	Results
		Hospitalization Results: Estimated household income was not associated with an increased odds of admission (OR per $10,000 increase: 1.2, p=0.16).
Castro et al., 2001[67]	Hospital Industry Data Institute database for 1995 United States Census 1940,1995 Death certificate information from the Bureau of Vital Statistics at the Missouri Department of Health	*Hospitalization Results:* The risk ratio for an adult with an income <$20,000 as compared to those with income >$50,000 to be admitted to the hospital was 4.5 (95% CI: 4.0-5.0).
Blixen et al., 1999[39]	Computer administrative/discharge database of a "large Midwestern health system" 1993-1995 United States Census 1990	*Hospitalization Results:* 34.7% of hospitalized African Americans and 4.9% of Caucasians were in the lowest quartile of median household income (<$14, 900) whereas 19.4% of African Americans and 37.7% of Caucasians were in the highest quartile of median household income (>$36,000). The differences observed were statistically significant.
Claudio et al., 1999[69]	New York State Department of Health Statewide Planning and Research Cooperative System Database 1994 INFOSHARE Software (Community Studies of New York, Inc., New York) - Based on United States Census 1990	*Hospitalization Results:* A significant correlation between increasing small-area income and decreasing admissions was observed.
Lin et al., 1999[70]	New York State Department of Health Statewide Planning and Research Cooperative System Database 1987-1993 United States Census 1990	*Hospitalization Results:* Geographic measures of household income were associated with a higher risk of admission for asthma in univariate and multivariate analysis for both rural and urban zip codes.
Gilthorpe et al., 1998[41]	United Kingdom Hospital Episodes Database 1995-1996 United Kingdom Census 1991	*Hospitalization Results:* Townsend index was strongly and linearly related to standardized admission ratios.
Ray et al., 1998[42]	California Hospital Discharge file 1993 United States Census 1990 (Tape 3B)	*Hospitalization Results:* Within each defined race/ethnicity group, the risk of asthma hospitalization significantly decreased with increasing median household income (p<0.01 for each race/ethnicity-age group). In a multivariate regression analysis small-area median household income was an independent predictor of admission for asthma.
Zoratti et al., 1998[72]	Large Detroit based HMO administrative/Discharge/Billing databases United States Census 1990	*ED Visit Results:* Adjusted analysis also revealed that lower income level was associated with increased emergency department use among the females (p = 0.013). *Hospitalization Results:* Adjusted analysis revealed that lower income level was associated with increased asthma hospitalizations (p = 0.038).
Erzen et al., 1997[80]	Manitoba Health Physician Claims Database 1998-1992 Canadian Census 1986-1991	*Hospitalization Results:* Children in low-income quintiles were twice as likely as those in high-income quintiles to be admitted to hospital (p<0.0001). In middle-aged patients, income had little effect on hospitalizations. In older adults, those in lower income quintiles were also twice as likely to be admitted to hospital as compared with those in high-income quintiles (p<0.0001).
Watson et al., 1996[51]	United Kingdom Census 1991 West Midlands Health Information System - Finished Consultant Episodes Data 1991-1994	*Hospitalization Results:* There was a strong association between the standardized admission ratio for asthma and the Townsend Index for each district (ρ=0.65; p=0.004).
Gottlieb et al., 1995[74]	PANDORA (a product of the Codman Research Group, Lebanon, NH) 1992 Massachusetts Data Massachusetts Health Data Consortium Records	*Hospitalization Results:* There was a strong correlation between asthma hospitalization rate and the percentage of the population living in poverty (r=0.68, p<0.001), and an

Author, Year	Data Sources	Results
	United States Census 1990 (Tape 3B) IMS America Medication Dispensing Records	inverse correlation with per capita income (r=0.51, p=0.016).
Targonski et al., 1995[52]	Illinois Health Care Cost Containment Council Administrative/Discharge Databases United States Census 1980 population data Chicago Department of Planning 1987-1989 population data Medicaid population data 1988	*Hospitalization Results:* Age-specific and age-adjusted admission rates showed a consistent inverse association with median household income. For persons less than 35 years old the correlation coefficient was r=-0.61, p=0.001.
Walters et al., 1995[76]	West Midlands Regional Health Authority Information Department Administrative/Discharge Databases 1988-1990 United Kingdom Census 1991 Environmental Health Departments of local authorities of the West Midlands, UK	*Hospitalization Results:* Townsend Index was a significant predictor of asthma-related hospital admissions for all age groups.
Billings et al., 1993[81]	New York Statewide Planning and Research Cooperative System (SPARCS) 1988 Donnelley Marketing Demographic Data (Based on United States Census Data 1980)	*Hospitalization Results:* Admission rates for asthma were 6.4 times higher in low-income areas than in high-income areas. More than 70 percent of the variation among areas explained by household income.
Carr et al., 1992[55]	New York State Department of Health Administrative/Discharge Databases 1982-1987 New York City Department of Health Vital Statistics Data United States Census 1980 (STF-3B Data file)	*Hospitalization Results:* Neighborhood asthma hospitalization rates showed a high negative correlation with neighborhood median income (r=-0.80). In a regression analysis median household income of the region accounted for 57% of the variability in admission rates (p<0.0001).
Garrett et al., 1988[57]	Individual Patients New Zealand Census of the Population 1981 Middlemore Hospital Administrative/Discharge Databases	*ED Visit Results:* Patients attending the ED had a lower SES status on the Elley-Irving Scale compared with the general South Auckland community (p<0.0005).

7.1.5 Asthma-related ED visits and Hospitalizations: Level of Educational Attainment

Author, Year	Data Sources	Results
Brandão et al., 2009[79]	Individual patients	*ED Visit Results:* Having 9 or fewer years of schooling was associated with a higher odds of an ED visit for asthma (OR = 1.53; 95% CI: 1.00-2.39).
Li et al., 2008[82]	Individual patients - Centre for Family and Community Medicine MigMed Database	*Hospitalization Results:* Persons with higher education (>12 years) had a statistically significantly lower standardized incidence ratio (SIR) of hospitalization in both males and females when compared with the general population (SIR 0.63 and 0.63 respectively).
Rowe et al., 2007[8]	Individual patients - Multicenter Asthma Research Collaboration Data 1996-1998 Canadian Census Data United States Census Data	*ED Visit Results:* Canadian and American ED visitors have similar levels of education. Sixty nine percent of ED visitors having attained a high school graduation certificate.
Markovitz et al.,	Individual Patients	*ED Visit Results:* No significant differences were observed.

Author, Year	Data Sources	Results
2006[11]		
Miller et al., 2006[13]	Individual patients - Data from the 'The Epidemiology and Natural History of Asthma: Outcomes and Treatment Regimes' study	*ED Visit Results:* 8.2% had less than a high school education, 20.9% had achieved a high school degree, 33.4% had some college or trade, and 37.6% had graduate or advanced degrees.
Ramos et al., 2006[16]	United States Census 2000 Pennsylvania Department of Transportation Traffic Data Pennsylvania Health Care Cost Containment Council Hospitalization data	*Hospitalization Results:* No significant association found.
Griswold et al., 2005[20]	Individual Patients The Sourcebook of ZIP code demographics, 12th ed.	*ED Visit Results:* In univariate analysis higher education was inversely associated with an increasing frequency of ED visits. Though, in a multivariate model, level of educational attainment was not a significant predictor of frequent ER visits (OR 0.94, P=0.58).
Dalcin et al., 2004[23]	Individual patients	*ED Visit Results:* 60.7% of ED visitors had <= 8 years of education, versus 27.4% with >9 years of education versus 4.8% with higher education.
Baybek et al., 2003[25]	Individual patients	*Hospitalization Results:* 56% of community controls versus 35% of persons hospitalized for asthma had high school or university graduation certificates. However, level of educational attainment differences did not attain statistical significance.
Boudreaux et al., 2003[26]	Individual Patients - Multicenter Asthma Research Collaboration Data 1996-1998 United States Census	*ED Visit Results:* Educational attainment (graduation from high school) was significantly different across ethnicity and ranged from 53-81%.
Fernandes et al., 2003[28]	Individual patients	*ED Visit Results:* Including current students, the majority of ED visitors (59.3%) had <= 8 years of formal education, 7% were illiterate, 26.7% had >8 years at school and 4.7% had a higher education. There were no significant differences between infrequent and frequent visitors.
Diette et al., 2002[33]	Individual patients - Managed Health Care Association Outcomes Management System Asthma Project	*Hospitalization Results:* Hospitalization increased inversely with reported educational attainment (<Eighth grade - 17.9%, Some high school - 18.3%, High school graduate - 10.1%, Some college - 8.5%, College graduate - 6.3%, Any postgraduate work 3.5%).
Weber et al., 2002[35]	Individual patients - Multi- center Airway Research Collaboration Data 1996-1998	*Hospitalization Results:* Graduation from high school was not associated with an increased odds of admission in asthma ED visitors (OR 1.0, p=0.97).
Castro et al., 2001[67]	Hospital Industry Data Institute database for 1995 United States Census 1940,1995 Death certificate information from the Bureau of Vital Statistics at the Missouri Department of Health	*Hospitalization Results:* The risk ratio for an adult with <12.5 years of schooling as compared to those with >15.5 years of schooling to be admitted to the hospital was 4.28 (95% CI: 3.7-4.9).
Chen et al., 2001[83]	Individual patients - Canadian National Population Health Survey 1994-1995	*Hospitalization Results:* Asthma as a 'risk factor' for admission demonstrated Canadians with a lower education had higher odds of hospitalization.
Eisner et al., 2001[68]	Individual patients	*Hospitalization Results:* No significant difference
Adams et al., 2000[38]	Individual patients - Western Region Asthma Pilot Project data 1995-1997	*ED Visit Results:* Emergency department visits (p = 0.0007) were significantly more frequent in those with 10 years or less of formal education.

