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Long-Term Impact of Western Red Cedar Asthma on Work, Health and Quality of Life

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Long-Term Impact of Western Red Cedar Asthma on Work, Health and Quality of Life

Report to the Research Secretariat of the
Workers' Compensation Board of British Columbia

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1.0 EXECUTIVE SUMMARY

Western red cedar asthma (WRCA) is the most common form of occupational asthma in British Columbia and in the northwest United States. Of concern are the long-term effects of WRCA on health outcomes and employment for diagnosed workers. We undertook a follow-up study of workers who had been diagnosed with western red cedar asthma. The purpose of the study was to determine whether there were differences in respiratory symptoms and quality of life measures according to whether or not workers with WRCA remained employed and continued to be exposed or not to western red cedar (WRC).

The study began in September 2003. Telephone based interviews were conducted using a questionnaire which included information on general and respiratory health, work history and quality of life (using the SF-36 and Marks Asthma quality of life questionnaires). Out of 643 potential subjects, only 302 were contacted. Of those contacted and eligible for the study, 70.5% (213) took part. Although there is a possibility of selection bias, there were few differences between the characteristics of study subjects and age-eligible non-participants.

Data analysis was performed comparing means and percentage distribution of characteristics and outcomes according to work exposure groups. Of 213 subjects interviewed, 47 (22%) were still working with WRC, 81 (38%) were employed but no longer exposed to WRC, 31 (15%) had quit working because of problems with asthma; the remainder had stopped working due to retirement or other reasons. Those subjects no longer working due to problems with asthma had the highest prevalence of chronic and acute asthma-like respiratory symptoms and reduced quality of life. In general, those who were employed had the most favourable outcome, particularly those no longer exposed to WRC. Workers exposed to WRC had a higher prevalence of wheeze and chest tightness than workers no longer exposed; the lower quality of life scores were not significantly different. There were few differences in respiratory health, apart from trends of increased wheeze and chest tightness when comparing those working only with WRC to those working with WRC and other woods; however many of the quality of life scores were significantly worse for those intermittently exposed.

After being diagnosed with WRCA, there were no obvious differences in symptoms, asthma severity or personal characteristics that distinguished which workers continued to be employed

and exposed to WRC, which remained working but were unexposed and which subjects stopped work. Over the follow-up period, the majority of the subjects who had initially worked with WRC had either switched to jobs without exposure to WRC or had stopped working due to problems with WRC. In contrast, none of the workers who had initially switched to an unexposed job developed problems with their asthma that were severe enough to cause them to quit work. Based upon exposure ascertainment incorporating job titles and job characteristics, higher estimated exposures to red cedar dust were found for subjects who had been exposed to WRC in their most recent job before quitting due to asthma or other reasons, than observed for those currently working with WRC. Very few subjects recalled being trained on the possible health hazards of dealing with WRC before they had started employment; most subjects became aware of the potential risks after being diagnosed with WRCA.

The study clearly illustrates that the consequences of WRCA are not only the potential for poor respiratory health; WRCA can also impact quality of life. Subjects who quit work due to problems with asthma had worse long-term symptomatic and quality of life outcomes. We recommend that better protective health measures in the workplace be instituted, such as engineering controls, in order to reduce exposure to WRC and subsequently the development of and deterioration of WRCA among workers. Workers diagnosed with WRCA should be offered re-training on other unexposed jobs, with monetary compensation, preferably within the same company. Education on the potential health risks of dealing with WRC, and the measures that should be taken by workers to help minimize personal exposure should be implemented during initial training and throughout employment. For subjects with WRCA, the goal is to achieve a reduction in severity of asthmatic symptoms and good quality of life despite their diagnosis.

Unfortunately western red cedar asthma is not just a disease of the past. Due to current economic challenges, there is the possibility that the wood industry may combine cedar and sawmill operations. This will result in exposure to red cedar dust for previously unexposed sawmill workers. The consequence may not only be an increase in new claims for WRCA, but also this may adversely affect claimants who had been successfully avoiding exposure to western red cedar dust.

2.0 INTRODUCTION

Asthma is a potentially disabling lung disease that is estimated to cost millions of dollars annually in Canada due to the cost of medications and loss of work time (1). The direct and indirect costs of asthma were evaluated between $504 and $648 million (1). The most prevalent occupational lung disease in developed countries is occupational asthma. Western red cedar asthma (WRCA) is the most common form of occupational asthma in British Columbia and in the northwest United States due in part to the important role of the cedar products industry to the economy.

Of concern are the long-term health and occupational outcomes of workers diagnosed with western red cedar asthma. For instance, it was not known what percentage are still working and remain exposed to western red cedar dust, what respiratory symptoms they may be experiencing and how quality of life has been affected.

We undertook a follow-up study of workers from British Columbia who had been diagnosed with western red cedar asthma in order to evaluate long term effects related to respiratory health and quality of life. The specific objectives of the study were:

1. To conduct a long-term follow-up of British Columbian workers with Western red cedar asthma, as identified by specific challenge testing since 1972.

2. To determine the prevalence of current respiratory symptoms.

3. To assess quality of life domains generally and specifically to asthma.

4. To evaluate the relationship of personal and work history factors to current respiratory symptoms and quality of life indicators.

5. To determine the working conditions of those who remained in the cedar industry, including duties, working location relative to dust sources and occupational hygiene measures taken to reduce red cedar dust exposure.

3.0 BACKGROUND

3.1 Occupational Asthma

Asthma is a chronic condition of the lungs that causes constriction (tightening of the muscles that surround the airways) and inflammation (swelling and irritation of the airways). Narrowing of the airways may result in symptoms such as wheezing, coughing, chest tightness or shortness of breath.

Occupational asthma is variable airway narrowing and/or bronchial hyperresponsiveness causally related to exposure in the working environment to airborne dusts, gases, vapours, or fumes (2). Some subjects may experience milder to moderate symptoms such as coughing, chest tightness and/or shortness of breath, while others may exhibit more severe symptoms such as nocturnal awakenings (3). Medications such as inhaled steroids or bronchodilators may help the individual cope with persistent asthma symptoms. Diagnosing occupational asthma involves a thorough evaluation including: a history and physical examination, serum levels of immunoglobulin E (IgE), non-specific bronchial challenge testing (to determine airway hyperresponsiveness), serial monitoring of peak expiratory flow rate (PEFR) or forced expiratory volume in one second (FEV_1) (within and outside of the workplace) and provocation testing with the suspected agent (4).

Bronchial challenge testing using methacholine may be used to confirm the diagnosis of asthma by measuring airway responsiveness. This test requires the patient to inhale one or more concentrations of methacholine, which causes a brief constriction of the bronchial airways, resulting in a measurable reduction in airflow to a standardized threshold; typically this threshold is a methacholine concentration of 8mg/mL and can result in a decrease of the patient's baseline FEV_1 by 20% or more. The most effective method in determining occupational asthma is by serial measurements of peak expiratory flow rates (5,6). A pattern where decreases in peak flow values occur during work or shortly after work is indicative of occupational asthma.

Specific inhalation provocation testing can be given where a specific causal agent in the workplace is suspected. There are a large variety of agents used in various industries that are known to cause occupational asthma (6). Some common occupational allergens include: animal dander, rubber latex, chemicals, metals, grain dust and wood dust. Occupational allergens are

either high molecular weight agents (>5000 daltons), e.g. latex and grain, or low-molecular weight agents such as isocyanates and plicatic acid from WRC (7). Once a diagnosis of occupational asthma has been made, it has been suggested that the most effective treatment method is cessation of exposure to the causative agent (8).

3.2 Western Red Cedar Asthma

Occupational asthma due to Western red cedar (WRCA) is the most common form of occupational asthma in British Columbia, in part due to the importance of cedar production to the provincial economy (9). Western red cedar (Thuja Plicata), which is native to the western coast of British Columbia and to Washington State, is well known for its high durability and is therefore suitable for production of poles, shakes, shingles and lumber (10). The first case study linking western red cedar with symptoms of asthma was by Doig in 1949 (11). Three Australian researchers (12-14) showed that men without a personal or familial history of allergy or asthma still suffered from irritant and respiratory symptoms which could progress to chronic asthma, when machining WRC, but worked problem-free with other woods. The clinical picture of patients with WRCA typically involves the development and worsening of symptoms of cough, chest tightness and wheeze. According to Chan-Yeung (1994) (15) 70% of all compensation claims for occupational asthma in British Columbia at that time were for WRCA.

Plicatic acid, a non-volatile component of this wood, is considered to be the etiological agent for WRCA, as demonstrated by Chan-Yeung and colleagues (16). It accounts for 50% by weight of all the extractives in Western red cedar and is readily soluble in water. As is characteristic of low molecular weight allergens, skin tests with plicatic acid and Western red cedar extract typically are negative in patients with proven diagnosis (10). The diagnosis of WRCA is confirmed from inhalation provocation tests that directly expose the subject to plicatic acid or other WRC extracts. A positive response results if the patient's FEV_1 was 15% or more below the value of a control test recorded on the same day. Patients either tended to show a precipitous drop in FEV_1 within 45 minutes after inhalation (immediate), severe pulmonary function deterioration up to 24 hours after exposure (delayed) or both reactions (dual hypersensitivity response patterns).

