Respiratory Health and Occupations among Canadian Adolescents and Adults

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Clinical Epidemiology

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Abstract

Workers are being constantly subjected to different exposures at work, which are linked with their respiratory health. Typically, exposure to irritants, sensitizers, or toxic substances at the workplace can result in airway diseases. Understanding these associations will be beneficial in terms of prevention and mitigation of the effects of exposures. There are limited studies in the literature among the Canadian working population in this regard. The aim of this thesis is to examine the association between occupational/industrial exposures with asthma, respiratory symptoms and lung function in the Canadian working population. Data on 15-75 years old participants in the Canadian Health Measures Survey (CHMS) Cycle 1 (2007) & Cycle 2 (2009), a representative sample of Canadian population, were considered in the thesis. Exposure variables were defined by broad occupational categories and by industrial sectors based on National Occupational Classification - Statistics (NOC-S) 2001 and North American Industry Classification System (NAICS) 2002, respectively. Information on asthma and respiratory symptoms were collected using interviewer-administered questionnaires, and lung function parameters were measured according to the American Thoracic Society/European Respiratory Society guidelines for spirometry. Multiple logistic and linear regression analyses was used to characterize the association of occupational categories and industrial sectors with asthma and lung function parameters after controlling for potential confounders. There were significant differences in several characteristics between the employed and non-employed respondents (mean age: 39.9 vs. 52.5 years; female sex: 47% vs. 64%; post-secondary education: 61.0% vs. 44.5%; self-rated very good or excellent health: 57.0% vs. 41.0%; respectively). After adjusting for the potential confounders, the prevalence of cough with phlegm, shortness of breath and COPD was significantly lower in employed respondents in comparison to non-employed respondents. This

pattern was reversed in the prevalence of current asthma with employed respondents reporting a greater prevalence than the non-employed respondents. After adjusting for potential confounders, the mean values of FVC, FEV_1 and $FEF_{25\%-75\%}$ were significantly greater in employed than in non-employed respondents among both male and female participants. There were significant overall differences in several characteristics (age, sex, ethnicity, education and total personnel income, self-rated health, smoking and daily energy expenditure) of the respondents between both industrial sectors and broad occupational categories, respectively. No significant differences were observed between the industrial sectors in the prevalence of respiratory health outcomes among the respondents. Among the occupational categories, occupations unique to primary industry and occupations unique to processing, manufacturing and utilities had the highest prevalence for cough with phlegm (15%) with health occupations having the lowest prevalence (2.4%). Overall the differences between the occupational categories in the prevalence of cough and phlegm were statistically significant ($p<0.05$). After controlling for smoking status, no significant differences were observed in the mean values of percent-predicted FVC, FEV_1 and FEV_1/FVC of the respondents within either industrial sectors or broad occupational categories. After adjusting for potential confounders, the respondents in the industrial Sector 11 (Agriculture, Forestry, Fishing and Hunting/Mining, Oil and Gas Extraction/Utilities) were less likely to have current asthma in comparison to the respondents in the referent category (OR: 0.3; 95% CI: 0.1, 1.0; p=0.05). After adjusting for potential confounders, the respondents in the natural and applied science related occupations were more likely to have ever asthma in comparison to the respondents in the management occupations (OR: 2.1; 95% CI: 1.0, 4.5; p=0.05). After adjusting for potential confounders, the mean values of FVC and FEV_1 in Sector 3 (arts, entertainment and recreation/accommodation and food services) were significantly lower than those in the referent

category (Sector 1). Similarly, the mean value of FVC in Sector 8 (whole-sale trades/ retail trade/ transportation and warehousing) was less than that in the referent category ($p < 0.05$). The main findings from the thesis are (i) there is a gender disparity in the Canadian working population; (ii) the healthy worker effect is apparent among the working population and (iii) the respiratory health of the working population is related with some of the industrial sectors and broad occupational categories. Further exploration of the effects of employment on the respiratory health of the Canadian workers is needed and will be helpful in improving their respiratory health.

Preface

This thesis is an original work by Verginia Lalantha Coonghe. The thesis has been written in traditional format according to the guidelines of the Faculty of Graduate Studies and Research at the University of Alberta. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Health Research Ethics Board (Project: "Respiratory Health and Occupations among Canadian Adolescents and Adults; A cross sectional study using data from CHMS Cycle 1 and 2" No: Pro00063890, January 25, 2018).

The thesis consists of introduction to the thesis (Chapter 1), literature review in relation to the main and specific objectives of the thesis (Chapter 2), methods (Chapter3), results (Chapter 4) and discussion and conclusions (Chapter 5).

Verginia Lalantha Coonghe was responsible for the study design, data analysis, and preparation of the thesis. A. Senthilselvan provided guidance to the study design, data analysis, interpretation of the results and preparation of the thesis. J. Beach contributed to the study design, interpretation of the results and preparation of the thesis.

Dedication

This thesis is dedicated to my dear husband Chamly who remains willing to engage with the struggle and to three lovely sons Amintha, Ayeshmantha and Anupama for their endless love and happiness brought to my life.

Also thanks to my parents and a special appreciation to my sister who always encourages me. I owe thanks to my friends who supported me in many ways.

Acknowledgements

I am grateful to Dr Jeremy Beach, a member of my supervisorial committee who always provided me with refreshing comments on my writing. His contribution, guidance and valuable suggestions are greatly appreciated.

My heartiest gratitude goes to Mrs. Irene Wong at the University of Alberta Research Data Centre (RDC). Her technical support was invaluable in accomplishing this thesis project. I extend my thanks to Statistic Canada for permitting me the access to microdata at RDC and also take this opportunity to thank all the Canadian Health Measures Survey respondents who participated in Cycle 1 and Cycle 2.

Most of all, I am profoundly grateful to Dr. Ambikaipakan Senthilselvan, my supervisor and mentor for his excellent support, constant guidance, patience, advice and the precious time he devoted to bring the best out of me. His expertise and guidance on data analysis helped me succeed. I consider myself fortunate to have him had as my supervisor and without his enormous support, completion of the Master's program would have never been possible.

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List of Abbreviations

ACBS	Asthma Call-Back Survey
AHR	Air Way Hyper Responsiveness
aOR	Adjusted Odds Ratio
ARIC	Atherosclerosis Risk in Communities Study
ATS	American Thoracic Society
BMRC	British Medical Research Council
BRFSS	Behavioral Risk Factor Surveillance System
CAI	Computer Assisted Interviewing
CDC	Centers for Disease Control and Prevention
CHMS	Canadian Health Measures Survey
CI	Confidential Interval
COPD	Chronic Obstructive Pulmonary Disease
CPAFLA	Canadian Physical Activity, Fitness and Lifestyle Approach
ECRHS	European Community Respiratory Health survey
$FEF_{25\%-75\%}$	Forced expiratory flow between 25% and 75% of forced vital capacity
FEV_1	Forced Expiratory Volume in 1 Second
FVC	Forced Vital Capacity
HC	Health Canada
HMS	Health Measures Specialist
ICD	International Classification of Diseases

ICOH	International Commission on Occupational Health
ILO	International Labour Office
ISCO	International Standard Classification of Occupation
LFS	Labor Force Survey
LLN	Lower Limit of Normal
MEC	Mobile Examination Clinic/Centre
NAICS	North American Industrial Classification System
NHANES	National Health and Nutrition Examination Survey
NHLI	National Heart and Lung Institute
NOC	National Occupational Classification
OR	Odds Ratio
PAARC	Pollution Atmosphérique et Affections Respiratoires Chroniques
PHAC	Public Health Agency of Canada
PIR	Poverty Income Ratio
PPE	Personnel Protective Equipment
PR	Prevalence Ratio
PRO	Prevalence Odds Ratios
RDC	Research Data Centre
SE	Standard Errors
SIC	Standard Industrial Classification
SIC-C	Standard Industrial Classification - Companies and Enterprises
SIC-E	Standard Industrial Classification - Establishments

UK	United kingdom of Great Britain and Northern Island
USA	United States of America

CHAPTER 1

INTRODUCTION

1.1 Statement of the Problem

Respiratory ill-health causes a substantial financial burden on the Canadian health care system. More than 3 million Canadians survive with one of five serious respiratory diseases, two of these being asthma and chronic obstructive pulmonary disease (COPD).[1] What is inhaled impacts considerably on respiratory health regardless whether it is in the home environment or the working environment. Air quality (indoor and outdoor) and tobacco smoke (through both personnel smoking and exposure to second hand smoke) have been identified as the two most preventable risk factors for respiratory disease. Poor indoor and outdoor air quality could aggravate the persisting symptoms of respiratory diseases. All Canadians are subjected to the effects of the poor quality of the air that they inhale, but the effects are more severe for those who have a respiratory ill health.[1] Obstructive airway diseases have emerged as the most prevalent category of occupational respiratory disorder. Recognition of work-relatedness for asthma and COPD may not be simple and straightforward. First, these are multifactorial diseases and are strongly associated with non-occupational exposures as well; second, occupational dose-response and temporal relationships for obstructive airway diseases are complex.[2] Numerous studies have been conducted to estimate the possible associations between various exposures and respiratory health.[3-5] Quantifying the exposures as well as the measurement of respiratory health is challenging and would be vital in assessing the estimates of the associations between the exposures and the respiratory health in the population. The use of personal protective equipment

(PPE), improvements in working environments, rules and policies regarding work rosters are few among many factors that have to be taken into consideration when assessing estimates of associations between the occupations /industries and lung health.

It is a well-established fact that workers in certain occupations and industries are at a greater risk of getting respiratory health effects than those in other occupations and industries. Studies conducted in several countries including China, USA, UK and India have shown that the levels of association between occupational and industrial exposures and respiratory health vary among different occupations and different industries.[6-11]

Typically, exposure to irritating, sensitizing, or toxic substances can result in airway diseases. Understanding these associations will be beneficial in terms of prevention and mitigation of the effects of exposures. Researchers also have made considerable attempts to assess how other factors could distort the estimates of the association between exposures and respiratory health. For example, studies conducted using different data sources, have identified smoking, gender and age are common confounders which distort the estimates of associations between occupational/ industrial exposures and respiratory outcomes.[12-16]

Occupational diseases can cause huge suffering yet remains largely unnoticed in comparison to industrial accidents and, the nature of occupational diseases is altering rapidly.[17] In the report from the Public Health Agency of Canada, it was stated that almost 6.5% of total health care costs of the Canadian Health Care system were related to respiratory diseases excluding lung cancer.[1]

Occupational and industrial exposures, work settings, policies regarding work shifts and labor laws are all subjected to considerable modification over the years and these changes have an effect on estimates of the associations of occupational/industrial exposures and respiratory health. Population estimates of the associations should be a determinant in policy making, resource allocation and when prioritizing the services for the public.

The primary focus of this thesis was to estimate associations between occupational /industrial exposures and respiratory health. Airway diseases, respiratory health symptoms and lung function measurements were used as indicators of respiratory health, Occupational categories and industrial sectors were used as indicators of exposure.

1.2 Study Objectives

1.2.1 General Objective

To examine the prevalence and determinants of respiratory health problems among Canadian adolescents and adults by industry and occupation using the data from the Canadian Health Measures Survey (CHMS) Cycle 1 and Cycle 2.

1.2.2 Specific Objectives

1. To determine and compare the prevalence and factors associated with prevalence of respiratory symptoms (cough, cough and phlegm, shortness of breath), by occupation and industry among the Canadian population.

2. To determine variations in lung function parameters by occupation and industry groups among the Canadian population.

3. To determine and compare the prevalence of self-reported asthma, chronic bronchitis, and COPD by occupation and industry groups among the Canadian population

4.To examine whether associations between the occupation and industrial sector and respiratory symptoms, self-reported asthma and lung function identified above are modified by controlling for potential confounders including age, gender, region, ethnicity, education, physical activity, family history of asthma, anthropometry, and smoking.

1.3 Thesis Submitted for the Partial Fulfillment of MSc

This thesis begins with a comprehensive literature review on industries and occupations and their effects on respiratory health in occupational and industrial setting in Chapter 2. This chapter consists of a literature review of what is currently known about industries and occupations, their classifications and their known effects on respiratory health. In Section 2.2, industrial classifications and the evolution of industrial classifications are summarized. Section 2.3 contains the definitions of occupation and it is followed in Section 2.4 by a summary of occupational categories of employment, occupational classification and the evolution of occupational classifications. In addition, a description of the relationship between the National Occupational Classification (NOC) and National Occupational Classification for Statistics (NOC-S) is presented in Section 2.4. Epidemiological studies on the associations between work and respiratory health including respiratory symptoms and between lung functions in Sections 2.5 and 2.6, respectively. The literature review of the methods and materials in Section 2.7 was conducted to identify, comprehend, and examine the different types of methods and materials used in studies examining the objectives similar to those in the thesis. In this section, the literature on measurements of symptoms and asthma, assessment of lung function, definition of employment, industry and occupation, and coding schemes used for epidemiological studies are reviewed. Finally, a summary of the literature review is presented in Section 2.8.

In Chapter 3, methods and materials used in both the CHMS and this thesis research are presented. This includes the CHMS sample design (Section 3.2.1), CHMS sample size (section 3.2.2), and data processing of the CHMS (Sections 3.2.3). The Section 3.3 contains the process of obtaining approval for accessing data at the Research Data Centre, University of Alberta. Section 3.4 explains the study population used in the thesis. The next four sections of the Chapter 3 explain how the data were collected for socio-demographic, respiratory health outcome, smoking, and employment, occupation and industry variables. In the Section 3.9, measurements at the MEC are presented. This includes respiratory health variables, anthropometry measurements and spirometry measurements. Statistical analysis is described in the Section 3.10, which includes a description of variables considered in the thesis, use of weights and bootstrap weights, and a detail description of univariate and multivariate analyses. Chapter 3 ends with a description of the sample size justification for multiple linear and logistics regression analyses.

In Chapter 4, results of the study are presented. In Section 4.1, characteristics of the study population are described under three subheadings. In Sections 4.3 and 4.4, the distribution of respiratory health outcomes and distribution of percent predicted lung function parameters are described among industrial sectors and among occupational categories, respectively. In Sections 4.5 and 4.6, association of asthma and lung function with industry and occupation are described.

Finally, general discussion and the conclusions are presented in Chapter 5. This chapter includes an overview of the thesis research and a summary of the results, comparison of the research findings with other similar studies, discussion of the importance of the research, strengths and limitations of the study and implications for future studies.

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CHAPTER 2

LITERATURE REVIEW

This chapter consists of a review of the literature related to the four specific objectives of the thesis. A review of literature related to occupational and industrial classification was performed mainly using the government databases.

2.1 Employment, Industry and Occupation

Industry and occupation are two distinct variables, which can be cross-tabulated to provide detailed information on employment. However, many occupations are found almost only within one particular industry. For example, mining and automobile assembly occupations occur each within their respective industrial sectors. Although the occupational breakdown resembles in part an industrial breakdown, the variables remain separate and distinct.[1] Industry was used in the development of classification categories for senior management occupations, for occupations unique to primary industry and for occupations in manufacturing, processing and utilities.[1]

2.2 Industry

The Standard Industrial Classification "SIC" is a system for classifying industries by a four-digit code established in the United States in 1937, used by government agencies to classify industry areas. Different versions of Standard Industrial Classifications (SIC) were developed and have been used by Statistics Canada since 1948 when the first Canadian Standard Industrial Classification was developed.[2] The 1948 SIC enabled the different industry descriptions that have been applied to industrial data to analyze different aspects of the economy. It simplified data comparability by providing a framework of common concepts, terminology and groupings of industries. Multiple revisions occurred to the classification from time to time and one of the major revisions occurred in 1980. In 1980, a separate classification of companies and enterprises was formed for the assembling of financial statistics related to enterprises. It was customary to revise the SIC at ten-year intervals; however, by 1990, not all the economic statistics programs of Statistics Canada had implemented the 1980 SIC. As a result, it was decided to postpone the revision and to take into account the statistical needs of the Free Trade Agreement signed in January 1994.[2] The needs were met by developing North American Industrial Classification System (NAICS), an industrial classification common to Canada, Mexico and the United States.[2]

2.2.1 Standard Industrial Classification - Establishments (SIC-E) 1980

The SIC-E is a system for classifying establishments according to their primary activity.[3] It is used to facilitate the collection, tabulation, presentation and analysis of production and related data. As a reference manual, the SIC-E provides a classification structure and a classified index, which includes industry definitions and examples to clarify the content of each industry. Comparison tables between this and the previous SIC as well as an introduction specifying the concepts and definitions underlying the classification were also included.[3] Hierarchical structure consisted of divisions, major groups, minor groups and classes with four-digit code. The SIC-E has currently been replaced by the North American Industry Classification System (NAICS) Canada.[2]

2.2.2 Standard Industrial Classification - Companies and Enterprises (SIC-C) 1980

The Canadian Standard Industrial Classification for Companies and Enterprises (SIC-C) 1980 is a system for classifying companies and enterprises according to the activities in which they are engaged.[3] It is used to facilitate the collection, tabulation, presentation and analysis of financial statistics and related data. As a reference manual, the SIC-C (1980) provides a classification structure and a classified index, which includes the definition of sub-segments and examples to clarify the content of each sub-segment; an alphabetical index; and comparison tables between this classification and the establishment based classification (SIC-C 1980). The hierarchical structure consisted of sectors, subsector segments and sub segments.[3] The SIC-C 1980 has been currently replaced by NAICS Canada.

Changes to national economies all over the world including in Canada continued to impact on classification systems. NAICS was revised in 2002 to achieve increased comparability among the three countries in selected areas and to identify additional industries for new and emerging activities.[2] To that end, the construction sector has been revised and comparability has been achieved, for the most part, at the NAICS industry (five-digit) level. New industries were created for the Internet service providers, web search portals and Internet publishing and broadcasting.[2]

2.2.3 NAICS – Canada 2012

NAICS-Canada 2012 is the agreed upon common framework by the statistical agencies of Canada, Mexico and the United States.[4] Purpose of the framework was to produce comparable data about employment. It is a comprehensive system, which includes all economic activities. It is a hierarchical structure, which is composed of sectors (two-digit code), subsectors (three-digit code), industry groups (four-digit code), and industries (five-digit code). At the highest level, it divides the economy into 20 sectors. At lower levels, it further differentiates the diverse economic activities in which businesses are engaged. The criteria used to group establishments into industries in NAICS are similarity of input structures, labor skills and production processes. The agreed framework of NAICS specifies only the limitations of the twenty sectors. Usually the use of same code across the three countries indicates that the class is comparable, even if the title is not similar because of the differences in the use of the language. Economic activities are described with consideration to the labour, capital, raw material and service inputs associated with a production process that are used to produce goods and services. NAICS Canada-2012 has been designed for statistical purposes.[4] The agreed upon common frame work of NAICS also allowed each country to generate industries below the NAICS level to meet each countries national needs. Canada and the US make sure that they establish the same or comparable national industries where and whenever possible. The nomenclature in NAICS Canada has six-digit codes.[1] First five digits are used to describe the NAICS levels that will be used by all three countries which makes data comparable.[4]

NAICS Canada-2012 classification is intended to categorize according to the production or the supply of goods or services.[4] Establishments are grouped into industries according to similarity in the production processes used to produce goods and services. NAICS Canada -2012 classification ensures that the three countries can generate information on raw materials and productions, industrial performance, output, unit labor costs, employment, and other statistics that reflect structural changes occurring in the three economies.[4] The activity of an establishment can be described in terms of what is produced, namely the type of goods and services produced, or how they are produced, the raw material and service inputs used and the process of production or skills and technology used.[4]

NAICS Canada -2012 has created standard short titles for the twenty industrial sectors to be used in dissemination of data classified in NAICS when space limitations prevent the use of full titles.[4] The short titles of the twenty industrial sectors are given below.[4]

11 Agriculture, Forestry, Fishing & Hunting

21 Mining & Oil & Gas Extraction

22 Utilities

23 Construction

31-33 Manufacturing

41 Wholesale Trade

44-45 Retail Trade

48-49 Transportation and Warehousing

51 Information & Cultural Industries

52 Finance & Insurance

53 Real Estate & Rental & Leasing

54 Professional, Scientific & Technical Services

55 Management of Companies & Enterprises

56 Admin, Support, Waste Management & Remedial Services

61 Educational Services

62 Healthcare & Social Assistance

71 Arts, Entertainment & Recreation

72 Accommodation & Food Services

81 Other Services (exc. Public Administration)

91 Public Administration

2.3 Occupation

In literature, the term "occupation" is defined in more than one way. Two related definitions of occupations are given below.