Author, Year	Data Sources	Results
		Hospitalization Results: Hospital admissions (p = 0.03) were significantly more frequent in those with 10 years or less of formal education.
Lin et al., 1999[70]	New York State Department of Health Statewide Planning and Research Cooperative System Database 1987-1993 United States Census 1990	*Hospitalization Results:* Geographic measures of educational attainment were associated with a higher risk of admission for asthma in univariate and multivariate analysis for both rural and urban zip codes.
Gottlieb et al., 1995[74]	PANDORA (a product of the Codman Research Group, Lebanon, NH) 1992 Massachusetts Data Massachusetts Health Data Consortium Records United States Census 1990 (Tape 3B) IMS America Medication Dispensing Records	*Hospitalization Results:* The percentage of the population holding a bachelor's degree was inversely correlated with asthma hospitalization rate (r=. 0.61, p=0.003). Trends in other measures of educational attainment were similar.
Haas et al., 1994[54]	Individual Patients	*Hospitalization Results:* 26% of patients with asthma admitted to hospital reported having 'some high school' versus 50% having graduated high school versus 24% having graduate or postgraduate degrees.

7.1.6 Asthma-related ED visits and Hospitalizations: Labor Force Activity

Author, Year	Data Sources	Results
Markovitz et al., 2006[11]	Individual Patients	*ED Visit Results:* 23% of ED visitors or urgent resource users were unemployed. Unemployed patients had an OR of 1.56 (95% CI: 1.24,1.97) for an ER visit or urgent resource utilization.
Miller et al., 2006[13]	Individual patients - Data from the 'The Epidemiology and Natural History of Asthma: Outcomes and Treatment Regimes' study	*ED Visit Results:* Of ED visitors, 47.9% were working full time, 11.7% were working part time, 17.7% were retired, and 22.7% reported 'other'.
Dalcin et al., 2004[23]	Individual patients	*ED Visit Results:* 30.9% of ED visitors were employed versus 69.1% who were unemployed.
Goeman et al., 2004[24]	Individual patients	*ED Visit Results:* 16.3% of ED visitors reported being retired or unemployed.
Fernandes et al., 2003[28]	Individual patients	*ED Visit Results:* Of ED visitors older than 18 years, 65.1% were unemployed and 16.3% were using disability leave. There were no significant differences between infrequent and frequent visitors.
Castro et al., 2001[67]	Hospital Industry Data Institute database for 1995 United States Census 1940,1995 Death certificate information from the Bureau of Vital Statistics at the Missouri	*Hospitalization Results:* The risk ratio for an adult in an area with > 10% unemployment as compared to those in an area with <3% unemployment to be admitted to the hospital was 3.68 (95% CI: 3.3-4.1).

Author, Year	Data Sources	Results
	Department of Health	
Lin et al., 1999[70]	New York State Department of Health Statewide Planning and Research Cooperative System Database 1987-1993 United States Census 1990	*Hospitalization Results:* A higher proportion of unemployment in a geographical region was associated with higher hospitalizations for asthma in upstate New York.
Kolbe et al., 1997[45]	Individual patients	*Hospitalization Results:* Of patients admitted for asthma, 56% were not engaged in paid employment. 11% of patients reported having lost their job in the previous year. 33% reported that their only source of income was social assistance.
Partridge et al., 1997[47]	Individual patients	*ED Visit Results:* Of adult visitors, 40.8% of ED visitors were employed, 17.7% were unemployed, 16.9% were homemakers, 16.0% were students, and 9.3% were retired. The national average unemployment at the time of the census was 8.3%.
Malveaux et al., 1993[84]	Individual Patients National Center for Health Statistics (NCHS) Death Certificate Data 1979-1983 United States Census 1980	*ED Visit Results:* 53% of asthma ED visitors reported no regular form of employment.

7.1.7 Asthma-related ED visits and Hospitalizations: Marital Status

Author, Year	Data Sources	Results
Markovitz et al., 2006[11]	Individual Patients	*ED Visit Results:* No significant difference.
Dalcin et al., 2004[23]	Individual patients	*ED Visit Results:* 54.9% of ED visitors identified as being single versus 45.1% that identified as having a current partner.
Fernandes et al., 2003[28]	Individual patients	*ED Visit Results:* 43.0% of ED visitors were married/with partner, 14.0% were divorced/widowed/separated, and 38.4% were never married. There were no significant differences between infrequent and frequent visitors.
Eisner et al., 2001[68]	Individual patients	*Hospitalization Results:* No significant difference.

