Asthma
in British Columbia

January 2007

Christopher McLeod MA
Terry Bogyo BSc MBA
Paul Demers PhD
Demet Edeer MHSc
Clyde Hertzman MD, FRCPC
Susan Kennedy PhD
Mieke Koehoorn PhD
Kimberlyn McGrail PhD
Lillian Tamburic BSc

Library and Archives Canada Cataloguing in Publication

Asthma in British Columbia [electronic resource] / C.B. McLeod ... [et al.].

Electronic monograph in PDF format.
ISBN 978-1-897085-10-3

1. Asthma--British Columbia. I. McLeod, Christopher B. II.
University of British Columbia. Centre for Health Services and Policy Research

RA645.A83A88 2007 614.5'9238009711 C2007-901678-2

Contents

About CHSPR

The Centre for Health Services and Policy Research (CHSPR) is an independent research centre based at the University of British Columbia. CHSPR's mission is to advance scientific enquiry into issues of health in population groups, and ways in which health services can best be organized, funded and delivered. Our researchers carry out a diverse program of applied health services and population health research under this agenda. The Centre's work is:

- Independent
- Population based
- Policy relevant
- Interdisciplinary
- Privacy sensitive

CHSPR aims to contribute to the improvement of population health by ensuring our research is relevant to contemporary health policy concerns and by working closely with decision makers to actively translate research findings into policy options. Our researchers are active participants in many policy-making forums and provide advice and assistance to both government and non-government organizations in British Columbia (BC), Canada and abroad.

Funding and Support

CHSPR receives core funding from the BC Ministry of Health, and ongoing support from the University of British Columbia and the UBC College of Health Disciplines. This enables the Centre to focus on research that has a direct role in informing policy and health reform, and facilitates CHSPR's continuing development of the BC Linked Health Database.

Our researchers are also funded by competitive external grants from provincial, national and international funding agencies. They include the Canadian Health Services Research Foundation, the Canadian Institutes of Health Research, the Commonwealth Fund, Health Canada, the Michael Smith Foundation for Health Research, and WorkSafeBC.

Data Services: The BCLHD

Much of CHSPR's research is made possible through the BC Linked Health Database, a valuable resource of data relating to the encounters of BC residents with various health care and other systems in the province. These data are used in a de-identified form for applied health services and population health research deemed to be in the public interest.

CHSPR has developed strict policies and procedures to protect the confidentiality and security of these data holdings and fully complies with all legislative acts governing the protection and use of sensitive information. CHSPR has over 30 years of experience in handling data from the BC Ministry of Health and other professional bodies, and acts as the access point for researchers wishing to use these data for research in the public interest.

About the WorkSafeBC-CHSPR Research Partnership

Work-related injury and illness are a substantial burden to British Columbia workers, their families, employers, and society at large. The WorkSafeBC-CHSPR partnership works to improve our understanding of the causes and consequences of these illnesses and injuries, identify high-risk industries and occupations, and investigate the impact of socio-demographic influences on the health of workers. The partnership's research is designed to help WorkSafeBC develop evidence-based policies and prevention programs, and ultimately, to provide safe and secure workplaces and the best opportunity for recovery if illness or injury does occur.

The initiative brings together policy-makers, researchers and data resources from both organizations to address current and emerging issues of work-related health in British Columbia. By combining WorkSafeBC data resources with the population-wide sources of information contained in the BC Linked Health Database, the partnership optimizes the benefits of using the data, and is gaining insights into the broader health, social and economic effects of work-related illness and injury.

For more information about the WorkSafeBC-CHSPR Research Partnership, visit: http://www.chspr.ubc.ca/research/worksafebc.

Acknowledgements

This project, the first formal project of the WorkSafeBC-CHSPR research partnership, is the result of advice, input and efforts of individuals from both organizations. It benefited from formal and informal reviews from the research partnership's steering committee, a project advisory committee, and from WorkSafeBC's Senior Executive Committee.

Thanks to: Roberta Ellis, Ed McCloskey and Anya Keefe from WorkSafeBC for their leadership and support; Corinne Balcaen, Dennis Campbell, Marshall Denhoff, Susan Furlong, Sara Gilbert, Karen Lindsay, Keith Mason, Gerry Paquette, Jay Rowland and Teresa White (all from WorkSafeBC) for their invaluable contributions to our understanding of the policy context for this work and the complex data from WorkSafeBC; to Anne-Marie Broemeling and participants in the CHSPR regular internal seminar series for assistance with, and comments on, the case definition methodology used in this report; Harold Yip for his skill in analyzing the data; Dawn Mooney and Chris Balma for their assistance in the graphic design, editing and layout of the final report; and Penny Lowe and Doug Jameson, whose good humour and organizational skills helped keep the project on track. A special note of thanks and remembrance goes to our late and dear colleague Peter Schaub for his endless supply of cartographic and graphic design skills and whose enthusiasm for this project is infused throughout.

Additional thanks go to others who provided publicly available data used in this report, including: Rebecca Ewing (BC Ministry of Forests), Duncan Ferguson (BC Ministry of Water, Land and Air Protection), Bill Wilson (Pacific Forestry Centre) and Howard Platt (BC Ministry of Health).

Any errors are the responsibility of the authors.

Executive Summary

This is the first population-based study in British Columbia that examines both the cumulative prevalence and the incidence of new cases of asthma in children and the working-age population. It also estimates the number of asthma cases that may be attributable to workplace exposures, and compares these results to compensated claims.

By using population-wide data on health service use from the BC Linked Health Database (BCLHD) and complete records of WorkSafeBC time-loss compensation claims for asthma, this report lays the foundation for a much broader occupational surveillance research agenda. Hopefully, it will also inform compensation policy and prevention program development, and demonstrate the potential of the BCLHD to contribute to such processes.

Key Findings

In 2000, the ten-year cumulative prevalence of asthma among the working-age population of British Columbia was 51 and 68 cases per 1,000 among males and females respectively.

Of this population, 37 per cent of females and 34 per cent of males received physician or hospital treatment for their asthma in 2000—an overall rate of 26 per 1,000. In the same year, 35 per cent of working-age females and 40 per cent of working-age males diagnosed with asthma in the ten-year period had not received treatment for at least three years. The prevalence of active asthma increased slightly between 1996 and 2000, most notably among adult females.

The incidence of new cases of asthma among the working age population was four and three cases per 1,000 among males and females respectively in 2000. Overall, the incidence of asthma remained relatively stable in the province between 1996 and 2000.

One epidemiological tool, Population Attributable Risk (PAR), estimates the proportion of the total cases of a disease that could be avoided if all workplace exposures were eliminated. A widely accepted, and relatively conservative, PAR for asthma is 15 per cent.

If one in seven cumulative prevalent cases of asthma can be attributed to workplace exposures, approximately 27,000 working-age British Columbians experienced work-related asthma in 2001 (nine cases per 1,000). Five-hundred-and-thirty occupational asthma claims were accepted by WorkSafeBC between 1991 and 2000—two per cent of estimated work-related asthma.

Applying the same 15 per cent Population Attributable Risk, approximately 9,000 working-age British Columbians were receiving treatment for active work-related asthma in 2000. Just over 100 occupational asthma claims were compensated in the same year—about one per cent of estimated work-related asthma. The difficulty of linking cases to workplace exposures may explain, at least in part, the gap between estimated asthma rates and actual compensation rates.

The cumulative prevalence of asthma among the immediate pre-working-age population (ages ten to 14) was 154 and 108 cases per 1,000 among males and females respectively. Some evidence from the last decade (mostly pertaining to childhood asthma) suggests that trends in asthma morbidity and mortality may have stabilized.

Even so, a high stable rate among children may predict higher rates of adult asthma. This large group of children who have, or have had, asthma indicates that a large percentage of young workers may enter the labour force with underlying sensitivities.

The potential burden of work-related asthma—whether active cases or cumulative prevalence—measures in the thousands and ten of thousands of cases. The estimates offered in this report, while broad, suggest that there is a need to focus prevention and screening efforts on this disease, which impacts one in 16 British Columbians.

Introduction

This report estimates the cumulative prevalence and incidence of new asthma among the working age and pre-working-age populations of British Columbia between 1996 and 2000 using a merged database of health records, hospitalizations and compensation claims. It also provides an estimate of the number of asthma cases attributable to work in comparison to the number of compensation claims in 2000. We are hopeful the report will inform policy development around compensation and prevention programs, and demonstrate the potential of the BC Linked Health Database to contribute to such processes.

The report begins with background on the importance of understanding population-based trends in asthma and the relationship of these trends to workers' compensation claims. This includes an overview of literature and statistics on the incidence and prevalence of asthma worldwide, in Canada and in British Columbia; the suspected causes of both asthma and variations in asthma rates; and estimates of the influence of work-related exposures on these rates. Next we present our findings on the incidence and prevalence of asthma in British Columbia and the estimates of work-related asthma in comparison to compensated occupational asthma in British Columbia. Finally, there is a summary of key findings and suggestions for related research that could build on this foundation.

What is Asthma?

Asthma is a chronic inflammatory disorder of the airways, characterized by variable airflow obstruction and airway hyper-responsiveness. People with asthma usually suffer from wheezing, coughing, and tightness of the chest associated with shortness of breath. Episodes of asthma with severe symptoms have been associated with missed work and school days, hospitalizations and—in rare cases—death (1-3). Asthma is most frequently diagnosed by a review of clinical history supplemented by tests of baseline pulmonary function, functional response to bronchodilation medication, and tests of bronchial hyper-responsiveness (4).

Although it is accepted that asthma is an inflammatory disease of the airways, the exact mechanisms are still not completely understood. It is clear, however, that asthma is a disease of multifactorial etiology (5), with both genetic and environmental factors being important. Risk factors can be grouped into host factors which either predispose or protect an individual from developing asthma, and environmental factors which affect the likelihood that an individual will develop asthma or suffer exacerbated symptoms (6).