3.2.1 Follow-up Studies on Patients with Western Red Cedar Asthma

WRCA patients diagnosed in Vancouver were subjects of a number of follow-up studies conducted by Dr. Moira Yeung and her colleagues. Of 232 subjects with WRCA and studied four years after diagnosis, 136 patients (58.6%) had left the industry and had no further exposure to cedar dust (17). Of these, 55 subjects (40.4%) were asymptomatic. The 81 subjects who were still symptomatic even after about four years of no exposure to WRC were shown on average to have had a longer duration of occupational exposure before onset of symptoms, a longer duration of symptoms before diagnosis and a greater reaction to plicatic acid during specific bronchial provocation testing. Patients who became asymptomatic showed improvement in spirometric measurements at follow-up, whereas those who were still symptomatic showed a decline in lung function even after cessation of work.

Lin and colleagues followed 280 male WRCA patients for one year. Subjects were compared to 399 cedar sawmill workers and results showed that WRCA patients who continued to be exposed to WRC had a greater rate of decline in lung function (FEV_1) than the comparison group(18). Cote and colleagues re-examined 48 out of the 68 patients with WRCA who remained in the same industry for an average of 6.5 years since diagnosis (19). Upon evaluation of asthma symptoms, medication requirements, spirometry and methacholine challenge testing none of the patients were found to have completely recovered. Most patients (62.5%) remained stable, some patients improved (10.4%), but over a third of patients deteriorated (37.5%). They also looked at the influence of decreasing exposure to WRC by changing jobs to a less dusty environment and the various types of respirators used. It was observed that transfer to a less dusty job did not make a difference in prevention of deterioration of symptoms and it was only the use of a twin-cartridge respirator that resulted in a more favourable outcome.

Clinical and socioeconomic impacts of WRCA were examined for 128 subjects by Marabini and colleagues (20). Along with methacholine challenge testing, a questionnaire was administered which contained information on demographic data, socioeconomic status, presence of respiratory symptoms, use of medication, current working status and exposure to WRC dust. The “working-exposed” group had significantly greater prevalence of symptoms of wheeze or shortness of breath, more medications and greater asthma severity than the “working-unexposed” and “unemployed” groups. Also, it was reported that the “working-unexposed” had a significantly

lower income than the "working-exposed" group. It was concluded that socioeconomic factors and not asthma severity were the main determinant in influencing working status for subjects with WRCA.

3.3 Measurement of Quality of Life

According to the World Health Organization (WHO): "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1948). Quality of life (QOL) is a broader concept as it not only includes the physical and mental dimensions of health but also an individuals' personal evaluation of everyday functioning. Traditional methods of assessing health through physiological and clinical practice does not cover the impacts of diseases on physical, social or emotional well-being (21).

Typically, QOL is measured in terms of domains such as physical status, psychological impact and social interactions. A number of generic health related QOL questionnaires have been developed, e.g. the SF-36 Health Survey (22); the Sickness Impact Profile (23); the Nottingham Health Profile (24); the Quality of Well-Being Scale (25) as well as a variety of asthma-specific QOL surveys, e.g. the Asthma Quality of Life Questionnaire (26); the Living with Asthma Questionnaire (27); the Life Activities Questionnaire for Adult Asthma (28); and the Asthma Quality of Life Questionnaire (29).

3.3.1 SF-36

The Short Form (SF)-36 is the most commonly used health related QOL instrument (30) and it has been useful in evaluating the impacts of more than 200 diseases and conditions (www.sf-36.com). As of August 2005, according to the Citation Index, the SF-36 has been cited 5,034 times. The SF-36 Health Status Survey (a short form with 36 items) was developed by Ware and Sherbourne and consists of eight domains used in assessing health status which represent the most frequently measured health concepts chosen from 40 health concepts included in the Medical Outcomes Study (22,31). Most questions are based on the four weeks preceding administration of the questionnaire. The SF-36 has been tested for its validity and reliability and it has continually proven to be a successful tool in measuring QOL (32,33). Additionally, the International Quality of Life Assessment (IQOLA) Project has translated the questionnaire into a

variety of different languages (34) allowing the SF-36 to become a worldwide accepted tool in assessing QOL (33,35).

3.3.2 Marks Asthma Quality of Life Questionnaire

Although many "Quality of Life" questionnaires have been developed specifically for asthma, (e.g. the Living with Asthma Questionnaire (27); the Life Activities Questionnaire for Adult Asthma (28); the Asthma Quality of Life Questionnaire (29)); the Marks Asthma Quality of Life Questionnaire (AQLQ) has the advantage of consisting of fewer questions, and has been validated for telephone administration (36).

The Marks AQLQ consists of 20 items covering a wide range of issues that may be commonly considered of importance to asthmatics (26). Like the SF-36, questions are based on the four weeks preceding administration of the questionnaire and four domains are used to assess the individuals' state of health and overall functioning. Marks and colleagues concluded that Marks AQLQ serves as an effective tool for measuring differences between individuals that improved or remained stable in their asthmatic symptoms over time (37). Gupchup and colleagues tested the reliability and validity of a telephone administered Marks AQLQ in the U.S. (38) They showed good acceptability among respondants as no questions were left blank or answered with "don't know," all items and domains had good internal consistency and good construct validity.

3.3.3 QOL Studies of Asthma

To date, there have been no scientific publications in which the SF-36 or Marks AQLQ questionnaires were used for examining the quality of life of subjects with occupational asthma or more specifically, WRCA. However, these tools have been used to investigate the QOL of subjects with asthma or other respiratory diseases. For example, SF-36 and Marks AQLQ questionnaires were used to determine the differences in the QOL of asthmatic patients undergoing two different treatments (39). For those subjects treated with dry powder inhalers, improved SF-36 and Marks scores in most domains were observed indicating that symptomatic improvement and decreased use of oral corticosteroids was accompanied by increased overall health-related QOL. The impact of coping and socioeconomic factors on health related QOL was explored in moderate to severe asthmatic subjects (40). The SF-36 and a slightly modified Marks AQLQ were administered at baseline and over a 12-month follow-up. Psychological factors,

particularly coping styles, and economic factors were found to be strongly associated with health related QOL of individuals. In another study the SF-36 health survey and Asthma Quality of Life Questionnaire (Juniper's) were administered to 196 subjects with persistent asthma (41). The results showed that for those that were unexposed, worse Asthma Quality of Life and SF-36 scores were seen versus those that were still working.

There are very few examples of applying QOL instruments to studies of occupational asthma. For instance, Malo et al. used the Asthma Quality of Life Questionnaire by Juniper to assess 134 subjects with occupational asthma that had been removed from exposure for two or more years (42). When compared to the control groups, the occupational asthma group showed greater impairment in their QOL.

4.0 METHODOLOGY

The design of the study was as a follow-up study of subjects diagnosed with WRCA at Vancouver General Hospital through questionnaire-based interview.

All study procedures were approved by the University of British Columbia's Behavioural Research Ethics Board before the commencement of the study.

4.1 Subjects

The subjects of the study were originally diagnosed at the UBC Respiratory Clinic located at Vancouver General Hospital, principally by one physician. Over 90% of the patients were referred by the compensation board. The criteria for diagnosis were standardized and remained consistent throughout the follow-up period. The subjects were diagnosed principally on the basis of having a typical reaction (immediate, dual or delayed) to plicatic acid challenge.

The original database consisted of 625 patients diagnosed with WRCA since 1972. In addition, patients diagnosed with WRCA in 2000-2003 by another physician (18 patients) were added to the database bringing the total to 643 potential subjects. In addition to a few deaths, patients were not interviewed if they met one of the following criteria: unable to participate due to illness, residence outside of BC, out of town during the interview period, unable to contact because of

incorrect address and/or telephone number, being older than 75 or were non-English/non-Punjabi speaking (i.e. some subjects were only Cantonese/Mandarin speaking).

4.2 Contacting subjects

Introductory letters, prepared in English and Punjabi were mailed out over the period of December 2002 until June 2003 and in December 2003 to all of the potential subjects. The letters explained the purpose of the study and the details concerning the questionnaire-based interview. After a minimum of one week from mailing the invitation letters, research assistants (both English and Punjabi-speaking) made attempts to contact subjects by telephone. Internet search engines (www.mytelus.com/phonebook/index.vm and www.canada411.com/eng/person.html) were used to confirm patient mailing addresses initially and upon receipt of an incorrect address notification. Where recent information was available on the subject's physician, attempts were made to contact physician offices to obtain correct addresses.

A compiled list of 157 subjects who could not be reached by our research team was sent to the Worker's Compensation Board (WCB). Attempts were made by WCB personnel to contact subjects in order to obtain permission for our study team to contact them in the cases where they had more up-to-date addresses and telephone numbers.

Potential subjects who were contacted by telephone were asked whether they had received the invitation letter and if they were willing to participate in the study. If a subject was willing to participate, a future date for the telephone interview was scheduled. A consent form, a stamped return envelope and an interview guide were mailed by the study coordinator to the subject. Consent forms were also translated into a Punjabi version. All interviews were conducted over the telephone (in English or Punjabi) except for two subjects who were interviewed in person at Vancouver General Hospital at their request. The duration of the interview ranged from 45 minutes to 2 hours and upon completion of the interview, thank-you letters were mailed to the participants.

4.3 Questionnaire

The questionnaire was divided into two main sections: (i) general information, health and quality of life and (ii) work history and work environment.