7.1.8 References

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7.2 Appendix II: SAS Program for Manuscript II

```
*************************************************************************************************
*******************************     Chi-Square Analysis of ORORN and Statistics
******************************* Canada Data for Selected Forward Sortation Areas (67)
*************************************************************************************************

This is the analysis program code for the Chi-Square statistics comparing the ORORN and
Statistics Canada samples
for manuscript II of masters thesis.


Note on dataset naming conventions:
***********************************
Dataset are named:

library.<data origin>_<variable of interest>_<operation performed>

Where:
(1) <Data Origin> = Indicates whether the data is from the ORORON or Statistics Canada
2001 Census data or both (e.g. ORORN, StatCan, StatCanORORN)

(2) <variable of interest> = Principal variable contained in dataset (e.g. gender,
married, combined, etc...).

(3) <operation performed> = Indicator of changes made to dataset. (e.g. stacked,
transposed, etc...).


Note on Weights, Data Manipulations, and Data Usage:
****************************************************

Recall that the Statistics Canada Observations are a 20% sample of the Canadian population
that is weighted to the actual population size. In order to crudely account for the
'artificial' increase in 'observations' that this causes, and therefore increased
confidence in the test statistic, the Statistics Canada count data have been reduced by a
factor of 5 (simple division).

For the employment data, I have not utilized ORORN retiree data. Hence the value of 'n' is
smaller for this analysis. I also have discrepant results when the analysis is conducted
than was provided in the analysis that Andrew and Miao gave me when they compared selected
versus not selected patients from the ORORN dataset.


Author and Modification Information:
************************************

Paul M. Heffernan, MD FRCPC FCCP
Last Edit: Monday, May 4, 2011 @ 20:05HRS

*************************************************************************************************
*************************************************************************************************
*************************************************************************************************;


ods rtf file='\\vmware-host\Shared Folders\My Desktop\Output - Chi Squares - May 9, 2011 -
2012HRS.rtf';

libname SES "z:\sas\asthma";


*************************************************************************************************
******************************** SEX CHI-SQUARE and MANTEL-HANSZEL
*************************************************************************************************

This Program restructures Statistics Canada and ORORN data and Calculates Chisq and
Mantel-Hanszel statistics controlling for FSA
```

```
*************************************************************************************************
*************************************************************************************************;

* Create a dataset with the Statistics Canada FSA, Gender, and Count data for each strata;
%LET SENDIV=5;

data work.StatCan_gender;
        set SES.temp;
        keep  GEOGRAPH SEX3 TOTALALL;
        label    SEX3='Patient    Gender'    TOTALALL='Statistics    Canada    Strata    Total'
GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Create a dataset with the ORORN FSA, Gender, and Count data for each strata ;

data work.ORORN_gender;
        set SES.temp;
        keep  GEOGRAPH SEX3 ORORN_nQuests;
        label    SEX3='Patient    Gender'    TOTALALL='Statistics    Canada    Strata    Total'
GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Make dummy encoding variables indicating origin of data Copy count data to a variable
called 'wVar' to be used
to 'weight' in statistical calculations ;

data work.StatCan_gender;
        set work.StatCan_gender;
        group=0;
        wVar=TOTALALL/&SENDIV;
run;

data work.ORORN_gender;
        set work.ORORN_gender;
        group=1;
        wVar=ORORN_nQuests;
run;

* Merge data vertically;

data work.StatCanORORN_gender_stacked;
        set work.StatCan_gender work.ORORN_gender;
        keep GEOGRAPH SEX3 wVar group;
run;

* Label Variables and Data;

data work.StatCanORORN_gender_stacked;
        set work.StatCanORORN_gender_stacked;
        label group ="StatsCan or ORORN data";
run;

proc format;
        value groupf 0="Statistics Canada" 1="ORORN";
run;

* Do regular Chi-square;

proc freq data=work.StatCanORORN_gender_stacked;
        weight wVar;
        format group groupf.;
        tables sex3*group /chisq NOCUM NOROW NOPERCENT ;
run;

* Do Cochran-Mantel-Haenszel Statistics;

proc freq data=work.StatCanORORN_gender_stacked;
        weight wVar;
```

```
        format group groupf.;
        tables GEOGRAPH*sex3*group /CMH NOPRINT;
run;


*************************************************************************************************
********************************** AGE CHI-SQUARE and MANTEL-HANSZEL
*************************************************************************************************


This Program restructures Statistics Canada and ORORN data and Calculates Chisq and
Mantel-Hanszel statistics controlling for FSA;

*************************************************************************************************
*************************************************************************************************;



* Create a dataset with the Statistics Canada FSA, AGE category, and Count data for each
strata;

data work.StatCan_AgeCategory;
        set SES.temp;
        keep  GEOGRAPH AGE5 TOTALALL;
        label  AGE5='Patient  Age  Category'  TOTALALL='Statistics  Canada  Strata  Total'
GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Create a dataset with the ORORN FSA, Age Category, and Count data for each strata;

data work.ORORN_AgeCategory;
        set SES.temp;
        keep  GEOGRAPH AGE5 ORORN_nQuests;
        label  SEX3='Patient  Age  Category'  TOTALALL='Statistics  Canada  Strata  Total'
GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Make dummy encoding variables indicating origin of data. Copy count data to a variable
called 'wVar' to be used to 'weight'
in statistical calculations ;

data work.StatCan_AgeCategory;
        set work.StatCan_AgeCategory;
        group=0;
        wVar=TOTALALL/&SENDIV;
run;

data work.ORORN_AgeCategory;
        set work.ORORN_AgeCategory;
        group=1;
        wVar=ORORN_nQuests;
run;

* Merge data vertically;

data work.StatCanORORN_AgeCategory_stacked;
        set work.StatCan_AgeCategory work.ORORN_AgeCategory;
        keep GEOGRAPH AGE5 wVar group;
run;

* Label Variables and Data;

data work.StatCanORORN_AgeCategory_stacked;
        set work.StatCanORORN_AgeCategory_stacked;
        label group ="StatsCan or ORORN data";
run;

proc format;
        value groupf 0="Statistics Canada" 1="ORORN";
run;
```

```
* Do regular Chi-square;

proc freq data=work.StatCanORORN_AgeCategory_stacked;
        weight wVar;
        format group groupf.;
        tables AGE5*group /chisq NOCUM NOROW NOPERCENT ;
run;

* Do Mantel-Haenszel Statistics;

proc freq data=work.StatCanORORN_AgeCategory_stacked;
        weight wVar;
        format group groupf.;
        tables GEOGRAPH*AGE5*group /CMH NOPRINT;
run;


*************************************************************************************************
********************************** INCOME Category CHI-SQUARE and MANTEL-HANSZEL
*************************************************************************************************

This Program restructures Statistics Canada and ORORN data and Calculates Chisq
and Mantel-Hanszel statistics controlling for FSA


*************************************************************************************************
*************************************************************************************************;

* Create a dataset with the Statistics Canada FSA, INCOME category, and Count data for
each strata;

data work.StatCan_IncCat;
        set SES.temp;
        keep  SEX3 AGE5 GEOGRAPH HHLDINCO TOTALALL;
        label HHLDINCO='Patient INCOME Category' TOTALALL='Statistics Canada Strata Total'
GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Create a dataset with the ORORN FSA, INCOME Category, and Count data for each strata;

data work.ORORN_IncCat;
        set SES.temp;
        keep  SEX3 AGE5 GEOGRAPH HHLDINCO ORORN_nQuests;
        label  SEX3='Patient  Age  Category'  TOTALALL='Statistics  Canada  Strata  Total'
GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Make dummy encoding variables indicating origin of data. Copy count data to a variable
called 'wVar' to be
used to 'weight' in statistical calculations;

data work.StatCan_IncCat;
        set work.StatCan_IncCat;
        group=0;
        wVar=TOTALALL/&SENDIV;
run;

data work.ORORN_IncCat;
        set work.ORORN_IncCat;
        group=1;
        wVar=ORORN_nQuests;
run;

* Merge data vertically;

data work.StatCanORORN_IncCat_stacked;
        set work.StatCan_IncCat work.ORORN_IncCat;
        keep GEOGRAPH SEX3 AGE5 HHLDINCO wVar group;
run;
```

```
* Label Variables and Data;

data work.StatCanORORN_IncCat_stacked;
        set work.StatCanORORN_IncCat_stacked;
        label group ="StatsCan or ORORN data";
run;

proc format;
        value groupf 0="Statistics Canada" 1="ORORN";
run;

* Do regular Chi-square;

proc freq data=work.StatCanORORN_IncCat_stacked;
        weight wVar;
        format group groupf.;
        tables HHLDINCO*group /chisq NOCUM NOROW NOPERCENT ;
run;

* Do Mantel-Haenszel Statistics;

proc freq data=work.StatCanORORN_IncCat_stacked;
        weight wVar;
        format group groupf.;
        tables GEOGRAPH*HHLDINCO*group /CMH NOPRINT;
run;

proc freq data=work.StatCanORORN_IncCat_stacked;
        weight wVar;
        format group groupf.;
        tables Sex3*age5*GEOGRAPH*HHLDINCO*group /CMH NOPRINT;
run;


*************************************************************************************************
****************************** EDUCATION Category CHI-SQUARE and MANTEL-HANSZEL
*************************************************************************************************

This Program restructures Statistics Canada and ORORN data and Calculates Chisq
and Mantel-Hanszel statistics controlling for FSA

*************************************************************************************************
*************************************************************************************************;

* Create a dataset with the Statistics Canada FSA, EDUCATION category, and Count data for
each strata;

data work.StatCan_EduCat;
        set SES.temp;
        keep  GEOGRAPH SCHOOLIN TOTALALL;
        label  SCHOOLIN='Patient  Education  Category'  TOTALALL='Statistics  Canada  Strata
Total' GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Create a dataset with the ORORN FSA, EDUCATION Category, and Count data for each strata;

data work.ORORN_EduCat;
        set SES.temp;
        keep  GEOGRAPH SCHOOLIN ORORN_nQuests;
        label  SEX3='Patient  Age  Category'  TOTALALL='Statistics  Canada  Strata  Total'