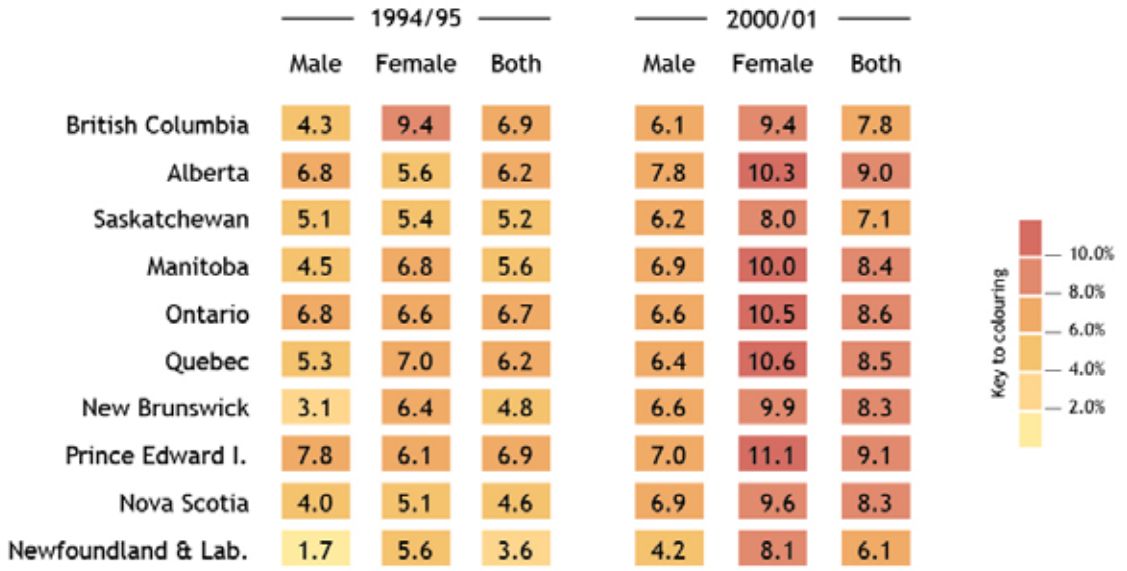
Why Focus on Asthma?

According to the Global Initiative for Asthma, approximately 300 million people worldwide live with asthma (7;8). The World Health Organization reports that in 2001 the worldwide burden of asthma was 15 million disability-adjusted life-years*—on par with diabetes, schizophrenia and injury due to falls (9). Asthma causes economic hardship for individuals and families, and generates significant costs for health care systems (7;10-13). According to a 1998 Health Canada report, asthma-related hospitalization and drug costs were in excess of $400 million (1998 CND) (11), while costs related to mortality and long-term disability were almost $750 million. In the United States, annual costs in 1998 were estimated at $12.7 billion (1998 USD) (12), while in California the annual per capita cost of asthma was estimated at $4,912 (1998 USD) of which almost one-third was related to the cessation or loss of work (13).

Asthma prevalence has increased worldwide and in Canada since the 1970s (1;6;14-18). In Canada, the percentage of males and females aged 15 to 64 who reported that they had asthma increased from 5.8 per

* Disability adjusted life years: a composite measure of the burden of a disease that reflects both years of potential life lost due to a disease (mortality) and years of disability (morbidity) lived with the disease weighted by the severity of the disability.

Figure 1: Asthma prevalence (%) by province for males, females, and both sexes, for population aged 15-64, 1994/95 and 2000/01



Source: Statistics Canada, National Population Health Survey (1994/95) and Canadian Community Health Survey (2000/01)

cent and 6.9 per cent to 6.5 per cent and 10.2 per cent respectively between 1994 and 2000 (19) (Figure 1). While below the national average, asthma prevalence in British Columbia in 2000 was 6.1 per cent (84,000) for males and 9.4 per cent (130,000) for females aged 15 to 64. Rates are much higher in children—11 per cent of those under 15 in British Columbia reported having asthma in 1998 (20). Some evidence from the last decade (mostly pertaining to childhood asthma) suggests that the increasing trend in asthma morbidity and mortality may have reached a plateau (15;17;20-23). Even so, a high stable rate among children may predict higher rates of adult asthma.

Work-related Asthma

Expert committees of the Canadian and American thoracic societies have reviewed and published guidance documents on work-related asthma in recent years (24;25). Both consider asthma to be work-related if occupational exposures either exacerbate pre-existing asthma (generally referred to as work-aggravated asthma) or cause a new onset (generally referred to as occupational asthma). A recent consensus statement identifies two broad types of occupational asthma, distinguished by whether they appear after a latency period:

1 "Immunological, characterized by a latency period, encompassing
   a) that caused by high and low-molecular-weight agents for which an immunologic (IgE) mechanism has been proven, and
   b) that caused by agents (e.g., western red cedar) for which a specific immune mechanism has not been identified.
2 Nonimmunological, (i.e., irritant induced asthma or reactive airways dysfunction syndrome (RADS)) which may occur after single or multiple exposures to non-specific irritants at high concentrations" (25).

At least 250 specific workplace agents have been identified as being associated with occupational asthma (26). These include proteins and other high molecular weight compounds (6) (e.g., grains, biologic enzymes, natural rubber latex) and low molecular weight chemicals (e.g., diisocyanates, anhydrides, amines, metal

salts, organic acids) found in industries as diverse as heavy industry, construction, healthcare, service sector and high technology.

The many different causes of asthma and the variety of ways the condition manifests itself can make it difficult to determine definitively whether a particular case is a work related. However, given the high prevalence of asthma in the general population, the added burden associated with even a small proportion of this disease being caused or worsened by workplace exposures can result in significant economic and health care costs and reduced quality of life.

Asthma severity and management are closely linked and there has been considerable improvement in our understanding of how best to manage the disease at different levels of severity. Better management improves quality of life, and reduces the number or severity of asthma attacks and associated use of medical services (6).

Increased severity of occupational asthma has been linked to continued exposure in the workplace, and there is growing evidence that early detection and subsequent removal from exposure increases the likelihood of a positive prognosis (27). A study using data from the Ontario Workers' Compensation Board (now the Workplace Safety and Insurance Board) between 1984 and 1988 found that outcomes were best with early diagnosis, removal of exposure and with milder impairment of pulmonary function at initial assessment (28). Similarly, in British Columba, Cote et al. followed 48 patients who had cedar-related asthma and continued working in the sawmill industry. During a follow-up period of 6.5 years they found that over one-third of the workers showed worsening asthma symptoms. They concluded that cedar asthma could best be managed by removing individuals from the exposure (29).

Recently, Tarlo and Liss conducted a literature review examining all aspects of prevention related to occupational asthma, ranging from the removal of, or protection from, asthma-related agents (primary prevention) to surveillance to detect early sensitization prior to the development of asthma (secondary prevention) to treatment (tertiary prevention) (30). They report evidence of some success in preventing the onset of occupational asthma through exposure controls (e.g., substitution in the case of natural rubber latex, engineering controls in the case of detergent enzymes and isocyanates, and personal protection in the case of farm antigens and isocyanates) and success in reducing the impact of occupational asthma through medical surveillance (e.g., skin prick tests for platinum and detergent enzyme exposures, asthma screening questionnaires and lung function testing). They also found that at present, most 'prevention' of occupational asthma happens after the fact through the removal of the patient from exposure upon diagnosis.

Nicholson and colleagues carried out a similar review at the request of the British Occupational Health Research Foundation (31). They also found that reducing exposure leads to fewer cases and that an improved outcome is more likely among workers who have no further exposure to the causative agent.

Recent research suggests that asthma caused or exacerbated by occupational exposures may be even more severe than other asthma in adults, possibly due to a failure to recognize the work-relatedness of symptoms and a failure to institute appropriate management (e.g., removal from exposure) (32).

In addition to respiratory impairment and reduced quality of life, patients with work-related asthma also suffer adverse economic and employment consequences. An English study indicates that 30 per cent of subjects with occupational asthma reported losing 40 per cent or more of their income than those whose asthma was unrelated to work (33). In the United States, researchers explored employment status 31 months after removal from exposure. During follow-up interviews, 69 per cent of study subjects were unemployed (34). A French study found that, on average, 3.1 years after an occupational asthma diagnosis 84 per cent of patients who left their jobs and 19 per cent of those still employed suffered a drop in income. This suggests that those who left their jobs due to occupational asthma were more likely to face financial hardship (35).

Workers' compensation systems have traditionally compensated few cases of asthma. There are a number of reasons why this may be the case:

- neither workers or physicians may make the link between symptoms and workplace exposures
- even when a link is suspected, it can be difficult to attribute asthma specifically to a workplace exposure
- even with a link established, policies used by compensation boards to adjudicate potential asthma cases reported to them often require a high standard of objective clinical evidence

The number of occupational asthma cases derived from physician reporting programs, surveillance systems and disease registries tends to be much higher than the number of cases accepted for compensation(36). Provencher and colleagues compared the number of highly likely occupational asthma cases (as determined by occupational physicians) with the number of cases accepted by Québec's Commission de la santé et de la sécurité du travail (CSST) between 1991 and 1994 (37). They found that the annual mean number of occupational asthma cases that the CSST compensated was slightly less than half of the number of highly likely cases. In contrast, the CSST accepted a higher number of cases of asbestos-related disease than were ascertained by occupational physicians. Using a similar surveillance system, chest physicians in British Columbia reported 124 cases of occupational asthma in 1991 (38) and the province's workers' compensation board accepted 41 lost-time occupational asthma claims in 1991 (39). Some researchers, however, have claimed these alternate reporting systems introduce their own biases and that many cases ascertained through alternative means would not meet the clinical requirements that most workers' compensation boards mandate (36). In other instances, workers may not be aware that their condition is work related, or do not apply for compensation for other reasons (40).

WorkSafeBC recently reviewed and changed its policies on compensation for occupational asthma and contact dermatitis (41). The previous policy provided compensation if a worker who developed an asthmatic reaction to a workplace substance had unresolved symptoms. WorkSafeBC's new policy permits the compensation of preexisting asthma if it has been significantly aggravated, activated or accelerated by an occupational exposure. A worker may also be eligible for permanent disability if they are left with a significant underlying allergy or sensitivity and must avoid workplaces containing the sensitizing agent (42). Changes to review policies (as above or, for example, an expansion of the list of causative agents deemed to lead to occupational asthma) have the potential to increase the number of asthma cases accepted for compensation. Even if policies do not change, increased rates of asthma in the general population suggests that the future workforce may enter the workplace more 'sensitized' and more prone to respond to even mild or moderate exposures.