2.3.1 Occupation- Definition 1

In the first definition, occupation is defined as a collection of jobs, adequately similar in work done and is grouped under a common label for classification purposes. A job, in turn, includes all the tasks carried out by a particular worker to complete his or her duties.[5]

2.3.2 Occupation- Definition 2

In the second definition, occupation denotes to the kind of paid work performed. The kind of work is defined in terms of tasks, duties and responsibilities, often including factors such as materials processed or used, the industrial processes used, the equipment used, and the products or services provided. Occupations are generally homogeneous with respect to skill type and/or skill level.[6]

The International Standard Classification of Occupation (ISCO) is one of the main international occupational classifications.[7] It can be used to classify and aggregate occupational data, collected by means of statistical census and surveys as well as through administrative records. This tool is based on the second definition and organizes jobs clearly into groups according to the tasks and duties pertaining to the job. One of the main aims of this classification is to provide the basis for the international exchange and comparison of data pertaining to occupations.[7]

ISCO has recently been updated to take into account the new developments in the world of work since 1988. The updated classification was adopted in December 2007 and is known as ISCO-08. Many countries are now updating their national classifications based on ISCO-08.[7]

2.4 Canadian Occupational Classifications

2.4.1 National Occupational Classification (NOC)

The NOC-S 2001 which is used in the two Canadian Health Measures Surveys (CHMS: Cycle 1 and Cycle 2) is based on the revised National Occupational Classification published by Human Resources Development Canada.[8] The NOC-S 2001 is a statistical classification designed by the Statistics Canada to classify data on occupations from the Census of Population and other Surveys conducted by the Statistics Canada. Although NOC-S 2001 is based on the National Occupational Classification, the aggregation structure is different between the two classifications because of the special requirements of a statistical classification in NOC-S 2001.[8]

2.4.2 Relationship between the NOC-S 2001 and NOC 2001

There are relative differences between the NOC 2001 and NOC-S 2001at the major group level. For the use of NOC-S 2001 as a statistical classification, the population distribution is a significant factor to determine the level of aggregation in the classification structure.[8] The population of a class determines the volume of cross-classification and geographic detail possible as well as the appropriateness of the class for surveys with a smaller sample. Major groups of NOC-S 2001 were planned to have a population distribution that was as even as possible with a population minimum that was sufficient to be used by the Census of Population for increased geographical detail and for cross classifications; and also to be suitable as detailed classes for the Labor Force Survey.[8] In NOC-S, some of the minor groups were re-aggregated. In NOC-S 2001, there are 47 major groups whereas in NOC, there are only 26 major groups.[8] The minor groups and broad occupational categories of the NOC-S are very similar to those of the NOC, except to the extent of the variations created by the differences in the treatment of the military. The major group level of the NOC-S 2001 structure represents an alternate statistical aggregation of the NOC 2001 and consists of 47 major groups based on skill type. It is important to note that the NOC 2001 and NOC-S 2001 are identical at the unit group and minor group levels. Since there are only twenty-six major groups in the NOC, the choice of skill level results in a certain loss of occupational detail.[8]

There is a two-part numbering system in statistic Canada publications to link the statistical aggregation to the NOC 2001 codes.[8] The first part of the numbering system indicates that the placement of the minor and unit groups within the NOC-S 2001 aggregation structure, and the second part of the numbering system, following a decimal point, represents the NOC 2001 code. This two-part numbering system allows users to relate data produced by Statistics Canada to the minor and unit groups of the NOC 2001. The NOC 2001 and the NOC-S 2001 represent one classification framework for measuring economic activity in the Canadian labor market and for providing information about the work of Canadians.[8]

2.5 Respiratory Health, Occupation and Industry

Chronic respiratory diseases are long term diseases that affects lungs causes breathing problems and includes asthma, chronic obstructive pulmonary disease (COPD), bronchitis lung cancer, cystic fibrosis, sleep apnea and occupational lung diseases are some of the chronic lung diseases. Respiratory diseases affect newborns to the old ages. All of the respiratory diseases have a major impact not only on the affected person, but also on the family, the society and the health care system.

Among many risk factors, the two most important risk factors are smoking (through personal smoking and exposure to second-hand smoke) and the air quality which includes both indoor and outdoor air quality.[9] Smoking increases the risk of asthma, COPD and lung cancer among smokers and worsens the symptoms among persons with asthma or COPD. Exposure to second-hand smoke also affects all Canadians causing cancer in adult non-smokers.[9] It has also shown that it affects sudden infant death syndrome in newborns. It is common that smoking worsens the symptoms of those with asthma or COPD.[9]

2.5.1 Respiratory Health and Occupation

There has been considerable research on the effect of work on respiratory health. A study carried out to estimate the prevalence of asthma in workers by occupation in Washington State, USA used the 2006-2009 Behavioral Risk Factor Surveillance System (BRFSS) and the BRFSS Asthma Call-Back Survey (ACBS) and reported that among 41,935 respondents who were employed during 2006-2009, the overall prevalence of current asthma, was 8.1% [95% CI: 7.8%, 8.5%].[10] In comparison to the reference group of executive, administration and managerial occupations, three occupational groups had significantly higher prevalence of current asthma: teachers, all levels, and counselors (prevalence ratio (PR) =1.3, 95% CI:1.1,1.6%); administrative support, including clerical (PR = 1. 5, 95% CI: 1.2,1.9%); and other Health Services (PR = 1.5, 95% CI: 1.2,1.9).[10]

The prevalence of asthma was examined by industry and occupation in another study conducted in the USA using the data from the two cycles (2001-2002 and 2003-2004) of the National Health and Nutrition Examination Survey (NHANES).[11] In this study, the definition of asthma was based on the self-report of physician diagnosed asthma. The two questions used to collect this information were "Has a doctor or other health professional ever told you that you have asthma and “Do you still have asthma?’’ Among occupational groups in the working population in USA, highest prevalence of current asthma was seen in teachers (13.1%) and health-related occupations (12. 6%) and followed by those employed in agriculture, forestry, and fishing occupations (1.8%) with freight, stock, and material handlers (1.0%) having the lowest prevalence of current asthma. This study further concluded that in comparison to the construction occupation odds ratios of current asthma adjusted for gender, BMI and poverty income ratio (PIR) were higher in adults working in management-related and clerical occupations (adjusted odds ratio (aOR) =1.8, 95% CI: 0.8,4.1); engineers and scientists (aOR 1.9, 95% CI: 0.8,4.6); those in health-related occupations (aOR = 2.4, 95% CI: 0.9,6.5); and teaching occupations (aOR = 2.6, 95% CI: 0.8,9.0); however, these difference were not statistically significant. Substantially lower odds ratios were observed for those employed in agriculture, forestry, and fishing occupations (aOR = 0.01, 95% CI: 0.0,0.6) compared to those in the construction trades. In this study, as age and smoking history were not found to be confounders, they were not included in the final regression models.[11]

A third study conducted in the USA examined the prevalence of life time asthma (ever asthma) and current asthma based on asthma attacks among working adults using the NHANES annual survey data for currently working adults aged ≥ 18 years during 1997–2004 period.[12] Asthma definition used for this study was asthma diagnosis by a physician or other health professional. The information on lifetime asthma and current asthma were based on the self-report to the questions: “Has a doctor or other health professional ever told you that you had asthma?” and “During the past 12 months, have you had an episode of asthma or an asthma attack?”, respectively.[12] Authors concluded that the estimated prevalence of lifetime asthma among the workers was 9.2%. The prevalence of current asthma among workers with lifetime asthma was

35.4%. The highest prevalence of lifetime asthma was observed in the social services religious and membership organizations industry (11.2%) and the health service occupation (10.9%). The highest prevalence of current asthma was observed in the primary metal industry (47.1%) and the health assessment and treating occupation (44.7%). In this study, the prevalence of current asthma among never smokers with asthma was approximately 50% in the furniture, lumber and wood and primary metal industries and the architects and surveyors and health assessment and treating occupations. Prevalence odds ratios (PROs) were estimated using multivariate logistic regression for asthma attacks (current asthma). The reference group used was the insurance, real estate and other finance for industry, and the secretaries, stenographers, and typists, and other administrative support for occupations. Reference group was selected based on the assumption that workers in these industries and occupations have minimal risk for asthma.[12]

After adjusting for age, gender, race or ethnicity, and smoking status, in comparison to the occupational group comprised of insurance, real estate and other finance for industry, and the secretaries, stenographers, and typists, and other administrative support, primary metal industry had the highest estimated prevalence odds ratio of current asthma (OR: 2.19; 95% CI 1.1-4.5) among all the industry groups.

In the fourth study from USA, conducted in 21 states, data from the 2013 Behavioral Risk Factor Surveillance System (BRFSS) industry and occupation module was considered.[13] In this study, industry-specific and occupation-specific prevalence of current asthma was examined by state among participants aged ≥18 years who were employed or had been out of work for <12 months at the time of the survey interview.[13] Based on the Asthma call back survey in the BRFSS, the prevalence of current asthma among adults, employed at any time in the 12 months preceding the interview was 7.7%. Interestingly, industry and occupation specific prevalence of current asthma varied between states. Current asthma prevalence was highest among workers in the information industry (18.0%) in Massachusetts and in health care support occupations (21.5%) in Michigan.[13]

This study reported that there were five industries that had the highest current asthma prevalence. Among those five, health care and social assistance was identified in 20 of the 21 states, retail trade in 16 states, and education in 14 states. Among the five occupations with the highest current asthma prevalence, office and administrative support was identified in 16 of the 21 states, health care practitioners and technical in 15 states, and sales and related in 13 states.[13]

A nested case-control study in China among women aged 40 to 70 years was conducted in China to determine the risk of asthma among different occupations.[14] Asthma history was obtained from a self-report of having ever been diagnosed with asthma by a physician. Occupation and industry were coded according to the Chinese National Standard Occupation and Industry Codes Manual (1986).[14] In this study, with no industrial or occupational exposure as the reference group, after adjusting for smoking, education, family income, and concurrent chronic bronchitis, risk of asthma was significantly elevated in occupations as farm workers and helpers (OR= 4.0; 1.2,13.0), laboratory technicians and analyzers (OR= 2.2; 1.2, 3.9), installation and maintenance workers for weaving and knitting machines (OR = 2.4; 1.1, 5.4) , electricians (OR =2.1; 1.1, 4.1), performers (OR =3.2; 1.4, 7.4), administrative workers in organizations and enterprisers (OR =1.8; 1.1,2.8), and postal and telecommunication workers (OR=3.5; 1.6, 7.6).[14]

A study conducted in India, Agrawal et al. examined the associations of high risk occupations with self-reported asthma among adult men and women in India concluded that the overall estimated prevalence of asthma among the working population was 1.9%.[15] This study used the data from India's third National Family Health Survey, 2005-2006.[15] After adjusting for age, education, household wealth index, current tobacco smoking, cooking fuel use, rural/urban residence and access to healthcare, men in the plant and machine operators and assemblers' major occupation category had the highest odds ratios for asthma (OR= 1.67; 95% CI: 1.14,2.45; p = 0.009) in comparison to the low-risk occupations comprised of professional, clerical or administrative jobs. For occupational subcategories, men working in machine operators and assemblers (OR=1.85; 95% CI: 1.24,2.76; p = 0.002) and in mining, and in construction, manufacturing and transport (OR=1.33; 95% CI: 1.00,1.77; p = 0.051) were at the highest risk of asthma. Men in extraction and building trades workers had reduced odds of asthma (OR=0.72, 95% CI: 0.53,0.97; p = 0.029). For women, none of the occupation categories or subcategories was found to have a significantly increased risk of asthma.

A 5-year prospective cohort study of female hair dressers conducted in Palestine examined the changes in self-reported respiratory symptoms and declining of lung functions over 5 years and concluded that hair dressing was associated with both self-reported respiratory symptoms and significant decline in lung functions after adjusting for age, height and BMI.[16] Annual decline in forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) in current hair dressers was 35ml/year (95% CI: 26, 44ml) and 31ml /year (95% CI: 25, 36ml), respectively.

In a study conducted in Beijing China, the association of occupational exposures to dusts, and gases/fumes with the chronic respiratory symptoms and level of pulmonary function was determined using data from a random sample of 3,606 adults of 40 to 69 years of age.[17] The prevalence of occupational dust exposure was 32%, and gas or fume exposure was 19% in the random sample. After adjusting for age, sex, area of residence, smoking status, coal stove heating, and education, the prevalence of chronic phlegm and breathlessness were significantly related to both types of exposures. In this study the occupational groups considered were not reported. Odds ratio of chronic cough and occupational dust exposure was 1.30 (95% CI:

1.09,1.48) and of persistent wheeze and occupational fume exposure was 1.27 (95% CI: 1.09,1.48). Chronic bronchitis and breathlessness were significantly associated with both exposures.

In a cross-sectional survey conducted in Ukraine among a random sample of working and former miners, authors concluded that the prevalence of respiratory symptoms was higher among former coal miners compared to current coal miners.[18] The prevalence of shortness of breath was 35.6% in former coal miners whereas it was 5.1% in current coal miners. Similarly, chronic bronchitis was 18.1% in former miners and 13.9% in current coal miners. In this health study, demographic, work, and health information were collected using a standardized questionnaire.

2.5.2 Respiratory Health and Industry

A study examining the prevalence of asthma categorized by industry and occupation in USA reported a wide range of prevalence among the industry groups (1.7% to17%).[11] The Estimated prevalence of asthma in workers in mining was the highest (17%) and followed by health related industries (12.5%). Among persons working in paper manufacturing, the prevalence of asthma was 3.3% repair services 3.0%, textile manufacturing (2.1%). Agriculture, forestry, and fishing (1.7%) displayed the lowest estimated prevalence.[11] In this study, after adjusting for gender, BMI, and PIR (poverty income ratio), employees in the mining (adjusted OR (aOR): 5.2, 95%CI: 1.1, 24.2) or health-related (aOR: 2.3, 95% CI: 1.1, 4.8) industries were associated with an increased odds of current asthma. Significantly lower odds of asthma (aOR=0.1, 95% CI: 0.0, 0.7) was observed among those employed in agriculture, forestry, and fishing compared to those employed in construction.

In a nested case-control study in China among women aged 40 -70 years, a significant excess risk of asthma was observed for manufacturing of metal tools (OR=2.4; 95% CI: 1.3, 4.7), metal household products (OR=1.6, 95% CI: 1.2, 2.4), ships (OR =2.6, 95%: CI: 1.0, 6.8), and clocks/watches/timing instruments (OR =1.9, 95% CI: 1.0, 3.4), as well as telecommunication services (OR =3.6 1.6, 7.6).[14]

A population based surveillance scheme of asthma among workers in British Columbia reported that age-adjusted active asthma rates per 1000 workers among males was 31.9 in the workers in utilities, 30.2 in transport/warehousing workers, 30.2 in wood and paper manufacturing, 30.8 in sawmill workers , 29.8% in health care and social assistance workers and 28.1 in workers in educational services which were significantly higher than the overall rate in the male working population (26.5).[19] Females were found to be at a higher risk of asthma in waste management /remediation (47.3 per 1000) and healthcare/social assistance industries (45.6 per 1000) than the overall rate for the female working population (40.6 per 1000).

A Norwegian study concluded that “manual” occupations had the strongest evidence for an association with respiratory symptoms.[20] Manual groups included agriculture/fishery and craft/related trade workers. After adjusting for age, gender, area of residence and smoking habits, significant associations were observed with wheezing (adjusted OR=1.2; 95% CI: 1.0, 1.5; $p<0.05$), wheezing without cold (adjusted OR=1.3; 95% CI: 1.1, 1.6; $p<0.05$) and asthma. (adjusted OR=1.61; 95% CI: 1.0, 2.5; $p<0.05$) However, the study concluded that these estimates could partly be attributed to specific socioeconomic factors that needed to be further investigated.[20]

The data from the Atherosclerosis Risk in Communities Study (ARIC) from USA were used to estimate at the association of current or most recent occupation of employment and self-reported and objective measures of respiratory health in a large population based cohort of adult men and women.[21] Associations were estimated for self-reported chronic cough, chronic bronchitis, wheeze, asthma and for measures of pulmonary functions. Selected occupations including construction and extractive trades had higher prevalence of wheeze and airway obstruction compared to the individuals in managerial and administrative jobs. Generally, 3% of participants reported having asthma at the time of the study. Among the respondents, 10% stated having chronic cough, and 11% reported wheeze. Based on FVC maneuvers of 6 seconds or longer, 9% of 14,497 participants were classified having airway obstruction. Adjusted prevalence rates (PRs) for respiratory outcomes were comparatively higher compared to the comparison population (managerial and administrative support occupations), and the differences were statistically significant in technical and sales occupations, service occupations, precision occupations and machine operating occupations.[21] Technical and sales occupations included health technology, sales and other technical and sales occupations. Service occupations included private hospital occupations, protective services, food preparation and services, health services, cleaning and building services and other service occupations. Precision occupations were mechanics and repairers, construction and extractive trades and other precision occupations. The adjusted prevalence rates of asthma were greater in food preparation and service occupations in comparison to the referent group (managerial and administrative support) (PR=1.96; 95% CI: 1.27, 3.01). The occupational category of mechanics and repairers also had a higher prevalence rate for asthma (PR=1.83; 95% CI: 1.17, 2.85). In this study, chronic bronchitis higher prevalence rates were observed in cleaning and building service occupations (PR =1.60; 95% CI

1.06, 2.40) and in all precision occupation groups including mechanics and repairers (PR:1.75; 95% CI 1.21, 2.53).[21] A higher prevalence rates was also observed in construction and extractive trades (PR: 1.91, 95% CI: 1.34, 2.72), and these are two relatively large occupational categories in the ARIC study population.[21] An elevated prevalence (13%) of chronic cough was observed in motor vehicle operation. In contrast, the prevalence rate of chronic bronchitis (PR=1.36, 95% CI:0.89, 2.07) was not that high in the same occupational category despite the fact that chronic cough was a component of chronic bronchitis.[21] In protective services, an elevated prevalence (PR=1.44; 95% CI: 1.00, 2.06) of wheezing was estimated. The highest prevalence of wheeze (17%) was reported in hand working occupations where PR was 1.52 (95% CI: 1.11, 2.08).[21]

In this study, among men it was concluded that there were no statistically significant associations between occupation and FEV_1.[21] However, there were observations of symptom related associations among men. Health technology and homemakers occupations showed associations with lower adjusted mean FEV_1 in women. After categorizing the participants with $FEV_1 < LLN$ (lower limit of normal) and $FEV_1/FVC < LLN$ as having airway obstruction, authors concluded that after adjusting for age, history of asthma, pack/years, race, sex, smoking status, and study centre, the prevalence rate for airway obstruction was elevated in private household occupations (PR=1.40; 95% CI:1.40, 1.86) and in the construction and extractive trades (PR=1.32; 95% CI:1.32, 1.65).[21]

In another population-based study conducted in 26 industrialized areas in 12 European countries, asthma was defined using the results from methacholine challenge test and using questionnaire data on respiratory symptoms and use of medication, respectively.[22] The associations varied depending on the way how asthma was defined. When it was defined using both bronchial hyper responsiveness and reported asthma symptoms or use of asthma medication, the highest risk was shown for farmers (OR =2·62; 95% CI: 1·29, 5·35), painters (OR=2·34; CI: 1·04, 5·28], plastic workers (OR=2·20; CI: 0·59, 8·29), cleaners (OR=1·97; CI: 1·33, 2·92), spray painters (OR:1·96; CI: 0·72, 5·34), and agricultural workers (OR=1·79; CI:1·02, 3·16). Similar risks were observed when asthma was defined reported asthma symptoms or medication use based on questionnaire data.[22] For occupations with high exposure to biological dusts, mineral dusts, and gases and fumes a significant excess of risk of asthma was shown for metalworkers (furnace operators, smiths, moulders, die casters, electroplaters, sheet-metal workers, galvanisers, others) and housewives. Cleaners had an excess risk of asthma in 11 of 12 countries. The proportion of asthma among young adults attributed to occupation was 5%-10%.[22]

In a study conducted in Beijing, China, dust exposure was a significant predictor for FEV_1, FEV_1/FVC, $FEF_{25\% - 75\%}$, and peak expiratory flow rate (PEFR).[17] There was also a significant decrease for FEV_1 and FVC with increased gas/fume exposure levels. Both current and former smokers appeared to be more susceptible to the effect of dusts than the never smokers.

A study conducted at the Beninese Company of Textile in Benin, Nigeria to evaluate the respiratory disorders among the textile workers exposed to cotton dust.[23] In this study, pulmonary function tests were performed in accordance with the American Thoracic Society (ATS)/European Respiratory Society guidelines. The factory had two sections; administrative and technical. Technical section comprised of spinning, weaving and the general service department. Workers having at least 2 years of work experience in the production chain were defined as the exposed population. The workers in the general administration and the workers in the informal sector located in the adjacent area of the factory having 2-year experience were defined as unexposed. Data on respiratory health were collected using an interviewer-administered questionnaire based on the International Commission on Occupational Health

(ICOH) questionnaire. This study concluded that there were statistically significant differences in prevalence of respiratory symptoms between those exposed and those non-exposed. Among the exposed, 16.8 % had cough whereas only 2.9 % of non-exposed had cough. The prevalence of asthma and chronic bronchitis was 1.5 % and 3.4 % among the exposed workers in comparison to 0% and 0.9 %, respectively in the unexposed workers. This study showed that there was a decrease in FEV_1 in the exposed individuals than in non-exposed individuals.[2]

2.6 Lung Function and Occupation and Industry

In a study of white adults in Australia examined the factors that affect normal lung function in white Australian adults concluded that the presence of airway hyper responsiveness (AHR), measured by histamine test, caused a mean reduction of FVC by 0.1 L and FEV_1 by 0.2 L.[24] Information on respiratory symptoms, current and past asthma, use of asthma medication, hospital and physician attendances, family history of asthma were collected. In addition, information about occupation and current smoking were also collected. All respondents were divided into five categories of occupations: professional, clerical (white collar), skilled (blue collar), unskilled, and unemployed. AHR was measured by histamine inhalation test. Participants with asthma-related symptoms had a mean reduction in FVC of 0.1 L (for both genders), and in FEV_1 of 0.08 L for women and 0.2 L for men. The effects of respiratory symptoms, asthma, AHR and occupation were estimated through regression models and the author concluded that neither history of past asthma or occupation had any significant effect on FVC, FEV_1, PEFR, or $FEF_{25\%-75\%}$ after adjusting for the effects of AHR, respiratory symptoms, and current smoking.

A study conducted in central Karnataka, India, on 25 female street sweepers and 25 healthy female control subjects who were comparable in age, height and weight concluded that acute inhalation of dust acutely affected the lung function of street sweepers and the sweepers were at a risk of developing occupation related lung function impairment.[25] This study reported that the workers worked for 4-5 hours per day and six days per week without using any personal protective equipment.

The Pollution Atmospherique et Affections Respiratoires Chroniques (PAARC) survey examined whether occupational exposures to dusts, gases, or chemical fumes, or to specific hazards estimated by job exposure matrices, were related to a decrease in forced expiratory volume in one second (FEV_1).[26] In this study, 23% of the men and 19% of the women reported an exposure to dusts, gases, or chemical fumes in their current job. Exposure to each hazard group was closely related between both sexes. Job exposure matrices showed a definite exposure response association between the level of exposure to dusts, gases and electrical fumes and a decrease in mean FEV_1.