GEOGRAPH="Forward Sortation Area (FSA)";
run;

* Make dummy encoding variables indicating origin of data. Copy count data to a variable
called 'wVar' to be used
to 'weight' in statistical calculations;

data work.StatCan_EduCat;
        set work.StatCan_EduCat;
```

```
        group=0;
        wVar=TOTALALL/&SENDIV;
run;

data work.ORORN_EduCat;
        set work.ORORN_EduCat;
        group=1;
        wVar=ORORN_nQuests;
run;

* Merge data vertically;

data work.StatCanORORN_EduCat_stacked;
        set work.StatCan_EduCat work.ORORN_EduCat;
        keep GEOGRAPH SCHOOLIN wVar group;
run;

* Label Variables and Data;

data work.StatCanORORN_EduCat_stacked;
        set work.StatCanORORN_EduCat_stacked;
        label group ="StatsCan or ORORN data";
run;

proc format;
        value groupf 0="Statistics Canada" 1="ORORN";
run;

* Do regular Chi-square;

proc freq data=work.StatCanORORN_EduCat_stacked;
        weight wVar;
        format group groupf.;
        tables SCHOOLIN*group /chisq NOCUM NOROW NOPERCENT ;
run;

* Do Mantel-Haenszel Statistics;

proc freq data=work.StatCanORORN_EduCat_stacked;
        weight wVar;
        format group groupf.;
        tables GEOGRAPH*SCHOOLIN*group /CMH NOPRINT;
run;


*************************************************************************************************
****************************** Employment Status CHI-SQUARE and MANTEL-HANSZEL
*************************************************************************************************

This program restructures Statistics Canada and ORORN data and calculates Chi-square
and Mantel-Hanszel statistics controlling for FSA

*************************************************************************************************
*************************************************************************************************;

* Create a dataset with the Statistics Canada FSA, Employment category, and Count data for
each strata;

*Create a dataset with the statistics Canada Data;

data work.StatCan_lfa;
        set SES.temp;
        keep  GEOGRAPH EMPLOYED UNEMPLOY NOTINTHE;
run;

* Create a dataset with the ORORN Data. Note: Retirees are excluded.;

data work.ORORN_lfa;
        set SES.temp;
```

```
        keep        GEOGRAPH    ORORN_employed    ORORN_unemployed    ORORN_notinlaborforce
/*ORORN_retired*/;
run;

* Make dummy encoding variables indicating originating dataset (StatCan or ORORN) of data.
Do not create retiree addition to not in LF;

data work.StatCan_lfa;
        set work.StatCan_lfa;
        group=0;
run;

data work.ORORN_lfa;
        set work.ORORN_lfa;
        /*ORORN_nilf = ORORN_notinlaborforce + ORORN_retired;*/
        group=1;
run;

* Generate a dataset for each category of 'labor force activity' for Statistics Canada
data and stack them.

There are three data steps for each:

(1) Get data
(2) Create Dummy for group
(3) Create new dataset;

data work.statcan_lfa_emp;
        set work.StatCan_lfa;
        keep GEOGRAPH EMPLOYED group;
run;

data work.statCan_lfa_emp;
        set work.statCan_lfa_emp;
        lfa = EMPLOYED/5;
        lfagroup=0;
run;

data work.statCan_lfa_emp;
        set work.statcan_lfa_emp;
        keep GEOGRAPH lfa lfagroup group;
run;

data work.statcan_lfa_nemp;
        set work.StatCan_lfa;
        keep GEOGRAPH UNEMPLOY group;
run;

data work.statCan_lfa_nemp;
        set work.statCan_lfa_nemp;
        lfa = UNEMPLOY/5;
        lfagroup=1;
run;

data work.statCan_lfa_nemp;
        set work.statcan_lfa_nemp;
        keep GEOGRAPH lfa lfagroup group;
run;

data work.statcan_lfa_nilf;
        set work.StatCan_lfa;
        keep GEOGRAPH NOTINTHE group;
run;

data work.statCan_lfa_nilf;
        set work.statCan_lfa_nilf;
        lfa = NOTINTHE/5;
        lfagroup=2;
run;
```

```
data work.statCan_lfa_nilf;
        set work.statcan_lfa_nilf;
        keep GEOGRAPH lfa lfagroup group;
run;

data work.statcan_lfa_stacked;
        set work.statcan_lfa_emp work.statcan_lfa_nemp work.statcan_lfa_nilf;
run;

* Generate a table for each category of 'Labor force activity' for ORORN data and stack
them;

data work.ORORN_lfa_emp;
        set work.ORORN_lfa;
        keep GEOGRAPH ORORN_employed group;
run;

data work.ORORN_lfa_emp;
        set work.ORORN_lfa_emp;
        lfa = ORORN_employed;
        lfagroup=0;
run;

data work.ORORN_lfa_emp;
        set work.ORORN_lfa_emp;
        keep GEOGRAPH lfa lfagroup group;
run;

data work.ORORN_lfa_nemp;
        set work.ORORN_lfa;
        keep GEOGRAPH ORORN_unemployed group;
run;

data work.ORORN_lfa_nemp;
        set work.ORORN_lfa_nemp;
        lfa = ORORN_unemployed;
        lfagroup=1;
run;

data work.ORORN_lfa_nemp;
        set work.ORORN_lfa_nemp;
        keep GEOGRAPH lfa lfagroup group;
run;

data work.ORORN_lfa_nilf;
        set work.ORORN_lfa;
        keep GEOGRAPH ORORN_notinlaborforce group;
run;

data work.ORORN_lfa_nilf;
        set work.ORORN_lfa_nilf;
        lfa = ORORN_notinlaborforce;
        lfagroup=2;
run;

data work.ORORN_lfa_nilf;
        set work.ORORN_lfa_nilf;
        keep GEOGRAPH lfa lfagroup group;
run;

data work.ORORN_lfa_stacked;
        set work.ORORN_lfa_emp work.ORORN_lfa_nemp work.ORORN_lfa_nilf;
run;

data work.StatCanORORN_lfa_stacked;
        set work.StatCan_lfa_stacked work.ORORN_lfa_stacked;
run;

* Label Variables;
```

```
data work.StatCanORORN_lfa_stacked;
        set work.StatCanORORN_lfa_stacked;
        label GEOGRAPH = "Forward Sortation Area (FSA)" lfagroup = "Labour Force Activity"
group ="StatsCan or ORORN data";
run;

*(1) Make labels and titles
(2) Perform Chi-sq statistics and MH statistics;

proc format;
        value lfagroupf 0="Employed" 1="Unemployed" 2="Not In Labor Force";
        value groupf 0="Statistics Canada" 1="ORORN";
run;

proc freq data=work.StatCanORORN_lfa_stacked;
        weight lfa;
        format lfagroup lfagroupf. group groupf.;
        tables lfagroup*group /chisq NOCUM NOROW NOPERCENT;
run;

proc freq data=work.StatCanORORN_lfa_stacked;
        weight lfa;
        format lfagroup lfagroupf. group groupf.;
        tables GEOGRAPH*lfagroup*group /CMH NOPRINT;
run;



*************************************************************************************************
********************************** Marital Status Status CHI-SQUARE and MANTEL-HANSZEL
*************************************************************************************************

This Program restructures Statistics Canada and ORORN data and Calculates Chi-square
and Mantel-Hanszel statistics controlling for FSA

*************************************************************************************************
*************************************************************************************************;

* Create a dataset with the Statistics Canada FSA, Marriage category, and Count data for
each strata;

* Create a dataset with the statistics Canada Data;

data work.StatCan_MarStat;
        set SES.temp;
        keep  GEOGRAPH SINGLENE MARRIEDI SEPARATE;
run;

* Create a dataset with the ORORN Data;

data work.ORORN_MarStat;
        set SES.temp;
        keep  GEOGRAPH ORORN_single ORORN_married ORORN_previouslymarried;
run;

* Make dummy encoding variables indicating originating dataset (StatCan or ORORN) of data;

data work.StatCan_MarStat;
        set work.StatCan_MarStat;
        group=0;
run;

data work.ORORN_MarStat;
        set work.ORORN_MarStat;
        group=1;
run;

* Generate a dataset for each category of 'Marrital Status' for Statistics Canada data and
stack them
```

```
There are three data steps for each:

(1) Get data
(2) Create Dummy for group
(3) Create new dataset
;

data work.statcan_MarStat_single;
        set work.StatCan_MarStat;
        keep GEOGRAPH SINGLENE group;
run;

data work.statCan_MarStat_single;
        set work.statCan_MarStat_single;
        MarStat = SINGLENE/5;
        MarStatgroup=0;
run;

data work.statCan_MarStat_single;
        set work.statcan_MarStat_single;
        keep GEOGRAPH MarStat MarStatgroup group;
run;

data work.statcan_MarStat_married;
        set work.StatCan_MarStat;
        keep GEOGRAPH MARRIEDI group;
run;

data work.statCan_MarStat_married;
        set work.statCan_MarStat_married;
        MarStat = MARRIEDI/5;
        MarStatgroup=1;
run;

data work.statCan_MarStat_married;
        set work.statcan_MarStat_married;
        keep GEOGRAPH MarStat MarStatgroup group;
run;

data work.statcan_MarStat_prevmar;
        set work.StatCan_MarStat;
        keep GEOGRAPH SEPARATE group;
run;

data work.statCan_MarStat_prevmar;
        set work.statCan_MarStat_prevmar;
        MarStat = SEPARATE/5;
        MarStatgroup=2;
run;

data work.statCan_MarStat_prevmar;
        set work.statcan_MarStat_prevmar;
        keep GEOGRAPH MarStat MarStatgroup group;
run;

data work.statcan_MarStat_stacked;
        set             work.statcan_MarStat_single             work.statcan_MarStat_married
work.statcan_MarStat_prevmar;
run;

* Generate a table for each category of 'Labor force activity' for ORORN data and stack
them;

data work.ORORN_MarStat_single;
        set work.ORORN_MarStat;
        keep GEOGRAPH ORORN_single group;
run;

data work.ORORN_MarStat_single;
        set work.ORORN_MarStat_single;
```

```
        MarStat = ORORN_single;
        MarStatgroup=0;
run;

data work.ORORN_MarStat_single;
        set work.ORORN_MarStat_single;
        keep GEOGRAPH MarStat MarStatgroup group;
run;

data work.ORORN_MarStat_married;
        set work.ORORN_MarStat;
        keep GEOGRAPH ORORN_married group;
run;

data work.ORORN_MarStat_married;
        set work.ORORN_MarStat_married;
        MarStat = ORORN_married;
        MarStatgroup=1;
run;

data work.ORORN_MarStat_married;
        set work.ORORN_MarStat_married;
        keep GEOGRAPH MarStat MarStatgroup group;
run;

data work.ORORN_MarStat_prevmar;
        set work.ORORN_MarStat;
        keep GEOGRAPH ORORN_previouslymarried group;
run;

data work.ORORN_MarStat_prevmar;
        set work.ORORN_MarStat_prevmar;
        MarStat = ORORN_previouslymarried;
        MarStatgroup=2;
run;

data work.ORORN_MarStat_prevmar;
        set work.ORORN_MarStat_prevmar;
        keep GEOGRAPH MarStat MarStatgroup group;
run;

data work.ORORN_MarStat_stacked;
        set               work.ORORN_MarStat_single              work.ORORN_MarStat_married
work.ORORN_MarStat_prevmar;
run;

data work.StatCanORORN_MarStat_stacked;
        set work.StatCan_MarStat_stacked work.ORORN_MarStat_stacked;
run;

* Label Variables;

data work.StatCanORORN_MarStat_stacked;
        set work.StatCanORORN_MarStat_stacked;
        label GEOGRAPH = "Forward Sortation Area (FSA)" MarStatgroup = "Marital Status"
group ="StatsCan or ORORN data";
run;

*(1) Perform Chi-sq statistics and MH statistics
(2) Make labels and titles;

proc format;
        value MarStatgroupf 0="Single" 1="Married" 2="Previously Married";
        value groupf 0="Statistics Canada" 1="ORORN";
run;

proc freq data=work.StatCanORORN_MarStat_stacked;
        weight MarStat;
        format MarStatgroup MarStatgroupf. group groupf.;
        tables MarStatgroup*group /chisq NOCUM NOROW NOPERCENT;
```

```
run;

proc freq data=work.StatCanORORN_MarStat_stacked;
       weight MarStat;
       format MarStatgroup MarStatgroupf. group groupf.;
       tables GEOGRAPH*MarStatgroup*group /CMH NOPRINT;
run;

ods rtf close;
```