Work-related illness, as opposed to injury, is receiving increased attention in compensation systems due to concerns that these systems may not be identifying all cases of illness caused by workplace exposures. A recent review by Leigh and Robbins comparing epidemiologic evidence regarding the work-related portion of diseases in the United States to workers' compensation claims in 1999 suggests that between 46,000 and 93,000 deaths and up to $23 billion (1999 USD) in medical costs have been 'missed' by compensation systems(43). While there are no comparable published estimates north of the border, given Canada's more homogenous policy environments in both the workers' compensation and attendant health care systems, the relative number of missed cases and associated costs may be less. Nonetheless, this is research that decision-makers in Canadian compensation boards lack. This study, in part, attempts to begin to fill this gap for British Columbia.

How Much Asthma is Work Related

Epidemiology provides the tools to estimate the number or proportion of asthma cases or events attributable to workplace exposures. One such tool, the Population Attributable Risk (PAR), estimates the proportion of the total cases of a disease that could be avoided if all workplace exposures were eliminated.

PAR values provide useful information about the proportion of cases of a disease that are likely to be preventable by the removal of a risk factor. However, the overall burden of a disease is also influenced by its prevalence in the population. For example, a condition such as silicosis that has a very high PAR (it is nearly always caused by workplace exposures) may constitute a relatively low overall burden of disease in the population at large because the disease is relatively rare. In contrast, a condition with a lower PAR may still represent a much higher burden because of the much higher occurrence of the condition in the population. Thus, changes in the overall population burden of a disease over time can be affected by a combination of changes in its population prevalence and changes in the risk associated with a particular exposure.

In 2003, an expert committee of the American Thoracic Society undertook a comprehensive review of the role of occupational risk factors for asthma. Their purpose was to assess the "occupational contribution to the burden of airway disease" (44). They reviewed all population-based studies published before January 2000 that had either calculated PAR values or contained sufficient data to enable the expert committee to calculate one. PAR values from this body of evidence—a total of 21 studies—ranged from four per cent to 58 per cent with a median value of 15 per cent. Although a range of values was found (due to differences in study design and populations studied) the team concluded that a median of 15 per cent was "a reasonable estimate of the occupational contribution to the population burden of adult asthma" (44). This finding was supported, in part, by two subsequent population-based studies that found PAR values of 18 per cent among a Canadian population (45), and 17 per cent among women and 29 per cent among men in a Finnish population (46).

Based on these findings, it seems reasonable to estimate that about one in seven cases of asthma among adult British Columbians is likely to have been caused or worsened by exposures in the workplace. The combination of this (relatively) high Population Attributable Risk and the (relatively) high population prevalence indicates that work-related asthma represents a substantial economic and social burden, and a significant potential source of workers' compensation cases.

Methods

Research Questions

1 What is the prevalence of asthma at the end of our study period (2000) in both the working-age and pre-working-age-populations? This provides insights into the current burden of work-exacerbated asthma as well as the potential future burden of asthma.
2 What is the prevalence of 'active' and 'inactive' asthma among the working-age and pre-working-age populations from 1996 to 2000? This reveals trends over time and what proportion of individuals diagnosed with asthma require ongoing treatment.
3 What is the incidence or 'pseudo-incidence' (a new case in an individual for whom there is no record of any asthma in the first five years of our study period) of asthma between 1996 and 2000? This is an indication of whether the incidence of asthma is increasing over time.
4 Applying a Population Attributable Risk (PAR) of 15 per cent to population-wide rates, what is the estimated prevalence of work-related asthma in British Columbia? This provides an idea of the overall work-related burden of both cumulative and active asthma at the end of our study period.
5 What is the prevalence of workers' compensated asthma and how does it compare to PAR estimates? This may reveal an underestimation of the prevalence of the disease, lead to improved disease management, and ultimately to a reduction in the overall population burden of work-related asthma.

Data Sources

This project relied on WorkSafeBC claims data and BC Ministry of Health (registry of BC residents, medical services plan billing records, and hospital records) data contained in the BC Linked Health Database (BCLHD). Access to the BCLHD is governed by a policy and application process designed to comply with BC's Freedom of Information and Protection of Privacy Act (47;48). Data extracted from these resources were available to researchers using an anonymous common study identifier. This allowed the research team to analyze person-specific but non-identifying data, thus protecting the privacy of individuals in the data sets. The UBC Behavioural Ethics Review Board (B03-0571) also approved this project.

Compensation claims data recorded cases of occupational asthma (where symptoms have been established as related to work exposures) resulting in at least one day of absence from work, permanent disability or death. The information available for compensated time-loss cases recorded date of injury or exposure, diagnosis (ICD-9 classification), and industry of employment. Health care only claims (those that require medical attention but do not result in time loss or permanent disability) did not include a diagnosis codes and were therefore not useful for case ascertainment.

The BCLHD registry of residents supplied information on age and sex. For the purposes of this analysis, the medical services records included data on service type (e.g., GP visit, specialist consultation), diagnoses code (ICD-9 classification) and date of service. The hospital records included data on admission date and diagnoses (up to 16 ICD-9 codes for each separation).

Study Population

The BCLHD registry was used to determine the eligibility of individuals. We restricted the cohort to those individuals who lived continuously in British Columbia between 1991 and 2001 (registered with the province's Medical Services Plan in every year of the study) or for life (registered in every year from birth or the following year) if born during the study period. This ensured we had a complete history on an individual throughout the study period so that the definition of asthma prevalence and incidence could be applied consistently over time. The study population was restricted to individuals under 65 in order to investigate asthma among the working-age population (15 to 64 years) and among those who may enter the workforce (0 to 14 years).

Asthma Case Definition

Individuals were considered to have asthma if they met one of the following criteria:

- two or more physician visits within a sliding 12-month window from first diagnoses for ICD-9 codes of 493 (asthma), 493.0 (extrinsic), 493.1 (intrinsic), 493.9 (unspecified) or 495.8 (red cedar);
- a hospital visit (overnight or day) with a primary (pre-admission co-morbidity.) or principal (diagnosis most responsible for hospitalization) asthma diagnoses; or,
- a workers' compensation claim with an asthma diagnoses during the follow-up period.

Alternative definitions using any one of the 16 hospital diagnoses codes with an asthma diagnoses and a more relaxed three-year window were explored in order to assess their impact on case ascertainment.‡

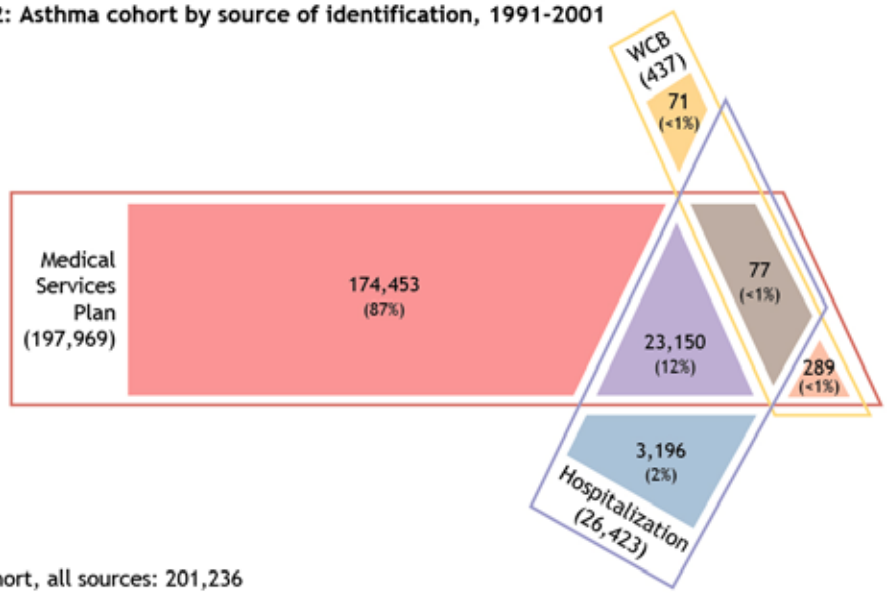
Once meeting the case definition, an individual was deemed a prevalent case in the year of first diagnosis and for each subsequent year of follow-up. If an individual received no asthma-coded services in the first five years of our study (1991 to 1995) they were deemed incident in the year of first diagnosis after 1995 (or pseudo-incident as we can not rule out a diagnosis prior to 1991 given the availability of administrative health records). For simplicity, we use the terms incident case or incidence.

Prevalence was then divided into active and inactive based on whether services (physician visit, procedure or hospitalization) were utilized or a workers' compensation claim was filed in a given year. For example, an individual who had several asthma-related contacts in 1996 but no further contacts with the health care or compensation systems until 2000 was categorized as an active case in 1996, as an inactive prevalent case 1997 through 1999, and as an active prevalent case in 2000.

Figure 2 shows the data source of identification for the final cohort. The majority of the cohort (98%) is identified through a combination of MSP or hospital data. Most (87%) are indentified only through MSP data. More than 26,000 cases are identified through hospital data. Of these, only 3,196 (less than 2% of the total cohort) are identified solely because of a diagnosis received in hospital. Of 530 asthma claims in WorkSafeBC data, 437 individuals met the continuous registration criterion to be counted as asthma cases. Of these, 71 are included in the cohort based on diagnoses in the claims data alone—the rest are also identified through MSP and/or hospital data.

‡ Including a relaxed three-year window and principal or primary diagnoses increased the case count by about ten per cent, but a more conservative definition was chosen.

Figure 2: Asthma cohort by source of identification, 1991-2001



Analysis

Asthma prevalence (active and inactive cases) and incidence (the rate of new cases) were calculated for each year from 1996 to 2000, stratified by sex and by five-year age groups for children (under 15) and ten-year groups for adults (15 to 64). To determine incidence we applied a five-year no-asthma window (1991 to 1995) and for prevalence we applied a five-year case-finding window. To derive these rates we created a comparable denominator comprised only of British Columbians continuously registered with MSP from 1991 to 2001 or continuously registered since birth if born during the period. This continuously registered population represents about 75 per cent of all British Columbians in any given year. Overall population counts were generated by multiplying these derived rates by population figures provided by BC Stats. To estimate the total number of asthma cases that might be attributable to occupational exposures we applied a Population Attributable Risk of 15 per cent to the number of cumulative prevalent cases for the working-age population in 2001, and to the total number of active prevalent cases for the working-age population in 2000. The year 2001 was chosen for cumulative prevalence in order to compare across all years for which we had information on workers compensated asthma. For the active prevalent comparison we chose 2000 because complete 2001 follow-up data on new cases (a component of active prevalence) were not available.