4.3.1 General information, health and quality of life

This section of the questionnaire contained questions on demographics, smoking habits and current asthma symptoms such as cough, presence of phlegm, wheeze, chest tightness and shortness of breath (dyspnea). Questions on acute asthma-like respiratory symptoms were based on the International Union Against Tuberculosis and Lung Diseases (IUATLD) questionnaire used for the European Community Health survey (43,44). Questions on chronic respiratory symptoms were based on the Epidemiology Standardization Project (45). The socio-economic section of the questionnaire investigated the circumstances of the original asthma claim submitted to the Workers' Compensation Board, if compensation was paid to the subject and any retraining offered to or taken by the subject. Additional questions also covered income, marital status, education history and unemployment history.

Quality of life was determined using the MOS 36-Item Short-Form Health Survey (SF-36) (22) and the Marks Asthma Quality of Life Questionnaire (26). The eight domains used from the SF-36 questionnaire were: 1) physical functioning – limitation in physical activities because of health problems; 2) role functioning – limitations in usual role activities because of physical or emotional problems; 3) social functioning – limitations in social activities because of physical or emotional problems; 4) bodily pain – intensity and effect of pain on normal work in and outside the house; 5) mental health – psychological distress and well-being; 6) vitality – energy and fatigue; 7) general health perceptions – personal evaluations of health; and 8) change in health – evaluation of current health compared to one year before the interview. Each of the 8 domains for the SF-36 is rated on a scale of 0-100, obtained by recoding specific items, computing the raw scale scores by summing across items in the same scale and by transforming raw scores to a 0-100 scale (31). Values scoring closest to 100 are equivalent to a better health state and overall functioning.

The four domains of the Marks Asthma Quality of Life Questionnaire are based on a 5-point Likert scale scored from 0 ("not at all") to 4 ("very severely") and include items on: Breathlessness, Mood Disturbance, Social Disruption and Concerns for Health. From this, a total score ranging from 0-80 was calculated which was then converted to a 0-10 scale (26). A low total score indicates better health status and overall functioning for the individual. All items contributed to the total scale score while selected items were calculated for the subscale scores.

Definitions of Symptoms

Chronic Respiratory Symptoms:

Chronic respiratory symptoms were defined as follows:

Wheeze:

Occasional:	Occasionally have wheeze apart from colds.
Most days/nights:	Wheezy or whistling in chest most days and nights.

Chest tightness:

Ever:	Ever having episodes of attacks of chest tightness.
Most days:	Having chest tightness on most days.

Trouble breathing:

Rarely:	Rarely have trouble with breathing.
Regularly-gets better:	Regular trouble with breathing but always gets completely better.
Always:	Breathing is never quite right.

Breathlessness:

Slight hill:	Being breathless when hurrying on level ground or when walking up a slight hill.
Own age:	Having to walk slower than people of own age because of breathlessness.
Own pace:	Stop for breath when walking at own pace on level ground.
100 yards:	Stop for breath after walking 100 yards on level ground.
Chronic cough:	Having cough for at least 3 consecutive months of the year.
Chronic phlegm:	Having phlegm for at least 3 consecutive months of the year.

Acute Respiratory Symptoms:

Acute respiratory symptoms are defined as the following and are pertaining to symptoms occurring in the last 12 months:

Wheeze anytime:	Having wheezing or whistling in your chest, apart from having a cold.
Woken with chest tightness	Having woken at night with a feeling of tightness in your chest.
Dyspnea during day:	Having an attack of shortness of breath that came on day when were not doing anything strenuous.
Woken by dyspnea:	Woken at night by shortness of breath.
Woken by cough:	Woken at night by cough.
Asthma-like symptoms:	Answering "yes" to at least one of the five acute respiratory symptoms described above.

4.3.2 Work history and work environment

The work history section contained information on jobs held since diagnosis including the type of industry, job title, duties and activities, substances worked with or came in contact with, duration of employment, hours per week worked, reason for leaving job (if not a current job) and if the subject was exposed to wood dust. The Job Exposure Matrix for Exposures Associated with Occupational Asthma, developed by Susan Kennedy and colleagues, was applied in order to determine whether or not there was potential exposure to asthmogenic agents (46). Examples of asthmogenic agents include flour, latex, cleaning products, wood dust, metal fumes, motor exhaust and isocyanates. The wood dust section contained information relating to the subject's work environment for those jobs with potential for wood dust exposure. Information in this section included: company's name, division and department worked in, type of mill or manufacturing facility, exposure to anti-fungal agents, spray paint, metal fumes and presence of mold or fungi on the wood, percentage of the type of wood(s) processed (including asthmogenic and non-asthmogenic woods), areas worked in (near saws, sanders and/or planers, inside a building, booth or enclosure), involvement of clean-up of dust, use of respirator protective equipment and personal protective measures.

4.3.3 Work Exposure Variables

Current Work Status: This category consisted of 4 groups: (i) working and still exposed to western red cedar, (ii) working and not exposed to western red cedar, (iii) not working due to problems with asthma and (iv) not working due to other reasons (e.g retired, having other illnesses, being laid off).

Currently Employed: Of those who are still working, further subdivisions were created: working with western red cedar 100% of the time, working with western red cedar <100% of the time, working and exposed to other asthmogenic agents and working and not exposed. Asthmogenic agents included those outlined in the Job Exposure Matrix for Exposures Associated with Occupational Asthma (46) as well as asthmogenic woods other than western red cedar (i.e. pine, oak, mahogany and some exotic woods).

Work History:

Initial Work Status: Subjects were categorized into 3 groups as determined by their work exposure status within one year after initial diagnosis: (i) working with WRC, (ii) working but not exposed to WRC and (iii) not working either due to problems with asthma or for other reasons.

WRC Exposure: Subjects exposed to WRC in their current or most recent job were divided into 4 groups: (i) working with 100% WRC, (ii) working with <100% WRC, (iii) not working due to problems with asthma, and (iv) not working due to other reasons.

4.4 Data Analysis

Information recorded on the questionnaires during the interview was coded numerically and entered into spreadsheets (Microsoft Excel 2000). Once questionnaires were entered, initial stages of data clean up involved visual scans of the spreadsheets to find and correct obvious entry errors. Data from each spreadsheet was saved as a file using the Statistical Package for the Social Sciences, Version 11.5 (SPSS, Chicago, Ill.). Further error analysis involved using descriptive and frequency functions.

4.4.1 Chart Review

A review of the subjects' clinical files was carried out in order to confirm a positive plicatic acid challenge test. Information on medication use, methacholine challenge testing and spirometry conducted at diagnosis were also obtained in order to calculate an asthma severity score as outlined by the American Thoracic Societies Guidelines for the Evaluation of Impairment/Disability in Patients with Asthma (47). An asthma severity score was determined using the following factors: percent predicted FEV_1, methacholine challenge test results (PC_{20}) and type of medication. This information was then rated as an impairment class ranging from 0-6 with 6 representing severe uncontrollable asthma.

4.4.2 Exposure Assessment

Verification of company information was obtained through the Madison's Canadian Lumber Directory (1967-2004) available at the MacMillan Library located on the UBC campus. This Directory also provided information on the percentage and type of wood processed at sawmills, shake and shingle mills, and remanufacturers. We were able to verify company names on 73.6% of the companies mentioned in the work history section. However the book entries were not necessarily up-to-date or accurate and not all companies had available information on the percentage and type of wood processed. There was 53.0% agreement between subjects' self-reported exposure to 100% WRC and information obtained from the lumber directory.

Intensity of Exposure:

The following lists the sequential steps used to determine level of exposure to WRC (i.e. low, medium or high) for each current or most recent job as well as cumulative exposure since diagnosis.

1. Sawmill based job titles were assigned a starting exposure level based on mean natural log (base-*e*) values from a wood dust database compiled from the Workers' Compensation Board of British Columbia compliance data and from four studies of sawmills (48-51).
   Starting scale:
   3 = <0.75 mg/m^3; 4 = 0.75-1.0 mg/m^3; 5 = 1.0-1.5 mg/m^3; 7 = >1.5 mg/m^3.

The scale range began at 3 in order to avoid a negative exposure level in later steps when exposure estimates were reduced to account for protective measures.

Table 1. Sawmill jobs by starting exposure level

		Job Title
Starting Exposure Level (mg/m^3)	**<0.75**	Offbearer, Grader, Tallyman, Boomman, Barker operator, Stacker operator, Watchman, Department foreman, Clerk
	0.75-1.0	Forklift driver, Head sawyer, Trimmer operator, Utility, Electrician, Gangsawyer
	1.0-1.5	Millwright, Planar feeder, Dropsorter, Hog operator, Mechanic, Spotter, Maintenance, Manager
	>1.5	Resawyer, Sawfiler, Carpenter, Tailsawyer

Sawmill jobs not captured by the method above were assigned the median exposure level (1.02 mg/m^3), and therefore used a starting scale of 5.

2. Non-sawmill jobs were assigned levels based on job title and tasks described in the interview. For example, a tree faller had a starting level of 3 while a cabinet maker performing finishing work had a starting level of 7.

3. The starting scale was adjusted according to an *a priori* list of tasks and determinants of exposure variables:

Task or Determinants of Exposure	Scale Adjustment
Sanded/planed wood less than 4 feet from the source or absence of local exhaust	+2
Sawed/routed wood less than 4 feet from the source or absence of local exhaust	+1
Operated mobile machinery not fully enclosed	+1
Involved in cleanup of wood dust or debris for 10 or more hours per week	+1
Worked inside a fully-enclosed booth	-1
Wore a respirator* for 6 or more hours per day	-1

* Airstream helmet, full-face with battery, full-face without battery or half mask twin-cartridge

4. The adjusted scale was multiplied by the percent of WRC processed, as indicated by the worker for the current job (or most recent job), for those not currently employed, and re-categorized as low, medium or high based on the frequencies of approximately one third of the total per group.