7.3 Appendix III: SAS Output for Manuscript II

7.3.1 Comparison of FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data – Sex

Table of SEX3 by group			
SEX3(Patient Gender)	group(StatsCan or ORORN data)		
Frequency Col Pct	Statistics Canada	ORORN	Total
Female	125648 51.99	674 66.21	126322
Male	116038 48.01	344 33.79	116382
Total	241686	1018	242704

Statistic	DF	Value	Prob
Chi-Square	1	82.1332	<.0001
Likelihood Ratio Chi-Square	1	83.9393	<.0001
Continuity Adj. Chi-Square	1	81.5644	<.0001
Mantel-Haenszel Chi-Square	1	82.1329	<.0001
Phi Coefficient		-0.0184	
Contingency Coefficient		0.0184	
Cramer's V		-0.0184	

Fisher's Exact Test	
Cell (1,1) Frequency (F)	125648
Left-sided Pr <= F	3.479E-20
Right-sided Pr >= F	1.0000
Table Probability (P)	1.569E-20
Two-sided Pr <= P	5.969E-20

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)				
Statistic	Alternative Hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	80.6359	<.0001
2	Row Mean Scores Differ	1	80.6359	<.0001
3	General Association	1	80.6359	<.0001

Estimates of the Common Relative Risk (Row1/Row2)				
Type of Study	Method	Value	95% Confidence Limits	
Case-Control	Mantel-Haenszel	0.5550	0.4872	0.6322
(Odds Ratio)	Logit **	0.5872	0.5137	0.6712
Cohort	Mantel-Haenszel	0.9976	0.9971	0.9981
(Col1 Risk)	Logit	0.9989	0.9985	0.9992
Cohort	Mantel-Haenszel	1.7945	1.5765	2.0425
(Col2 Risk)	Logit **	1.6950	1.4842	1.9358

Breslow-Day Test for Homogeneity of the Odds Ratios	
Chi-Square	69.6254
DF	61
Pr > ChiSq	0.2100

7.3.2 Comparison of FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data – Age Group

Table of AGE5 by group			
AGE5(Patient Age Category)	group(StatsCan or ORORN data)		
Frequency Col Pct	Statistics Canada	ORORN	Total
20-39 years	96636 39.98	543 53.34	97179
40-59 years	91739 37.96	342 33.60	92081
60 years and over	53311 22.06	133 13.06	53444
Total	241686	1018	242704

Statistic	DF	Value	Prob
Chi-Square	2	87.4790	<.0001
Likelihood Ratio Chi-Square	2	89.7903	<.0001
Mantel-Haenszel Chi-Square	1	86.0910	<.0001
Phi Coefficient		0.0190	
Contingency Coefficient		0.0190	
Cramer's V		0.0190	

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)				
Statistic	Alternative Hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	103.2459	<.0001
2	Row Mean Scores Differ	2	104.3494	<.0001
3	General Association	2	104.3494	<.0001

7.3.3 Comparison of FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data – Household Income

Table of HHLDINCO by group			
HHLDINCO(Patient INCOME Category)	group(StatsCan or ORORN data)		
Frequency Col Pct	Statistics Canada	ORORN	Total
Persons in households with household income $25,000 to 49,999	56451 23.36	394 38.70	56845
Persons in households with household income $50,000 and over	145811 60.33	271 26.62	146082
Persons in households with household income <= $24,999	39424 16.31	353 34.68	39777
Total	241686	1018	242704

Statistic	DF	Value	Prob
Chi-Square	2	501.9094	<.0001
Likelihood Ratio Chi-Square	2	484.8257	<.0001
Mantel-Haenszel Chi-Square	1	2.3478	0.1255
Phi Coefficient		0.0455	
Contingency Coefficient		0.0454	
Cramer's V		0.0455	

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)				
Statistic	Alternative Hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	1.8951	0.1686
2	Row Mean Scores Differ	2	396.9411	<.0001
3	General Association	2	396.9411	<.0001

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)				
Statistic	Alternative Hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	1.8273	0.1765
2	Row Mean Scores Differ	2	446.0853	<.0001
3	General Association	2	446.0853	<.0001

7.3.4 Comparison of FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data – Highest Level of Educational Attainment

Table of SCHOOLIN by group			
SCHOOLIN(Patient Education Category)	group(StatsCan or ORORN data)		
Frequency Col Pct	Statistics Canada	ORORN	Total
Some or completed trade or college	80393 33.26	399 39.19	80792
Some or completed university certificates or degrees	61878 25.60	165 16.21	62043
High school graduation certificate	35527 14.70	250 24.56	35777
Without high school graduation certificate	63888 26.43	204 20.04	64092
Total	241686	1018	242704

Statistic	DF	Value	Prob
Chi-Square	3	128.2443	<.0001
Likelihood Ratio Chi-Square	3	123.1297	<.0001
Mantel-Haenszel Chi-Square	1	5.6109	0.0178
Phi Coefficient		0.0230	
Contingency Coefficient		0.0230	
Cramer's V		0.0230	

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)				
Statistic	Alternative Hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	9.2918	0.0023
2	Row Mean Scores Differ	3	113.5811	<.0001
3	General Association	3	113.5811	<.0001

7.3.5 Comparison of FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data – Employment Status

Table of lfagroup by group			
lfagroup(Labour Force Activity)	group(StatsCan or ORORN data)		
Frequency Col Pct	Statistics Canada	ORORN	Total
Employed	154941 63.92	683 67.42	155624
Unemployed	10473 4.32	156 15.40	10629
Not In Labor Force	76971 31.76	174 17.18	77145
Total	242385	1013	243398