In a study conducted on 7840 graduates from hairdressing vocational schools in Denmark to examine the prevalence of asthma and respiratory symptoms among hairdressers.[27] Hairdressers with and without asthma reported similar smoking pattern. Local exhaust ventilation was used consistently only by 63.8% of the hairdressers engaged in permanent waving and hair coloring procedures at the workplace. In this study, asthma prevalence was reported to be 11.2% and 25.3% of the hairdressers reported having cough. The prevalence of reported nasal congestion was 24.0%. The prevalence for reported rhinitis was 18.2%. Less than one third of all hairdressers with suspected occupational asthma reported their asthma as an occupational disease.

A study was conducted in the cotton industry in Pakistan to evaluate the respiratory symptoms among cotton workers.[28] In the cotton industry in Pakistan, there was a broader variety of different types of plants ranging from small weaving to large spinning and compact units. The Evaluated respiratory symptoms evaluated in the study included fever, shortness of breath, chest tightness and cough.[28] The authors concluded that the prevalence symptoms varied between areas of the work place. There was a 12.5 % ($p<0.001$) prevalence of fever, 17.5 % ($p<0.001$) prevalence of shortness of breath, 31.2 % ($p<0.001$) prevalence of chest tightness 31.3% ($p<0.001$) prevalence of dry cough, and 8.8% $p<0.001$ prevalence of mucous cough in the spinning section. Prevalence of each symptom differed between areas of the work place. The highest symptom frequency was seen in weaving factories, especially those of small and medium size. The prevalence of shortness of breath was the highest in small weaving plants (28.7%) in comparison to the other plants. Similarly, the prevalence of chest tightness was also the highest in the small weaving plants (48.1%) compared to medium weaving (36.8%), big weaving (32.7%), spinning (31.7%) and compact plants (10.7%). It is interesting that the prevalence of symptoms differed depending on whether it was a small, medium or a big plant after adjusting to confounders including age and smoking. Authors speculated that the observed differences in the symptoms between the plants might be due to many factors such as availability of PPE, roster policies, hygiene practices, availability of the medical and health facilities, and differences in the working environments.

A study conducted in two cement factories in Ethiopia reported that production workers had a significantly higher prevalence of shortness of breath ($p < 0.005$) and chest tightness ($p < 0.008$) compared to the controls in the cement industry.[29] The workers (security workers) who were considered that the exposure was low served as the controls for the study. The cleaners had significantly higher prevalence than production workers of cough ($p<0.001$) and shortness of breath ($p = 0.012$) than controls. When the data for cleaning and production workers were merged, the prevalence of all chronic respiratory symptoms among this group (exposed) was significantly higher than among the controls.

2.7 Review of Measurements: Outcomes and Exposures and materials

In this section, different methods used in measuring the respiratory outcomes and exposures associated with the outcomes (independent and confounding variables) are reviewed. Some of the methods are discussed in the following section.

2.7.1 Measurements of Respiratory Symptoms and Asthma

In a study examining the prevalence of lifetime asthma and current asthma working adults in USA using the 1997-2004 national health interview survey data, prevalence of lifetime asthma and current asthma were estimated based on the information gathered from the following questions in the 1997-2004 national health interview survey data: “Has a doctor or other health professional ever told you that you had asthma?” (lifetime asthma), and “During the past 12 months, have you had an episode of asthma or an asthma attack?” (current asthma). In this survey, participants completed an interviewer- assisted health questionnaire.[12]

In the Behavioral Risk Factor Surveillance System (BRFSS) conducted in 2013, which collected data from participants aged ≥18 years in 21 states in the U.S., current asthma was defined based on an affirmative response to the following questions from participants aged ≥18 years. “Has a doctor, nurse, or other health professional ever told you that you had asthma?” and “Do you still have asthma?”.[13]

In the Palestine hairdressers 5-year prospective cohort study, the questionnaire used to collect information was a modified version of a standardized questionnaire on respiratory symptoms from the American Thoracic Society.[16] Respiratory symptoms collected included chest tightness, shortness of breath, wheezing, cough and phlegm during the past 12 months. This study also assessed the physician-diagnosed respondent reported asthma.

In the population based surveillance of asthma in British Columbia using a linked health database examined the association between asthma and “at risk” exposure based on industry of employment.[19] In this study, asthma cases were identified by the presence of an asthma diagnosis ICD-9 code 493 in the health records. One of the following criteria was used to identify the cases of asthma: a hospitalization for asthma, two asthma-related physician visits in a 12-month period, one asthma-related worker’s compensation claim, or two prescriptions for any asthma-related drugs and at least one asthma-related physician visit within a 12-month period.

In the study of textile worker’s in Benin, Nigeria, the respiratory symptoms were determined using a questionnaire based on the International Commission on Occupational Health (ICOH) questionnaire.[23] This study was conducted among textile workers exposed to cotton dusts. The respiratory symptom part of the questionnaire included questions about the respiratory symptoms such as cough, phlegm, chest tightness, wheeze and breathlessness. Chronic bronchitis was diagnosed in accordance with the following definition from the British Medical Research Council: “A cough that occurs every day with sputum production that lasts for at least 3 months in two consecutive years.” The persons with chronic sufficient cough to meet this definition but without phlegm were diagnosed as having a chronic dry cough. In contrary to many other studies these respiratory illnesses were not based on the self-report of a physician-diagnosed illnesses. Rather, researchers collected symptom data and they themselves arrived at the diagnosis for the purpose of the study.

In a population-based case-control study conducted for the general population sample in North Italy study, which consisted of 417 participants who were exposed to dusts chemicals, or gases and 1,218 controlled participants who reported no exposure, a standardized interviewer administered questionnaire was developed as a modified Italian version of the standardized National Heart and Lung Institute (NHLI) questionnaire.[30] This questionnaire included questions about respiratory symptoms and respiratory diseases and risk factors for respiratory illnesses.

Incidence of asthma and its determinants among adults in Spain was determined in a follow up study of the subjects who participated in the 1998-1999 European Community Respiratory Health Survey (ECRHS), which was conducted in 1998-1999. The follow- up included 1640 subjects aged 20-44 years from selected study areas. They were asked to complete a short screening questionnaire on respiratory symptoms.[31] In this study two definitions of asthma were used. Asthma was assessed by methacoline challenge test and by questionnaire data on respiratory symptoms and use of medication. For the symptom- based definition, asthma was defined as an attack of asthma during the past 12 months, or having been woken by an attack of shortness of breath during the past 12 months, or current use of asthma medication. For the definition of asthma based on methacholine challenge test, bronchial responsiveness was defined as a 20% fall in FEV_1 during methacholine challenge with an estimated cumulative dose of 8µmol of methacholine.

In the study of lung function reduction and chronic respiratory symptoms among workers in the cement industry, used a modified version of the British Medical Research Council (BMRC) questionnaire was used for recoding of the chronic respiratory symptoms.[29] The questionnaire had three parts, which included personal and work characteristics, smoking habits and chronic respiratory health symptoms. [29] The questions on personal and work characteristics included age, educational level, employment history, previous illness, years worked in the cement factory and years worked in dusty industries elsewhere.

2.7.2 Assessment of Lung Function

In the Palestine female hairdressers cohort study, the lung function testing was performed by all participants using a PC based spirometer and a disposable mouthpiece filter and nose clip during the test. American Thoracic Society/European Respiratory Standards guidelines were followed for spirometry.[16]

In the study conducted among textile workers at a textile company in the Northern parts of Benin, pulmonary function testing was performed before and after the shift with a dry spirometer (Vitalograph, Buckingham, UK).[23] Prior to the work shift forced expiratory volume in one second (FEV_1) and forced expiratory capacity (FVC) of each worker were recorded in accordance with the American Thoracic Society (ATS) guidelines. After two hours of rest at the end of the shift, the test was repeated. Out of the three maximum tests before and after the work shift, only the best test was used for analysis. Sex, age, race and weight were taken into the estimation of the FEV_1 predictive value using standard equations. The pre-shift and post-shift values in FEV_1 were used to calculate the percentage change during the day.

In the study of respiratory effects of occupational exposure in a general population sample in North Italy, Flow-volume curves, diffusing capacity of carbon monoxide, and slope of alveolar plateau of nitrogen were spirometry was performed on a variable different proportions of subjects.[30]

In the Atherosclerosis Risk in Communities Study (ARIC) which was conducted to assess the etiology of atherosclerosis and its clinical consequences included 15,792 men and women aged 45 to 64 years in 4 U.S. communities.[21] In this prospective cohort study, the baseline examination (Visit 1) was conducted in 1987- 1989. The information collected included the health history, current health status, and other social, demographic, and behavioral factors. The social and behavioral factors included the current and the most recent job held by the respondent. The baseline clinical examination conducted at Visit 1 also included spirometry, which was conducted using Collins Survey II spirometers.[21] The spirometry testing was standardized across the four field centers in the four U.S. communities. Quality control measures of the pulmonary function testing were coordinated by a single pulmonary function reading center. For each respondent, race and sex specific equations were used to estimate the lower limits of the normal (LLN) distributions of FEV_1 and FEV_1 /FVC ratio. The respondents with $FEV_1 <$ LLN and FEV_1/FVC LLN < were categorized as having airway obstruction.

In the incidence of asthma and its determinants among adults in Spain in addition to the data collected during ECRHS, the participants in the second phase were asked to complete a second detailed questionnaire, which included information on smoking, occupation, housing, and the use of medical care.[31] A forced spirometric test and a methacholine challenge test of bronchial reactivity were performed and the details of spirometry was not found in this article.

In street sweepers study, lung function testing was performed using a computerized RMS medspirior spirometer.[25] It was equipped with a software which can predict the values of test on the basis of sex, age, height and weight. The spirometry was performed before and after sweeping. A short time was given to the subjects to get adapted to the spirometer. A trial test was performed before the actual pulmonary function testing.

The maneouver of spirometry test was explained to the subjects and the tests were conducted while subjects were sitting comfortably on stools after the maneouver of test was explained to the subjects. A trial test was performed before the actual pulmonary function testing. Each test was repeated three times, with an interval of five minutes between the tests and the best of three readings was taken.

2.7.3 Definition of Employment, Industry and Occupation

In the study examining prevalence of asthma by industry and occupation among working populations in the USA, working population study, currently employed adults included in the study were those who reported as they were working at a job or business or they have a job or business but not at work at the time of survey.[12] It also included the respondents who reported that they were working but not for pay. Respondents who were involved in business at the time of survey and as well as a week prior to their interview were also considered as currently working. Information was obtained from each respondent regarding his or her industry and occupation of employment, asking open-ended questions. The information collected through open-ended questions was subsequently recoded into two two-digit industry or occupation groups (41 industry and 43 occupation groupings), that were consistent with the classification systems. The data source for this study was the NHANES which is an annual survey conducted since 1957 in the U.S.

In the study titled, "asthma among employed adults by industry and occupation", collected information on the industry and occupation of respondents employed at the time of the survey or had been out of work for <12 months preceding the interview for their current or most recent job.[13] Data from the 2006–2007 adult Behavioral Risk Factor Surveillance System (BRFSS) Asthma Call-back Survey (ACBS) were used in this study. In the same study, participants who, at the time of the interview, indicated that they were employed for wages, out of work for <1 year, or self-employed in the 12 months before the interview, were considered currently employed. To collect information for occupation and industry, the industry and occupation module (http://www.cdc.gov/brfss/questionnaires/index.htm.) was administered in 19 U.S. states.[13] In two additional states Washington and Wyoming used state added extra questions in the survey to collect data for industry and occupation.

In the population based cohort study conducted among Chinese women to evaluate occupation and adult onset asthma, unlike in other studies reviewed under this chapter, collected the life time work history for all jobs lasted more than 12 months for all the respondents .[14] The availability of a lifetime work history provided a unique opportunity to examine the relationships between occupational factors and occurrence of asthma among adult women in the Chinese population. Work history included name of work place, job title, main duties and products, year the job started, and the year the job ended.

In the study of respiratory effects of occupational exposure in a general population sample in North Italy a detailed information on type and duration of jobs and specific exposures to dusts and chemicals were also considered to classify the occupation to estimate the association of occupation and respiratory effects.[30]

In Occupation and the prevalence of respiratory health symptoms and conditions: The Atherosclerosis Risk in Communities study, used the responses about current employment status to identify a population of homemakers.[21] For the remaining participants, the occupation was identified after evaluating the responses to series of questions about the current employment status and the current or most recent occupation.

In the study conducted in Spain, occupation was defined by job-titles. Participants were classified by current occupation or, for those who had changed occupation for health reasons, their occupation at the time when respiratory problems occurred. The European Community socioeconomic status classification was used to code reported occupations. In total, 350 occupational categories were aggregated into 30 sets, each of which covered all possible codes for similar occupations.[31]

In the PAARC survey conducted to test whether occupational exposures to dusts, gases, or chemical fumes or to specific hazards were related to a decrease in forced expiratory volume in one second (FEV_1), the exposures were measured by an interviewer administered questionnaire.[26] Subjects were interviewed and information on exposure and occupations was obtained. The occupational exposure in their most recent occupation was coded using the 1968 INSEE (National Institute of Statistics and Economics Studies) four-digit classification developed by the National Institute of Statistics and Economics Studies and about exposure. Information was also obtained about for previous jobs. Two external job exposure matrices, a British one with occupation coded by the British classification, and other an Italian one based on the International Labor Office (ILO) classification were used for the analysis of the lung function by occupation and by industries.[26]

2.7.4 Coding Schemes for Industry and Occupation

In the study of asthma among employed adults, by industry and occupation in -21 states, 2013 BRFSS, the information on respondent's industry/occupation of employment were coded by CDC coders based on the 2002 North American Industry Classification System and the 2000 Standard Occupational Classification System, respectively.[13] In the statistical analysis, the study used 21 industry categories and 23 occupational categories.

In the population based cohort study conducted among Chinese women to evaluate occupation and adult onset asthma, each occupation and industry was coded according to the Chinese National Standard Occupation and Industry Codes Manual (1986).[14]

In the cross-sectional study conducted in Norway which evaluated the association of asthma related symptoms with occupational groups assigned occupational codes using 1988 International Standard of Classification of Occupation (ISCO-88).[20]

In the ARIC study, the occupations were assigned a three-digit code using 1980 census occupation codes.[21] Coding was performed centrally at the ARIC Coordinating Center. Next the occupation codes were grouped into major categories of occupations using categories published by the 1980 Census of Population and Housing. Within each major category, occupational groups that included <1% of the study population (n<152) were classified into groupings of other occupations (e.g., other technical and sales occupations, other service occupations, other precision occupations).

2.7.5 Summary of the Literature Review

This literature review was conducted with an intention to explore how the studies in relation to the general and the specific objectives of this thesis were planned and conducted and understand the current status of research. The focus of the review was mainly on studies examining the association between respiratory health of workers in different occupational ad industrial classifications and on how occupational and industrial exposures, respiratory health outcomes and related factors were measured. Literature review was extended to review different occupational and industrial classifications, how employment was defined and to examine what other factors were taken in to consideration in similar studies. As the literature review was limited by time and resource, this review may have not covered all available methods and materials of similar studies. However, this review presented that there are similarities as well as differences in; how occupational and industrial exposures were measured, how the respiratory health outcomes were measured, how occupation/industry was coded and how employment was defined. Ever asthma, cough and phlegm, shortness of breath and lung function measurements were common respiratory health outcomes measured in the studies reviewed. Exposures were measured based on the occupational and industrial classifications. Many studies in this review lacked data pertaining to workplace conditions and individual behaviors that can alter the estimate of the association between the exposures and respiratory health outcomes. In spite of the differences between the methods and materials of the studies, which could possibly make the comparison between the study results difficult, there were evidences to show that the respiratory health outcomes were associated with occupational and/or industrial exposures to varying degrees.

Only a few studies have been conducted in Canada to understand the respiratory health problems in working population. The results from thesis will provide additional information to the current literature on the prevalence and determinants of respiratory health problems among Canadian adolescents and adults by industry and occupation.

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CHAPTER 3

METHODS

3.1 Canadian Health Measures Survey

The Canadian Health Measures Survey (CHMS) is a cross-sectional survey conducted biannually by the Statistics Canada in collaboration with Health Canada and the Public Health Agency of Canada. The purpose of the survey was to increase the comprehensiveness of current health information.[1] The first survey (CHMS-Cycle 1) was conducted from March 19th 2007 to February 25th 2009, which included a representative sample of 5,600 Canadians aged 6 to 79 years[1]. A sample of 6,395 Canadians aged 3 to 79 years was surveyed in CHMS-Cycle 2, which was conducted from August 2009 to November 2011.[2] The CHMS included completion of an inter-viewer administered household questionnaire at home and a visit to the Mobile Examination Centre (MEC) to complete a clinic questionnaire and provide physical, blood and urine measures.

3.2 Development of CHMS

Health Canada Research Ethics Board reviewed the survey protocol of CHMS-Cycle 1.[1] The protocol of the survey in Cycle 2 was reviewed and approved by Health Canada (HC) and the Public Health Agency of Canada (PHAC) Research Ethics Board.[2]

Participation in the survey, and the visit to the Mobile Examination Centre (MEC) was voluntary. Informed consent was taken after providing information through an introductory letter, a brochure, video, and through Statistics Canada website. A consent booklet was used to obtain informed consent from the respondents. Consent was not just one-time but was a process. A nine-point interactive consent process was used throughout the household interview, before and during the process of administering the questionnaire and during the mobile examination centre visit[1]. Questions and any concerns that the respondents may have had regarding the implications of participating in the survey, physical measure testing and the use of the data were answered to their satisfaction.[1] The office of the Privacy Commissioner of Canada performed an assessment of the privacy impact of the CHMS survey in cooperation with provincial commissioners.[1,2] The survey was administered with the highest respect to Canadian's health and safety and privacy, by a team of provincial and municipal officials with the support of health professionals.[1,2]

3.2.1 CHMS-Sample Design

A multi stage sampling strategy was used and the sampling of collection sites, dwellings and respondents were similar in both cycles[1,2]. Collection sites identified through Labour Force Survey (LFS) were stratified into geographic regions in a similar way for both Cycles; sampled dwellings within the collection sites were stratified based on the ages of the inhabitants in the dwellings. The number of inhabitants to include in the sample from one dwelling was based on the household composition.

3.2.2 CHMS-Sample Size

In CHMS-Cycle 1, 5,600 respondents aged 6 to 79 years old were sampled.[1] In CHMS-Cycle 2, 5,700 participants were surveyed.[2] The target population in Cycle 2 included individuals between 3 to 79 years living at home and residing in the 10 provinces and three territories. Exclusion criteria for the target population in both cycles were persons living in reserves and other Aboriginal settlements in the provinces, full-time members of the Canadian Forces, institutionalized persons and residents of certain remote regions with population density less than

400 people per square kilometer. The percentage that was excluded by these criteria was less than 4% of the target population in both cycles.[1,2]

3.2.3 Data processing in CHMS

In CHMS there were three data sets; household data, clinic measurement data and laboratory data for each respondent.[1,2] The three sets of data were organized together in order to link the data for each respondent before processing. Data were validated at three levels. First at the record level and then at the individual variable level, followed by detailed top down editing. Processing of the household data occurred daily while the data was being collected. This was done rapidly as it was required the household data to be available at the MEC at the time of the respondent's visit to the MEC. Laboratory data were processed as immediately as possible to be able to make the results available to the respondents in case if there was a necessity.

Templates with pre-coded answer categories were available for the data collectors. For certain data, which included job description information, the information was collected as an open answer. Processed data were assigned codes according to a number of pre-coded answer categories. Interviewers used a computer assisted interviewing (CAI) application to search databases to find standard descriptions for the answer categories to assign codes for the answers. Whenever the responses were not specific enough to assign codes, responses were entered in the "other' category as long answers and later those were reviewed thoroughly at the head office level and were coded in to the existing list whenever it was appropriate. If not new categories were created based on the availability of the number of responses within that particular category. For the assignment of industry and occupation codes, all records with data in the job description fields were extracted and sent for manual industry and occupation coding. North American Industry Classification System (NAICS) 2002 and National Occupational Classification -

Statistics (NOC-S) 2001 were used to classify industrial sectors and occupational categories. Manual coding started with matching of the collected data to a database of previously coded job descriptions.[1,2]

3.3 Consent for the thesis

The thesis proposal was submitted to Canadian Initiative on Social Statistics (CISS), a joint initiative between Statistics Canada, the Social Sciences and Humanities Research Council and the Canadian Institute of Health Research for approval to use confidential micro-data at the Research Data Centre (RDC) in the University of Alberta. The proposal was approved and access to the use confidential micro-data at the RDC subject was granted subject to fulfilling to the following steps: completing the security screening process, signing the Oath of Office and Security, participating in an RDC Orientation session and signing a Microdata Research Contract with Statistics Canada by the candidate and supervisors. Ethical approval for the thesis research proposal was obtained from the Health Research Ethics Board, University of Alberta.

3.4 Study population

The data from CHMS-Cycle 1 and CHMS-Cycle 2 were appended for the current study, which resulted in a larger sample size for the statistical analysis. This allowed for more precise estimates for the characteristics with low prevalence and parameters in the regression models. Appending data from CHMS-Cycle 1 and CHMS-Cycle 2 resulted in a sample size of 11,995. As the minimum age for employment in Canada is 15 years and the primary objective of this study was to characterize the association of respiratory outcomes with occupation and industry, the records of the CHMS respondents below 15 years of age were excluded from the combined data file. Because of possible retirement from workforce, the records of the CHMS respondents over

75 years were also excluded from the sample. After excluding the records of the pregnant women, the combined data file contained 7,930 records of employed and non-employed respondents between 15 to 75 years. Pregnant women were excluded from the study as they were not eligible to participate in the spirometry measurements. Of the 7,930 respondents, there were about 5900 participants who identified themselves as employed. In the final multiple linear regression models, to characterize the association of lung function parameters with occupational and industrial exposures, the observations with unacceptable measurements for FVC and FEV_1 were excluded.