Strengths and Limitations

This is the first population-based study in British Columbia that examines both the prevalence and incidence of asthma in childhood and working-age populations. Our data capture information on nearly all use of physician and hospital services in British Columbia, and all accepted time-loss compensation for asthma in the WorkSafeBC system. An advantage of using population-based, administrative data is that the larger number of individuals involved allows for robust analysis of age, sex and other demographic trends, compared to data limited by sample size. Administrative data are a very rich source of information on the use of services such as health care utilization and workers' compensation. Secondary analyses of administrative data has a long history of fruitful use in research (49).

However, these data are also secondary sources for analysis and as such may diverge from clinical assessments of the presence of asthma. The administrative data were not collected with this specific research question in mind and are inevitably less than perfect in their application for this purpose. In particular, our case definition of asthma is sensitive to changes in treatment or prescribing practices that may be unrelated to the underlying 'true' incidence of asthma that would be established by objective clinical means. For example, we found that between the years of 1991 and 2001 the average number of asthma-coded MSP visits fell for those who had one or more asthma-related visits in a given year. We were unable to determine if this was related to changes in treatment patterns, coding or billing practices, or related to changes in the rate or severity of asthma cases. We are further constrained by our lack of information on other respiratory outcomes and asthma-related prescriptions, which limit our ability to conduct sensitivity analysis on other case definitions and on potential misclassification between related ICD9 codes.

Finally, we followed only those individuals registered with MSP for the entire ten years of our study (about 75% of the population), excluded those people for whom we had incomplete retrospective follow-up information, and then applied the rates derived from this continuously registered cohort to the entire population aged under 65 to estimate counts. If rates in the continuously registered cohort differed from those not continuously registered (more likely to be new immigrants, young, have lower incomes and be transient) then our overall count of asthma may be biased.

In light of these potential drawbacks, we deliberatively chose a conservative approach (i.e., excluding potential cases where the possibility for misclassification, misdiagnosis or bias seemed likely) in developing our case and cohort definitions. The results of this study, then, may be considered an estimate of the lower bound of the total burden of physician- and hospital-diagnosed asthma in the population of British Columbia.

Findings

Cumulative Prevalence

The cumulative prevalence of asthma in 2000 (based on ten years of continuous follow-up data) was 72 cases per 1,000 for both males and females (Figure 3). The similarities in the overall asthma rate between males and females, however, belie a marked difference in rates between the sexes when stratified by age. Prevalence rates for working-age males and females were 51 and 68 cases per 1,000 respectively, and among the pre-working-age population were 133 and 85 cases per 1,000. Among males, asthma prevalence rates were highest in children and about 1.6 times the rate for females of the same age. In contrast, prevalence rates for females, while highest in childhood, were about 1.3 times higher than males in adulthood.

Active and Inactive Prevalence

Figure 4 illustrates the proportion of individuals receiving asthma-related medical services or who filed a compensation claim in the current year (active) verses those who had not accessed services or filed a claim for the previous three years (inactive). In 2000, 37 per cent of adult females who had been identified as a prevalent asthma case (a previous diagnoses in the past ten years) had an asthma-related medical contact, while 35 per cent had no asthma-related medical contact for three or more years. Almost identical percentages were found for young females. Thirty-four per cent of adult males had an asthma-related medical contract in 2000, while 40 per cent had no contact for three or more years. Among young males these percentages dropped to 38 per cent and 34 per cent respectively.

Figure 5 illustrates trends in active asthma (individuals receiving medical care or compensation for asthma in the year) among males and females. Among males, active asthma remains largely stable with a rate of about 25 cases per 1,000 for all age groups—although, there is a small, but consistent 13 per cent increase in active asthma between 1996 and 2000 for adult males. A similar trend is observed for females. Young females' rates are stable, while adult females' rates of active asthma exhibit a 17 per cent rate of increase

Figure 3: 10-year cumulative asthma prevalence, males and females, by age group, 2000

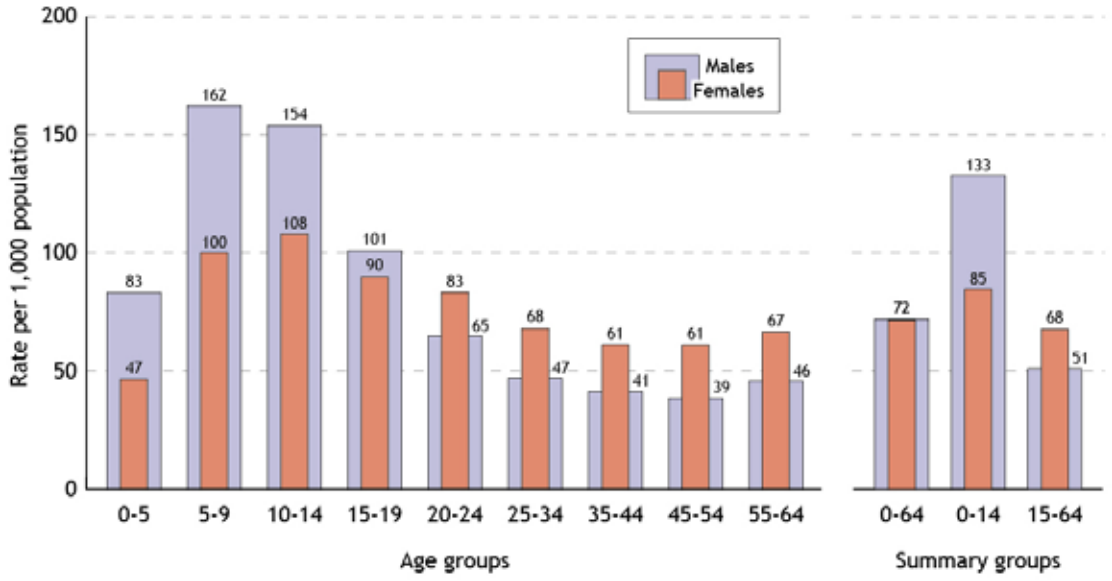
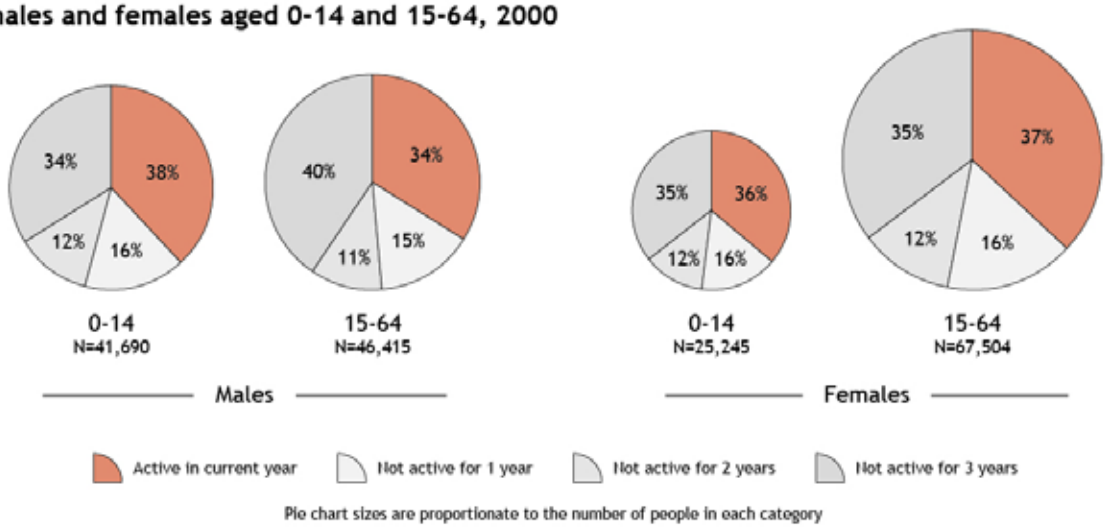


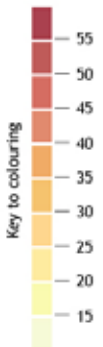
Figure 4: Three-year inactive prevalence and asthma activity in current year, males and females aged 0-14 and 15-64, 2000



over time. In 2000 there were 4,599 individuals in the pre-working-age population (ages ten to 14) or a rate of 36 per 1,000 who had active asthma, while for working-age adults there were 59,276 individuals or a rate of 21 per 1,000.The pattern of active asthma rates by age and gender is similar to that of cumulative prevalence, with one notable exception. The 'sex-crossover effect' (where asthma rates becomes higher among females) takes place at a younger age for active asthma compared to prevalent asthma. By ages 15 to 19, females have a 21 per cent higher active asthma rate than males (26 and 21 per 1,000 for females and males in 2000), while cumulative prevalence among females did not increase until ages 20 to 24.

Figure 5: Active asthma in current year per 1,000 population, males and females, by age group, 1996-2000

	Males					Females				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
0-4	50.9	55.8	53.7	51.9	52.3	26.5	29.2	29.2	28.1	28.6
5-9	56.6	58.3	56.2	54.2	57.7	34.3	36.3	35.1	32.3	34.0
10-14	38.7	40.3	39.5	37.7	42.2	28.1	28.8	28.3	28.3	29.5
15-19	19.7	20.6	20.8	20.6	21.6	26.2	26.3	25.3	24.7	26.1
20-24	16.7	16.4	16.8	16.5	17.1	23.6	24.8	25.3	25.4	24.9
25-34	15.1	16.2	17.3	17.9	18.4	20.6	22.5	23.4	24.5	26.2
35-44	13.1	13.9	14.7	14.7	15.5	19.1	21.0	21.8	22.6	23.7
45-54	13.8	14.3	14.5	14.8	15.0	20.3	22.0	22.8	23.3	23.9
55-64	18.5	19.0	19.5	20.1	19.4	23.4	25.5	27.2	27.3	27.1
All ages (0-64)	24.2	25.4	25.3	24.9	25.9	23.2	24.9	25.4	25.5	26.3



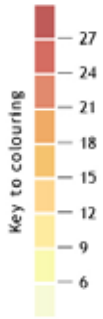
Incidence

This project's measure of asthma incidence attempts to track the number of new cases of asthma in our study population and may provide an indicator of exposure to environmental allergens, including those in the work environment. Accordingly, and as detailed in the methods section, we present rates for cases diagnosed in the last five years of our study period (1996 to 2000) in individuals who had not received asthma-related services in the first five years of our study period (1991 to 1995).