5. *Cumulative exposure*: For all jobs held since diagnosis, the adjusted scale was multiplied by the percent of WRC processed and by the number of months worked at each job. The scale was summed for all jobs and re-categorized (low, medium or high) based on the frequencies of approximately one third of the total per group.

4.4.3 Statistical Analysis

Cross tabulations of the data were conducted for categorical variables using Chi-square analysis. Analysis of Variance (ANOVA) was utilized for comparisons of more than two means, with Scheffe's test applied for post-hoc comparisons. Logistic and multiple regression analyses were also conducted for the multivariate analysis of binary and continuous dependant variables respectively, using Statistical Software for Professionals (Stata/SE 8.0, College Station, TX). Examples of binary outcomes were respiratory symptoms, while continuous outcomes were quality of life domain scores. For all analyses, a p-value < 0.05 was regarded as statistically significant.

5.0 RESEARCH FINDINGS

5.1 Study Population

Of 643 potential subjects interviewed for the study almost half (341 subjects) were excluded for reasons listed in Table 2. The participation rate was 70.5% with 213 out of 302 eligible subjects taking part. In total 62 subjects refused to participate and 27 subjects were scheduled for interviews but on subsequent calls no further contact could be made.

Table 2. Participation rate of western red cedar asthmatics

Population	# Of Individuals
Total	643
Excluded:	341
Deceased	19
Illness	3
Age 75 or older	84
Non English and non Punjabi speaking	9
Unable to contact subject:	
Not residing in BC	24
Out of town	7
Incorrect address/phone number	123
No answer	72
Number eligible	302
Refused	62
Contacted but unavailable	27
Number of participants	**213**
Participation rate	**70.5%**

Attempts were made to contact a total of 159 physician offices to obtain current contact information for potential study subjects. We were unable to contact 34 (21.4%) of the offices and physicians from 4 offices refused to send us contact information on their patients. There was no follow-up information available from 40 (25.2%) of the offices and 21 offices (13.2%) had the same contact information. Of the 60 offices able to give us new contact information, almost half were incorrect addresses and/or telephone numbers. In total, more up to date contact information was obtained for only 31 subjects (19.5%).

Personnel from the WCB were able to provide new contact information for 19 subjects who had given permission for our research team to contact them.

Table 3 shows a comparison of personal characteristics and asthma severity between the study participants and 346 non-participants who had satisfied the age requirements for eligibility. The study participants tended to be more atopic and hyperresponsive. However, only ethnicity was statistically significant, due to the larger percentage of East Indian participants.

Table 3. Characteristics of current study participants and eligible non-participants at diagnosis

Characteristics	Study participants (n=213)	Non-participants (n=346)	p-value*
Age (years±SD)	37.0±9.9	36.2±10.0	0.395
Gender (% males)	97.2	97.4	0.905
Ethnicity (%)			0.036
Caucasian	43.7	44.4	
East Indian	54.5	49.1	
Smoking status (%)			0.103
Never smoker	68.4	71.5	
Ex-smoker	28.7	22.6	
Current Smoker	2.9	5.9	
Respiratory Symptoms (%):			
Cough	87.0	86.4	0.844
Phlegm	43.1	42.5	0.893
Wheeze	74.6	76.4	0.641
Chest tightness	71.3	74.6	0.390
Shortness of breath	88.5	86.1	0.417
Positive skin prick test (%)	48.2	42.3	0.186
FEV_1 (% predicted)	88.6±16.1	89.7±14.4	0.414
Methacholine PC_{20} (mg/ml)	3.1±5.0	4.2±6.6	0.081

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

The average age of the 213 study subjects was 54.9 years and the range was 26 to 77 years of age. Although the intent was to exclude subjects aged 75 or older, 6 subjects age 75 to 77 who had been inadvertently sent a letter of invitation agreed to participate. The years of diagnosis ranged from 1970 to 2003, with a median year of diagnosis of 1985.

5.2 Current Work Status

5.2.1 Characteristics

The personal characteristics of the study subjects at the time of follow up examination are shown in Table 4. The majority of subjects were males (97%), of East Indian ethnicity (53%), married (92%) and never smokers (72%), with only 7% living with a smoker. Almost one half of the subjects had less than 12 years of education. The average period of follow up was 17.8 years.

Of the 213 subjects, 47 subjects remained exposed to WRC whereas 166 were no longer exposed to WRC. Age, years since diagnosis and work history with WRC differed according to current work status. Those not working for reasons other than asthma were 10 years older on average and there was a greater time interval since diagnosis. All of the subjects no longer working due to asthma had been most recently working in jobs in which they were exposed to WRC. Only 5 of the subjects (2.3%) had hobbies in which they may have exposure to western red cedar. They were evenly distributed across groups.

Table 4. Characteristics of western red cedar (WRC) asthmatics by current work status

Characteristic	Current Work Status				Total (n=213)	P-value*
	Working		Not working			
	WRC (n=47)	No WRC (n=81)	Asthma (n=31)	Other (n=54)		
Age in years (±SD)	51.6±7.2	49.8±8.3	55.6±14.2	64.9±8.6	54.9±11.1	<0.001
Gender: % males	47(100%)	78(96.3%)	29(93.5%)	52(96.3%)	206(96.7%)	0.45
Ethnicity: Caucasian	21(44.7%)	37(45.7%)	11(35.5%)	25(46.3%)	94(44.1%)	0.22
East Indian	26(55.3%)	42(51.9%)	20(64.5%)	25(46.3%)	113(53.1%)	
Other	0(0.0%)	2(2.5%)	0.0%	4(7.4%)	6(2.8%)	
Highest education level:						
<12 years	23(48.9%)	31(38.3%)	19(61.3%)	28(53.8%)	101(47.9%)	0.13
Completed high school	18(38.3%)	33(40.7%)	8(25.8%)	21(40.4%)	80(37.9%)	
Post secondary	6(12.8%)	17(21.0%)	4(12.9%)	3(5.8%)	30(14.2%)	
Marital Status:						
Common law/Married	45(95.7%)	74(91.4%)	26(83.9%)	51(94.4%)	196(92%)	0.51
Divorced/Separated	1(2.1%)	5(6.2%)	3(9.7%)	1(1.9%)	10(4.7%)	
Single/Widowed	1(2.1%)	2(2.5%)	2(6.5%)	2(6.5%)	7(3.3%)	
Live with smoker	7(14.9%)	6(7.4%)	1(3.2%)	1(1.9%)	15(7.0%)	0.06
Family asthma	13(27.7%)	18(22.2%)	2(6.5%)	12(22.2%)	45(21.1%)	0.15
Years since diagnosis (±SD)	15.6±7.2	17.7±6.2	14.5±7.9	21.7±6.7	17.8±7.2	<0.001
Work history with WRC:						
Always	39(83.0%)	0(0.0%)	26(83.9%)	31(57.4%)	96(45.1%)	<0.001
Intermittent	8(17.0%)	1(1.2%)	1(3.2%)	1(1.9%)	11(5.2%)	
Ceased: <1 yr from diagnosis	0(0.0%)	43(53.1%)	0(0.0%)	9(16.7%)	52(24.4%)	
>1 yr since diagnosis	0(0.0%)	37(45.7%)	4(12.9%)	13(24.1%)	54(25.4%)	

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

The socioeconomic status and compensation details of the study population are presented in Table 5. The frequency of claims submitted to and accepted by the WCB differed among current work status groups. Those not employed due to asthma had greater asthma severity as indicated by the high percentage that had received compensation (90.6%) or were still receiving

compensation (48.4%) at the time of the interview. Also, significant differences among current work status groups were seen for number of persons per household, number of non-earning subjects in the family and household income. As could be expected those not employed had a much lower income on average. It is important to note that some limitations existed for household income as subjects tended to feel uncomfortable in disclosing such information and therefore all subjects did not answer this question (n=157 versus n=213 for the total population). Statistics Canada reports that the average household income in 2000 was $55,016 (52). Just over one half of the subjects were below the Canadian average of household income.

Unemployment and a change of job have previously been associated with a decrease in income among WRCA patients (20). Marabini et al. (1993) illustrated that those that were still employed and exposed or not to WRC were younger, had a higher monthly income and larger families than the unemployed. In our study, subjects that continued to work, exposed or unexposed, were also younger and also had larger families.