3.5 Socio-demographic variables

Age of the subject was determined at the time of interview using the date of interview and the date of birth and the age was further confirmed at the mobile examination centre (MEC).[3,4] The interviewer noted the sex of the respondent and entered in the database. Ethnicity/race was derived from the information from the response to the following questions: “Are you an Aboriginal person, that is, North American Indian, Métis or Inuit?”, “Are you White? Chinese? South Asian, Black? Filipino? Southeast Asian? Arab? West Asian? Japanese? Korean? Other - Specify?”.[3] The respondents who identified themselves as Aboriginal were coded as not applicable[5] in the ethnicity/race variable (sdcdcgt) in CHMS, which had 13 categories. The categories were white, black, Korean, Filipino, Japanese, Chinese, South Asian, South East Asian, Arab, West Asian, Latin American, other racial or cultural origin, and multiple racial/cultural origins.[6] In the thesis the variable ethnicity was recoded in to two categories as “Caucasians” and “Others.” The Aboriginal respondents, who were coded not applicable, were included in the category “Others”.

The variable indicating highest educational level achieved by the respondent had four levels and was derived from the responses to the following four questions. “What is the highest grade of elementary or high school ever completed?” “Did the respondent graduate from high school (secondary school)?” “Has the Respondent received any other education that could be counted towards a degree, certificate or diploma from an educational institution?” “What is the highest degree, certificate or diploma the respondent has obtained”? Based on the responses to the four questions, Statistics Canada derived a variable with four categories indicating the highest level of education achieved by the.[3] Variable indicating the total personal income of the respondents was derived by the Statistics Canada based on the responses to the following questions. “Was your total personal income less than $10,000 or $10,000 or more?” “Was your total personal income less than $5,000 or $5,000 or more?” “Was your total personal income less than $15,000 or $15,000 or more?” and “Was your total personal income less than $30,000 or $30,000 or more?” Self-rated health of the respondent was obtained from the responses to the questions “In general, would you say your health is excellent, very good, good, fair, or poor?”[3]

The daily energy expenditure variable indicated the typical daily energy usage on leisure time activities during the past three months. Questions were asked from the respondent about leisure time physical activities including walking, gardening or yard work, popular or social dance, ice hockey, ice skating, in-line skating or rollerblading, jogging or running, golfing, participation in an exercise class or aerobics, downhill skiing or snowboarding, bowling, baseball or softball, play tennis, weight training, fishing, playing volleyball, basketball, soccer, and/or other activities. Intensity (low, medium high) of the leisure time activity was not obtained from the respondent but was assumed low for each activity. The reason not to obtain the intensity of the activities from the respondent was that usually the individuals tend to overestimate the intensity, occurrence as well as how much time the individual spent on each activity. This method was adopted from the Canadian Fitness and Lifestyle Research Institute.[5] Energy expenditure was calculated by using following formula.

EE (Energy Expenditure for each activity) = (N * D * MET value) / 365

Where:

N = the number of times a respondent engaged in an activity over a 12-month period

D = the average duration in hours of the activity

MET value = the energy cost of the activity expressed as kilocalories expended per kilogram of body weight per hour of activity (kcal/kg per hour)/365 (to convert yearly data into daily data).[5]

3.6 Respiratory Health Outcomes

The CHMS questionnaire included a section on chronic health conditions with the following instructions for the interviewer "Now I'd like to ask about certain chronic health conditions which you may have. We are interested in "long-term conditions" which are expected to last or have already lasted 6 months or more and that have been diagnosed by a health professional." In this section, several chronic conditions including asthma, COPD and chronic bronchitis were included. The **"**ever asthma" used in the thesis was based on the response to the question **"**Do you have asthma?" The current asthma in the thesis was based on the response to the question **"**Have you had any asthma symptoms or asthma attacks in the past 12 months?" This question was asked to all the respondents who gave an affirmative response to the question on ever asthma. Information about chronic bronchitis and COPD were obtained from the response to the questions similar that used for "ever asthma". However, the question on COPD was restricted to the respondents of ages 30 years and above. Under the section on the family medical history within the household questionnaire, respondents were asked “Has anyone in your immediate family ever had asthma” and the immediate family included the respondent’s birth parents, birth siblings and birth children, alive or deceased.

3.7 Smoking

The CHMS questionnaire included several questions on smoking. Statistics Canada derived the variable “type of smoker” based on the responses to those questions. The question asked: At “the present time, do you smoke cigarettes daily, occasionally or not at all?” after providing a description of what it means by a cigarette. The interviewer asked “have you smoked a total of 100 or more cigarettes (about 4 packs) in your life time? “At the present time, do you smoke cigarettes daily, occasionally or not at all? “How old were you when you started smoking at least one cigarette a month? “When you started smoking cigarettes daily, how many cigarettes did you usually smoke each day?”[3] Responses to these questions were used to derive a variable on smoking, which had three categories “non-smoker”, “former smoker” and “current smoker”.

3.8 Employment, Occupation and Industry

Information about the current or most recent employment status, occupation and industry were collected under labor force section of the household questionnaire. The following open ended questions were asked to collect the information about the employment status of the respondent: “Last week, did you work at a job or business?’ The respondent was instructed to include part-time jobs, seasonal work, contract work, self-employment, baby-sitting and any other paid work, regardless of the number of hours worked with yes or no options. For the respondents who had an affirmative response to the first question, the following question was asked. “Did you have more than one job or business last week? The possible responses included part-time jobs seasonal work, contract work, self-employment, baby-sitting and any other paid work, regardless of the number of hours worked". For the respondents who answered "no" to the above question, the following question was asked. "Last week, did you have a job or business from which you were absent?"[3] Responses gathered by the three questions were coded for employment status and the respondents who worked for any duration of time within past one year were considered as currently employed. The question asked was: "Did you work at a job or business any time in the past 12 months?" Similar to the other two categories, the respondents were also instructed to include part time jobs, seasonal work, contract work, self-employments, baby siting and other paid work, regardless of the number of hours worked.

Among the respondents who were considered as employed, information was collected in order to classify the occupation and the industry of the employment according to the NOC-S 2001 and NAICS Canada 2002. Interviewers asked questions about the current or most recent job or the business. If the respondent currently held more than one job or if the last time when the respondent worked on more than one job, the above information was gathered on the job for which the number of hours worked per week was the greatest.

Information about whether the respondent was the employee or self–employed was also obtained. If the respondent was the employer, a question was asked whether the respondent had any employees or not was. The name of the business for whom the respondent worked, and the type of business, industry or service were also gathered. Interviewers entered the answers to these open ended questions with a maximum of 50 characters per question and then asked the respondent to describe what kind of work were they doing.[3] The answer to this open-ended question was inserted with a maximum of 80 characters. The most important activities or duties, whether the job was permanent or not, and the manner it was not permanent if not permanent, were also gathered. If the respondent was absent of work within the last week, the main reasons that the respondent was absent from work during last week was collected. Approximate number of hours the respondent work of a week at his/her work was collected. If the respondent usually worked extra number of hours, whether it was paid or unpaid, and the number of extra hours worked also collected. The best description of the hours they usually worked at their job or business was collected based on regular daytime schedule or shift (regular evening shift, regular night shift or rotating shift). Whether the respondent worked weekends on the second job was also collected with the employment status during the past 12 months. For the answers of some of the open-ended questions, characters were limited to a maximum of 80. Data were collected as long answers for job description information and codes for the jobs were assigned later.

3.9 Measurements at the Mobile Examination Centre (MEC)

At the mobile clinic, respondent's identification was verified and a label was provided to the respondent with the identification number (CLINICID). After signing the informed consent form, respondents were screened for the adherence of the pretesting guidelines. Anthropometry and spirometry were performed at the MEC only after completing the eligibility criteria for the physical measures testing.

3.9.1 Respiratory Health Variables

Information obtained regarding physical and health conditions at household interview was confirmed at the MEC. The question asked to confirm a respiratory condition was "During the interview in your home, it was reported that you had asthma/ chronic bronchitis/ chronic obstructive pulmonary disease (COPD). Is this correct?" Respiratory variables for which the responses were confirmed at MEC were used as respiratory health indicators in the thesis. Responses to the questions about individual respiratory symptoms were used to determine the presence of regular cough, cough with phlegm and shortness of breath symptoms from the affirmative responses to the questions "Do you cough regularly", "Do you cough up phlegm regularly?", and "Do even simple chores make you short of breath?", respectively.

3.9.2 Anthropometry Measurements

Prior to taking the anthropometric measurements, participants with any acute conditions were excluded. Acute conditions included any leg condition like casts that makes the respondent unable to stand. Anthropometric measurements were taken using standard procedures based on 3rd edition of the Canadian Physical Activity, Fitness and Lifestyle Approach (CPAFLA). The standing height was measured by a Health Measures Specialist (HMS) on all respondents of ages 6 years and older who could stand unassisted. Standing height was measured with a fixed stadiometer with a vertical backboard and a moveable headboard using a procedure based on the CPAFLA.[1,2] Self-reported heights was taken for respondents who were not able to stand. Weight was measured in kilogram (kg) using a Mettler Toledo digital scale. Respondents with acute conditions or pregnant were not included in the weight measurement. Measured weight and the standing height were used to calculate the body mass index (BMI) using the following formula BMI = weight (kg) / [height (m)].[2] For some individuals who were reluctant or found it impossible to attend the MEC, anthropometric measurements were taken using portable equipment in their homes to reduce the non-response rate. There were 22 and 49 home visits for data collection in CHMS-Cycle 1[1], and CHMS-Cycle 2, respectively.[2]

3.9.3 Spirometry Measurements

The 1994 Update of the Standardization of Spirometry guidelines published by the American Thoracic Society were followed to take spirometry measurements.[1] Spirometry was performed by a trained technician using Respironics KoKo spirometer (PDS) (Instrumentation, Louisville, Co). As lung function measures and spirometry equipment were very sensitive to room temperature fluctuations, all possible efforts were taken to retain the MEC at a comfortable and persistent ambient temperature of 21°C ± 2°C.[1,2] Respondents, who were pregnant (>27 weeks), who have had a heart attack within the last 3 months or major surgery on their chest or abdomen within the last 3 months were excluded from the spirometry based on the responses given at the household interview.[1] MEC staff also excluded any respondents with acute respiratory condition, stoma, persistent cough, recent eye surgery, treatment for tuberculosis, and breathing difficulties. Forced vital capacity (FVC) and the forced expiratory volume in one second (FEV_1) were the primary measurements taken during the spirometry. As the spirometry test was effort dependent, the Health Measures Specialist gave in-depth instructions to the respondents prior to testing.

During spirometry, each respondent's appropriate racial adjustment was made to the equation as the size of the lungs varies between the different ethnicities even with similar standing height.[1] A respondent's self-reported cultural and racial background in response to questions on cultural or racial background collected at the household interview was not used for the Correction Factor in the Hankinson equation for spirometry if more than one was reported. Instead, the Health Measures Specialist decided on racial adjustment based on visual cues if the self-reported cultural/racial background was inconclusive.[1]

After making the racial adjustment for each respondent, the HMS selected the appropriate predicted equation and ethnic group to be applied for spirometry through the KOKO software.[3] A detailed description of the spirometry is seen elsewhere.[1] Spirometry test results were saved in KOKO software and transferred to the clinic server.[1]

An external reviewer reviewed all the spirometry results to ensure the quality of the measurements. Next, a quality review of all spirometry results was conducted by a spirometry expert, an external reviewer, using a custom application that was developed for the CHMS. This was performed prior to any analysis or calculation with the spirometry test results. The custom application was based on the American Thoracic Society testing criteria. The external reviewer's duty was first to approve any exclusions made by the application and second to identify any unsatisfactory tests mark the inferior quality ones that were not identified by the application.[1] The review included an assessment of all trials to define trial acceptability and test reproducibility/quality. Each trial result was given a code to indicate the acceptability (1= acceptable or 2=unacceptable) and the unacceptable trials were excluded from further analysis. A trial was coded as unacceptable if there was cough in the first or second trial; there was a huge induced capacity caused by extreme reluctance; the reviewer evaluated that the information within the trial could upset the exactness of best-derived variables; or the reviewer noted that the whole trial was of inferior quality to be used for analysis. All the acceptable trials were reevaluated to conclude the quality and reproducibility before subjected to analysis. Reproducibility and quality for FVC and FEV_1 were indicated by the variables SPM_QFVC and SPM_QV1 variables in the CHMS survey. The quality of FVC and FEV_1 were coded A or B if the quality and the reproducibility was excellent or good, respectively. When the quality and the reproducibility were questionable or highly questionable, they were coded C or D. After assigning the quality factor for each spirometry result, percent-predicted FVC and FEV_1 were calculated.[1] The predicted equations were taken from the third National Health and Nutrition Examination Survey in the Unites States (NHANES III).[1] In this thesis, a sensitivity analysis was conducted to assess the impact of exclusion of these trials. When they were included in the analysis, the percentages meeting the various criteria for airflow obstruction did not differ notably from analysis that excluded them. FVC, FEV_1, FEV_1/FVC, $FEF_{25\%-75\%}$ and percent-predicted FVC, FEV_1, and FEV_1/FVC were considered in the statistical analysis.

3.10 Statistical Analysis

Statistical analysis including data cleaning, recoding, descriptive analysis and regression analysis were performed at the Research Data Centre located at the campus of the University of Alberta under restricted conditions for data confidentiality. The procedures for the analysis of complex survey data in the statistical program, STATA, were used in statistical analysis (StataCorp LP. 2007, Release 14). These procedures allowed for inclusion of design weights and bootstrap weights in the statistical analyses.

3.10.1 Recoded Variables

The age was considered as a continuous variable as well as a categorical variable (age groups) with three age categories: 15 - 20 years, 21- 60 years and 61 -75 years. The variable province of residence was recoded in to five regions: East Atlantic Region (New Brunswick, Newfound land & Labrador, Prince Edward Islands and Nova Scotia), Quebec, Ontario, Prairies (Alberta, Manitoba, Saskatchewan, Yellowknife, and Northwest Territories), and British Columbia, which included Whitehorse and Yukon. Measured height and weight were used as continuous variables in the thesis. A dichotomous variable indicating early and late onset asthma was generated based the response to question on onset of asthma: “How old were you when asthma was diagnosed?” If the onset of asthma was 15 years of age or earlier, it was considered as early onset. Otherwise it was considered late onset. This variable was created based on the information collected by the question “how old were you when asthma was diagnosed?” The ethnicity or cultural background variable was recoded into a dichotomous variable as “Whites” and “Other” with the respondents who identified themselves as Aboriginals being categorized as “Other”. Total personal income groups, self-rated health, measured BMI, daily energy expenditure and highest educational level achieved were derived by the Statistics Canada. In this thesis, categories of the total personnel income variable were recoded to have following four categories as <$30K, $30k- <$50k, $50k- <$80k, and ≥ 80k.

The self-rated health variable had five categories: excellent, very good, good, fair, and poor. In this thesis, it was recoded in order to comply with the vetting rules of Statistic Canada. Some cells of the frequency distribution were populated with numbers smaller than that required by the Statistics Canada (n ≥ 5) pertaining to the confidentiality and privacy of the respondents. Consequently “Fair” and “poor” categories were grouped together, and the “excellent” and “very good” categories were also grouped together resulting in three categories.

3.10.2 Occupational Categories

The variable “lbf_soc” from the CHMS, which had 10 broad occupational categories, was used to generate the variable broad occupational category. Among the 10 broad occupational categories, two categories, *occupations unique to primary industry* (162) and *occupations unique to processing manufacturing and utilities* (239) had frequencies less than 250 and were collapsed together to form one broad occupational category. Consequently 10 original broad occupational were recoded in to 9 occupational categories. The category, *management occupations*, was used as the referent category in the statistical analysis.

3.10.3 Industrial Sectors

The variable "lbf_sic" from the CHMS was used to generate the variable indicating industrial sectors in this study. The original variable had 20 industrial sectors and some of those sectors were collapsed because of the small number of records within the sectors were not adequate to fit the regression models. Thirteen of the 20 industrial sectors were collapsed to form four recoded industrial sectors (see Table A). Industrial sectors were collapsed based on the assumption of their potential similarity of the industrial exposures. Among 20 industrial sectors in the original variable, the sectors "*information and cultural industries*", "*finance and insurance*", "*real estate and rental and leasing*", "*management of companies and enterprises*", "*administrative and support waste management and remediation services*" were collapsed together and labeled as Sector 1. Similarly, "*arts, entertainment and recreation*" and "*accommodation and food services*" were collapsed together to form Sector 3. In total, 20 industrial sectors were re-coded into 11 industrial sectors (See Table A) In this thesis, the industrial Sector1 was used as the referent industrial sector for analysis.

Table 3.1 Distribution of recoded industrial sectors (NAICS Canada 2002) (CHMS-Cycles 1 & 2)

Industrial sectors with original two digit NAICS codes	Recoded industrial sector	Proportion (%)
Information and cultural Industries (51) Finance and Insurance (52) Real estate and rental leasing (53) Management of companies and enterprises (55)	1	14.1

Administrative and support, Waste management and remediation services (56)		
Professional, Scientific and Technical Services (54)	2	8.0
Arts, Entertainment and Recreation (71) Accommodation and Food Services (72)	3	11.3
Public Administrations (91)	4	5.4
Other Services (except Public Administration (81)	5	4.1
Educational Services (61)	6	8.0
Health Care and Social Assistance (62)	7	10.7
Wholesale Trades (41) Retail Trade (44-45) Transportation and Warehousing (48-49)	8	18.6
Constructions (23)	9	7.0
Manufacturing (31-33)	10	9.0
Agriculture, Forestry, Fishing and Hunting (11) Mining, Oil and Gas Extraction (21) Utilities (22)	11	4.1
Missing		<0.1

3.10.4 Use of Weights in Statistical Analysis

In order for the estimates generated from CHMS data to be representative of the Canadian population covered by the survey, not simply of the sample itself, survey weights provided by the Statistics Canada (wgt_full) were incorporated in the estimation. In order to allow for the complex sampling design of the CHMS, 500 bootstrap weights variables (bsw1-bsw500) provided by Statistics Canada, was linked to the combined data files from the two cycles. Bootstrap weights were applied in variance estimation for descriptive statistics, regression coefficients and 95% confidence intervals in the thesis. Linking the bootstrap weights to the data file permitted to estimate the precise variances by resampling the CHMS sample in all the statistical analyses in the thesis. The combined CHMS-Cycle 1 and CHMS- Cycle 2 database allowed for inclusion of 24 independent variables or 24 degrees of freedom for the regression analyses.[7]

3.10.5 Comparison between Employed and Unemployed Respondents

A comparison of the population characteristics between employed and non-employed was carried out. The population characteristics included demographic, anthropometric, and socioeconomic factors and smoking status. Means and standard deviations were used to describe the continuous variables, and proportions were used to describe the categorical variables. Significant differences in these characteristics between employed and non-employed were determined using simple linear regression for continuous variables and chi-square tests for categorical variables.

Comparisons between employed and non-employed respondents were also carried out among males and females. After excluding lung function measurements with questionable or highly questionable quality (quality C or D), the mean values of FEV_1, FVC, FEV_1/FVC ratio and $FEF_{25\%-75\%}$ were compared between employed and non- employed participants among males and females, independently, after adjusting for smoking using multiple linear regression.

3.10.6 Descriptive Analysis by Industrial Sectors and Occupational Categories

For statistical analyses related to industrial sectors and occupational categories, the respondents who were unemployed were excluded from the analysis, which resulted in a sample of 5,910 respondents. Anthropometric, demographic and socioeconomic variables and smoking status were compared between industrial sectors and occupational categories using chi-squared test for categorical variables and multiple linear regression continuous variable and

3.10.7 Association between Respiratory Health Outcomes and Industrial Sectors and Occupational Categories

The distribution of respiratory health outcomes was compared between industrial sectors and occupational categories. The respiratory health outcomes included ever asthma, cough, cough with phlegm and shortness of breath. Logistic regression analysis was used to determine the significant differences in the respiratory health outcomes between industrial sectors and occupational categories after controlling for smoking status. The referent category for occupations was managerial occupations (occupation code A). The referent category for industrial sectors was Sector 1(Cultural Industries/Finance, Insurance/Real Estate and Rental Leasing/Management of Companies& Enterprises/Administrative and Support, Waste Management and Remediation Services). Logistic regression was used to determine the association between ever asthma and current asthma with industrial sectors and occupational categories after adjusting for age and sex. For each outcome, association was described with odds ratios (ORs) with 95% confidence intervals (CIs).

3.10.8 Association between Lung Function and Industrial Sectors and Occupational Categories

After excluding lung function measurements with questionable or highly questionable quality, 5,520 records were available for the statistical analyses. Multiple linear regression analyses were used to determine the significant differences in the mean values of percent-predicted FEV_1, FVC and FV_1/FVC ratio between industrial sectors and occupational categories after controlling for smoking status.

3.11 Selection of Confounders

Risk factors and/or confounders that have been identified in the literature as potentially associated with respiratory health were considered in the comparison between industrial sectors and occupational categories. Age, sex, height, weight, BMI, ethnicity, highest educational level achieved, total personal income, self-rated health, daily energy expenditure and smoking status were considered as potential confounders.

3.12 Sample Size Justification

The sample size is justified for both multiple linear and logistic regression analyses.