Infants and very young children have the highest incidence of asthma (Figure 6). By ages ten to 14, the incidence rates for males and females are almost identical, ranging between five and seven cases per 1,000. For males incidence ranges between 25 and 29 cases per 1,000 during the years 1996 to 2000, and for females incidence ranges between 15 and 17 cases. By ages ten to 14, the incidence rates for males and females are almost identical, ranging between five and seven cases per 1,000. Among the working age population (Figure 7), incidence is highest for females ranging between four and five cases per 1,000 between 1996 and 2000. On average, males have a 38 per cent lower incidence rate, ranging between two and three cases per 1,000 during the same time period. Overall, rates for both sexes appear stable throughout this time period, with the exception of a slight decline for young male adults (15 to 24 years).

Figure 6: Incidence per 1,000 children (0-14), males and females, by age group, 1996-2000

		1996	1997	1998	1999	2000
Males	0-4	25.3	28.8	25.4	25.8	26.7
	5-9	9.9	10.7	9.3	9.1	10.7
	10-14	6.4	6.6	5.1	4.7	5.3
	0-14	**13.9**	**15.4**	**13.4**	**13.3**	**14.3**
Females	0-4	14.6	16.7	15.9	14.6	16.0
	5-9	8.5	8.6	7.9	6.7	7.3
	10-14	6.4	6.6	5.9	5.4	5.8
	0-14	**9.8**	**10.6**	**9.9**	**9.0**	**9.7**



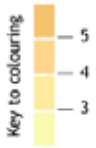
Workers' Compensation Claims for Asthma in British Columbia

There were 530| individuals with an asthma-related lost-time claim compensated by WorkSafeBC from 1991 to 2001. Over half were male (59%) and most were between the ages of 25 and 54. In contrast, individuals with asthma in the general working-age population were more likely to be female (60%) and young adults aged 15 to 24 (8.5% of claims verses 18.5% of general working-age population) or older adults aged 55 to 65 (11.7% of claims versus 16.3% of general working-age population). These differences by age likely reflect the smaller (relative) proportion of employed persons in these age groups compared to middle adulthood. Workers' compensated cases also displayed a higher number of asthma-related physician visits compared to the non-hospitalized general population (4.5 visits versus 2.1 visits) but a similar number of physician visits compared to the general population who had been hospitalized (4.5 versus 4.2 visits).

| There were in fact 534 asthma-related lost-time claims, but four could not be identified in the BCLHD registry population, and were not included for the sake of consistency.

Figure 7: Incidence per 1,000 working-age adults (15-64), males and females, by age group, 1996-2000

		1996	1997	1998	1999	2000
Males	15-24	2.8	2.9	2.4	2.2	2.2
	25-34	2.8	3.0	2.8	2.8	2.7
	35-44	2.5	2.8	2.7	2.4	2.4
	45-54	2.5	2.6	2.4	2.6	2.3
	55-64	2.9	3.1	3.2	3.2	3.0
	15-64	**2.7**	**2.8**	**2.7**	**2.6**	**2.5**
Females	15-24	4.9	4.9	4.3	4.0	4.2
	25-34	4.1	4.3	4.5	4.3	4.4
	35-44	4.1	4.4	4.3	4.1	4.1
	45-54	4.0	4.5	4.3	4.1	4.1
	55-64	4.5	4.8	5.0	4.6	4.4
	15-64	**4.3**	**4.5**	**4.4**	**4.2**	**4.2**

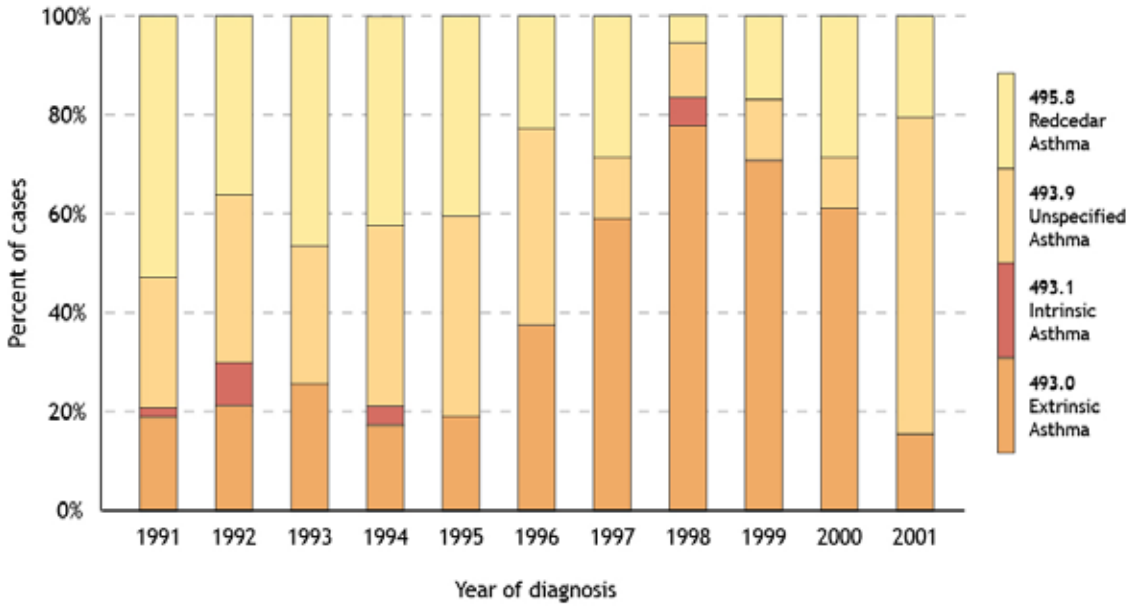


Red Cedar Asthma

Nearly one in three compensated cases of asthma in British Columbia is diagnosed as red cedar asthma. However, the proportion of red cedar claims as a proportion of all claims has declined over time (Figure 8). In 2001, the most common asthma diagnoses was 'unspecified'. This may reflect changes in coding practices rather than trends in the experience of asthma in the workplace.

Wood and paper products generated the highest proportion of asthma claims by industrial sector, although this is in part a reflection of the proportion of the overall workforce in British Columbia employed in those sectors (Figure 9). The health care and social assistance, education and deposit sectors also generate a high proportion of claims.[Δ]

Figure 8: Workers' -compensated asthma by diagnostic code type, 1991-2001

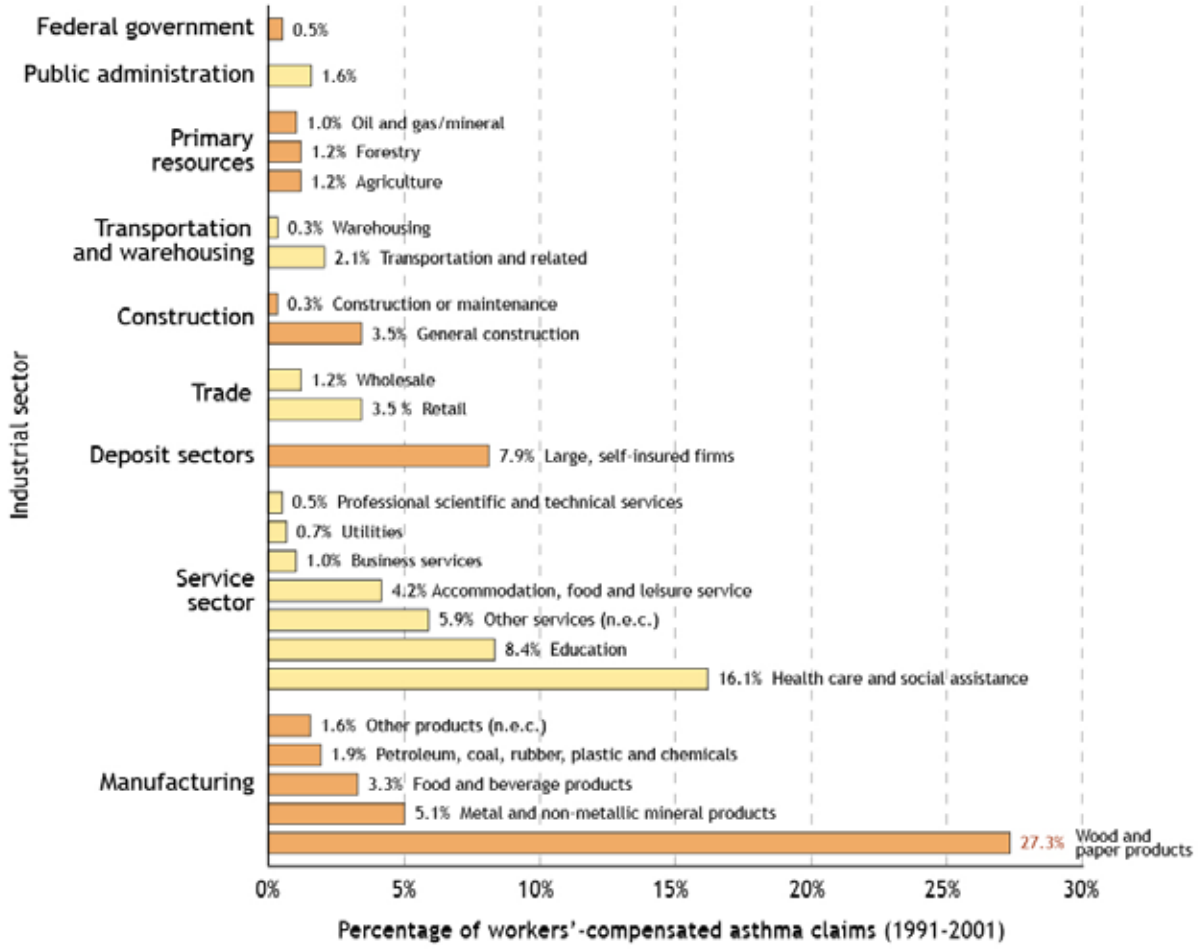


Expected Versus Actual Work-related Asthma

Asthma is a relatively common chronic disease in British Columbia, affecting one in 16 residents of the province aged 15 to 64. Estimates of the influence of occupational exposures suggest that 15 per cent of all cases of asthma are work related. While the population-wide prevalence of asthma is similar to that described in the literature, compensation rates are far below the levels predicted by the use of a 15 per cent Population Attributable Risk (Figures 10 and 11).