Statistic	DF	Value	Prob
Chi-Square	2	353.1275	<.0001
Likelihood Ratio Chi-Square	2	254.0048	<.0001
Mantel-Haenszel Chi-Square	1	38.6826	<.0001
Phi Coefficient		0.0381	
Contingency Coefficient		0.0381	
Cramer's V		0.0381	

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)				
Statistic	Alternative Hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	57.4512	<.0001
2	Row Mean Scores Differ	2	345.6112	<.0001
3	General Association	2	345.6112	<.0001

7.3.6 Comparison of FSA's with ≥50% market share of ED visits and Statistics Canada General Population Data – Marital Status

Table of MarStatgroup by group			
MarStatgroup(Marital Status)	group(StatsCan or ORORN data)		
Frequency Col Pct	Statistics Canada	ORORN	Total
Single	47697 19.68	279 27.54	47976
Married	157544 65.00	559 55.18	158103
Previously Married	37143 15.32	175 17.28	37318
Total	242384	1013	243397

Statistic	DF	Value	Prob
Chi-Square	2	49.1140	<.0001
Likelihood Ratio Chi-Square	2	46.3227	<.0001
Mantel-Haenszel Chi-Square	1	10.1178	0.0015
Phi Coefficient		0.0142	
Contingency Coefficient		0.0142	
Cramer's V		0.0142	

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)				
Statistic	Alternative Hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	14.5421	0.0001
2	Row Mean Scores Differ	2	48.7697	<.0001
3	General Association	2	48.7697	<.0001

7.4 Appendix IV: SAS Program for Manuscript III

```
*********************************************************************************
*********************************************************************************
*******************    Regression analysis for Masters's    *********************
*******************          Thesis - Manuscript III         *********************
*******************                                          *********************
*******************        Paul M. Heffernan, MD FRCPC       *********************
*********************************************************************************
*********************************************************************************


This program conducts all the data manipulation, organization, and analytic

procedures or all portions of Manuscript III of the Master's Thesis.


Note on dataset naming conventions:

**********************************

Dataset are named:

library.<data origin>_<variable of interest>_<operation performed>


Where:

(1) <Data Origin> = Indicates whether the data is from the ORORON or Statistics
Canada 2001 Census data or both (e.g. ORORN, StatCan, StatCanORORN).


(2) <variable of interest> = Principal variable contained in dataset (e.g.
gender, married, combined, etc...).


(3) <operation performed> = Indicator of changes made to dataset. (e.g. stacked,
transposed, etc...).



Poisson Regression:

*******************

The population at risk, or denominator will be the strata population from Statistics
Canada.

The observations, or numerator,  will be a weighted derivative of the ORORN strata
counts.

The weight will be the the reciprocal of the sum of ORORN strata counts for an FSA
divided by the number of ED visits recorded by NACRS for that FSA if the observations
are weighted.

The weight will be the the sum of ORORN strata counts for an FSA
divided by the number of ED visits recorded by NACRS for that FSA if the observations
are weighted.


Author and Modification information:

************************************
```

```
Paul M. Heffernan, MD FRCPC

Last edit: May 9, 2011 @ 20:15 HRS

********************************************************************************
********************************************************************************
********************************************************************************;

OPTIONS nodate nonumber nocenter formdlim="-";


libname asthma "z:\sas\asthma";


*libname asthma "c:\Users\Paul\Desktop\";


* Read in dataset and create a full and working copy of the dataset called

work.FullDataSet and label Data that will be used. Make PoissonRegression dataset

to perform calculations to use as a working dataset.;


ods pdf  file='z:\My Desktop\index.pdf';


*      ods      html      body='poissonregression.html'      contents='poissoncontents.html'
frame='poisson.html' style=statistical;



%LET SENDIV=1000;


data work.FullDataSet;

        set asthma.temp;

        label AGE5='Age Group';

        label EMPLOYED='Statistics Canada Strata Count of Employed Persons';

        label GEOGRAPH='Forward Sortation Area (FSA)';

        label HHLDINCO='Household Income Category';

        label NOTINTHE='Statistics Canada Strata Count of Persons *Not* Active in the
Labour Force';

        label ORORN_NotInLaborForce='ORORN Strata Count of Persons *Not* Active in the
Labour Force';

        label ORORN_employed='ORORN Strata Count of Employed Persons';

        label ORORN_married='ORORN Strata Count of Married Persons';

        label SEX3='Gender';

        label SCHOOLIN='Educational Attainment Category';
```

```
        label TOTALALL='Statistics Canada Strata Count';

        label SINGLENE='Statistics Canada Strata Count of Single Persons';

        label SEPARATE='Statistics Canada Strata Count of Previously Married Persons';

        label UNEMPLOY='Statistics Canada Strata Count of Unemployed Persons';

        label ORORN_nQuests='ORORN Strata Count';

        label ORORN_single='ORORN Strata Count of Single Persons';

        label ORORN_previouslymarried='ORORN Strata Count of Previously Married Persons';

        label ORORN_unemployed='ORORN Strata Count of Unemployed Persons';

        label ORORN_retired='ORORN Strata Count of Retired Persons';

        label  NACRS_Total='NACRS  Total  number  of  Asthma-Related  Emergency  Department
Visits for an FSA';

        label ORORN_nRespondAllQuests='Sum or ORORN strata counts across FSA';

        label MARRIEDI='Statistics Canada Strata Count of Married Persons';

run;


data work.PoissonRegression;

        set work.FullDataSet;

        keep  GEOGRAPH  AGE5  SEX3  HHLDINCO  SCHOOLIN  TOTALALL  SINGLENE  SEPARATE  EMPLOYED
UNEMPLOY MARRIEDI

                        NOTINTHE    ORORN_nQuests    ORORN_single    ORORN_previouslymarried
ORORN_married ORORN_employed

                        ORORN_unemployed  ORORN_retired  ORORN_NotInLaborForce  NACRS_Total
ORORN_nRespondAllQuests;

run;



*************************************************************************************
Set-up and Calculation of Weights and Poisson Regression analyses
*************************************************************************************;


/* This demonstrates that there are 8 strata that have '0' count from statistics    */
/* Canada despite a matching questionaire from ORORN. These ORORN observarions are  */
/* lost to the analysis and leave a remainder of 1010 observations for the analysis.*/


data work.zerovalues;

        set work.poissonregression;

        if TOTALALL ne 0 then DELETE;
```

```
        if ORORN_nQuests = 0 then DELETE;
        KEEP GEOGRAPH AGE5 SEX3 HHLDINCO SCHOOLIN TOTALALL ORORN_nQuests;
run;

/*

title 'Zero Population in Strata from Statistics Canada *or* no ORORN Responders';
proc print data=work.zerovalues;
run;

*/

/* Calculate the Proportion of NACRS visits that I caputred in my dataset. */
Data work.PoissonRegression;
        set work.PoissonRegression;
        ProportionOfNACRS=ORORN_nRespondAllQuests/NACRS_total;
run;


/* Cannot use log of Zero in offset. Therefore, remove these rows.  - Currently commented
out and will let error messages appear in log */
/* Calculate Offset(StatCanWeightedStrataCount) */

Data work.PoissonRegression;
        set work.PoissonRegression;
        *if TOTALALL=0 then DELETE;
        *if ProportionOfNACRS=0 then DELETE;
        StatCanWeightedStrataCount=log(ProportionOfNACRS*TOTALALL/&SENDIV);
        label StatCanWeightedStrataCount='Log of weight factor or offset variable';
run;

/*  Do  poisson  regressions.  First  with  just  stratification  variables  as  univariate
comparisons, then the multiple regression   */
/* Note that parameter estimates are included as are type III analytics. Finally, the
pearson chi-square overdispersion correction is applied. */
```

```
/* Level of Educational Attainment - Controlled for Age and Gender */


title 'Poisson: Educational Attainment - Univariate - Age and Sex Controlled';


proc genmod data=work.PoissonRegression;

	class SCHOOLIN(ref='Some or completed university certificates or degrees'
param=ref) AGE5 SEX3;

	model ORORN_nQuests = SCHOOLIN AGE5 SEX3 / offset=StatCanWeightedStrataCount
link=log dist=poisson pscale type3;

run;


proc genmod data=work.PoissonRegression;

	class SCHOOLIN AGE5 SEX3;

	model ORORN_nQuests = SCHOOLIN AGE5 SEX3 / offset=StatCanWeightedStrataCount
link=log dist=poisson pscale type3;

	lsmeans SCHOOLIN /CL;

	estimate 'Some or completed trade or college' int 1 SCHOOLIN 1 0 0 0 /exp;

	estimate 'Some or completed university certificates or degrees' int 1 SCHOOLIN 0 1
0 0 /exp;

	estimate 'High school graduation certificate' int 1 SCHOOLIN 0 0 1 0 /exp;

	estimate 'Without high school graduation certificate' int 1 SCHOOLIN 0 0 0 1 /exp;

run;



title 'Poisson: Household Income - Univariate - Age and Sex Controlled';

/* Household Income Univariate - Controlled for Age and Gender*/


proc genmod data=work.PoissonRegression;

	class HHLDINCO(ref='Persons in households with household income $50,000 and over'
param=ref) AGE5 SEX3;

	model ORORN_nQuests = HHLDINCO AGE5 SEX3 / offset=StatCanWeightedStrataCount
link=log dist=poisson pscale type3;

run;


proc genmod data=work.PoissonRegression;

	class HHLDINCO AGE5 SEX3;

	model ORORN_nQuests = HHLDINCO AGE5 SEX3 / offset=StatCanWeightedStrataCount
link=log dist=poisson pscale type3;

	lsmeans HHLDINCO /CL;
```

```
        estimate 'Persons in households with household income $25,000 to 49,999' int 1
HHLDINCO 1 0 0 /exp;

        estimate 'Persons in households with household income $50,000 and over' int 1
HHLDINCO 0 1 0 /exp;

        estimate 'Persons in households with household income <= $24,999' int 1 HHLDINCO 0
0 1 /exp;

run;


/* Sex Univariate */


title 'Poisson: Sex - Univariate';


proc genmod data=work.PoissonRegression;

        class SEX3;

        model   ORORN_nQuests   =   SEX3   /   offset=StatCanWeightedStrataCount   link=log
dist=poisson pscale type3;

        lsmeans SEX3 /CL;

        estimate 'Female' int 1 SEX3 1 0 /exp;

        estimate 'Male' int 1 SEX3 0 1 /exp;

run;


/* Age Univariate */


title 'Poisson: Age  - Univariate';


proc genmod data=work.PoissonRegression;

        class AGE5;

        model   ORORN_nQuests   =   AGE5   /   offset=StatCanWeightedStrataCount   link=log
dist=poisson pscale type3;

        lsmeans AGE5 /CL;

        estimate '20-39 years' int 1 AGE5 1 0 0 /exp;

        estimate '40-59 years' int 1 AGE5 0 1 0 /exp;

        estimate '60 years and over' int 1 AGE5 0 0 1 /exp;

run;


/* Full Model */
```

```
title 'Poisson: Multivariate Model';



proc genmod data=work.PoissonRegression;

class AGE5(ref='60 years and over') SEX3(ref='Male') HHLDINCO(ref='Persons in households
with household income $50,000 and over') SCHOOLIN(ref='Some or completed university
certificates or degrees') /PARAM=ref;

model ORORN_nQuests = AGE5 SEX3 HHLDINCO SCHOOLIN / offset=StatCanWeightedStrataCount
link=log dist=poisson pscale type3;

run;



proc genmod data=work.PoissonRegression;

        class AGE5 SEX3 HHLDINCO SCHOOLIN;

        model      ORORN_nQuests      =      AGE5      SEX3      HHLDINCO      SCHOOLIN      /
offset=StatCanWeightedStrataCount link=log dist=poisson pscale type3;

        lsmeans AGE5 SEX3 HHLDINCO SCHOOLIN /CL;



        estimate 'Some or completed trade or college' int 1 SCHOOLIN 1 0 0 0 /exp;

        estimate 'Some or completed university certificates or degrees' int 1 SCHOOLIN 0 1
0 0 /exp;

        estimate 'High school graduation certificate' int 1 SCHOOLIN 0 0 1 0 /exp;

        estimate 'Without high school graduation certificate' int 1 SCHOOLIN 0 0 0 1 /exp;



        estimate 'Persons in households with household income $25,000 to 49,999' int 1
HHLDINCO 1 0 0 /exp;

        estimate 'Persons in households with household income $50,000 and over' int 1
HHLDINCO 0 1 0 /exp;

        estimate 'Persons in households with household income <= $24,999' int 1 HHLDINCO 0
0 1 /exp;



        estimate 'Female' int 1 SEX3 1 0 /exp;

        estimate 'Male' int 1 SEX3 0 1 /exp;



        estimate '20-39 years' int 1 AGE5 1 0 0 /exp;

        estimate '40-59 years' int 1 AGE5 0 1 0 /exp;

        estimate '60 years and over' int 1 AGE5 0 0 1 /exp;

run;



ods pdf close;
```