3.12.1 Multiple logistic regression

A logistic regression of a binary response variable (self- reported asthma/not, cough & phlegm/not) on a binary independent variable (X, exposure to a certain occupation /not) with a sample size of approximately 5,000 observations (of which 70% are in the group X=0 and 30% are in the group X=1) achieves 80% power at a 0.05 significance level to detect a change in probability (Y=1) from the baseline value of 0.080 to 0.109. This change corresponds to an odds ratio of 1.4, after allowing for an R^2 value of 0.2 for the correlation between the independent variable of interest and other potential confounding variables in the model. The sample size of approximately 5,900 subjects who were currently employed at the time of survey in CHMS combined sample is adequate to conduct the proposed analysis in this study.[8,9]A logistic regression of a binary response variable (Y, respiratory symptom, airway disease) on a continuous, normally distributed variable (age) with a sample size of approximately 4,000 observations achieves 80% power at a 0.05 significance level to detect a change in Probability (Y=1) from the value of 0.08 at the mean of X to 0.094 when X is increased to one standard deviation above the mean. This change corresponds to an odds ratio of 1.2 after adjusting an R^2 of 0.2 for the correlation between the independent variable of interest on the other independent variables in the logistic regression.[8, 9]

3.12.2 Multiple linear regression

With a power of 80 % and 5% level of significance, a sample size of 42 is required to detect an

R^2 of 0.1 attributed to adding one more independent variable in a regression model, already with 4 independent variables with an R^2 of 0.4. Combined sample of CHMS Cycles has adequate sample size in each specific subgroup to examine the objective 4 related to lung functions.[10]

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CHAPTER 4

RESULTS

4.1 Characteristics of the study population

Of the 7,930 respondents aged 15 to 75 years in the combined database, approximately 75% reported a current or most recent employment. There was a statistically significant difference in the sex distribution between the employed and non-employed respondents ($p<0.001$).

4.1.1 Characteristics of Employed and Non-employed Respondents

Among the employed, 53% was male whereas among the non-employed, it was only 36% and 53% had never smoked in employed whereas among non-employed it was 49%, with the difference being statistically non-significant (Table 4.1.1). The percentage of the respondents who were currently smoking at the time of the interview was 21% among employed and 20% among non-employed and the difference was not statistically significant (Table 4.1.1). Among the employed, 57% rated their health as either very good or excellent whereas among the non-employed it was only 41% who rated their health as very good or excellent with the difference being statistically significant ($p<0.001$). Among the non-employed respondents, 19% rated their health as either poor or fair whereas among the employed respondents, 7.5% rated their health as either poor or fair and the difference was not statistically significant (Table 4.1.1). Employed respondents were significantly taller and heavier than the non-employed respondents (Table 4.1.1). However, there was no significant difference in the BMI between the two groups.

As commonly assumed, the percentages of the highest educational level achieved for upper three levels were higher among the employed than that among the non-employed (Table 4.1.1). The percentage of the respondents who had less than secondary level education as the highest level of education was greater among non-employed (30.1%) than that observed among the employed (12.0%). The difference of the percentages did not achieve statistical significance. The percentage of post-secondary level education was 61% among employed and 44% among non-employed with the difference being statistically significant ($p<0.001$).

4.1.2 Characteristics of Employed and Non-employed Respondents among Males and Females

The characteristics of employed and not employed respondents are shown in Table 4.1.2 for males and in Table 4.1.3 for females. Interestingly, as shown in Table 4.1.2, among males, there was a statistically significant difference ($p<0.001$) in the percentages of the respondents who never smoked between the employed (50.0%) and non-employed (42.0%). The largest proportion (83%) of employed males was aged between 21 to 60 years old (Table 4.1.2) while among male non-employed the highest proportion (49%) belonged to 61 to 75year age group. These differences in the distribution of age groups between the employed and non-employed were statistically significant. Sex distributions of some anthropometric variables between employed respondents and non-employed respondents were very similar (Table 4.1.2 and Table 4.1.3). Differences in the mean weight and BMI among the male and female respondents were not statistically significant between the employed and non-employed. In contrast, the mean height of employed males was 175.8cm (Table 4.1.2) and for females, it was 162.5cm (Table 4.1.3). In employed males, mean height was significantly different from their non-employed counterpart ($p<0.001$).

4.1.3 Prevalence of Respiratory Outcomes in Employed and Non-employed Respondents

The prevalence of chronic bronchitis (1.4%), ever asthma (8.0%), cough (13.0%) cough with phlegm (8.9%), shortness of breath (6.5%) and chronic obstructive pulmonary disease (COPD) (0.4%) were lower among the employed respondents compared to those among the non-employed respondents. The differences in all these respiratory outcomes between non-employed and employed were statistically significant (Table 4.1.4). While the prevalence of most respiratory symptoms were greater among the non-employed than employed, the prevalence of current asthma was comparatively higher in employed compared to non-employed ($p = 0.003$) after adjusting for age, sex, ethnicity, BMI, daily energy expenditure, smoking status and family history of asthma. Statistically significant prevalence differences were observed in the prevalence of cough with phlegm ($p = 0.01$) and shortness of breath ($p<0.001$) between the employed and the non-employed after adjusting for age, height, weight ethnicity, daily energy expenditure, region and smoking status (Table 4.1.4).

4.1.4 Distribution of Lung Function in Employed and Non-employed Respondents among Males and Females

In both males and females, mean FVC and mean FEV_1 were significantly greater in those who were employed than their non-employed counterparts (Table 4.1.5). In contrast, mean FEV_1/ FVC ratio was similar in employed and non-employed respondents among males and females. As shown in Table 4.15, after adjusting for age, height, weight ethnicity, daily energy expenditure, region and the smoking status mean percent-predicted FVC was significantly greater in employed (100.3%) than that of non-employed (97.5%) in female respondents. Mean $FEF_{25\%-75\%)}$ of employed female respondents (2.7 l/s) was significantly greater than that of their non-employed counterparts (2.1 l/s). As shown in Table 4.1.5, after adjusting for weight, ethnicity, daily energy expenditure, region, and the smoking status, mean percent-predicted FEV_1, and mean percent-predicted FEV_1 / FVC of employed female respondents were slightly greater than that of their unemployed counterparts ($p<0.001$).

Table 4.1.1 Characteristics of participants by employment status: Adolescents and adults aged 15-75 years (CHMS-Cycles 1 & 2) *

Characteristics		Employed (n~ 5,910)	Non-employed (n~ 2,010)	Total (n~7,930)
Age (years)	mean (se)	39.9† (0.2)	52.5 (0.6)	42.5 (0.1)
Height (cm)	mean (se)	169.7† (0.2)	165.0 (0.3)	168.8 (0.2)
Weight (kg)	mean (se)	77.7 † (0.6)	74.4 (1.0)	77.0 (0.6)
BMI (kg/height in metres^2)	mean (se)	26.8 (0.1)	27.3 (0.3)	26.9 (0.1)
Daily energy expenditure (kcal/kg per hour)/365)	mean (se)	1.9 (0.05)	1.9 (0.08)	1.9 (0.05)
Age groups (%)	15-20 years	9.8	11.0	10.0
	21-60 years	83.0†	40.0	74.0
	61-75 years	7.7	49.0	16.0
Sex (%)	Female	47.0†	64.0	50.0
	Male	53.0	36.0	50.0
Ethnicity (%)				
	Caucasian	80.0	77.0	79.0
	Other than Caucasian	20.0	23.0	21.0
Region (%)	Atlantic	7.0	6.3	6.9
	Quebec	23.0	27.0	24.0
	Ontario	39.0	39.0	39.0
	Prairies	18.0	13.0	17.0
	British Columbia	13.0	15.0	13.0
Highest educational level achieved (%)	Less than secondary	12.0	30.1	15.0
	Secondary	17.0	16.6	17.0
	Some post-secondary	11.0	9.5	11.0
	Post-secondary	61.0 †	44.0	57.0
Total personal income groups (%)	Less than $30k	38.0 †	80.0	46.0
	$30k-50K	26.0	15.0	24.0
	$50k-$80	22.0	4.2	19.0
	>$80k	14.0	1.1	11.0
Self-rated Health (%)	Poor/Fair	7.5	19.0	9.8
	Good	36.0	40.0	37.0
	Very Good/Excellent	57.0 †	41.0	53.0
Family history of asthma	Yes	23.0	24.0	23.0
	No	77.0	76.0	77.0
Smoking status (%)	Never smoke	53.0	49.3	52.0
	Former smoker	26.0	31.1	27.0
	Current smoker	21.0	20.0	210
Onset of asthma (%)	No asthma	92.0	91.0	92.0

Early	4.0	3.8	3.9
Late	4.0	5.5	4.4

* Survey design weights and 500 bootstrap weights were used in calculating percentages, mean values, and standard errors (SE)

ǂ $p < 0.001$ for the difference in the mean/proportion between employed and non-employed

Table 4.1.2 Characteristics of male participants by employment status: Adolescents and adults aged 15-75 years (CHMS-Cycles 1 & 2)*

Characteristics		Employed	Non- employed	Total
Age, years	mean (se)	40.0† (0.2)	52.8 (0.9)	42.0 (0.2)
	(95%CI)	(39.5, 40.5)	(50.7, 54.7)	(41.6, 42.3)
Height, (cm)	mean (se)	175.8† (0.2)	173.0 (0.5)	175.4 (0.2)
	(95% CI)	(175.3, 176.3)	(172.1, 174)	(174.9, 175.9)
Weight, kg	mean (se)	84.3 (0.7)	81.8 (1.7)	83.9 (0.7)
	(95% CI)	(82.9, 85.70)	(78.2, 85.3)	(82.3, 85.4)
BMI (kg/height in metres^2)	mean (se)	27.2 (0.2)	27.3 (0.5)	27.2 (0.2)
	(95% CI)	(26.8, 27.6)	(26.3, 28.2)	(26.8, 27.7)
Daily energy expenditure (kcal/kg per hour)/365	mean (se)	2.1 (0.1)	2.3 (0.1)	2.1 (0.1)
	(95% CI)	(1.9, 2.2)	(2.0, 2.5)	(1.9, 2.2)
Age groups (%)	Age 15-20	9.0	17.0	10.1
	Age 21-60	83.0†	28.0	74.4
	Age 61-75	8.3	55.0	15.4
Ethnicity (%)	Caucasians	79.0†	80.0	20.0
	Other than Caucasians	21.0	20.0	20.0
Region (%)	Atlantic	7.0	6.1	6.9
	Quebec	23.0	27.0	24.0
	Ontario	38.0	42.0	39.0
	Prairies	18.0	12.0	17.0
	British Columbia	13.0	13.0	13.0
Highest education (%)	Less than secondary	13.0	35.0	16.0
	Secondary	17.0	12.0	16.0
	Some post-secondary	10.0	9.9	10.0
	Post-secondary	60.0†	43.0	57.0
Total personal income (%)	<$30k	29.0†	71.0	35.0
	$30k-$50K	25.0	21.0	24.0
	$50k-$80K	26.0	7.1	23.0
	>$80k	21.0	1.8	18.0
Self-rated Health (%)	Poor/Fair	7.2	17.0	8.7
	Good	36.0	40.0	37.0
	Very Good/Excellent	57.0†	43.0	55.0
Family history of asthma	Yes	19.0	24.0	19.0
	No	81.0	76.0	81.0
Smoking status (%)	Never smoker	50.0†	42.0	49.0
	Former smoker	27.0	39.0	29.0
	Current smoker	23.0	19.0	22.0

Onset of asthma (%)	No	92.0‡	93.0	92.0
	Early	4.1	4.2	4.1
	Late	3.5	3.1	3.5

***** Survey design weights and 500 bootstrap weights were used in calculating percentages, mean values, and standard errors (SE)
‡ p <0.001 for the difference in the mean/proportion between employed and non-employed

Table 4.1.3 Characteristics of female participants by employment status: Adolescents and adults aged 15-75 years (CHMS-Cycles 1 & 2)*

Characteristic		Employed	Non-employed	Total
Age, years	mean (se)	39.7† (0.2)	52.4 (6.0)	43.1 (0.2)
	(95% CI)	(39.2, 40.3)	(51.0, 53.8)	(42.7, 43.4)
Height(cm)	mean (se)	162.84† (0.3)	160.4 (0.3)	162.2 (0.3)
	(95% CI)	(162.23, 163.44)	159.7, 161.1	161.6, 162.7
Weight, (kg)	mean (se)	70.1 (0.7)	70.1(0.9)	70.1 (0.7)
	(95% CI)	(68.6, 71.6)	(68.2, 72.1)	(68.7, 71.5)
BMI (kg/height in metres^2)	mean (se)	26.4 (0.2)	27.3 (0.3)	26.7 (0.2)
	(95% CI)	(25.9, 26.9)	(6.6, 28.0)	(26.2, 27.2)
Daily energy expenditure (kcal/kg per hour)/365	mean (se)	1.8 (0.1)	1.7 (0.1)	1.8 (0.1)
	(95% CI)	(1.7, 1.9)	(1.6, 1.9)	(1.6, 1.9)
Age, years (%)	15-20 years	11.0	8.1	10.0
	21-60 years	82.0†	46.0	73.0
	61-75 years	6.9	46.0	17.0
Ethnicity (%)	Caucasians	81.0	76.0	80.0
	Others	19.0	24.0	20.0
Region (%)	Atlantic	7.1	6.4	6.9
	Quebec	22.0	27.0	23.0
	Ontario	40.0	36.0	39.0
	Prairies	18.0	14.0	17.0
	British Columbia	13.0	16.0	14.0
Highest education (%)	Less than secondary	11.0	28.0	15.0
	Secondary	16.0	19.0	17.0
	Some post-secondary	11.0	9.4	11.0
	Post -secondary	62.0	44.0	57.0
Total personal income (%)	<$30k	48.0	85.3	58.0
	$30k -$50K	27.0	12.0	24.0
	$50k -$80k	19.0	2.6	15.0
	>$80k	5.7	0.7	4.4

Self-rated health (%)	Poor/Fair	7.9	20.0	11.0
	Good	36.0	40.0	37.0
	Very good /Excellent	56.0	40.0	52.0
Family history of asthma (%)	Yes	28.0	25.0	27.0
	No	72.0	75.0	73.0
Smoking status (%)	Never smoker	55.0	53.0	55.0
	Former smoker	26.0	26.0	26.0
	Current smoker	19.0	20.0	19.0
Onset of asthma (%)	No	91.0	89.0	91.0
	Early	3.9	3.6	3.8
	Late	4.6	6.9	5.2

*Survey design weights and 500 bootstrap weights were used in calculating percentages, mean values, and standard errors (SE).

ǂ Statistically significant difference in the mean / proportions between employed and non-employed ($p < 0.001$)

Table 4.1.4 Distribution of respiratory health outcomes by employment status: Adolescents and adults aged 15-75 years (CHMS-Cycles 1 & 2)*

	Employed (%)	Non-Employed (%)	p –value †
Current asthma	4.7†	3.5	0.03
Ever asthma	8.0	9.3	0.08
Chronic Bronchitis	1.4	3.1	<0.001 ††
Cough regularly	13.0	15.0	0.78
Cough with Phlegm	8.9	13.6	0.01
Shortness of breath	6.5†	16.0	< 0.001
COPD (≥ 30 years)	0.4	1.8	<0.001 ††

*For COPD, only the respondents ≥ 30 years were included to determine the prevalence
† p-value is adjusted for age sex, ethnicity, BMI, daily energy expenditure, smoking status and family history of asthma
†† Adjusted p-value could not be obtained for the variables because the sample sizes were small.

Table 4.1.5 Distributions of lung function parameters by employment status and by sex in Canadian adolescents and adults aged 15-75 years (CHMS-Cycles 1 & 2) *

Lung function parameter		Male		Female	
		Employed	Non-employed	Employed	Non-employed
FVC (L)	mean (se)	4.96 (0.03)††	4.24 (0.05)	3.60 (0.02)††	3.11(0.03)
	(95% CI)	(4.9, 5.0)	(4.1, 4.3)	(3.5, 3.7)	(3.0, 3.2)
FEV_1 (L)	mean (se)	3.86 (0.02)††	3.24 (0.04)	2.85 (0.02)††	2.39 (0.03)
	(95% CI)	(3.8, 3.9)	(3.2, 3.3)	(2.8, 2.9)	(2.3, 2.5)
FEV_1/FVC	mean (se)	0.79 (0.002)	0.76(0.003)	0.79 (0.002)††	0.76 (0.003)
	(95% CI)	(0.77, 0.78)	(0.75, 0.77)	(0.78, 0.79)	(0.76, 0.77)
$FEF_{25\%-75\%}$ (L/S)	mean (se)	3.45 (0.04)	2.76 (0.072)	2.70 (0.033)†	2.11 (0.04)
	(95% CI)	(3.4, 3.6)	(2.6, 2.9)	(2.6, 2.8)	(2.0, 2.2)
FVC percent-predicted (%)	mean (se)	98.9 (0.39)†	96.18 (0.71)	100.35 (0.38)†	97.48 (0.7)
	(95% CI)	(98.0, 99.8)	(94.9, 97.5)	(99.5, 101.1)	(96.0, 99.0)
FEV_1 percent-predicted (%)	mean (se)	96.49 (0.40)	94.72 (0.85)	96.74 (0.44)††	94.14 (0.70)
	(95% CI)	(95.7, 97.3)	(93.0, 96.5)	(95.8, 97.7)	(92.7, 95.6)
FEV_1/FVC percent-predicted (%)	mean (se)	97.44 (0.32)	98.29 (0.40)	96.16 (0.26)	96.11 (0.45)
	(95% CI)	(96.8, 98.1)	(97.5, 99.1)	(95.6, 96.7)	(95.2, 97.1)

*Survey design weights and 500 bootstrap weights were used in calculating percentages, mean values, and standard errors (SE).
† $p < 0.01$, †† $p < 0.001$. p-value indicates the significance in the mean lung functions (FEV_1, FVC and $FEF_{25\% -75\%}$) between employed and non-employed after adjusting for height, weight ethnicity, daily energy expenditure, region and the smoking status.
For percent predicted lung function parameters p-value indicates the significance of the difference of the estimated average lung functions between employed and non-employed after adjusting only for smoking status

4.2 Distribution of Characteristics in Industrial Sectors and Occupational Categories

4.2.1 Distribution of Age and Sex

As shown in the Table 4.2.1, the largest proportion of the workers in all the industrial sectors was in the middle age group (21 to 60 years). The proportions in this age group ranged from 66.0% to 91.0% from Sector 1 to Sector 11 and were 66% in the Sector 3 (arts, entertainment and recreation/accommodation and food services), 91% in the Sector 4 (public administration). Notably unlike in other industrial sectors, in Sector 3 (arts, entertainment and recreation, accommodation and food services), 29% of the employees were in the younger age group (15 to 20 years). In all the other sectors, representation of this young age group was below 14%. The lowest representation (3%) of the younger age group (15 to 21years) was reported in the Sector 2 (professional scientific and technical services). The highest representation (13%) of the older age group (61 to 75 years) was in the Sector 11 (agriculture, forestry, fishing and hunting/Mining, oil and gas extraction/ utilities). The lowest representation (5.6%) of the older age group was in Sector 10 (manufacturing) and it was similar (5.7%) in the Sector 3 (arts, entertainment and recreation/accommodation and food services).

As shown in Table 4.2.2, in the largest proportion in all occupational categories was also in the middle age group (21 to 60 years). In the sales and service occupations, 24 % of respondents were in the younger age group (15 to 20 years); a higher proportion than in the other age groups. In occupations unique to primary industry and unique to processing, manufacturing and utilities, 9% of respondents were in the older age group (61-75 years). The lowest mean age for both males (35.6 years) and females (34.9years) was observed in sales and service occupations (Table 4.2.2.). The highest mean ages for males (45.5 years) and females (46.1 years) were observed the in the management occupations. The differences in the mean age between the broad occupational categories were statistically significant in male and females. The proportions of some characteristics were not reported for several broad occupations in Table 4.2.2 to be compliant with the Statistics Canada data confidentiality guidelines.

The distribution of sex among industrial sectors varied significantly (Table 4.2.1). Among the industrial sectors, Sector 7 (health care and social assistance) had the largest proportion of females with more than 80%. In contrast to Sector 7, the proportion of females in the Sector 9 (*construction* industry) was only 9% (Table 4.2.1). Among the industrial sectors, the proportion of males were greater than the proportion of females in Sector 1, Sector 2, Sector 8, Sector 9, Sector 9 and Sector 11 with a higher proportion of females being observed in other industrial sectors.

Similar to the pattern observed in the distribution of females between industrial sectors, 82% of those in health care occupations were females (Table 4.2.2). In the occupation of art, culture, recreation and sports, the proportion of females and males was approximately equal. In the trades, transport and equipment operators and related occupations, more than 90% respondents were males with the difference between males and females being statistically significant.

4.2.2 Distribution of Education: Highest Education Level Achieved

In the industrial Sector 3 (arts, entertainment and recreation/accommodation and food services), 43 % of the respondents had either less than secondary or secondary level education as the highest level of education achieved. That was the highest proportion for the two lowest level of education as the highest level of education achieved among the 11 industrial sectors considered in this research. This lowest level of education was also observed in Sector 8 (wholesale trades, retail trade/transportation and warehousing; 42%) and Sector 11 (agriculture, forestry, fishing and hunting/mining, oil and gas extraction/ utilities; 42%). In the Sector 2 (professional scientific and technical services), the proportion of the respondents who had secondary or less than secondary level of education as the highest level of education achieved, was the lowest proportion (5.7%) observed in this analysis. Among all the sectors, the proportions of the respondents who had some post-secondary level of education as the highest level of education achieved were always lower than the estimated proportions for other two educational categories. In the Sector 2 (professional scientific and technical services), 87% of the respondents reported that their highest level of education achieved was post-secondary level of education, which was the highest proportion between the 11 industrial sectors. Among the respondents in the Sector 3 (arts, entertainment and recreation/accommodation and food services), 37% reported that post-secondary level of education as their highest level of education achieved. That was the lowest proportion observed among the 11 industrial sectors in this analysis. The second highest proportion of post-secondary level of education as the highest educational level achieved was observed in the Sector 7 (health care and social assistance, 77%*)* and was closely followed by Sector 4 (public administration, 76%). The overall differences of the proportions of the highest educational achieved between the industrial sectors were statistically significant.