Of the more than four million people in British Columbia, 2.8 million are of working age. MSP, hospital and WorkSafeBC data provide a combined estimate of 179,635 people of working age (15 to 64 years) who have asthma in 2001. Applying a 15 per cent PAR to this number suggests that about 26,945 will have asthma that is in some way related to occupational exposure. In contrast, only 530 cases of asthma (related to claims for lost time from the job) were paid by WorkSafeBC from 1991 through 2001–approximately two per cent of estimated work-related asthma.

Figure 9: Workers' -compensated asthma, percentage of claims by industrial sector and subsector, 1991-2001



An estimated 59,276 working-age individuals experienced active asthma in 2000. Of these, (applying a 15% PAR) 8,891 had asthma that is in some way related to occupational exposures. In 2000, 103 cases of asthma (ongoing cases with loss-time compensation or newly accepted cases in the year) were compensated by WorkSafeBC—approximately one per cent of estimated active work-related asthma. Further, of all compensated cases of asthma from 1991 to 2000, 249 were in receipt of asthma-related medical services in 2000, compared to 103 with an active claim.

[Δ] Deposit sectors are large employers with special statutory arrangements for setting aside funding for workplace injuries (i.e., they self-fund or self insure). In many cases these employers are national (e.g., Air Canada) and so have to adhere to policies and practices in multiple provinces. These employers are concentrated in the transportation sector but may also include other large private and pubic sector firms.

Figure 10: Comparison of workers'-compensated asthma claims to individuals with work-related asthma, 2001

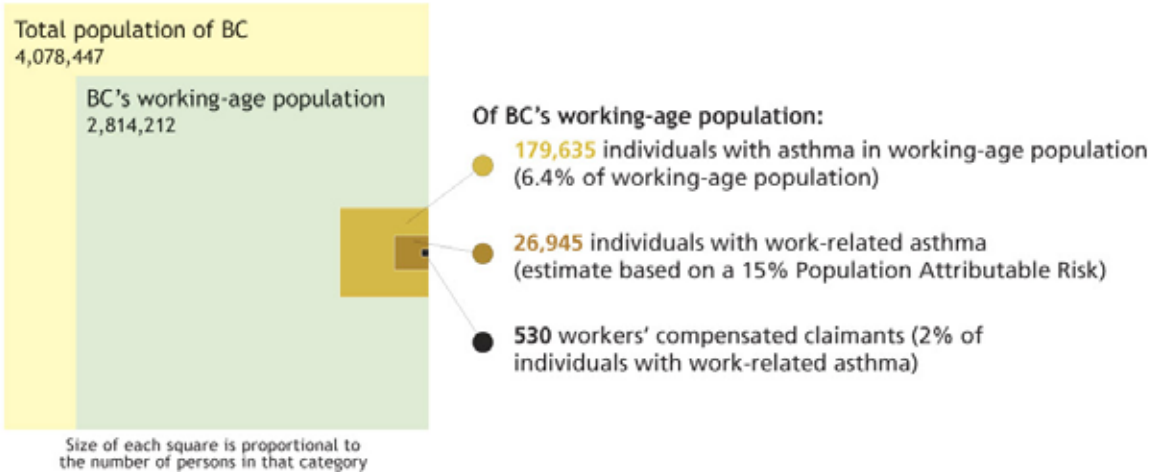
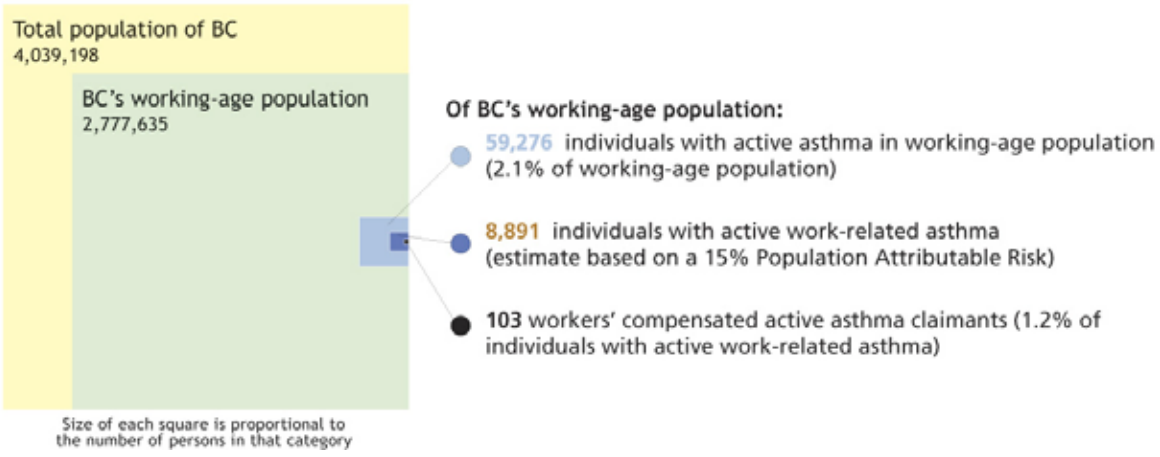


Figure 11: Comparison of workers'-compensated active asthma claims to individuals with active work-related asthma, 2000



Discussion

The cumulative prevalence of asthma among the working-age population of British Columbia in 2000 was 51 and 68 cases per 1,000 among males and females respectively.

Previous work (50) in British Columbia that used data on asthma-related prescriptions in addition to physician visit and hospitalization data to identify cases reported a prevalence of 90 cases per 1,000 among those aged five to 54 in 2000/01. Statistics Canada survey data for British Columbia indicates a self-reported rate of 61 cases per 1,000 for males and 94 for females aged 15 to 64 in 2000/01 (19). The higher rates in these studies may be due to the use of self-report, sample-based data, as well as the use of prescription data in identifying cases.

The cumulative prevalence of asthma among the immediate pre-working-age population (ages ten to 14) was 154 and 108 cases per 1,000 among males and females respectively.

Other research conducted in 1998 indicated a prevalence of approximately 110 cases per 1,000 in British Columbia, which is consistent with our study. Although based on different age groupings, Habbick et al. report higher prevalence in the two Canadian centres participating in the International Study of Asthma and Allergies in Childhood. The lifetime prevalence of asthma was 170 per 1,000 in Hamilton and 110 per 1,000 in Saskatoon for children aged six and seven respectively and 190 and 120 for children aged 13 and 14 respectively (51). A report using Ontario physician services and hospitalization administrative data reported a childhood prevalence rate of 200 per 1,000 in 1998/99 (52).

Canadian rates of childhood asthma appear to be higher than rates reported from concurrent surveys conducted in the United States, although this may be partially attributable to instrument design (prior to 1997, the National Health Interview Surveys collected information on current annual asthma prevalence rather than lifetime prevalence). However, irrespective of whether rates are assessed through lifetime prevalence, current prevalence or through symptom-based surveys, Canadians have some of the highest rates of asthma worldwide (53).

Of cases diagnosed between 1990 and 2000, 26 per 1,000 were categorized as active in 2000. The prevalence of active asthma increased slightly between 1996 and 2000, most notably among adult females.

Asthma rates have been increasing worldwide since the 1970s (1;6;14-18). Self-report surveys indicate an increase in the prevalence of asthma in Canada (54), and increases have been observed in the United States (15;55-59) and Australia (16). Our study design, restricted to a fixed ten-year cohort, does not allow us to examine whether the overall burden of asthma, defined as 'ever' asthma, is increasing. We can assess, however, what proportion of those meeting our definition of 'ever' asthma receive asthma-related medical services in a subsequent year, and whether there is an increase in the rate of individuals who exhibit 'active' asthma symptoms to the extent that they require continued treatment. While we do observe an increase in active asthma in some age groups between 1996 and 2000 (particularly females aged 25 and older), the overall increase is slight.

Rates of asthma symptoms in adults in Canada are higher than those reported in other countries. For example, in six Canadian cities, using the European Community Respiratory Health Survey (ECRHS) protocol, Manfreda and colleagues (60) found that 4.4 to 6.3 per cent of men and 5.2 to 9.5 per cent of women reported having an asthma attack in the past year, compared to an ECRHS median of slightly less than three per cent. Our estimate of active asthma in BC using a different protocol for case ascertainment is closer to this latter estimate (approximately 30 cases per 1,000).

The incidence of new cases of asthma among the pre-working-age population of British Columbia was ten and 14 cases per 1,000 among males and females respectively in 2000. Among the working-age population, this rate was four and three cases per 1,000 among males and females respectively. Overall, the incidence of asthma remained relatively stable in the province from 1996 to 2000.

The research literature has given a great deal of consideration to the marked increase in the prevalence of childhood asthma, and to concerns that this increase may be due to lifestyle changes, increased exposure to environmental pollutants, and altered immune system functioning associated with interactions between the environment and the developing immune system (61). Joint findings from the National Population Health Survey and the National Longitudinal Survey of Children and Youth (Statistics Canada), reported that seven per cent of children under four, and 13 per cent of children aged five to 14 were diagnosed with asthma in 1994/5. About half had experienced an asthma attack in the 12 months preceding the survey. The Institute for Clinical Evaluation Sciences (ICES), using administrative data on asthma-related physician services and hospitalizations, found that the incidence of asthma among children under ten decreased between 1994 and 1998 from 3.7 to 2.6 per cent, while the prevalence of asthma ('ever' asthma) increased from 15 to 20 per cent(52). Our results may differ from the ICES results as they used a shorter "burn-in" period to control for initial case finding (which will increase rates earlier in the study period).

Some evidence from the last decade (mostly pertaining to childhood asthma) suggests that prevalence and incidence may have reached a plateau (15;17;21-23;52). Our study confirms these findings—for children we did not observe an increase in either the incidence or active prevalence of asthma. Even so, a high, though stable rate among children may predict higher rates of asthma as these children enter adulthood and the workforce.

The experience of asthma does vary by sex, with changing patterns in the sex distribution by age (62-64). While asthma is more prevalent in males during childhood, females take the lead after puberty. An analysis of the European Community Respiratory Health Survey (ECRHS) reported that during childhood, females had a significantly lower risk of developing asthma compared to males, while females had a higher risk of developing asthma at older ages (63). Similarly, studies in Canada (64) and the Unities States (62) indicate that males are hospitalized twice as often as females in childhood for asthma-related treatment, and that females are hospitalized three times as often in adulthood.