Table 5. Socioeconomic status & compensation of western red cedar (WRC) asthmatics by current work status

	Current Work Status					
	Working		Not Working			
	WRC (n=47)	No WRC (n=81)	Asthma (n=31)	Other (n=54)	Total (n=213)	P-value*
Asthma claim:						
Submitted claim	37(78.7%)	57(70.4%)	30(96.8%)	40(74.1%)	164(77.0%)	0.03
Claim accepted	31(66.0%)	48(59.3%)	29(93.5%)	35(64.8%)	143(67.1%)	0.01
Compensation received	30(63.8%)	45(56.3%)	28(90.3%)	34(63.0%)	137(64.6%)	0.01
Still receiving compensation	9(19.1%)	6(7.5%)	15(48.4%)	14(25.9%)	44(20.8%)	<0.001
# of persons per household ±SD	3.6±1.3	3.8±1.5	3.4±1.5	2.8±1.3	3.5±1.4	<0.001
Non-earning subjects in family ±SD	1.5±1.3	1.8±1.4	2.4±1.1	1.9±1.0	1.9±1.3	0.03
Retraining taken	5(10.9%)	14(17.7%)	5(16.7%)	4(7.4%)	28(13.4%)	0.32
N	35	62	21	39	157	
Household income:						<0.001
0-25 000	0(0%)	1(1.6%)	8(38.1%)	11(28.2%)	20(12.7%)	
25 001-50 000	14(40.0%)	27(43.5%)	12(57.1%)	22(56.4%)	75(47.8%)	
50 001-75 000	15(42.9%)	20(32.3%)	1(4.8%)	5(12.8%)	41(26.1%)	
> 75 000	6(17.1%)	14(22.6%)	0(0%)	1(2.6%)	21(13.4%)	

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

As shown in Table 6, there was a statistically significant difference only for cigarette smoking status between current work status groups. Those employed with WRC had the largest percent of current smokers (8.5%) although on average they tended to smoke less than one pack per day. The majority of all the subjects were never smokers (71.8%) and there were very few who smoked pipes or cigars.

Table 6. Smoking habits of western red cedar (WRC) asthmatics by current work status

	Current Work Status					
	Working		Not Working			P-value*
	WRC (n=47)	No WRC (n=81)	Asthma (n=31)	Other (n=54)	Total (n=213)	
Cigarettes:						0.05
Never smoker	30(63.8%)	66(81.5%)	22(71.0%)	35(64.8%)	153(71.8%)	
Ex-smoker	13(27.7%)	12(14.8%)	8(25.8%)	19(35.2%)	52(24.4%)	
Current smoker	4(8.5%)	3(3.7%)	1(3.2%)	0%	8(3.8%)	
Current smoker:						
Age started	19.5±4.9	15.7±3.2	N/A	0	17.6±4.2	0.52
Duration-yrs ±SD	32.8±8.7	26.3±9.3	N/A	0	31.5±9.2	0.37
Packs/day ±SD	0.9±0.2	0.6±0.3	N/A	0	0.7±0.3	0.14
Ex-Smoker:						
Age started	17.5±5.1	16.6±2.4	18.9±2.7	16.7±5.0	17.2±4.2	0.63
Duration-yrs ±SD	10.2±7.7	23.5±16.2	17.4±22.4	23.1±13.0	19.1±15.2	0.07
Packs/day ±SD	0.7±0.4	0.8±0.3	0.9±1.0	0.8±0.5	0.8±0.5	0.96
Cigars:						0.56
Never smoked	44(93.5%)	80(98.8%)	30(96.8%)	52(96.3%)	206(96.7%)	
Ex-smoker	2(4.3%)	1(1.2%)	1(3.2%)	2(3.7%)	6(2.8%)	
Current smoker	1(2.1%)	0(0.0%)	0%	0%	1(0.5%)	
Pipe:						0.40
Never smoked	47(100%)	80(98.8%)	30(96.8%)	52(96.3%)	209(98.1%)	
Ex-smoker	0(0.0%)	0(0.0%)	1(3.2%)	2(3.7%)	3(1.4%)	
Current smoker	0(0.0%)	1(1.2%)	0%	0%	1(0.5%)	

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

5.2.2 Respiratory Symptoms

Chronic Respiratory Symptoms:

There were statistically significant differences between groups according to current work status for most chronic respiratory symptoms (Table 7). In general, a greater prevalence of respiratory symptoms was found in those not employed; particularly for those who stopped working due to

problems with asthma. Those who were working but no longer exposed to WRC showed slightly less prevalence of chronic symptoms than those exposed to WRC. However, there were no statistically significant differences observed between the employed groups.

Table 7. Prevalence of chronic respiratory symptoms of western red cedar (WRC) asthmatics by current work status

Symptoms	Current Work Status					
	Working		Not Working			
	WRC (n=47)	No WRC (n=81)	Asthma (n=31)	Other (n=54)	Total (n=213)	P-value*
Wheeze:						
Occasional	17(36.2%)	22(27.2%)	16(51.6%)	19(35.2%)	74(34.7%)	0.11
Most days/nights	12(25.5%)	14(17.3%)	12(38.7%)	16(29.6%)	54(25.4%)	0.10
Chest tightness:						
Ever	22(46.8%)	28(34.6%)	28(90.3%)	20(37.0%)	98(46.0%)	<0.001
Most days	4(8.7%)	6(7.4%)	15(50.0%)	6(11.1%)	31(14.7%)	<0.001
Trouble breathing:						<0.001
Rarely	25(53.2%)	58(71.6%)	6(19.4%)	21(39.6%)	110(51.9%)	
Regularly-gets better	12(25.5%)	13(16.0%)	8(25.8%)	15(28.3%)	48(22.6%)	
Always	10(21.3%)	10(12.3%)	17(54.8%)	17(32.1%)	54(25.5%)	
Breathlessness:						
Slight hill	24(51.1%)	30(37.0%)	25(80.6%)	30(55.6%)	109(51.2%)	<0.001
Own age	17(36.2%)	22(27.2%)	23(74.2%)	23(42.6%)	85(39.9%)	<0.001
Own pace	12(25.5%)	12(14.8%)	19(61.3%)	21(38.9%)	64(30.0%)	<0.001
100 yards	8(17.0%)	10(12.3%)	17(54.8%)	20(37.0%)	55(25.8%)	<0.001
Chronic cough	8(17.0%)	7(9.1%)	10(32.3%)	12(25.5%)	37(18.3%)	0.02
Chronic phlegm	5(10.6%)	13(16.5%)	7(24.1%)	12(22.6%)	37(17.8%)	0.34

* Significance testing based on chi-square testing for comparison of proportions.

Acute Respiratory Symptoms:

All acute asthma-like symptoms in the past 12 months were significantly related to current work status (Table 8). Those not employed generally showed a higher prevalence for all acute respiratory symptoms. Statistically significant differences were shown between the two working groups for wheeze and woken with chest tightness, which were higher in prevalence for those currently working with WRC.

Table 8. Prevalence of asthma-like symptoms in the past 12 months of western red cedar (WRC) asthmatics by current work status

Symptoms	Current Work Status					
	Working		Not Working			
	WRC (n=47)	No WRC (n=81)	Asthma (n=31)	Other (n=54)	Total (n=213)	P-value*
Wheeze anytime	22(46.8%)	21(25.9%)	18(58.1%)	22(40.7%)	83(39.0%)	0.01
Woken with chest tightness	14(29.8%)	12(14.8%)	24(77.4%)	17(31.5%)	67(31.5%)	<0.001
Dyspnea during day	8(17.0%)	17(21.0%)	20(64.5%)	18(33.3%)	63(29.6%)	<0.001
Woken by dyspnea	10(21.3%)	14(17.3%)	20(64.5%)	18(33.3%)	62(29.1%)	<0.001
Woken by cough	9(19.1%)	16(19.8%)	14(45.2%)	17(31.5%)	56(26.3%)	0.02
Asthma-like symptoms	26(55.3%)	40(49.4%)	29(93.5%)	33(61.1%)	128(60.1%)	<0.001

* Significance testing based on chi-square testing for comparison of proportion.

After adjustments were made for the influences of age, sex, ethnicity, education, smoking status, living with a smoker and family asthma, and comparisons were made to those working and exposed to WRC, the group not working due to problems with asthma showed elevated risk estimates for most chronic and acute respiratory symptoms (Tables 9 & 10). Although not statistically significant, the working but unexposed group showed a trend of having a lower risk for most chronic and acute asthma-like symptoms.

Table 9. Association of work status and chronic respiratory symptoms of western red cedar (WRC) asthmatics using logistic regression analysis*

Respiratory Symptoms	Working no WRC	Not working Asthma	Not working Other
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Wheeze:			
Occasional	0.7 (0.3, 1.6)	2.2 (0.8, 6.0)	0.9 (0.3, 2.5)
Most days/nights	0.5 (0.2, 1.3)	1.8 (0.6, 5.1)	1.0 (0.3, 2.8)
Chest tightness:			
Ever	0.6 (0.3, 1.4)	13.6† (3.4, 54.7)	1.1 (0.4, 2.8)
Most days	0.6 (0.2, 2.6)	8.2† (2.2, 30.4)	1.2 (0.3, 5.3)
Trouble breathing - always	0.5 (0.2, 1.2)	4.2† (1.4, 12.1)	1.7 (0.6, 4.8)
Breathlessness:			
Slight hill	0.5 (0.2, 1.1)	3.9† (1.2, 12.4)	0.7 (0.3, 1.8)
Own age	0.6 (0.2, 1.3)	5.1† (1.6, 16.0)	0.9 (0.3, 2.3)
Own pace	0.4 (0.1, 1.0)	3.5† (1.2, 10.2)	1.2 (0.4, 3.3)
100 yards	0.6 (0.2, 1.7)	4.5† (1.5, 13.8)	1.9 (0.6, 5.7)
Chronic cough	0.5 (0.1, 1.5)	2.1 (0.6, 6.7)	1.2 (0.4, 3.9)
Chronic phlegm	2.1 (0.5, 8.2)	5.3† (1.1, 26.2)	3.0 (0.7, 13.6)

* Comparisons were made to those working and exposed to WRC, adjusting risk estimates for age, sex, ethnicity, education, smoking status, living with a smoker and family asthma

† $p<0.05$

Table 10. Association of work status and acute respiratory symptoms within the last 12 months of western red cedar (WRC) asthmatics using logistic regression analysis*