As shown in Table 4.2.2, among the broad occupational categories, 91% of the respondents in the occupations in social science, education, government service and religion reported that the post-secondary level education as the highest level of education achieved. The second highest proportion (90%) was in the occupations in natural and applied sciences and related occupations. Among the occupations unique to primary industry and occupations unique to processing, manufacturing and utilities, 43% of the respondents reported that the less than secondary or secondary level of education as their highest level of education achieved. Slightly lower proportion (47%) of the respondents among the occupations in trades, transport and equipment operators and related occupations reported that lass than secondary or secondary level of education as the highest level of the education achieved. Among the broad occupational categories, the smallest proportion (4.8%) of the respondents who had less than secondary or secondary level of education as the highest level of education achieved was reported in the occupations in social science, education, government service and religion. The next smallest (5.5%) was reported in natural and applied sciences and related occupations.

4.2.3 Distribution of Self-Rated Health

Sixty-nine percent of the responders in the Sector 6 (educational services) rated their health as very good or excellent (Table 4.2.1). That was the highest proportion of the respondents among the industrial sectors who rated their health as either excellent or good. The least proportion (49%) was reported in the Sector 10 (manufacturing industries). Except in the Sector 10, in all the other sectors, over 50% of the respondents rated their health either as excellent or very good. A little less than 10% of the respondents in the Sector 8 and Sector 10 rated their health as either poor or fair and that was the highest proportion of the respondents who rated their health as either poor or fair. In all the industrial sectors, the highest proportion of the respondents within each sector rated their health as either very good or excellent compared to the other two categories of the self-rated health. The differences in the proportions of self-rate health categories between the industrial sectors did not achieve statistical significance.

As shown in Table 4.2.2, among those reporting occupations in in art, culture, recreation and sports, 72% of the respondents rated their health either as very good or excellent. Among those reporting occupations in social science, education, government service and religion, the percentage that rated their health as either very good or excellent was 68% (Table 4.2.2). Among all broad occupational categories, more that 50% of the respondents rated their health as either very good or excellent. The highest proportion (10%) of the respondents who rated their health either as fair or poor was in the sales and service occupations. The difference in the proportions of self-rated health categories between the occupational categories were statistically significant ($p=0.01$)

4.2.4 Distribution of Daily Energy Expenditure

The distribution of average daily energy expenditure was given independently for males and females in Table 4.2.2 for the industrial sectors and in Tables 4.2.3 in the occupational categories.

Typical average daily energy expenditures were approximately 2 kcal/kg/day in this analysis. It was slightly over 2 kcal/kg/day for meals and slightly less than 2 kcal/kg/day for females except in Sector 5 (Other Services except Public Administration) and Sector 6 (Educational Service). The highest average daily expenditure 2.9 (0.2) kcal/kg/day for males in the Sector 6 (educational service). Among industrial sectors, the average daily energy expenditure was estimated higher among males than females except in Sector 5 (other services except public administration). These differences in the mean daily energy expenditure between the industrial sectors were not statistically significant for males and females (Table 4.2.1).

Overall respondent average daily energy expenditure was generally higher in males than females, in all the occupational categories except for trades, transport and equipment operators and related occupations and occupations in natural and applied sciences and related occupations (Table 4.2.2). The overall differences in estimated average daily energy expenditure for males between occupational categories was statistically significant ($p < 0.01$).

4.2.5 Distribution of Total Personal Annual Income

Among the industrial sectors, slightly over 70 percent of the respondents in the Sector 3 (arts, entertainment and recreation/accommodation and food services) reported that the total personal annual income was below 30K (Table 4.2.1). It was the highest proportion of respondents with lowest total personal annual income among all the industrial sectors. The second highest (51%) was observed in the Sector 5 (other services except public administration) and it was followed by the respondents in Sector 8 (whole sale trades/retail trade/transportation and warehousing) with 50% reporting the total personal annual income being below 30K. The lowest proportion (13%) of the respondents who reported the total personal annual income below 30K was in the Sector 4 (public administration). In more than half of the industrial sectors, the majority of the respondents reported that their total personal annual income was below 30K. Interestingly in the Sector 6 (educational services), the proportion of respondents who reported their total personal annual income below 30K, 30K-50K and 50K-80K were similar (27%) with the rest of the respondents (18%) reporting a total personal annual income of above 80K. The highest proportion of total personal annual income of above 80K (29%) was reported in the Sector 2 (professional scientific and technical services) and the lowest proportion of total personal annual income of above 80K (1.7%) was reported in Sector 3 (arts, entertainment and recreation/accommodation and food services). Overall differences in the total personal annual income categories between the industrial sectors were statistically significant ($p < 0.001$).

As shown in Table 4.2.2, the highest proportion (64%) of the respondents with a total annual personal income less than 30K was in sales and service occupations and the lowest proportion of the respondents with a total annual personal income less than 30K was in natural and applied sciences and related occupations. Twenty-eight percent of the respondents in management occupations and the respondents in natural and applied sciences and related occupations reported the total personal annual income above 80K. The differences between the proportions among the occupational categories achieved the statistical significance ($p < 0.001$).

4.2.6 Distribution of Smoking

As shown in Table 4.2.1 and Table 4.2.2, among all the industrial sectors and all the broad occupational categories, the proportions of never smokers were higher than the proportions of former smokers and current smokers. The proportion of never smokers was the lowest among the respondents in occupations in construction industry. As seen in Table 4.2, the proportion of current smokers was the highest (36%) in the Sector 9 (construction) and lowest (12%) in the Sector 2 (professional scientific and technical services). In Sector 7 (health care and social assistance industry and Sector 11 (agriculture, forestry, fishing and hunting/mining, oil and gas extraction/ utilities), the proportion of never smokers was similar (19%).

The highest proportion of current smokers (31%) was in the occupations in trades, transport and equipment operators and related occupations (Table 4.2.2). The lowest proportion (12%) was in the occupations in social science, education, government service and religion. In health occupations, there was a large proportion of non-smokers (59.0%). The overall differences in the proportions of smoking categories between the broad occupational categories were statically significant.

Table 4.2.1 Characteristics of employed participants by industrial sectors: Adolescents and adults aged 15-75 years (CHMS-Cycles 1 & 2) *

	Recoded Industrial Sectors											
	Sector1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Sector 9	Sector 10	Sector 11	p-value †
Age groups, years (%)												
15-20	7.9	1.5	29.0	3.0	13.0	6.4	3.6	14.0	5.6	5.3	7.0	
21-60	85.0	88.0	66.0	91.0	81.0	87.0	89.0	78.0	86.0	89.0	80.0	**<0.001**
61-75	7.2	11.0	5.7	6.4	7.0	6.6	7.8	8.2	8.7	5.6	13.0	
Sex (%)												
Males	55.0	61.0	43.0	47.0	41.0	37.0	20.0	59.0	91.0	73.0	69.0	**<0.001**
Females	45.0	39.0	57.0	53.0	59.0	63.0	80.0	41.0	9.0	27.0	31.0	
Ethnicity (%)												
Caucasian	76.0	77.0	74.0	93.0	77.0	86.0	83.0	78.0	87.0	74.0	89.0	
Non Caucasians	24.0	23.0	26.0	7.0	23.0	14.0	17.0	22.0	13.0	26.0	11.0	**< 0.01**
Region (%)												
Atlantic	9.0	6.0	5.6	8.4	9.1	6.0	9.8	6.7	6.6	3.7	6.7	
Quebec	20.0	27.0	21.0	28.0	24.0	20.0	19.0	23.0	22.0	27.0	25.0	
Ontario	44.0	35.0	40.0	40.0	35.0	44.0	38.0	37.0	39.0	43.0	26.0	NC
Prairies	16.0	15.0	21.0	18.0	15.0	17.0	20.0	18.0	23.0	14.0	28.0	
British Columbia	12.0	17.0	12.0	6.0	17.0	13.0	13.0	15.0	9.8	13.0	14.0	
Highest Level of Education (%)												
>Secondary/secondary	26.1	5.7	43.0	17.4	29.0	8.6	13.8	42.0	35.5	35.0	41.0	
Some post-secondary	6.7	7.1	19.0	7.1	14.0	6.6	9.7	14.5	11.0	08.3	13.0	**<0.001**
Post-secondary	67.0	87.0	37.0	76.0	57.0	85.0	77.0	43.5	53.5	57.0	46.0	
Total Personal income (%)												
<30 K	40.0	17.0	71.0	13.0	51.0	27.0	34.0	50.0	27.0	25.0	29.0	
30K-50K	23.0	26.0	20.0	23.0	35.0	27.0	31.0	23.0	32.0	29.0	23.0	
50K- 80K	22.0	27.0	07.4	39.0	11.0	27.0	24.0	17.0	30.0	29.0	22.0	**<0.001**
>80K	15.0	29.0	1.7	25.0	3.0	18.0	12.0	9.1	11.0	16.0	26.0	

Self-rated Health (%)												
Fair/poor	6.5	5.9	8.5	4.3	6.7	4.3	8.6	9.7	7.0	9.7	6.1	0.09
Good	32.0	32.0	38.0	35.0	37.0	26.0	33.0	40.0	39.0	41.0	38.0	
Very good/excellent	61.0	62.0	53.0	60.0	56.0	69.0	59.0	50.0	54.0	49.0	56.0	
Smoking status (%)												
Never	52.0	61.0	52.0	50.0	47.0	66.0	56.0	49.0	38.0	53.0	56.0	**<0.01**
Former smoker	28.0	27.0	20.0	35.0	33.0	22.0	26.0	27.0	26.0	26.0	25.0	
Current smoker	21.0	12.0	27.0	16.0	20.0	11.0	19.0	24.0	36.0	21.0	19.0	
Onset of asthma (%)												
No Asthma	92.0	90.0	89.0	92.0	91.0	95.0	94.0	93.0		93.0		
Early onset (<15 years)	5.0	3.1	5.5	1.7	4.7	1.9	2.1	5.0		2.7		0.24
Late onset	2.9	6.6	5.1	6.7	4.0	3.0	4.2	2.3		4.0		
Age, years												
Male mean (se)	38.9(0.9)	43.2(1.1)	34.9(1.4)	44.8(1.4)	41.6(1.8)	40.9(1.6)	43.6(2.1)	37.6(0.7)	39.9(1.1)	41.4(1 .8)	43.7(1.8)	< 0.01
Female mean (se)	40.3(1.0	40.5(1.7)	32.6(1.2)	46.2(1.0)	33.3(1.9)	41.7(1.0)	42.3(1.1)	38.4(0.9)	42.8(2.3)	43.7(1.1)	43.0 (2.6)	**<0.001**
Weight, (kg)												
Male mean (se)	83.9(1.4)	84.8(1.6)	81.4(1.1)	86.3(2.0)	83.3(2.1)	85.4(2.5)	84.5(2.3)	83.1(1.1)	85.3(1.3)	84.6(1.7)	88.3(3.0)	0.32
Female mean (se)	69.0(1.3)	69.3(2.7)	65.6(1.0)	76.0(2.0)	73.6(2.9)	68.3(1.5)	71.0(1.2)	72.4(2.0)	72.0(4.1)	69.2(2.7)	69.3(2.0)	**<0.01**
Height (cm)												
Male mean (se)	175.8(0.6)	176.4(0.6)	175.4(0.8)	176.4(0.4)	173.4(1.0)	177.6(1.0)	176.4(1.1)	175.7(0.4)	175.1(0.7)	175.3(0.8)	177.4(0.9)	0.47
Female mean (se)	162.3(0.7)	161.7(1.1)	163.0(0.7)	163.4(0.8)	163.6(1.1)	163.4(0.6)	163.4(0.5)	163.20.5)	161.7(1.0)	161.1(0.9)	160.2(1.4)	0.46
BMI (kg/m2)												
Male mean(se)	27.1(0.4)	27.2(0.5)	26.4(0.5)	27.7(0.7)	27.6(0.6)	27.0(0.7)	27.1(0.7)	26.9(0.3)	27.7(0.4)	27.4(0.4)	28.0(0.9)	0.49
Female mean(se)	26.2(0.6)	26.4(0.9)	24.7(0.4)	28.4(0.6)	27.6(1.1)	27.6(0.5)	26.6(0.5)	27.1(0.6)	27.5(1.6)	26.5(0.8)	27.0(0.7)	0.03

Daily energy expenditure (kcal/kg/day)												
Male mean (se)	2.2(0.2)	2.3(0.1)	2.6(0.3)	2.4(0.2)	1.9(0.2)	2.9(0.2)	2.4(0.4)	1.7(0.1)	1.9(0.2)	1.9(0.3)	1.5(0.2)	0.02
Female mean(se)	1.6(0.1)	1.7(0.1)	1.8(0.1)	1.9(0.3)	2.0(0.2)	2.2(0.1)	1.7(0.2)	1.6(0.1)	1.8(0.3)	1.6(0.2)	1.8(0.3)	0.21

[*]Survey design weights and 500 bootstrap weights were used in calculating percentages, mean values, and standard errors (SE)
Sector1: Information, Cultural Industries/Finance, Insurance/Real Estate and Rental Leasing/Management of Companies& Enterprises/Administrative and Support, Waste Management and Remediation Services; **Sector 2:** Professional Scientific and Technical Services**; Sector 3:** Arts, Entertainment and Recreation/Accommodation and Food Services; **Sector 4:** Public Administration; **Sector 5:** Other Services except Public Administration; **Sector 6:** Educational Service; **Sector 7:** Health Care and Social Assistance; **Sector 8:** Whole sale Trades/Retail trade/Transportation and Warehousing; **Sector 9:** Constructions; **Sector 10:** Manufacturing; **Sector 11**: Agriculture, Forestry, Fishing and Hunting/Mining, Oil and Gas Extraction/ Utilities.
Statistically significant difference in percentages/mean values at least in one industrial sector among 11 industrial sectors $p<0.01$, [†]$p<0.001$ from chi-squared test for categorical variables and from the multiple linear regression analysis for differences in the sex-specific means of continuous variable.
NC: p-value was not calculated because the degrees of freedom of 40 for the cross-tabulations was greater than the maximum number of degrees of freedom of 24 allowed in the analysis using merged CHMS-Cycle 1 and CHMS-Cycle 2 databases

Table 4.2.2 Characteristics of employed participant by broad occupational categories: Adolescents and adults aged 15-75 years (CHMS-Cycle 1 & 2) *

	Broad occupational Categories									
Characteristics	Management occupations	Business, finance & administrative occupations	Natural and applied sciences and related occupations	Health occupations	Occupations in Social science, education, government service and religion	Occupations in art, culture, recreation and Sport	Sales and service occupations	Trades, transport and equipment operators and related occupations	Occupations unique to primary industry and occupations unique to processing, manufacturing and utilities	p-value†
Age(years) (%)										
15-20		5.5	1.7		2.8	15.0	24.0	5.1	13.0	
21-60	**	87.0	93.0	**	91.0	79.0	69.0	86.0	77.0	**<0.001**
61-75		7.0	5.6		6.2	6.0	6.4	8.8	9.6	
Sex (%)										
Males	67.0	34.0	79.0	18.0	36.0	49.0	43.0	93.0	76.0	**<0.001**
Females	33.0	66.0	21.0	82.0	64.0	51.0	57.0	7.0	24.6	
Ethnicity (%)										
Caucasian	80.0	80.0	72.0	80.0	86.0	89.0	76.0	83.0	81.0	**< 0.05**
Other than Caucasians	20.0	20.0	28.0	20.0	14.0	11.0	24.0	17.0	19.0	
Region (%)										
Atlantic	6.6	7.6	8.1	8.7	7.1	6.7	7.3	6.0	4.7	
Quebec	27.0	22.0	24.0	18.0	18.0	19.0	22.0	28.0	25.0	
Ontario	39.0	37.0	39.0	40.0	46.0	39.0	42.0	32.0	40.0	0.75
Prairies	15.0	19.0	16.0	20.0	18.0	16.0	19.0	21.0	15.0	
British Columbia	13.0	15.0	13.0	13.0	11.0	19.0	10.0	14.0	15.0	
Highest Level of education (%)										
<Secondary/secondary	26	24.5	5.5	9.3	4.8	11.5	41.0	47.0	48.0	
Some post-secondary	3.9	1.1	4.9	6.3	4.5	18.0	17.0	9.8	12.0	**<0.001**
Post-secondary	71.0	64.0	90.0	84.0	91.0	70.0	42.0	44.0	40.0	
Total Personal income (%)										
<30 K	21.0	34.0	11.0	28.0	25.0	47.0	64.0	29.0	43.0	
30K<50K	24.0	33.0	24.0	32.0	24.0	25.0	19.0	30.0	24.0	
50k- 80k	26.0	21.0	37.0	25.0	29.0	22.0	11.0	28.0	23.0	**<0.001**
>80K	28.0	12.0	28.0	15.0	23.0	6.5	5.8	12.0	9.8	

Self-rated Health (%)										
Fair/poor	6.8	6.9	4.7	4.8	5.6	4.7	10.0	9.3	7.0	
Good	35.0	35.0	33.0	33.0	26.0	24.0	39.0	40.0	43.0	**0.01**
Very good/excellent	58.0	58.0	63.0	62.0	68.0	72.0	51.0	50.0	50.0	
Smoking status (%)										
Never smoker	46.0	54.0	57.0	59.0	61.0	54.0	54.0	40.0	50.0	**<0.001**
Former smoker	32.0	29.0	26.0	25.0	27.0	28.0	22.0	29.0	26.0	
Current smoker	22.0	17.0	17.0	16.0	12.0	18.0	24.0	31.0	24.0	
Onset of asthma before 15 years (%)										
No asthma	93.0	93.0	89.0	**	96.0	90.0	91.0	94.0	**	
Yes	4.1	3.6	4.2		1.6	2.9	5.6	3.5		0.02
No	2.7	3.5	7.1		2.7	7.0	3.9	3.0		
Age, years										
Male										
mean(se)	45.5 (0.1)	40.5 (1.1)	39.8 (0.9)	43.1 (2.6)	44.1 (1.5)	40.8 (1.8)	35.6 (1.0)	40.4 (1.0)	38.8 (1.4)	**<0.001**
Female										
mean(se)	46.1 (1.2)	42.6 (0. 8)	39.8 (2.0)	41.9 (1.6)	41.5 (1.0)	38.7 (2.0)	34.9 (0.6)	33.8 (4.8)	42.9 (2.3)	**<0.001**
Weight, (kg)										
Male										
mean (se)	89.8(1.6)	84.3 (1.3)	84.1(1.5)	82.7 (3.6)	85.3 (2.1)	86.2 (1.9)	81.1 (1.3)	84.2 (1.2)	84.4 (2.2)	0.04
Female										
mean (se)	70.2 (1.1)	71.5 (1.1)	68.7 (1.4)	70.2 (1.4)	70.7 (1.9)	67.3 (2.0)	69.4 (1.4)	71.0 (3.1)	68.9 (4.4)	0.90
Height (cm)										
Male										
mean (se)	176.1(0.6)	176.2 (0.8)	175.2 (0.4)	174.9 (1.4)	176.7 (0.7)	179.0 (1.0)	175.8 (0.4)	174.8 (0.5)	176.4 (0.8)	0.05
Female										
mean (se)	163.4 (0.6)	161.8 (0.3)	162.7 (0.9)	163.6 (0.6)	163.7 (0.4)	164.0 (0.7)	162.8 (0.6)	165.3(2.2)	161.0 (1.3)	0.02
BMI (kg/m^2)										
Male										
mean (se)	28.9 (0.5)	27.1 (0.4)	27.4 (0.5)	27.0 (0.9)	27.2 (0.6)	26.9 (0.8)	26.3 (0.4)	27.5 (0.4)	27.1 (0.6)	0.07
Female										
mean (se)	26.3 (0.4)	27.2 (0.4)	26.0 (0.5)	26.2 (0.5)	26.4 (0.7)	25.1 (0.8)	26.1 (0.4)	25.9(0.9)	26.3 (1.4)	0.47
Daily energy expenditure kcal/kg /Day										
Male†										
mean (se)	1.9 (0.2)	2.1 (0.1)	2.0 (0.1)	2.2 (0.6)	2.6 (0.2)	2.7 (0.3)	2.4 (0.2)	1.7 (0.1)	2.1(0.3)	<0.01
Female										
mean (se)	1.8 (0.2)	1.6 (0.1)	2.0 (0.1)	1.7 (0.2)	2.0 (0.1)	2.2 (0.2)	1.7 (0.1)	2.5 (0.7)	1.4 (0.3)	0.19

*Survey design weights and 500 bootstrap weights were used in calculating percentages, mean values, and standard errors (SE)
**Some cells of the table were suppressed to be compliant with the Statistic Canada data confidential guideline
ǂp<0.001 from chi-squared test for categorical variables and from the multiple linear regression analysis for differences in the sex-specific means of continuous variable

4.3 Distribution of Respiratory Health Outcomes by Industrial Sectors and Occupational Categories

The prevalence of ever asthma was 13% in the industrial Sector 11(agriculture, forestry, fishing and hunting/mining, oil and gas extraction/ utilities), which was the highest prevalence observed among the industrial sectors. It was followed by the industrial Sector 3 (arts, entertainment and recreation/accommodation and food services) with the prevalence of ever asthma of 11%. The lowest prevalence of ever asthma (6.3%) was observed the industrial Sector 6 (educational services). The prevalence of ever asthma was 9.1% in the industrial Sector 9 (construction). After adjusting for smoking, the overall difference in the prevalence of ever asthma between the industrial sectors was not statistically significant.

Industrial specific prevalence of current asthma was suppressed to be compliant with the Statistic Canada confidential data publication guidelines. The overall prevalence of current asthma was 4.7% in employed respondents and 3.5 % in non-employed (See Table 4.1.4).