7.5 Appendix V: SAS output for Manuscript III

7.5.1 Poisson: Educational Attainment - Univariate - Age and Sex Controlled

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	4078	3107.9729	0.7621
Scaled Deviance	4078	1523.8327	0.3737
Pearson Chi-Square	4078	8317.3918	2.0396
Scaled Pearson X2	4078	4078.0000	1.0000
Log Likelihood		-960.0695	
Full Log Likelihood		-1134.6975	
AIC (smaller is better)		2283.3951	
AICC (smaller is better)		2283.4225	
BIC (smaller is better)		2327.6006	

Analysis Of Maximum Likelihood Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits	Wald Chi-Square	Pr > ChiSq	
Intercept		1	1.2977	0.1209	1.0608	1.5345	115.30	<.0001
SCHOOLIN	Some or completed trade or college	1	0.6453	0.1335	0.3838	0.9069	23.38	<.0001
SCHOOLIN	High school graduation certificate	1	1.0078	0.1450	0.7235	1.2920	48.29	<.0001
SCHOOLIN	Without high school graduation certificate	1	0.4125	0.1551	0.1086	0.7165	7.08	0.0078
AGE5	20-39 years	1	0.4329	0.0661	0.3033	0.5624	42.87	<.0001
AGE5	40-59 years	1	-0.0188	0.0698	-0.1556	0.1180	0.07	0.7879
SEX3	Female	1	0.3027	0.0476	0.2095	0.3959	40.51	<.0001
Scale		0	1.4281	0.0000	1.4281	1.4281		

LR Statistics For Type 3 Analysis						
Source	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
SCHOOLIN	3	4078	18.10	<.0001	54.30	<.0001
AGE5	2	4078	22.50	<.0001	44.99	<.0001
SEX3	1	4078	42.66	<.0001	42.66	<.0001

Model Information		
Data Set	WORK.POISSONREGRESSION	
Distribution	Poisson	
Link Function	Log	
Dependent Variable	ORORN_nQuests	ORORN Strata Count
Offset Variable	StatCanWeightedStrataCount	Log of weight factor or offset variable

Least Squares Means Effect	SCHOOLIN	Estimate Mean	Standard Error L'Beta	DF	Chi-Square	Pr > ChiSq	Alpha		Confidence Limits	
SCHOOLIN	Some or completed trade or college	6.9797	1.9430	0.0821	1	560.30	<.0001	0.05	1.7821	2.1039
SCHOOLIN	Some or completed university certificates or degrees	3.6607	1.2977	0.1209	1	115.30	<.0001	0.05	1.0608	1.5345
SCHOOLIN	High school graduation certificate	10.0286	2.3054	0.0977	1	557.00	<.0001	0.05	2.1140	2.4969
SCHOOLIN	Without high school graduation certificate	5.5299	1.7102	0.1014	1	284.52	<.0001	0.05	1.5115	1.9089

7.5.2 Poisson: Household Income - Univariate - Age and Sex Controlled

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	4079	2678.5230	0.6567
Scaled Deviance	4079	1566.9997	0.3842
Pearson Chi-Square	4079	6972.3658	1.7093
Scaled Pearson X2	4079	4079.0000	1.0000
Log Likelihood		-1019.9363	
Full Log Likelihood		-1228.3026	
AIC (smaller is better)		2468.6052	
AICC (smaller is better)		2468.6258	
BIC (smaller is better)		2506.4957	