While asthma prevalence is much higher in childhood, a large proportion of these cases appear to involve acute symptoms, and many children, after initial treatment, do not receive asthma-related medical services in subsequent years. This is consistent with other literature which indicates that many children, particularly very young children, 'grow out' of their asthma (5;63). Adult asthma, particularly for those aged 25 or older, appears to be more chronic and more likely to involve treatment in subsequent years. These statements come with two caveats. First, individuals presently asymptomatic might be at risk for a future asthma episode, particularly in the presence of occupational or environmental triggers. Second, we can not differentiate whether a lack of subsequent asthma activity is due to well-controlled asthma, incorrect initial diagnoses or because exposure to allergens has been reduced—as opposed to it being due to an individual no longer having symptoms.

Research on the incidence of adult onset asthma has largely been based on self-report survey data.
A recent review of this literature reports a pooled estimate for the incidence of asthma of 4.6 per 1,000 in females and 3.6 per 1,000 in males (65). However, many of these studies are cross-sectional, retrospective and subject to recall bias (66), and almost all rely on self-report measures. Indeed, research into asthma incidence is marked by divergence measures, methods and results. Lundback and colleagues, for example, showed that by validating survey measures of asthma incidence against objective clinical diagnostic tests, incidence initially estimated at between eight and four cases per 1,000 (depending on follow-up period and exclusion criteria) fell

to 2.3 cases per 1,000 (67). Of the few studies that rely on medical records or clinical measures, asthma incidence rates are lower. A study using physician records from Manitoba found that the overall incidence of asthma was around 1.5 cases per 1,000 (68) while a Swiss study, using a denominator of overall physician consultations, found rates of between 0.62 and 0.72 per 1,000 consultations (69). Our results, while using medical records, are more consistent with incidence rates from surveys. This may relate to differences in how the denominator is calculated but could also relate to differences in coding and treatment practices across jurisdictions. One consistency that does emerge across physician record-based studies is that asthma incidence appears to be stable, and in a one study was found to be declining.

If 15 per cent of cumulative prevalent asthma cases can be attributed to workplace exposures, approximately 27,000 working-age British Columbians experienced work-related asthma in 2001 (nine cases per 1,000). Five-hundred and thirty occupational asthma claims were accepted by WorkSafeBC between 1991 and 2000—two per cent of estimated work-related asthma.

Using the same 15 per cent Population Attributable Risk rate, approximately 9,000 working-age British Columbians were receiving treatment for active work-related asthma in 2000. Just over 100 occupational asthma claims were compensated in the same year—about one per cent of estimated work-related asthma.

Estimates of the burden of work-related asthma have used administrative data, asthma surveillance systems and reviews of population-based studies of asthma among adults. Kraut et al. used administrative data from a sample of the labor force in Manitoba to explore physician-diagnosed asthma (defined as three or more physician encounters during a four-year period) in various occupations. They found a higher risk of asthma in three occupation groups: 1) teachers in community colleges, vocations and the arts, 2) occupations involving fabricating, installing and repairing electric and electronic equipment, and 3) other occupations in laboring and elemental work. They also concluded that the use of such data sets "for surveillance of work-related diseases in general, and for asthma in particular" showed promise (70).

Occupational surveillance systems around the world have estimated an average annual incidence rate of between 19 and 174 work-related asthma cases per million employees; between 19 and 43 cases per million in the UK (71;72); 80 cases per million in Sweden (1990 to 1992) (73) and 174 cases per million in Finland (1989 to 1995) (74). If we apply the PAR of 15 per cent to our overall incidence rate (3 per 1,000 in 2000) we would generate a comparative work-related incidence rate of about 500 cases per million, much higher than what has been reported by occupational surveillance systems above. However, these surveillance systems tend to report only new onset occupational asthma, not work-aggravated asthma.

The gap between PAR estimates of work-related asthma and the number of compensated claims may be due, in part, to the fact that until recently WorkSafeBC only considered new onset occupational asthma as potentially compensable. We were also not able to examine workers' records who received health care treatment only for asthma through the compensation system. Recent changes to compensation policy that expand the definition of potentially compensable asthma to include preexisting asthma that is seriously aggravated by workplace exposures may increase the number of compensated cases.

This study has found that the potential burden of work-related asthma—whether active prevalence or cumulative prevalence—measures in the thousands and ten of thousands of cases. These estimates, while broad, suggest that there is a need to focus prevention and screening efforts on this disease. In addition, the large cohort of children who have, or have had, asthma indicates that a large percentage of young workers may enter the labour force with underlying sensitivities to asthmogens or preexisting asthma.

Conclusion

This report represents one of the first research outputs of the WorkSafeBC-CHSPR partnership. By incorporating the BCLHD into occupational health research, and through ongoing support from WorkSafeBC, this project has laid the foundation for a much broader occupational surveillance research agenda.

Work is underway to refine the methodology developed in this project to provide more focused estimates by industry, occupation and demographic characteristics. In particular, we will be updating our surveillance protocol to include data on asthma-related prescriptions from BC PharmaNet. Secondly, building on another partnership project that incorporates industry of employment information into the BCLHD, we will examine whether actual rates of asthma do in fact differ for those employed in industries typically associated with a high risk of occupational asthma.

The results from this research may improve WorkSafeBC's ability to identify workers in need of compensation, as well as better focus their prevention efforts.

The BCLHD holds broader potential. For example, the longitudinal nature of the BCLHD and the comprehensive nature of health care billing records means that we will soon be able to examine how entering the workforce affects asthma-related health care utilization among children diagnosed with asthma.

Future enhancements of the administrative data shows great promise for occupational health research in general, and asthma-related research in specific. Under the auspices of the University of British Columbia's Population Health and Learning Observatory, it will soon be possible to link exposure data to a workers' compensation and medical records.

References

1 Soriano JB, Kiri VA, Maier WC, Strachan D. Increasing prevalence of asthma in UK primary care during the 1990s. Int J Tuberc Lung Dis 2003 May;7(5):415-21.

2 Leigh JP, Romano PS, Schenker MB, Kreiss K. Costs of occupational COPD and asthma. Chest 2002 Jan; 121(1):264-72.

3 Wilkins K, Mao Y. Trends in rates of admission to hospital and death from asthma among children and young adults in Canada during the 1980s. CMAJ 1993 Jan 15;148(2):185-90.

4 Boulet LP, Becker A, Berube D, Beveridge R, Ernst P. Canadian Asthma Consensus Report, 1999. Canadian Asthma Consensus Group. CMAJ 1999 Nov 30;161(11 Suppl):S1-61.

5 Bel EH. Clinical phenotypes of asthma. Curr Opin Pulm Med 2004 Jan;10(1):44-50.

6 National Institutes of Health. Global Strategy for Asthma Management and Prevention. Bethesda, MD: National Heart, Lung, and Blood Institute; 2002. Report No.: NIH Publication No 02-3659.

7 World Health Organization. Bronchial Asthma Fact Sheet No: 206 [mongraph on the internet]. World Health Organization 2000 [cited 2004 Sep 11]; Available from: URL: http://www.who.int/media-centre/factsheets/fs206/en/index.html

8 Masoli M, Fabian D, Holt S, Beasley R. The global burden of asthma: executive summary of the GINA Dissemination Committee Report. Allergy 2004;59(5):469-78.

9 World Health Organization. The World Health Report 2002: Reducing Risks Promoting Health Life [monograph on the internet]. World Health Organization 2002 [cited 2006 Apr 13];Available from: URL: http://www.who.int/whr/2002/en/whr02_en.pdf

10 Krahn MD, Berka C, Langlois P, Detsky AS. Direct and indirect costs of asthma in Canada, 1990. CMAJ 1996 Mar 15;154(6):821-31.

11 Health Canada. Economic Burden of Illness in Canada (1998). Ottawa, ON: Minister of Public Works and Government Services; 2002.

12 Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. Assessing the economic impact. J Allergy Clin Immunol 2001 Jan;107(1):3-8.

13 Cisternas MG, Blanc PD, Yen IH, Katz PP, Earnest G, Eisner MD, et al. A comprehensive study of the direct and indirect costs of adult asthma. J Allergy Clin Immunol 2003 Jun;111(6):1212-8.

14 Aberg N, Hesselmar B, Aberg B, Eriksson B. Increase of asthma, allergic rhinitis and eczema in Swedish schoolchildren between 1979 and 1991. Clin Exp Allergy 1995 Sep;25(9):815-9.

15 Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma--United States, 1980-1999. MMWR Surveill Summ 2002 Mar 29;51(1):1-13.

16 Ruffin R, Wilson D, Smith B, Southcott A, Adams R. Prevalence, morbidity and management of adult asthma in South Australia. Immunol Cell Biol 2001 Apr;79(2):191-4.

17 Senthilselvan A, Lawson J, Rennie DC, Dosman JA. Stabilization of an increasing trend in physician-diagnosed asthma prevalence in Saskatchewan, 1991 to 1998. Chest 2003 Aug;124(2):438-48.

18 Senthilselvan A. Prevalence of physician-diagnosed asthma in Saskatchewan, 1981 to 1990. Chest 1998 Aug;114(2):388-92.

19 Statistics Canada. Canadian Community Health Survey Cycle 1.1 (2000-2001), Public use micro data file. 2002. Ottawa, ON, Statistics Canada. Ref Type: Data File.

20 Millar WJ, Hill GB. Childhood asthma. Health Rep 1998;10(3):9-21.

21 To T, Dick P, Feldman W, Hernandez R. A cohort study on childhood asthma admissions and readmissions. Pediatrics 1996 Aug;98(2 Pt 1):191-5.

22 Crighton EJ, Mamdani MM, Upshur RE. A population based time series analysis of asthma hospitalisations in Ontario, Canada: 1988 to 2000. BMC Health Serv Res 2001;1(1):7.

23 Fleming DM, Sunderland R, Cross KW, Ross AM. Declining incidence of episodes of asthma: a study of trends in new episodes presenting to general practitioners in the period 1989-98. Thorax 2000 Aug;55(8):657-61.

24 Tarlo SM, Boulet LP, Cartier A, Cockcroft D, Cote J, Hargreave FE, et al. Canadian Thoracic Society guidelines for occupational asthma. Can Respir J 1998 Jul;5(4):289-300.