The highest prevalence of chronic cough (17%) and prevalence of cough with phlegm production was observed in the industrial Sector 9 (constructions industry). In the industrial Sector 7 (health care and social assistance), the prevalence of chronic cough was 6.9%, which was the lowest prevalence of chronic cough observed among the industrial sectors.

The prevalence of shortness of breath was the highest (8.9%) in the industrial Sector 5; (other services except public administration) and in the industrial Sector 8 (wholesale trades/retail trade/transportation and warehousing). After adjusting for smoking, there were no statistically significant differences in the prevalence of chronic cough, cough with phlegm production and shortness of breath between the industrial sectors.

As seen in Table 4.3.2, the group with the highest prevalence of ever asthma was in occupations unique to primary industry and occupations unique to processing, manufacturing and utilities (12.3%). In the natural and applied sciences and related occupations specific ever asthma prevalence was 11%. There was a statistically significant difference in the prevalence of cough with phlegm production between occupational categories after adjusting for smoking (Table 4.3.2). The prevalence was the highest (15%) in occupations unique to primary industry and occupations unique to processing, manufacturing and utilities and was (14%) was reported in trades, transport and equipment operators and related occupations. The prevalence of cough with phlegm production was the lowest in health care occupations. Among the occupational categories, a similar prevalence of chronic cough and cough and phlegm ($p<0.01$) were estimated in trades, transport and equipment operators and related occupations. The prevalence of shortness of breath prevalence was reported 8.9% in sales and service occupations, which was the highest among the broad occupational categories. In occupations unique to primary industry and occupations unique to processing, manufacturing and utilities, the prevalence of shortness of breath was 6.2%.

Table 4.3.1 Distribution of respiratory health outcomes by industrial sectors: Adolescents and adults aged 15-75 years (CHMS-Cycle 1 & 2)*

Recoded Industrial sector	Ever asthma (%)	Cough (%)	Cough with phlegm (%)	Shortness of breath (%)
Sector 1	7.9	12.0	6.0	6.2
Sector 2	9.7	13.0	10.0	4.3
Sector 3	11.0	15.0	8.0	4.5
Sector 4	8.5	7.6	4.9	4.4
Sector 5	8.7	12.0	8.3	8.9
Sector 6	4.8	6.9	5.6	4.6
Sector 7	6.3	13.0	7.7	6.2
Sector 8	7.3	15.0	9.8	8.9
Sector 9	9.1	17.0	15.0	8.6
Sector 10	6.7	13.0	14.0	4.8
Sector 11	13.0	**	8.8	7.0
p- value ⸸	0.84	0.60	0.31	0.33

***Sector1:** Information, Cultural Industries/Finance, Insurance/Real Estate and Rental Leasing/Management of Companies& Enterprises/Administrative and Support, Waste Management and Remediation Services; **Sector 2:** Professional Scientific and Technical Services**; Sector 3:** Arts, Entertainment and Recreation/Accommodation and Food Services; **Sector 4:** Public Administration; **Sector 5:** Other Services except Public Administration; **Sector 6:** Educational Service; **Sector 7:** Health Care and Social Assistance; **Sector 8:** Whole sale Trades/Retail trade/Transportation and Warehousing; **Sector 9:** Constructions; **Sector 10:** Manufacturing; **Sector 11:** Agriculture, Forestry, Fishing and Hunting/Mining, Oil and Gas Extraction/ Utilities.

**Prevalence was suppressed to be compliant with the Statistic Canada data confidential guideline

⸸ p-values for the differences between industrial sectors were obtained after controlling for smoking status using logistic regression analysis

**Prevalence was suppressed to be compliant with the Statistic Canada data confidential guidelines

Table 4.3.2 Prevalence respiratory health outcomes by broad occupational categories: Adolescents and adults aged 15 - 75 years (CHMS-Cycle 1 & 2) *

Occupational Categories (NOC-S)2001	Ever asthma %	Cough %	Cough with Phlegm %	Shortness of breath %
Management occupations	6.8	13.0	8.2	5.8
Business, finance and administrative occupations	7.0	13.0	7.5	6.4
Natural and applied sciences and related occupations	11.0	11.0	9.3	5.6
Health occupations	6.2	9.8	2.4	2.9
Occupations in social science, education, Government service and religion	4.3	10.0	6.2	4.2
Occupations in art, culture, recreation and sport	9.9	**	8.6	3.0
Sales and service occupations	9.5	14.0	8.3	8.9
Trades, transport and equipment operators and related occupations	6.5	14.0	14.0	6.5
Occupations unique to primary industry and occupations unique to processing, manufacturing and utilities	12.3	**	15.0	6.2
p-value	0.04†	0.45†	<0.01†	0.49†

*Survey design weights and 500 bootstrap weights were used in calculating the percentages

† p value adjusted for smoking. Among the respiratory health variables evaluated, chronic bronchitis, current asthma and COPD are suppressed to be compliant with the Static Canada publication guidelines.

**Prevalence was suppressed to be compliant with the Statistic Canada data confidential guidelines

4.4 Distribution of Percent-predicted Lung Function Parameters by Industrial Sectors and among Occupational Categories

As shown in Table 4.4.1, there were no statistically significant overall differences between the industry specific means of percent-predicted FVC, FEV_1, and FEV_1/FVC ratio after adjusting for smoking. The mean percent-predicted FEV_1 in the Sector 2 (professional scientific and technical services) and Sector 9 (constructions industry) was greater than that in the referent category (Sector 1) by 1.75% and 0.51%, respectively. Those differences did not achieve statistical significance. In all other industrial sectors, mean percent-predicted FEV_1 was less than that observed in the referent category with the differences being less than 3%. The mean percent-predicted FVC in the industrial Sector 2 (professional scientific and technical services), Sector 5 (other services except public administration), Sector 6 (educational service) and Sector 9 (constructions) were greater than that observed in the referent category (Table 4.4.1). The differences between the referent sector and other industrial sectors were less than 3% and none of the differences was statistical significant. The mean percent-predicted FEV_1/FVC ratio in Sector 2 (professional scientific and technical services) and Sector 11 (agriculture, forestry, fishing and hunting/mining, oil and gas extraction/ utilities) was greater than that observed in the referent category with the differences being statistically non-significant. In other sectors, the mean percent-predicted FEV_1/FVC was less than that observed in the referent category with the differences being less than 1.5% (Table 4.4.1).

As shown in Table 4.4.2, after controlling for smoking, none of the differences in the mean percent-predicted lung function parameters between the referent category (management category) and other occupational groups was statistically significant except for the health occupations. Among the occupational groups, occupations unique to primary industry &

occupations unique to processing, manufacturing and utilities had a lower mean percent-predicted FEV_1 in comparison to the referent category. In comparison to the referent category, the greatest difference in the percent-predicted FEV_1 was observed in health occupations.

In all occupational groups, mean percent-predicted FVC was greater than that observed in the referent category. As shown in Table 4.4.2, the greatest difference (3.92%) was in health care occupations. In the occupations in art, culture, recreation and sports, mean percent-predicted FVC was 2.37% greater compared to the referent category.

Except in two broad occupational groups, in other occupational groups, mean percent FEV_1 /FVC ratio was less than the referent category (Table 4.4.2). The two occupational groups that had higher mean percent-predicted FEV_1/FVC were business, finance and administrative occupations (0.14%) and natural and applied sciences and related occupations (0.36%). Other occupational categories reported lower values for mean percent-predicted FEV_1/FVC compared to the referent category and none of them achieved statistical significance after adjusting for smoking.

Table 4.4.1 Differences in percent-predicted lung function parameters between industrial sectors: Results from the multiple linear regression analysis. (CHMS-Cycles 1 & 2)

Industrial Sectors	FEV_1 Percent predicted Beta coefficient (se)**	p-value	FVC Percent predicted Beta coefficient (se)**	p-value	FEV_1 /FVC Percent predicted Beta coefficient (se)**	p-value
Sector 1	Referent sector		Referent sector		Referent sector	
Sector 2	1.75 (1.32)	0.19	1.15 (1.36)	0.40	0.91 (0.65)	0.18
Sector 3	-1.56 (0.93)	0.10	-0.62 (1.00)	0.54	-0.69 (0.72)	0.35
Sector 4	-2.39 (1.79)	0.19	-2.51 (1.68)	0.15	-0.19 (0.72)	0.80
Sector 5	-0.73 (1.67)	0.67	0.53 (1.59)	0.75	-0.76 (0.96)	0.44
Sector 6	-0.55 (1.18)	0.65	0.60 (0.85)	0.75	-1.15 (0.76)	0.15
Sector 7	-0.89 (1.42)	0.53	-0.07 (1.40)	0.96	-0.91(0.63)	0.17
Sector 8	-1.39 (0.89)	0.13	-0.90 (0.75)	0.24	-0.29 (0.58)	0.62
Sector 9	0.51 (1.36)	0.97	1.10(1.10)	0.32	-0.87 (0.75)	0.26
Sector 10	-0.59 (1.33)	0.66	-0.49 (0.93)	0.61	-0.04 (0.75)	0.96
Sector 11	-1.07 (1.25)	0.40	-1.16 (1.35)	0.40	0.33 (1.14)	0.78
p-value Ϯ		0.36		0.17		0.43

***Sector1:** Information, Cultural Industries/Finance, Insurance/Real Estate and Rental Leasing/Management of Companies& Enterprises/Administrative and Support, Waste Management and Remediation Services; **Sector 2:** Professional Scientific and Technical Services**; Sector 3:** Arts, Entertainment and Recreation/Accommodation and Food Services; **Sector 4:** Public Administration; **Sector 5:** Other Services except Public Administration; **Sector 6:** Educational Service; **Sector 7:** Health Care and Social Assistance; **Sector 8:** Whole sale Trades/Retail trade/Transportation and Warehousing; **Sector 9:** Constructions; **Sector 10:** Manufacturing; **Sector 11:** Agriculture, Forestry, Fishing and Hunting/Mining, Oil and Gas Extraction/ Utilities.

**Survey design weights and bootstrap weights were included in estimating β coefficients and standard errors (se); Beta = regression coefficient in the multiple regression analysis

Ϯ p-values were obtained from multiple linear regression analysis after controlling for smoking status.

Table 4.4.2 Differences in percent predicted lung function parameters between broad occupational categories: Results from simple linear regression analysis (CHMS-Cycles1 & 2)

Broad occupational Category	FEV_1 Percent predicted Beta coefficient (se)*	p-value	FVC Percent predicted Beta coefficient (se)*	p-value	FEV_1/FVC Percent predicted Beta coefficient (se)*	p-value ŧ
Management occupations	Referent category		Referent category		Referent category	
Business, finance and administrative occupations	1.03 (1.32)	0.44	0.65 (0.83)	0.44	0.14 (0.85)	0.87
Natural and applied sciences and related occupations	1.95 (1.22)	0.12	1.87 (1.08)	0.10	0.36 (0.97)	0.71
Health occupations	3.64 (1.74)	0.05	3.92 (1.46)	0.01	-0.17 (1.20)	0.89
Occupations in social science, education, government service and religion	0.60 (1.61)	0.71	1.32 (1.09)	0.24	-0.79 (0.99)	0.43
Occupations in Art, culture, recreation and sport	1.50 (2.05)	0.47	2.37 (1.39)	0.10	-0.78 (1.28)	0.55
Sales and service occupations	1.04 (1.08)	0.34	1.43 (0.86)	0.11	-0.15 (0.70)	0.83
Trades, transport and equipment operators and related occupations	1.13 (1.51)	0.46	1.45 (1.20)	0.24	-0.07 (0.75)	0.93
Occupations unique to primary industry &occupations unique to processing, manufacturing and utilities	-0.65 (1.37)	0.64	0.37 (1.33)	0.78	-0.96 (0.79)	0.23
p-value ŧ		0.36		0.14		0.22

* Survey design weights and bootstrap weights were included in estimating β coefficients and standard errors (se); Beta (β) = regression coefficient in the multiple regression analysis

ŧ p-values were obtained from multiple linear regression analysis after controlling for smoking status

4.5 Association between Industrial Sectors and Occupational Categories and Current Asthma and Ever Asthma

Associations between the different industrial sectors with current asthma and ever asthma are shown in Table 4.5.1. After adjusting for age, sex, ethnicity, BMI, daily energy expenditure smoking status and family history of asthma, relative to the Sector 1 (information, Cultural Industries/Finance, Insurance/Real Estate and Rental Leasing/Management of Companies& Enterprises/Administrative and Support, Waste Management and Remediation Services), higher adjusted ORs for current asthma were seen for Sectors 2, 3, 4, 5, 6, 8, 9 and 10. A statistically significant reduced risk [OR: 0.3; 95% CI: 0.1, 1.0); p=0.05] for current asthma was observed for Sector 11 in comparison to the referent category. Estimated ORs of ever asthma for industrial Sectors 5, 6, 7 and 8 were lower when compared to the referent category after adjusting for age, sex, ethnicity, BMI, daily energy expenditure, smoking status, and family history of asthma. None of the associations other than that between current asthma and Sector 11 was statistically significant (Table 4.5.1).

As seen in Table 4.5.2, none of the associations between occupation groups and current asthma or ever asthma were statically significant except for the association between natural and applied science related occupations and ever asthma [OR: 2.1; (95% CI: 1.0, 4.5), p=0.05]. A reduced risk of ever asthma and health occupations and occupations in social sciences, education, government service and region were observed after adjusting to age, sex, ethnicity BMI, daily energy expenditure. None of the adjusted occupation specific associations with current asthma was statistically significant.

Table 4.5.1 Association between industrial sectors and current/ever asthma: Results from the multiple logistic regressions (CHMS-Cycles 1 & 2)

	Current Asthma		Ever Asthma	
Factor	Odds ratio (95% CI)*	p-value	Odds ratio (95% CI)*	p-value †
Recoded Industrial Sector				
Sector 1	1.0		1.0	
Sector 2	1.4 (0.7, 3.0)	0.33	1.4 (0.7, 2.9)	0.36
Sector 3	1.4 (0.5, 3.8)	0.55	1.2 (0.5, 2.9)	0.60
Sector 4	1.7 (0.6, 4.7)	0.34	1.2 (0.5, 3.0)	0.63
Sector 5	1.2 (0.4, 3.9)	0.74	0.9 (0.4, 2.1)	0.81
Sector 6	1.4 (0.4, 5.1)	0.61	0.6 (0.3, 1.1)	0.10
Sector 7	0.9 (0.4, 2.0)	0.85	0.8 (0.4, 1.6)	0.48
Sector 8	1.1 (0.5, 2.1)	0.85	0.9 (0.6, 1.6)	0.79
Sector 9	1.6 (0.5, 4.8)	0.40	1.4 (0.6, 3.1)	0.41
Sector 10	1.1 (0.3, 4.4)	0.93	1.0 (0.4, 2.3)	0.98
Sector 11	0.3 (0.1, 1.0)	0.05	1.6 (0.5, 5.0)	0.39
Age	0.99 (0.98, 1.00)	0.34	1 (0.97, 1.0)	0.87
Sex				
Male	1.0		1.00	
Female	1.2 (0.8, 1.9)	0.25	1.2 (0.9, 1.5)	0.27
Ethnicity				
Caucasians	1.0	0.25	1.0	0.37
Other than Caucasians	1.3 (0.8, 2.2)		1.2 (0.8, 1.7)	
BMI Kg/height^2	1.0 (0.9, 1.1)	0.07	1.0 (0.90, 1.1)	0.11
Daily energy expenditure (kcal/kg per hour)/365)	1.1 (1.0, 1.2)	0.05	1.1 (1.0, 1.2)	0.01
Smoking status				
Never smoker	1.00		1.0	
Former smoker	1.2 (0.7, 2.0)	0.49	1.1 (0.7, 1.6)	0.78
Current smoker	1.1 (0.6, 1.9)	0.74	1.1(0.7, 1.7)	0.63
Family history of asthma				
No	1.00		1.00	
Yes	4.0 (2.6, 6.1)	<0.001	4.3 (3.2, 5.8)	<0.001

***Sector1:** Information, Cultural Industries/Finance, Insurance/Real Estate and Rental Leasing/Management of Companies& Enterprises/Administrative and Support, Waste Management and Remediation Services; **Sector 2:** Professional Scientific and Technical Services**; Sector 3:** Arts, Entertainment and Recreation/Accommodation and Food Services; **Sector 4:** Public Administration; **Sector 5:** Other Services except Public Administration; **Sector 6:** Educational Service; **Sector 7:** Health Care and Social Assistance; **Sector 8:** Whole sale Trades/Retail trade/Transportation and Warehousing; **Sector 9:** Constructions; **Sector 10:** Manufacturing; **Sector 11:** Agriculture, Forestry, Fishing and Hunting/Mining, Oil and Gas Extraction/ Utilities. Survey design weights and bootstrap 500 weights were included in calculating percentages and 95% CI

† p-values were obtained from the multiple logistic regression analysis after controlling for age, sex, ethnicity, BMI, daily energy expenditure smoking status and family history of asthma.

Table 4.5.2 Association between broad occupational categories and current /ever asthma: Results from the multiple logistic regressions. (CHMS-Cycles 1 & 2)

	Current Asthma		Ever Asthma	
Factors	Odds ratio (95%CI)*	p-value	Odds ratio (95%CI)*	p- value †
Broad occupational category				
Management occupations	Referent category		Referent category	
Business, finance and administrative occupations	1.4 (0.6, 3.4)	0.39	1.2 (0.7, 2.2)	0.56
Natural and applied science related occupations	1.3 (0.5,3.0)	0.55	2.1 (1.0, 4.5)	0.05
Health occupations	1.2 (0.3, 5.0)	0.80	0.9 (0.3, 3.0)	0.89
Occupations in social sciences, education, government service and religion	1.5 (0.3, 6.9)	0.56	0.7 (0.3, 1.5)	0.34
Occupations in art, culture, recreation and sport	2.3 (0.6, 9.1)	0.21	1.8 (0.8, 3.9)	0.16
Sales and service occupations	1.8 (0.8, 4.1)	0.16	1.3 (0.7, 2.6)	0.39
Trades, transport, equipment operators and related occupations	1.3 (0.4, 4.1)	0.60	1.1 (0.4, 2.7)	0.84
Occupations unique to primary industry, processing, manufacturing & utilities	1.2 (0.2, 6.6)	0.82	2.1 (0.9, 5.0)	0.09
Age	0.99 (0.98, 1.0)	0.52	0.99 (0.98, 1.0)	0.13
Sex				
Male	1		1.00	
Female	1.2 (0.8, 1.8)	0.44	1.2 (0.9, 1.5)	0.23
Ethnicity				
Caucasians	1.00		1.00	
Other than Caucasians	1.3 (0.8, 2.3)	0.26	1.1 (0.8, -1.6)	0.46
BMI Kg/height^2	1.0 (0.9, 1.1)	0.08	1.0 (0.99, 1.1)	0.11
Daily energy expenditure (kcal/kg per hour)/365)	1.1 (1.0, 1.2)	0.04	1.1 (1.0, 1.2)	0.01
Smoking status				
Never smoker	1.0		1.0	
Former smoker	1.2 (0.7, 2.1)	0.44	1.1 (0.7, 1.6)	0.74
Current smoker	1.1 (0.6, 1.9)	0.74	1.1 (0.7, 1.76)	0.64
Family history of asthma				
No	1.0		1.0	
Yes	3.9 (2.6, 6.1)	<0.001	4.29 (3.1, 5.9)	<0.001

* Survey design weights and bootstrap 500 weights were included in calculating percentages and 95% CI

† Associations were characterized by the multiple logistic regression analysis after controlling for age, sex, ethnicity, BMI, daily energy expenditure smoking status and family history of asthma

4.6 Association between Lung Function Parameters and Industrial Sectors and Occupational Categories

Association between lung function parameters and the industrial sectors was determined using multiple linear regression analyses after controlling for the confounders (age, sex, ethnicity, height, weight, daily energy expenditure, region and smoking status) and the results are shown in Table 4.6.1.

As shown in Table 4.6.1, the mean values of FVC and FEV_1 in Sector 3 (arts, entertainment and recreation/accommodation and food services) was significantly lower than those in the referent category (Sector 1) after adjusting for the confounders (difference in FVC: -0.18L, $p<0.01$; difference in FEV_1, $p<0.001$). Similarly, the mean value of FVC in Sector 8 (whole sale trades / retail trade /transportation and warehousing) was less than that in the referent category (Sector 1) after controlling the confounders (difference: -0.15; $p <0.05$).

Table 4.6.2 depicts the association between lung function parameters and occupational categories after controlling for the confounders. The mean value of FVC for sales and service occupations, occupations unique to primary industry and occupations unique to processing, manufacturing and utilities was lower than that for the referent category (management occupations) with the difference being statistically non-significant. None of the differences between occupation group-specific mean values of FVC, FEV_1, FEV_1 /FVC (%) and $FEF_{25\%-75\%}$ and the referent category were not statistically significant (Table 4.6.2).