Respiratory Symptoms	Working no WRC	Not working Asthma	Not working Other
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Wheeze anytime	0.4† (0.2, 0.9)	2.3 (0.8, 6.1)	0.7 (0.3, 1.9)
Woken with chest tightness	0.4 (0.2, 1.0)	8.3† (2.7, 25.3)	1.1 (0.4, 3.0)
Dyspnea during day	1.0 (0.4, 2.8)	8.3† (2.7, 25.1)	2.6 (0.9, 7.8)
Woken by dyspnea	0.8 (0.3, 2.2)	9.0† (3.0, 27.4)	2.0 (0.7, 5.9)
Woken by cough	0.9 (0.3, 2.5)	4.6† (1.5, 14.1)	1.8 (0.6, 5.4)
Asthma-like symptoms	0.8 (0.4, 1.7)	14.5† (3.0, 70.9)	1.2 (0.5, 3.1)

* comparisons to those working and exposed to WRC, adjusting risk estimates for age, sex, ethnicity, education, smoking status, living with a smoker and family asthma

† $p<0.05$

As could be expected, the group who quit work because of problems with asthma had a higher prevalence of specialized treatment for asthma and increased medication use of all types (Table 11). Those workers who were unexposed to WRC had the lowest prevalence of any type of medication use. There was a relatively high prevalence of inhaled steroid use among those currently working with WRC. Marabini and colleagues also found in their shorter follow-up study that the "working-exposed" used more medications for the control of symptoms (20). Among the listed illnesses, there was a statistically significant difference between groups only for a history of high blood pressure

Table 11. Asthma severity, medication use and history of illnesses of western red cedar (WRC) asthmatics by current work status

	Working		Not Working			
Characteristic	**WRC (n=47)**	**No WRC (n=81)**	**Asthma (n=31)**	**Other (n=54)**	**Total (n=213)**	**P-value***
ER treatment for asthma	10(21.3%)	23(28.4%)	18(58.1%)	19(35.2%)	70(32.9%)	<0.001
Hospitalization for asthma	10(21.3%)	28(34.6%)	17(54.8%)	15(27.8%)	70(32.9%)	0.02
Current asthma medication use	27(57.4%)	27(33.3%)	28(90.3%)	28(51.9%)	110(51.6%)	<0.001
Type of asthma medication:						<0.001
Bronchodilators only	7(14.9%)	11(13.6%)	5(16.1%)	8(14.8%)	31(22.5)	
Inhaled corticosteroids	18(38.3%)	11(13.6%)	12(38.7%)	12(22.2%)	53(24.9)	
Oral corticosteroids	2(4.3%)	5(6.2%)	11(35.5%)	8(14.8%)	26(12.2)	
History of illnesses:						
Pneumonia	6(12.8%)	10(12.3%)	8(25.8%)	8(14.8%)	32(15.0%)	0.33
Bronchitis	7(14.9%)	15(18.5%)	5(16.1%)	15(27.8%)	42(19.7%)	0.36
Emphysema	0(0%)	0(0%)	0%	1(1.9%)	1(0.5%)	0.40
Other chest illnesses	2(4.3%)	2(2.6%)	0%	6(11.3%)	10(4.8%)	0.07
High blood pressure	5(10.9%)	16(19.8%)	7(22.6%)	20(37.0%)	48(22.6%)	0.02
General injuries/medical conditions	13(27.7%)	18(22.2%)	8(25.8%)	20(37.0%)	59(27.7%)	0.31

* Significance testing based on chi-square testing for comparison of proportion.

Table 12 illustrates the percent predicted spirometry, methacholine challenge and and skin prick test results for assessment of atopy which were done at diagnosis, according to their current work status. Lung function at diagnosis was worse for those that eventually quit work because of problems with asthma.

Table 12. Lung function and skin prick tests of western red cedar (WRC) asthmatics at diagnosis by current work status

Test results at diagnosis	Current Work Status					
	Working		Not Working			
	WRC (n=47)	No WRC (n=81)	Asthma (n=31)	Other (n=54)	Total (n=213)	P-value*
FEV1 (% predicted)	96.0±13.0	88.6±16.3	80.3±17.4	87.0±14.7	88.6±16.1	<0.001
FVC (% predicted)	103.9±13.3	99.3±13.7	89.7±13.5	98.5±14.9	99.0±14.4	<0.001
Methacholine PC20 (mg/ml)	3.5±5.5	3.4±5.3	2.4±4.5	2.8±4.3	3.1±5.0	0.80
Skin prick test(% positive)	24(51.2)	44(54.5)	17(55.2)	17(32.0)	102(47.9)	0.07

* Significance testing based on chi-square testing for comparison of proportions.

5.2.3 Quality of Life

Significant differences were observed between groups for all quality of life indicators (Table 13). Generally, those not employed showed lower overall health-related functioning. Typically, QOL scores were higher, but not statistically significant, for those still working and not exposed to WRC versus those still exposed to WRC. The Marks Asthma Quality of Life scores showed a similar pattern of higher functioning (lower average score) among the working groups, particularly for the group not exposed to WRC in comparison to the unemployed groups.

The QOL scores for the unemployed groups of western red cedar asthmatics were similar to that found in Schmier's study (39) for patients with severe persistent asthma. Their scores for physical functioning, role functioning due to physical reasons and general health averaged between 50 and 60 (compared to scores of 30 to 60 in our study) and this contrasted to US norms of between 70 and 80.

Table 13. Quality of life of western red cedar (WRC) asthmatics by current work status

Domains	Current Work Status					
	Working		Not Working			
	WRC (n=47)	No WRC (n=81)	Asthma (n=31)	Other (n=54)	Total (n=213)	p-value*
SF-36 Transformed scale**:						
Physical functioning	77.7±22.7	85.9±17.2	57.1±24.7	63.8±28.8	74.3±25.4	<0.001
Role functioning-physical	71.3±37.2	85.8±26.8	37.1±45.6	55.6±42.0	67.8±40.1	<0.001
Role functioning-emotional	77.3±36.8	83.1±33.0	36.6±46.6	64.8±44.6	70.4±41.9	<0.001
Social functioning	84.3±18.1	89.8±17.5	54.8±30.4	75.7±23.2	79.9±24.3	<0.001
Bodily pain	82.9±21.1	89.2±20.2	63.9±28.1	77.3±26.1	81.1±24.6	<0.001
Mental health	82.1±14.9	84.8±14.6	67.7±23.5	77.4±18.3	79.9±18.0	<0.001
Vitality	58.8±17.3	64.3±16.0	43.6±18.1	51.4±18.8	56.8±18.8	<0.001
General health perceptions	61.6±20.9	69.9±19.7	42.1±26.2	54.3±23.7	60.0±23.9	<0.001
Change in health	60.1±25.9	66.7±24.7	56.5±31.6	53.2±22.3	60.3±25.9	0.02
Marks Asthma QOL Scale**:						
Scale total	1.6±1.3	1.3±1.5	3.9±2.3	2.3±2.1	2.0±1.9	<0.001
Breathlessness	1.8±1.3	1.2±1.5	3.8±2.5	2.5±2.5	2.0±2.1	<0.001
Mood	1.1±1.2	0.9±1.4	3.0±2.5	1.9±2.0	1.5±1.8	<0.001
Social	1.7±1.6	1.6±2.1	4.4±2.9	2.5±2.4	2.2±2.4	<0.001
Concerns	1.5±1.5	1.3±1.8	4.2±2.6	2.1±2.0	1.9±2.2	<0.001

*Significance testing based one-way analysis of variance for comparison of means.

**SF-36 Transformed scale: 1 = worst and 100=best; Marks Asthma QOL Scale: 0=best and 10=worst.

Table 14 shows the results of regression analyses of the effect of employment status on QOL indices after adjustment for age, sex, interview language, taking pills or inhalers, and symptoms of dyspnea, chest tightness and wheeze in the past 12 months (adjustment for symptoms take into account potential effects of being symptomatic on perceived QOL). When comparisons were made to those working with WRC, those not employed because of asthma had significantly worse scores (negative regression coefficients) for the SF-36 domain social functioning and for Marks AQLQ scale total, mood, social and concerns. Although not statistically significant, those

not working with WRC showed a trend of having better functioning on average for most QOL domains when compared to the working exposed group.

Analyses were also done without statistical adjustment for symptoms. In this case, exposed workers had significantly worse scores for physical functioning and role functioning-physical when compared to the unexposed workers.

Table 14. Association of current work status with quality of life of western red cedar (WRC) asthmatics using multiple regression*

Domains	Current Work Status					
	Working no WRC		Not Working Asthma		Not Working Other	
	B	SE	B	SE	B	SE
SF-36 Transformed scale:						
Physical functioning	4.2	3.9	-3.8	5.6	-12.9	5.5
Role functioning-physical	3.1	5.9	-7.4	8.5	-19.9†	8.3
Role functioning-emotional	-3.4	6.4	-17.0	9.2	-32.7†	9.1
Social functioning	0.9	3.7	-17.4†	5.3	-10.1	5.3
Bodily pain	3.9	4.0	-4.7	5.7	-2.0	5.6
Mental health	2.1	3.0	-4.0	4.4	-7.5	4.3
Vitality	2.7	3.1	-4.8	4.5	-4.6	4.4
General health perceptions	3.7	3.7	-2.6	5.3	-8.6	5.2
Change in health	4.2	4.5	11.2	6.5	5.6	6.4
Marks Asthma QOL Scale:						
Scale total	-0.01	0.2	1.1†	0.4	0.4	0.4
Breathlessness	-0.1	0.2	0.5	0.4	0.3	0.4
Mood	-0.2	0.3	0.9†	0.4	0.8†	0.4
Social	0.2	0.4	1.4†	0.5	0.3	0.5
Concerns	0.05	0.3	1.3†	0.4	0.4	0.4

* Linear regression coefficient for comparison with those working with WRC, adjusted for age, sex, interview language, taking pills or inhalers, and symptoms of dyspnea, chest tightness and wheeze in the past 12 months

† $p<0.05$

5.3 Currently Employed

Subjects who were currently employed comprised 60.1% of the total study population. Those working with WRC (i.e. 100% or <100% exposure) were compared to those who were exposed or not to other asthmogenic agents such as motor exhaust, cleaning products and highly reactive chemicals. Two subjects were exposed to asthmogenic woods (pine and mahogany) and three subjects were exposed to non-asthmogenic woods (alder, fir and hemlock).