25 American Thoracic Society. Proceedings of the First Jack Pepys Occupational Asthma Symposium. Am J Respir Crit Care Med 2003 Feb 1;167(3):450-71.

26 Chan-Yeung M, Malo JL. Aetiological agents in occupational asthma. Eur Respir J 1994 Feb;7(2):346-71.

27 Cullinan P, Tarlo S, Nemery B. The prevention of occupational asthma. Eur Respir J 2003;22(5):853-60.

28 Tarlo SM, Liss G, Corey P, Broder I. A workers' compensation claim population for occupational asthma. Comparison of subgroups. Chest 1995 Mar;107(3):634-41.

29 Cote J, Kennedy S, Chan-Yeung M. Outcome of patients with cedar asthma with continuous exposure. Am Rev Respir Dis 1990 Feb;141(2):373-6.

30 Tarlo SM, Liss GM. Prevention of occupational asthma-practical implications for occupational physicians. Occupational Medicine-Oxford 2005;55(8):588-94.

31 Nicholson PJ, Cullinan P, Newman Taylor AJ, Burge PS, Boyle C. Evidence based guidelines for the prevention, identification, and management of occupational asthma. Occup Environ Med 2005 May 1;62(5):290-9.

32 Le Moual N, Siroux V, Kauffmann F, Kennedy SM, Epidemiological Study on the Genetics and Environment of Asthma. Asthma severity and exposure ot occupational asthmogens. American Journal of Respiratory and Critical Care Medince 2005;172(4):440-5.

33 Cannon J, Cullinan P, Newman TA. Consequences of occupational asthma. BMJ 1995 Sep 2;311(7005):602-3.

34 Gassert TH, Hu H, Kelsey KT, Christiani DC. Long-term health and employment outcomes of occupational asthma and their determinants. J Occup Environ Med 1998 May;40(5):481-91.

35 Ameille J, Pairon JC, Bayeux MC, Brochard P, Choudat D, Conso F, et al. Consequences of occupational asthma on employment and financial status: a follow-up study. Eur Respir J 1997 Jan;10(1):55-8.

36 Gautrin D, Newman-Taylor AJ, Nordman H, Malo JL. Controversies in epidemiology of occupational asthma. Eur Respir J 2003;22:551-9.

37 Provencher S, Labreche FP, DeGuire L. Physician based surveillance system for occupational respiratory diseases: The experience of PROPULSE, Quebec, Canada. Occup Environ Med 1997;54(4):272-6.

38 Contreras GR, Rousseau R, Chan-Yeung M. Occupational respiratory diseases in British Columbia, Canada in 1991. Occup Environ Med 1994;55(10):710-2.

39 WorkSafeBC. Occupational Disease in BC: 1981-2005 [monograph on the internet]. WorkSafeBC 2006Available from: URL: http://www.worksafebc.com/publications/reports/statistics_reports/occupational_disease/pub_10_20_50.asp

40 Malo JL, Chan-Yeung M. Occupational asthma. Journal of Allergy and Clinical Immunology 2001;108:317-27.

41 WorkSafeBC. Compensation for Occupational Asthma and Contact Dermatitis [monograph on the internet]. WorkSafeBC 2006 February [cited 2006 Mar 15];Available from: URL: http://worksafebc.com/regulation_and_policy/policy_consultation/assets/pdf/asthma_and_dermatitis.pdf

42 WorkSafeBC. The Workers' Compensation Board of British Columbia Resolution of the Board of Directors, Re: Compensation for Occupational Asthma and Contact Dermatitis [monograph on the internet]. WorkSafeBC 2006 [cited 2006 Mar 12];Available from: URL: http://www.worksafebc.com/regulation_and_policy/policy_decision/board_decisions/2006/november/assets/20061107-03.pdf

43 Leigh JP, Robbins JA. Occupational Disease and Workers' Compensation: Coverage, Costs, and Consequences. Milbank Quarterly 2004 Dec 1;82(4):689-721.

44 Balmes J, Becklake M, Blanc P, Henneberger P, Kreiss K, Mapp C, et al. American Thoracic Society Statement: Occupational contribution to the burden of airway disease. Am J Respir Crit Care Med 2003 Mar 1;167(5):787-97.

45 Tarlo SM, Leung K, Broder I, Silverman F, Holness DL. Asthmatic subjects symptomatically worse at work: prevalence and characterization among a general asthma clinic population. Chest 2000 Nov;118(5):1309-14.

46 Karjalainen A, Kurppa K, Martikainen R, Klaukka T, Karjalainen J. Work is related to a substantial portion of adult-onset asthma incidence in the Finnish population. Am J Respir Crit Care Med 2001 Aug 15;164(4):565-8.

47 British Columbia Legislative Assembly. Freedom of Information and Protection of Privacy Act. RSBC 1996, Chapter 1651-81. 1993. Ref Type: Statute

48 British Columbia Ministry of Health and Centre for Health Services and Policy Research (UBC). Access policy for research uses of linked health data. Victoria, BC: British Columbia Ministry of Health; 1996.

49 Roos LL, Gupta S, Soodeen RA, Jebamani L. Data quality in an information-rich environment: Canada as an example. Canadian Journal on Aging-Revue Canadienne du Vieillissement 2005;24:153-70.

50 BC Health Services - Chronic Disease Management. Asthma in British Columbia - An Administrative Data View [monograph on the internet]. Government of British Columbia 2004 [cited 2004 Nov 9];Available from: URL: http://www.healthservices.gov.bc.ca/cdm/research/asthmadataview.pdf

51 Habbick BF, Pizzichini MM, Taylor B, Rennie D, Senthilselvan A, Sears MR. Prevalence of asthma, rhinitis and eczema among children in 2 Canadian cities: the International Study of Asthma and Allergies in Childhood. CMAJ 1999 Jun 29;160(13):1824-8.

52 To T, Dell S, Cicutto L, Harris J, Tassoudji M, Duong-Hua M. Burden of Childhood Asthma. Toronto, Ontario: ICES; 2004.

53 The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. Lancet 1998;351:1225-32.

54 Statistics Canada. Health Indicators - Asthma household population aged 12 and over 2000/01 by sex, Canada, provinces, territories, health regions and peer groups. http://www statcan ca/english/freepub/82-221-XIE/00502/hlthstatus/conditions2 htm 2002 [cited 2004 Nov 9];2003 (1)

55 Mannino DM, Homa DM, Pertowski CA, Ashizawa A, Nixon LL, Johnson CA, et al. Surveillance for asthma--United States, 1960-1995. MMWR CDC Surveill Summ 1998 Apr 24;47(1):1-27.

56 Blackwell DL, Collins JG, Coles R. Summary health statistics for U.S. adults: National Health Interview Survey, 1997. National Centre for Health Statistics; 2002. Report No.: 10.

57 Bloom B, Tonthat L. Summary health statistics for U.S. children: National Health Interview Survey, 1997. National Center for Health Statistics; 2002. Report No.: 10.

58 Bloom B, Cohen RA, Vicherie JL, Wondimu EA. Summary health statistics for U.S. children: National Health Interview Survey, 2001. National Center for Health Statistics; 2003. Report No.: 10.

59 Lucas JW, Schiller JS, Benson V. Summary health statistics for U.S. adults: National Health Interview Survey, 2001. National Center for Health Statistics; 2004. Report No.: 10.

60 Manfreda J, Becklake MR, Sears MR, Chan-Yeung M, Dimich-Ward H, Siersted HC, et al. Prevalence of asthma symptoms among adults aged 20-44 years in Canada. CMAJ 2001 Apr 3;164(7):995-1001.

61 Sears MR. Epidemiology of childhood asthma. Lancet 1997 Oct 4;350(9083):1015-20.

62 Skobeloff EM, Spivey WH, St Clair SS, Schoffstall JM. The influence of age and sex on asthma admissions. JAMA 1992 Dec 23;268(24):3437-40.

63 de Marco R, Locatelli F, Sunyer J, Burney P. Differences in incidence of reported asthma related to age in men and women. A retrospective analysis of the data of the European Respiratory Health Survey. Am J Respir Crit Care Med 2000 Jul;162(1):68-74.

64 Chen Y, Stewart P, Johansen H, McRae L, Taylor G. Sex difference in hospitalization due to asthma in relation to age. J Clin Epidemiol 2003 Feb;56(2):180-7.

65 Eagan TML, Brogger JC, Eide GE, Bakke RS. The incidence of adult asthma: a review. International Journal of Tuberculosis and Lung Disease 2005;9(6):603-12.

66 Brogger J, Eagan T, Eide GE, Bakke P, Gulsvik A. Bias in retrospective studies of trends in asthma incidence. European Respiratory Journal 2004 Feb;23(2):281-6.

67 Lundback B, Ronmark E, Jonsson E, Larsson K, Sandstrom T. Incidence of physician-diagnosed asthma in adults--a real incidence or a result of increased awareness? Report from The Obstructive Lung Disease in Northern Sweden Studies. Respiratory Medicine 2001 Aug;95(8):685-92.

68 Dik N, Anthonisen NR, Manfreda J, Roos LL. Physician-diagnosed asthma and allergic rhinitis in Manitoba: 1985-1998. Annals of Allergy, Asthma, & Immunology 2006 Jan;96(1):69-75.

69 Bollag U, Capkun G, Caesar J, Low N. Trends in primary care consultations for asthma in Switzerland, 1989-2002.[see comment]. International Journal of Epidemiology 2005 Oct;34(5):1012-8.

70 Kraut A, Walld R, Mustard C. Prevalence of physician-diagnosed asthma by occupational groupings in Manitoba, Canada. Am J Ind Med 1997 Sep;32(3):275-82.

71 McDonald JC, Keynes HL, Meredith SK. Reported incidence of occupational asthma in the United Kingdom, 1989-97. Occup Environ Med 2000 Dec;57(12):823-9.

72 Gannon PF, Burge PS. The SHIELD scheme in the West Midlands Region, United Kingdom. Midland Thoracic Society Research Group. Br J Ind Med 1993 Sep;50(9):791-6.

73 Toren K. Self reported rate of occupational asthma in Sweden 1990-2. Occup Environ Med 1996 Nov;53(11):757-61.

74 Karjalainen A, Virtanen S, Keskinen H, Nordman H. Incidence of occupational asthma by occupation and industry in Finland. American Journal of Industrial Medicine 2000;(37):451-8.