Analysis Of Maximum Likelihood Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits	Wald Chi-Square	Pr > ChiSq	
Intercept		1	0.9141	0.0872	0.7431	1.0850	109.84	<.0001
HHLDINCO	Persons in households with household income $25,000 to 49,999	1	1.4184	0.1040	1.2147	1.6222	186.18	<.0001
HHLDINCO	Persons in households with household income <= $24,999	1	1.6835	0.1072	1.4734	1.8936	246.63	<.0001
AGE5	20-39 years	1	0.4933	0.0586	0.3785	0.6081	70.95	<.0001
AGE5	40-59 years	1	0.1720	0.0641	0.0464	0.2977	7.20	0.0073
SEX3	Female	1	0.2663	0.0436	0.1808	0.3517	37.28	<.0001
Scale		0	1.3074	0.0000	1.3074	1.3074		

LR Statistics For Type 3 Analysis						
Source	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
HHLDINCO	2	4079	158.02	<.0001	316.03	<.0001
AGE5	2	4079	49.69	<.0001	99.38	<.0001
SEX3	1	4079	39.06	<.0001	39.06	<.0001

Model Information		
Data Set	WORK.POISSONREGRESSION	
Distribution	Poisson	
Link Function	Log	
Dependent Variable	ORORN_nQuests	ORORN Strata Count
Offset Variable	StatCanWeightedStrataCount	Log of weight factor or offset variable

Least Squares Means										
Effect	HHLDINCO	Estimate Mean	Standard Error L'Beta	DF	Chi-Square	Pr > ChiSq	Alpha		Confidence Limits	
HHLDINCO	Persons in households with household income $25,000 to 49,999	10.3035	2.3325	0.0721	1	1047.6	<.0001	0.05	2.1912	2.4737
HHLDINCO	Persons in households with household income $50,000 and over	2.4945	0.9141	0.0872	1	109.84	<.0001	0.05	0.7431	1.0850
HHLDINCO	Persons in households with household income <= $24,999	13.4316	2.5976	0.0756	1	1179.3	<.0001	0.05	2.4494	2.7459

7.5.3 Poisson: Sex – Univariate

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	4083	3313.9685	0.8117
Scaled Deviance	4083	1576.5353	0.3861
Pearson Chi-Square	4083	8582.7024	2.1021
Scaled Pearson X2	4083	4083.0000	1.0000
Log Likelihood		-980.5309	
Full Log Likelihood		-1149.9683	
AIC (smaller is better)		2303.9365	
AICC (smaller is better)		2303.9395	
BIC (smaller is better)		2316.5667	

Analysis Of Maximum Likelihood Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept		1	1.6551	0.0785	1.5012	1.8090	444.37	<.0001
SEX3	Female	1	0.5964	0.0965	0.4073	0.7854	38.21	<.0001
SEX3	Male	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	1.4498	0.0000	1.4498	1.4498		

LR Statistics For Type 3 Analysis						
Source	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
SEX3	1	4083	40.23	<.0001	40.23	<.0001

Model Information	
Data Set	WORK.POISSONREGRESSION
Distribution	Poisson
Link Function	Log
Dependent Variable	ORORN_nQuests
Offset Variable	StatCanWeightedStrataCount
	ORORN Strata Count
	Log of weight factor or offset variable

Least Squares Means										
Effect	SEX3	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq	Alpha			
		Mean	L'Beta						Confidence Limits	
SEX3	Female	9.5013	2.2514	0.0561	1	1613.2	<.0001	0.05	2.1416	2.3613
SEX3	Male	5.2334	1.6551	0.0785	1	444.37	<.0001	0.05	1.5012	1.8090

7.5.4 Poisson: Age – Univariate

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	4082	3307.5205	0.8103
Scaled Deviance	4082	1531.1733	0.3751
Pearson Chi-Square	4082	8817.6163	2.1601
Scaled Pearson X2	4082	4082.0000	1.0000
Log Likelihood		-952.6819	
Full Log Likelihood		-1117.5648	
AIC (smaller is better)		2241.1296	
AICC (smaller is better)		2241.1355	
BIC (smaller is better)		2260.0748	

Analysis Of Maximum Likelihood Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept		1	1.4826	0.1284	1.2309	1.7343	133.30	<.0001
AGE5	20-39 years	1	0.8174	0.1431	0.5368	1.0979	32.61	<.0001
AGE5	40-59 years	1	0.3982	0.1512	0.1019	0.6946	6.94	0.0084
AGE5	60 years and over	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	1.4697	0.0000	1.4697	1.4697		

LR Statistics For Type 3 Analysis						
Source	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
AGE5	2	4082	21.07	<.0001	42.13	<.0001

Least Squares Means										
Effect	AGE5	Estimate Mean	Standard Error L'Beta	DF	Chi-Square	Pr > ChiSq	Alpha		Confidence Limits	
AGE5	20-39 years	9.9739	2.3000	0.0632	1	1322.4	<.0001	0.05	2.1760	2.4239
AGE5	40-59 years	6.5590	1.8808	0.0798	1	555.17	<.0001	0.05	1.7244	2.0373
AGE5	60 years and over	4.4044	1.4826	0.1284	1	133.30	<.0001	0.05	1.2309	1.7343

7.5.5 Poisson: Multivariate Model

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	4076	2576.5930	0.6321
Scaled Deviance	4076	1741.7815	0.4273
Pearson Chi-Square	4076	6029.5698	1.4793
Scaled Pearson X2	4076	4076.0000	1.0000
Log Likelihood		-1144.0958	
Full Log Likelihood		-1384.8655	
AIC (smaller is better)		2787.7309	
AICC (smaller is better)		2787.7751	
BIC (smaller is better)		2844.5666	

Analysis Of Maximum Likelihood Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.2855	0.1702	-0.6189	0.0480	2.81	0.0934
AGE5	20-39 years	1	1.0590	0.1235	0.8170	1.3010	73.56	<.0001
AGE5	40-59 years	1	0.7435	0.1284	0.4919	0.9951	33.55	<.0001
SEX3	Female	1	0.5185	0.0812	0.3594	0.6777	40.78	<.0001
HHLDINCO	Persons in households with household income $25,000 to 49,999	1	1.4011	0.0972	1.2107	1.5916	207.90	<.0001
HHLDINCO	Persons in households with household income <= $24,999	1	1.7075	0.1008	1.5100	1.9051	286.99	<.0001
SCHOOLIN	Some or completed trade or college	1	0.5049	0.1140	0.2814	0.7284	19.61	<.0001
SCHOOLIN	High school graduation certificate	1	0.8344	0.1239	0.5916	1.0772	45.37	<.0001
SCHOOLIN	Without high school graduation certificate	1	0.0353	0.1335	-0.2264	0.2971	0.07	0.7913
Scale		0	1.2163	0.0000	1.2163	1.2163		

LR Statistics For Type 3 Analysis						
Source	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
AGE5	2	4076	43.35	<.0001	86.69	<.0001
SEX3	1	4076	42.68	<.0001	42.68	<.0001
HHLDINCO	2	4076	179.61	<.0001	359.21	<.0001
SCHOOLIN	3	4076	22.97	<.0001	68.90	<.0001
Model Information						
Data Set	WORK.POISSONREGRESSION					
Distribution	Poisson					
Link Function	Log					
Dependent Variable	ORORN_nQuests	ORORN Strata Count				
Offset Variable	StatCanWeightedStrataCount	Log of weight factor or offset variable				

Least Squares Means Effect	AGE5	SEX3	HHLDINCO	SCHOOLIN	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq	
					Mean	L'Beta				
AGE5	20-39 years				11.1634	2.4126	0.0564	1	1827.6	<.0001
AGE5	40-59 years				8.1432	2.0972	0.0688	1	930.16	<.0001
AGE5	60 years and over				3.8717	1.3537	0.1117	1	146.88	<.0001
SEX3		Female			9.1501	2.2138	0.0546	1	1641.7	<.0001
SEX3		Male			5.4479	1.6952	0.0724	1	548.15	<.0001
HHLDINCO			Persons in households with household income $25,000 to 49,999		10.1697	2.3194	0.0687	1	1138.5	<.0001
HHLDINCO			Persons in households with household income $50,000 and over		2.5050	0.9183	0.0817	1	126.23	<.0001
HHLDINCO			Persons in households with household income <= $24,999		13.8157	2.6258	0.0723	1	1318.0	<.0001
SCHOOLIN				Some or completed trade or college	8.2956	2.1157	0.0700	1	913.43	<.0001
SCHOOLIN				Some or completed university certificates or degrees	5.0071	1.6108	0.1033	1	243.28	<.0001
SCHOOLIN				High school graduation certificate	11.5334	2.4452	0.0836	1	855.81	<.0001
SCHOOLIN				Without high school graduation certificate	5.1871	1.6462	0.0879	1	350.90	<.0001