5.3.1 Characteristics

Table 15 illustrates the personal characteristics of those who were currently employed. Significant differences between groups were observed for education and smoking status. There was a higher percentage of current smokers working exclusively with WRC. On average those not exposed to asthma inducing substances were better educated.

Table 15. Personal characteristics of western red cedar (WRC) asthmatics by current employment

Characteristics	Current Employment				
	Exposed to WRC		Asthmogenic exposures (n=43)	Not exposed (n=38)	p-value*
	100%† (n=22)	<100% (n=25)			
Age in years ± SD	52.8 ± 4.4	50.5 ± 9.0	48.1 ± 8.8	51.8 ± 7.3	0.07
Gender: % males	22(100%)	25(100%)	42(97.7%)	36(94.7%)	0.47
Ethnicity:					
Caucasian	10(45.5%)	11(44.0%)	17(39.5%)	20(52.6%)	
East Indian	12(54.5%)	14(56.0%)	25(58.1%)	17(44.7%)	0.85
Other	0%	0%	1(2.3%)	1(2.6%)	
Highest education level:					
< 12 years	10(45.5%)	13(52.0%)	22(51.2%)	9(23.7%)	
Completed high school	9(40.9%)	9(36.0 %)	18(41.9 %)	15(39.5%)	0.02
Post Secondary	3(13.6%)	3(12.0%)	3(7.0%)	14(36.8%)	
Smoking status:					
Never smoker	14(63.6%)	16(64.0%)	36(83.7%)	30(78.9%)	
Ex-smoker	4(18.2%)	9(36.0%)	6(14.0%)	6(15.8%)	0.03
Current smoker	4(18.2%)	0%	1(2.3%)	2(5.3%)	
Live with smoker	3(13.6%)	4(16.0%)	2(4.7%)	4(10.5%)	0.45
Family asthma	5(22.7%)	8(32.0%)	7(16.3%)	11(28.9%)	0.43
N	12	23	33	29	
Household income:					
0-25 000	0%	0%	1(3.0%)	0%	
25 001-50 000	1(8.3%)	13(56.5%)	13(39.4%)	14(48.3%)	0.16
50 001-75 000	9(75.0%)	6(26.1%)	11(33.3%)	9(31.0%)	
> 75 000	2(16.7 %)	4(17.4%)	8(24.2%)	6(20.7%)	

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

† 100% WRC – working only with WRC and not other woods

A higher percentage of subjects who were exposed at work only to WRC were still receiving compensation (Table 16). The average number of non-earning family members was higher for

those exposed to non-WRC asthmogenic substances. The percentage who had undertaken retraining was consistently low at less than 20%.

Table 16. Socioeconomic status & compensation of western red cedar (WRC) asthmatics by current employment

	Current Employment				
	Exposed to WRC		Asthmogenic exposures (n=43)	Not exposed (n=38)	p-value*
	100%† (n=22)	<100% (n=25)			
Asthma claim:					
Submitted claim	19(86.4%)	18(72.0%)	28(65.1%)	29(76.3%)	0.31
Claim accepted	16(72.7%)	15(60.0%)	21(48.8%)	27(71.1%)	0.13
Compensation received	16(72.7%)	14(56.0%)	21(48.8%)	24(64.9%)	0.24
Still receiving compensation	8(36.4%)	1(4.0%)	3(7.0%)	3(8.1%)	<0.001
# of persons per household ± SD	3.5 ± 1.4	3.8 ± 1.2	4.1 ± 1.5	3.5 ± 1.5	0.23
Non-earning subjects in family±SD	1.6 ± 1.4	1.5 ± 1.3	2.2 ± 1.3	1.4 ± 1.5	0.04
Retraining taken	3(14.3%)	2(8.0%)	7(16.7%)	7(18.9%)	0.69

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

† 100% WRC – working only with WRC and not other woods

Significant differences in work characteristics among those currently employed were observed for type of industry, having the same job since diagnosis, average number of jobs held since diagnosis and work history with WRC (Table 17). Most subjects were in the sawmill industry at diagnosis (76.6%). Transportation was the most common industrial sector for those exposed to asthmogenics; for those unexposed to asthmogenic agents, the predominant work was in retail or the restaurant industry.

Table 17. Work characteristics of western red cedar (WRC) asthmatics by current employment

Characteristics	Current Employment				
	Exposed to WRC		Asthmogenic exposures	Not exposed	p-value*
	100%† (n=22)	<100% (n=25)	(n=43)	(n=38)	
Duration in current job (years ± SD)	15.8 ± 9.1	13.5 ± 10.2	11.3 ± 6.6	10.6 ± 7.4	0.07
Current type of industry:					
Sawmill	19(86.4%)	17(68.0%)	2(4.7%)	3(7.9%)	
Construction/carpentry	1(4.5%)	3(12.0%)	5(11.6%)	4(10.5%)	
Forestry	1(4.5%)	2(8.0%)	0%	3(7.9%)	
Trades	0%	0%	6(14.0%)	9(23.7%)	
Janitorial	0%	0%	5(11.6%)	1(2.6%)	
Transportation	0%	1(4.0%)	16(37.2%)	0%	
Farm	0%	2(8.0%)	3(7.0%)	0%	<0.001
Protective services	0%	0%	1(2.3%)	2(5.3%)	
Maintenance	0%	0%	2(4.7%)	2(5.3%)	
Retail/restaurant	0%	0%	1(2.3%)	9(23.7%)	
Education	1(4.5%)	0%	0%	2(5.3%)	
Financial	0%	0%	0%	2(5.3%)	
Health	0%	0%	2(4.7%)	1(2.6%)	
Hours per week worked (± SD)	40.0 ± 0	43.7 ± 18.6	46.2 ± 12.5	45.3 ± 10.5	0.27
Job at diagnosis:					
Sawmill	18(81.8%)	21(84.0%)	38(88.4%)	29(76.3%)	
Construction/carpentry	3(13.6%)	3(12.0%)	3(7.0%)	6(15.8%)	0.74
Forestry	1(4.5%)	1(4.0%)	0%	2(5.3%)	
Other	0%	0%	2(4.7%)	1(2.6%)	
Same job since diagnosis	12(54.5%)	7(28.0%)	0%	1(2.6%)	<0.001
# of jobs since diagnosis ± SD	1.7 ± 1.1	2.1 ± 1.2	2.8 ± 1.3	2.7 ± 1.0	<0.001
Work history with WRC:					
Always	19(86.4%)	20(80.0%)	0%	0%	
Intermittent	3(13.6%)	5(20.0%)	0%	1(2.6%)	<0.001
Ceased: < 1 yr from diagnosis	0(0.0%)	0(0.0%)	22(51.2%)	21(55.3%)	
>1yr since diagnosis	0(0.0%)	0(0.0%)	21(48.8%)	16(42.1%)	

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means. † 100% WRC – working only with WRC and not other woods

5.3.2 Respiratory Symptoms

Chronic Respiratory Symptoms:

As shown in Table 18 the highest prevalence of most chronic respiratory symptoms were in the group partially exposed to WRC; however the only statistically significant difference observed between groups was for trouble breathing.

Table 18. Prevalence of chronic respiratory symptoms of western red cedar (WRC) asthmatics by current employment

Symptoms	Current Employment				
	Exposed to WRC		Asthmogenic exposures (n=43)	Not exposed (n=38)	p-value*
	100%† (n=22)	<100% (n=25)			
Wheeze:					
Occasional	6(27.3%)	11(44.0%)	10(23.3%)	12(31.6%)	0.34
Most days/nights	5(22.7%)	7(28.0%)	7(16.3%)	7(18.4%)	0.68
Chest tightness:					
Ever	8(36.4%)	14(56.0%)	17(39.5%)	11(28.9%)	0.19
Most days	1(4.5%)	3(12.5%)	4(9.3%)	2(5.3%)	0.68
Trouble breathing:					
Rarely	9(40.9%)	16(64.0%)	31(72.1%)	27(71.1%)	
Regularly-gets better	9(40.9%)	3(12.0%)	5(11.6%)	8(21.1%)	0.05
Always	4(18.2%)	6(24.0%)	7(16.3%)	3(7.9%)	
Breathlessness:					
Slight hill	10(45.5%)	14(56.0%)	16(37.2%)	14(36.8%)	0.40
Own age	8(36.4%)	9(36.0%)	12(27.9%)	10(26.3%)	0.76
Own pace	5(22.7%)	7(28.0%)	7(16.3%)	5(13.2%)	0.46
100 yards	5(22.7%)	3(12.0%)	6(14.0%)	4(10.5%)	0.60
Chronic cough	4(18.2%)	4(16.0%)	5(12.2%)	2(5.6%)	0.46
Chronic phlegm	4(18.2%)	1(4.0%)	6(14.3%)	7(18.9%)	0.38

* Significance testing based on chi-square testing for comparison of proportions.