Table 4.6.1 Association between lung functions and Industrial sectors: Results from the multiple linear regression of lung function parameters (CHMS-Cycles 1 & 2)

	FVC (L)		FEV_1 (L)		FEV1/FVC (%)		$FEF_{25\%-75\%}$ (L/S)	
	Beta (95%CI)*	p- value	Beta (95%CI)*	p-value	Beta (95%CI)*	p-value	Beta (95%CI)*	p-value
Industrial sector (recoded)								
Sector 1	Referent sector		Referent sector		Referent sector		Referent sector	
Sector 2	0.07 (-0. 05, 0.19)	0.25	0.05 (-0.05,0.15)	0.27	0.004 (-0.004, 0.01)	0.32	0.22 (0.04, 0.41)	0.02
Sector 3	-0.18 (-0.28, -0.07)	**<0.01**	-0.15 (-0.23,- 0.6)	**<0.01**	-0.001 (-0.01, 0.01)	0.74	-0.03 (-0.26, 0.19)	0.76
Sector 4	-0.04 (-0.17, 0.10)	0.59	- 0.03 (-0.14, 0.09)	0.64	0.002 (-0.009, 0.1)	0.76	0.09 (-0.11, 0.28)	0.39
Sector 5	0.04 (-0.04, 0.09)	0.48	- 0.05 (-0.1, 0.04)	0.23	-0.005 (-0.02, 0.01)	0.55	0.03 (-0.18, 0.23)	0.81
Sector 6	-0.03 (-0.04, 0.09)	0.43	- 0.03 (-0.10, 0.05)	0.47	-0.009 (-0.02, 0.001)	0.83	-0.03 (-0.22, 0.16)	0.74
Sector 7	- 0.04 (0.16, 0.7)	0.45	- 0.05(-0.14, 0.04)	0.23	-0.002 (-0.01, 0.01)	0.64	0.05 (-0.09, 0.19)	0.50
Sector 8	-0.08 (-0.15, 0.0003)	**0.05**	- 0.06 (-0.14, 0.01)	0.09	-0.0004 (-0.009, 0.008)	0.91	0.05 (-0.13, 0.22)	0.56
Sector 9	0.12 (0.0001, 0.23)	0.05	0.06 (-0.04, 0.16)	0.28	- 0.006 (-0.01, 0.01)	0.29	0.12 (-0.04, 0.27)	0.14
Sector 10	0.01 (-0.08, 0.11)	0.81	-0.01 (-0.12, 0.10)	0.84	- 0.001(-0.01, 0.01)	0.84	0.13 (-0.09, 0.36)	0.24
Sector 11	- 0.02 (-0.18, 0.15)	0.84	- 0.02 (-0.11, 0.08)	0.74	0.001 (-0.01, 0.02)	0.89	0.17 (-0.12, 0.46)	0.24
Age (years)	-0.02 (-0.02, -0.01)	<0.001	- 0.02 (-0.03, - 0.20)	<0.001	- 0.002(-0.002, 0.002)	<0.001	-0.04 (-0.04,-0.03)	<0.001
Sex								
Male	0	0	0		0		0	
Female	-0.60 (-0.64 ,-0.54)	<0.001	- 0.49 (-0.53, -0.44)	<0.001	-0.003 (-0.01, 0.004)	0.42	-0.44 (-0.57,-0.31)	<0.001
Ethnicity								
Caucasian	0	0	0	0	0		0	
Other than Caucasians	-0.41 (-0.48, -0.32)	<0.001	-0.27 (-0.34, 0.20)	<0.001	0.01 (0.006, 0.02)	0.002	-0.06 (-0.18, 0.06)	0.30

Height (cm)	0.06 (0.05, 0.06)	<0.001	0.04 (0.38, 0.04)	<0.001	-0.001 (-0.002, -0.001)	<0.001	0.02 (0.01, 0.02)	<0.001
Weight (kg)	-0.003 (- 0.01, -0.001)	<0.001	-0.002(-0.003, -0.001)	0.01	0.0001(-0.00003, 0.0003)	0.95	0.003 (0.0001, 0.01)	0.05
Daily energy expenditure (kcal/kg per hour)/365)	0.01 (-0.003, 0.03)	0.13	0.01 (0.003 ,0.03)	0.02	0.001 (- 0.0005,0.002)	0.17	0.007 (-0.01, 0.03)	0.50
Smoking status								
Never smoker	0		0	0	0	0	0	
Former smoker	0.04 (-0.02, 0.09)	0.18	- 0.02 (-0.06, 0.03)	0.41	- 0.01 (-0.02, -0.004)	0.01	- 0.07 (-0.20, 0.05)	0.24
Current smoker	0.02 (-0.03,- 0.08)	0.39	- 0.1 (- 0.18, -0.07)	<0.001	- 0.03 (-0.04, -0.03)	<0.001	-0.33 (-0.44, -0.22)	<0.001
Region								
Atlantic	0		0		0	0	0	
Quebec	-0.08 (-0.14, -0.02)	0.01	-0.10 (-0.15, -0.05)	<0.001	-0.009 (-0.02, 0.0003)	0.05	- 0.13 (-0.34, 0.08)	0.22
Ontario	-0.005 (-0.07, 0.08)	0.89	-0.01 (-0.06, 0.04)	0.73	-0.002 (-0.01, 0.004)	0.40	- 0.05 (-0.27, 0.17)	0.63
Prairies	0.03 (-0.05, 0.11)	0.45	-0.01 (-0.07, 0.04)	0.62	-0.006 (-0.01, 0.001)	0.08	- 0.03 (-0.25, 0.19)	0.77
British Colombia	0.07 (-0.03, -0.18)	0.18	0.04 (-0.03, 0.13)	0.22	-0.001 (-0.01, 0.01)	0.80	-0.02 (-0.22, 0.18)	0.80
Constant	-4.588	<0.001	-2.104	<0.001	1.10	<0.001	1.24	0.07

***Sector1:** Information, Cultural Industries/Finance, Insurance/Real Estate and Rental Leasing/Management of Companies& Enterprises/Administrative and Support, Waste Management and Remediation Services; **Sector 2:** Professional Scientific and Technical Services; **Sector 3:** Arts, Entertainment and Recreation/Accommodation and Food Services; **Sector 4:** Public Administration; **Sector 5:** Other Services except Public Administration; **Sector 6:** Educational Service; **Sector 7:** Health Care and Social Assistance; **Sector 8:** Whole sale Trades/Retail trade/Transportation and Warehousing; **Sector 9:** Constructions; **Sector 10:** Manufacturing; **Sector 11:** Agriculture, Forestry, Fishing and Hunting/Mining, Oil and Gas Extraction/ Utilities. Survey design weights and bootstrap 500 weights were included in calculating percentages and 95% CI

* Results from multiple regression analysis. β =regression coefficient. Survey design weights and bootstrap weights were included in calculating standard errors of β and 95% confidence intervals.

Table 4.6.2 Association between lung functions and broad occupational categories: Results from the multiple linear regression of lung function parameters (CHMS-Cycles 1 & 2)*

	FVC(L)		FEV_1 (L)		FEV_1/FVC (%)		$FEF_{25\%-75\%}$ (L/S)	
	Beta (95% CI)*	p- value	Beta (95% CI)*	p-value	Beta (95%CI)*	p-value	Beta (95%CI)*	p-value
Occupational categories								
Management occupations	Referent category		Referent category		Referent category		Referent category	
Business, finance and administrative occupations	0.01 (-0.08, 0.09)	0.89	0.03 (-0.07, 0.13)	0.49	0.002 (-0.01, 0.02)	0.64	0.01 (-0.22, 0.24)	0.93
Natural and applied sciences and related occupations	0.08 (-0.01, 0.17)	0.07	0.05 (-0.02, 0.14)	0.15	- 0.002 (-0.02, 0.01)	0.78	0.01 (-0.21, 0.23)	0.92
Health occupations	0.05 (-0.07, 0.18)	0.86	0.06 (-0 .07, 0.18)	0.33	0.002 (-0.01, 0.02)	0.75	0.04 (-0.22, 0.29)	0.78
Occupations in social science, education, government service and religion	0.01 (-0.06, 0.09)	0.64	-0.01 (-0.10, 0.09)	0.89	- 0.006 (0.02, 0.009)	0.43	-0.09 (-0.32, 0.13)	0.38
Occupations in art, culture, recreation and sport	0.001 (-0.12, 0.13)	0.97	-0.01 (-0.16, 0.13)	0.84	- 0.002 (-0.02, 0.02)	0.82	-0.5 (-0.34, 0.25)	0.69
Sales and service occupations	-0.07 (-0.15, 0.02)	0.10	-0.03 (-0.12, 0.06)	0.48	0.001 (-0.01, 0.01)	0.84	-0.1 (-0.27, 0.06)	0.21
Trades, transport and equipment operators and related occupations	0.06 (-0.04, 0.17)	0.24	0.05 (-0.06, 0.17)	0.32	- 0.001 (-0.01, -0.01)	0.92	0.04 (-0.17, 0.26)	0.68
Occupations unique to primary industry &occupations unique to processing, manufacturing and utilities	-0.03 (-0.15, 0.10)	0.69	-0.04 (-0.16, 0.06)	0.37	- 0.01 (-0.02, -0.001)	0.24	- -0.09 (-0.29, 0.12)	0.38
Age (years)	-0.02 (-0.02, -0.02)	<0.001	-0.02 (-0.03, -0.02)	<0.001	- 0.002 (-0.002, -0.001)	<0.001	0.04 (-0.04, -0.03)	<0.001
Sex								
Male	0		0				0	
Female	-0.60 (-065, -0.55)	<0.001	-0.50 (-0.55, -0.45)	<0.001	- 0.004 (-0.01, -0.003)	0.22	- 0.58 (-0.6, -0.32)	<0.001

Ethnicity								
Caucasian	0		0		0		0	
Other	-0.41 (-0.49 , -0.33)	<0.001	- 0.27(-0.34, - 0.20)	<0.001	0.01 (0.006, 0.02)	<0.01	- 0.07 (-0.18, 0.05)	0.23
Height (cm)	0.06 (0.05, 0.06)	<0.001	0.04 (0.03, 0.04)	<0.001	-0.001 (-0.002, -0.001)	<0.001	0.02 (0.01, 0.02)	<0.001
Weight (Kg)	-0.003(-0.005, -002)	<0.001	- 0.001 (-0.003, - 0.001)	0.01	0.0001 (-0.00003, -0.0004)	0.10	0.003 (0.001, 0.006)	0.03
Daily energy expenditure(kcal/kg per hour)/365)	0.01 (-0.002, -0.03)	0.10	0.02 (0.004, 0.03)	<0.01	0.001 (-0.001, 0.002)	0.19	0.008 (-0.02, 0.03)	0.49
Smoking status								
Never	0		0		0		0	
Former	0.04 (-0.02, 0.09)	0.23	-0 .02 (-0.07, 0.02)	0.34	-0.01 (-0.02, -0.004)	<0.01	- 0.08 (-0.2, 0.04)	0.20
Current	0.02 (- 0.04, 0.08)	0.37	- 0.13 (-0.19, -0.07)	<0.001	-0.03 (-0.04, -0.03)	<0.001	- 0.34 (-0.44, -0.23)	<0.001
Region								
Atlantic	0		0		0		0	
Quebec	-0.08 (-0.14, -0.02)	0.01	-0.09 (-0.15, -0.04)	<0.01	- 0.01 (-0.02, 0.001)	0.07	- 0.12 (-0.32, 0.09)	0.26
Ontario	0.01 (-0.07, 0.09)	0.75	-0.001 (-0.06, -0.05)	0.96	- 0.002 (-0.01, 0.004)	0.45	- 0.04 (-0.25, 0.17)	0.69
Prairies	0.03 (- 0.05, 0.10)	0.46	-0.02 (-0.07, 0.06)	0.78	- 0.01 (-0.01, 0.001)	0.09	- 0.03 (-0.25, 0.19)	0.81
British Colombia	0.07 (-0.02, 0.17)	0.13	0.05 (-0.03, 0.12)	0.19	- 0.001 (-0.01, 0.01)	0.87	- 0.02 (-0.21, 0.17)	0.84
Constant	-4.62		-2.17		1.10		1.33	

* Survey design weights and bootstrap weights were included in calculating β coefficients and standard errors and 95% CI Beta = regression coefficients; Associations were characterized by the multiple linear regression analysis after controlling for age, sex, ethnicity, height, weight, daily energy expenditure, region and smoking status

Chapter 5

Discussion and conclusions

5.1 Summary of findings

In this thesis, the effect of occupation/industry among the Canadian working population was examined to assess its influence on a number of respiratory health outcomes. The main objectives of this thesis were to examine the effects of industrial and occupational exposures on respiratory diseases, respiratory symptoms, and on lung function measures within this population, and to examine which factors can modify the effects of those industrial and occupational exposures identified using the data from CHMS Cycle 1 and Cycle 2.

Chapter 2 included a narrative review of the industrial and occupational classifications used, and a review of the known associations of respiratory health with industrial and occupational exposures. In general, the literature identified suggested that industrial and occupational exposures exert negative effects on respiratory outcomes in working populations. Similarly, the literature on spirometry concluded that industrial and occupational exposures are among the factors that can affect lung function leading to airway diseases.

The results outlined the findings from the combined data of CHMS Cycle 1 and Cycle 2, which were collected in household interviews and mobile examination clinics. Data included information on the demographics, employment, and respiratory health of participants including direct measures of anthropometry and lung function.

In spite of the higher prevalence of most respiratory symptoms among the non-employed respondents, the findings of this thesis suggested that the prevalence of current asthma was comparatively higher in those employed (4.7%) than in those non-employed (3.5%), ($p<0.05$).

Age, sex, ethnicity, BMI, daily energy expenditure, smoking status and family history of asthma were found to be significant predictors of current asthma. The higher prevalence of current asthma among the employed respondents suggests it may be work related, and could be due to persistent/recurrent exposures at work. The relationship of the employed group, and the association of specific exposures, with current asthma should be further examined in future studies.

The data on of the effects of occupation suggested that the prevalence of cough with phlegm was significantly higher (15%, $p<0.01$) in occupations unique to primary industry and occupations unique to processing, manufacturing and utilities. A significantly higher risk of ever asthma (OR: 2.1 95% CI 1.0, 4.5 $p=0.05$) was observed in the respondents who were in natural and applied science related occupations.

Sex stratified statistical analysis of lung function parameters identified a significant difference in the average lung function parameters between the employed and the non-employed in both males and in females. The mean FVC (5.0L) and FEV_1 (3.9L) of employed males were higher than in non-employed males (FVC: 4.2L, FEV_1: 3.2L). This is compatible with both an effect of work itself, or a healthy worker selection effect wherein the working population is healthier than the general population. In general, mean lung function measures in the employed were significantly higher than in the non-employed. Analyses also showed that average percent-predicted lung function measures (i.e adjusted for age, sex, height, and race) were significantly higher in employed females than in non-employed females. Among the employed after adjusting for confounders, the findings of these data suggested that both the FVC (-0.18L, 95% CI -0.28, -0.07, $p<0.01$) and FEV_1 (-0.15L, 95% CI -0.23, - 0.6, $p<0.01$) of respondents in arts, entertainment and recreation/accommodation and food services were significantly lower compared to the referent industrial sector. The mean value of FVC among the respondents in the wholesale trades/retail trade/transportation and warehousing was also lower than that of the referent category (-0.08L, 95% CI -0.15,0.0003 p=0.05).

5.2 Importance of study

Occupational diseases cause an enormous burden in terms of morbidity and cost, and yet still they remain mostly unseen in comparison to industrial injuries.[1] Moreover, changes in the nature of work and society more generally (for example increases in female employment in some sectors) means the nature of occupational diseases are constantly changing. Intensive efforts are required to understand fully the burden of occupational diseases, an important first step in reducing this burden.[1]

Good data is one factor, which can provide a foundation for a mitigation strategy. Nevertheless, most countries globally do not have adequate data on occupational diseases.[1] Research into the risk factors for respiratory diseases and respiratory symptoms among the working population can possibly lead to early identification and better management of work related respiratory ill health.

It is worth noting, that this study was one of the largest conducted in Canada in terms of sample size and nationwide coverage. This study therefore adds considerably to what had been previously observed in similar research.

The results from the thesis indicated that work in the arts, entertainment and recreation/ accommodation and food services industries may possibly be associated with impaired lung function and other work related respiratory ill health. Previous studies conducted to examine the relationship of the respiratory ill health and the industry/occupation have made similar conclusions, albeit based on different methodologies.[2,3,4,5,6]

In the thesis, there was a significantly higher risk of ever asthma (OR: 2.1, 95% CI: 1.0, 4.5 p=0.05) in the CHMS respondents who worked in natural and applied science related occupations. A study conducted in Indian adults found male workers in plant and machine operators and assemblers had a significant association with self _reported asthma (OR: 1.67, 95% CI: 1.14, 2.45 p =0.009) after controlling for age, education, household wealth index, current smoking, household cooking fuel use, urban/rural residence and access to health care. Similar to the current thesis, the referent occupational category of this study also mostly included management occupations.[6] In the analysis conducted in the thesis, similar confounders were also controlled for the significance of the association of asthma with the different occupations. In the study conducted in India, authors further explained that the extent of exposure was different between males and females even within the same occupations and the women who worked in the same occupation as men did not show a significant association with self-reported asthma.[6]

In the thesis, the prevalence of cough and phlegm was significantly higher (15%, p<0.01), after controlling for smoking, in occupations unique to primary industry and occupations unique to processing, manufacturing and utilities. A study conducted in China also had shown the similar results.[4] The authors concluded that the higher prevalence of chronic cough and persistent wheeze were seen in workers with occupational dust and fume exposures,[4] whereas had concluded that the increased prevalence of chronic phlegm and breathlessness was significantly related to occupational gas and fume exposure after controlling for confounders including smoking.

The study of previous studies reporting asthma among employed adults by industry and occupation are consistent with many of the findings of this thesis.[2] The authors reported that in addition to exposure to agents potentially causing asthma in the workplace, age, race/ethnicity, and education, socioeconomic factors, health insurance coverage, and state laws, are all also possibly relevant and risk for exposure to agents causing asthma in the workplace.

5.3 Strengths and Limitations

The CHMS Cycles 1and 2 combined data allowed up to 24 variables to be included in the final regression models to obtain estimates after controlling for confounding factors. A major strength of the study was that the CHMS data were representative of the national population improving the generalizability of the results to the Canadian population. The second major strength was the use of objective measurements of the lung function, which were measured in compliance with the American Thoracic Society guidelines. This should have reduced measurement error resulting in increased validity.

In general, the limitations of the study are similar to the limitations that are inherent to any cross-sectional study. Due to the cross-sectional nature of the CHMS, the data could provide only a snapshot of exposure and outcome measures which may not directly relate to each other. Exposure and outcome variables were measured simultaneously and the temporal relationship of the independent and dependent variables cannot be established. Hence, reverse causality cannot be excluded. The temporal sequence of the association between lung function and occupational/industrial exposures can also not be established, and this too limits the ability of the data to establish causality.

All the primary exposure variables, confounding variables and almost all the dependent variables except spirometry measurements, were derived from self-reported information and could have been subject to recall errors. Much of the information collected was by Statistics Canada interviewers at the household interview and the mobile examination clinic interview. It is possible there could have been an interviewer bias in spite of the training given to the interviewers, and despite pretesting of the data collection tools, it is also likely that there would have been some misclassification of exposure data. The job descriptions were extracted and sent for manual industry and occupation coding according to North American Industry Classification System (NAICS) 2002 and National Occupational Classification - Statistics (NOC-S) 2001 codes.[7,8] While there were open ended questions in the CHMS questionnaire about participants employment and job description, the interviewer had only a limited number of characters to enter the response and there may have been instances where the interviewer had to make a choice when editing the response to fit the character limits. The subjective and non-standardized format that was used for collecting the information for this variable also potentially increased the potential for misclassification of industry and occupation.

Occupational and industrial classifications in the study were based on responses about the current or most recent (within the past year) employment held by the respondent. As lifetime work history was not collected, if the respondent has changed their job one year or more prior to the administration of the CHMS questionnaires, previous jobs would not have been captured in CHMS, and as a result the respiratory health outcome may have been erroneously attributed to the incorrect employment.

Even within a similar industry or occupation, the details of the exposure will likely not be the same for each and every worker. Exposure not only depends on the industry or occupation itself but also on various other factors such as personal behaviors, work place rules and regulations, which were not collected in CHMS.

The diagnosis of asthma in CHMS was obtained from a self-report of having been previously diagnosed by a health professional. No objective verification was used to confirm the diagnosis. While this likely will result in some error, several previous epidemiological studies have used the same self-report of asthma-diagnosis by a healthcare worker, and studies have reported good agreement between the self-report of asthma-diagnosis by a healthcare worker and objective measures of asthma in adolescents and adults.[9,10]

Missing data on some variables could also have potentially affected the accuracy of the estimates, particularly if non-random. The reasons why data were missing in the CHMS files are generally unknown. If the reason for the missing data in the exposure variable was related to the outcome, then any estimate quantifying the association between the exposure variable and outcome could be biased. However, the proportion of missing data was not high in the CHMS. Consequently, any impact from this should be minimal.

5.4 Conclusions

The main findings from the thesis are (i) there is a gender disparity in the Canadian working population; (ii) the healthy worker effect is apparent among the working population and (iii) the respiratory health of the working population is related with some of the industrial sectors and broad occupational categories. Further exploration of the effects of employment on the respiratory health of the Canadian workers is needed and will be helpful in improving their respiratory health.

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APPENDIX

Ethics approval for the study from the University of Alberta

2/27/2018 https://remo.ualberta.ca/REMO/Doc/0/[illegible]/fromString.html

Health Research Ethics Board

308 Campus Tower
University of Alberta, Edmonton, AB T6G 1K8
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Notification of Approval (Renewal)

Date:	January 25, 2018
Amendment ID:	Pro00063890_REN2
Principal Investigator:	Ambikaipakan Senthilselvan
Study ID:	MS2_Pro00063890
Study Title:	**Respiratory Health and Occupations among Canadian Adolescents and Adults.**
Approval Expiry Date:	Thursday, January 24, 2019

Thank you for submitting this renewal application. Your application has been reviewed and approved.

This re-approval is valid for another year. If your study continues past the expiration date as noted above, you will be required to complete another renewal request. Beginning at 30 days prior to the expiration date, you will receive notices that the study is about to expire. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

All study related documents should be retained so as to be available to the Health REB upon request. They should be kept for the duration of the project and for at least 5 years following study completion.

Sincerely,

Anthony S. Joyce, PhD.
Chair, Health Research Ethics Board - Health Panel

Note: This correspondence includes an electronic signature (validation and approval via an online system).