† 100% WRC – working only with WRC and not other woods

Acute Respiratory Symptoms:

No significant differences were observed among current employment groups for any of the acute symptoms within the last 12 months (Table 19). Wheeze was the most common symptom; approximately one half of each of the employed groups experienced at least one of the asthma-like symptoms in the past 12 months.

Table 19. Prevalence of acute respiratory symptoms in the past 12 months of western red cedar (WRC) asthmatics by current employment

Symptoms	Current Employment				
	Exposed to WRC		Asthmogenic exposures (n=44)	Not exposed (n=38)	p-value*
	100%† (n=22)	<100% (n=25)			
Wheeze anytime	11(50.0%)	11(44.0%)	10(23.3%)	11(28.9%)	0.10
Woken with chest tightness	6(27.3%)	8(32.0%)	6(14.0%)	6(15.8%)	0.23
Dyspnea during day	4(18.2%)	4(16.0%)	9(20.9%)	8(21.1%)	0.95
Woken by dyspnea	5(22.7%)	5(20.0%)	7(16.3%)	7(18.4%)	0.93
Woken by cough	2(9.1%)	7(28.0%)	8(18.6%)	8(21.1%)	0.43
Asthma-like symptoms	13(59.1%)	13(52.0%)	21(48.8%)	19(50.0%)	0.88

* Significance testing based on chi-square testing for comparison of proportions.

† 100% WRC – working only with WRC and not other woods

5.3.3 Quality of Life

For most comparisons, those intermittently exposed to WRC tended to have lower quality of life scores, but the comparisons were statistically significant only for the domain of physical role functioning (Table 20). Marks QOL indices showed fewer differences between groups according to employment exposures.

Table 20. Quality of life of western red cedar (WRC) asthmatics by employment

Domains	Current Employment			
	Exposed to WRC	Asthmogenic	Not exposed	p-

	100%† (n=22)	<100% (n=25)	exposures (n=43)	(n=38)	value*
SF-36 Transformed scale**:					
Physical functioning	73.6 ± 26.7	81.2 ± 18.4	84.9 ± 17.9	87.0 ± 16.5	0.07
Role functioning-physical	80.7 ± 29.8	63.0 ± 41.5	84.9 ± 28.4	86.8 ± 25.2	0.02
Role functioning-emotional	89.4 ± 26.0	66.7 ± 41.9	81.4 ± 35.9	85.1 ± 29.7	0.10
Social functioning	85.2 ± 14.2	83.5 ± 21.3	88.4 ± 19.4	91.4 ± 15.1	0.32
Bodily pain	87.4 ± 16.8	79.0 ± 24.0	91.8 ± 18.5	86.3 ± 21.8	0.11
Mental health	86.0 ± 8.5	78.7 ± 18.4	86.2 ± 15.5	83.2 ± 13.5	0.19
Vitality	60.2 ± 11.1	57.6 ± 21.6	63.5 ± 17.2	65.3 ± 14.7	0.29
General health perceptions	63.3 ± 18.6	60.1 ± 22.9	67.1 ± 20.6	73.0 ± 18.4	0.07
Change in health	64.8 ± 25.2	56.0 ± 26.3	68.0 ± 25.8	65.1 ± 23.6	0.30
Marks asthma QOL scale**:					
Scale total	1.5 ± 0.9	1.7 ± 1.5	1.4 ± 1.7	1.2 ± 1.2	0.64
Breathlessness	1.8 ± 1.1	1.7 ± 1.4	1.2 ± 1.6	1.3 ± 1.4	0.22
Mood	1.0 ± 1.1	1.2 ± 1.3	0.8 ± 1.5	1.0 ± 1.3	0.71
Social	1.4 ± 1.2	1.9 ± 2.0	1.7 ± 2.2	1.4 ± 1.9	0.73
Concerns	1.3 ± 1.0	1.6 ± 1.8	1.5 ± 2.0	1.0 ± 1.5	0.54

*Significance testing based on one-way analysis of variance for comparison of means.
**SF-36 Transformed scale: 1 = worst and 100=best; Marks Asthma QOL Scale: 0=best and 10=worst.

† 100% WRC – working only with WRC and not other woods

5.4 Work History

5.4.1 Initial Work Status

Personal characteristics and respiratory symptoms at diagnosis were available for 210 participants according to their work status within one year of diagnosis (Table 21). A relatively small number of subjects had stopped working within one year due to problems with asthma (n=21, 10%) or for other reasons (n=4, 1.9%) including three subjects who had retired and one subject who had stopped working because of another illness. Bronchial hyperreactivity, defined as having a methacholine PC_{20} value of less than 8 mg/ml, was evident for all groups. On average, subjects were diagnosed with WRCA at age 37 years and most subjects were male, of East Indian ethnicity and were never smokers.

No statistically significant differences were observed among groups for all characteristics ascertained at diagnosis, in fact the distribution of impairment class used for asthma severity was virtually identical between groups. Similarily, Marabini and colleagues also found no differences in personal characteristics, respiratory symptoms, percent of predicted lung function values or bronchial hyperreactivity between work groups at diagnosis (20).

Table 21. Personal characteristics of western red cedar (WRC) asthmatics by initial work status

Characteristics	Initial Work Status			
	Working		Not working (n=25)	p-value*
	WRC (n=143)	No WRC (n=42)		
Age (years±SD)	37.6±9.8	34.5±8.6	38.8±11.3	0.13
Gender (% males)	137(95.8%)	41(97.6%)	25(100%)	0.52
Ethnicity:				0.78
Caucasian	59(41.3%)	20(47.6%)	13(52.0%)	
East Indian	81(56.6%)	21(50.0%)	12(48.0%)	
Other	3(2.1%)	1(2.4%)	0(0%)	
Smoking status:				0.37
Never smoker	95(67.9%)	26(61.9%)	20(83.3%)	
Ex-smoker	39(27.9%)	15(35.7%)	4(16.7%)	
Current Smoker	6(4.3%)	1(2.4%)	0(0%)	
Duration of exposure prior to symptoms (#months±SD)	48.8±54.1	31.4±42.8	47.7±68.2	0.19
Asthma Severity				0.90
Impairment Class: 0	2(1.8%)	0(0%)	1(4.5%)	
1	64(56.1%)	20(57.1%)	12(54.5%)	
2	46(40.4%)	14(40%)	9(40.9%)	
3	2(1.8%)	1(2.9%)	0(0%)	
FEV_{PP}	100.5±25.6	102.2±23.4	107.5±20.5	0.42
Methacholine PC_{20} (mg/ml)	2.7±4.5	3.8±6.3	4.6±4.9	0.18
Allergy skin test (% positive)	58(43.0%)	18(46.2%)	12(52.2%)	0.70
Respiratory Symptoms:				
Cough	118(84.3%)	38(90.5%)	24(100%)	0.08
Phlegm	66(47.1%)	13(31.0%)	10(41.7%)	0.18
Wheeze	102(72.9%)	33(78.6%)	20(83.3%)	0.47
Chest tightness	99(70.7%)	31(73.8%)	17(70.8%)	0.93
Shortness of breath	124(89.2%)	36(85.7%)	21(87.5%)	0.82

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

There were significant differences in current chronic symptoms of breathlessness according to work status at diagnosis (Table 22). Those who had started working without exposure to WRC had a lower prevalence at follow-up of breathlessness when walking at their own pace and in comparison to others of their own age.

Table 22. Chronic respiratory symptoms at follow-up of western red cedar (WRC) asthmatics by initial work status

Respiratory Symptoms	Initial Work Status			
	Working		Not working (n=25)	p-value*
	WRC (n=143)	No WRC (n=42)		
Wheeze:				
Occasional	47(32.9%)	14(33.3%)	12(48.0%)	0.33
Most days/nights	35(24.5%)	9(21.4%)	9(36.0%)	0.39
Chest tightness:				
Ever	70(49.0%)	14(33.3%)	14(56.0%)	0.12
Most days	24(16.9%)	4(9.5%)	3(12.5%)	0.47
Trouble breathing:				
Rarely	69(48.6%)	27(64.3%)	12(48.0%)	0.44
Regularly-gets better	35(24.6%)	7(16.7%)	5(20.0%)	
Always	38(26.8%)	8(19.0%)	8(32.0%)	
Breathlessness:				
Slight hill	78(54.5%)	17(40.5%)	13(52.0%)	0.28
Own age	64(44.8%)	10(23.8%)	10(40.0%)	0.05
Own pace	51(35.7%)	6(14.3%)	7(28.0%)	0.03
100 yards	43(30.1%)	5(11.9%)	7(28.0%)	0.06
Chronic cough	29(21.5%)	4(10.0%)	4(16.7%)	0.25
Chronic phlegm	23(16.4%)	6(14.6%)	8(33.3%)	0.11

* Significance testing based on chi-square testing for comparison of proportions.

In addition, those who switched to an unexposed job within one year from diagnosis had a lower prevalence of acute asthma-like symptoms of woken with chest tightness and dyspnea during day and being woken by dyspnea in the past 12 months after long-term follow-up (Table 23).

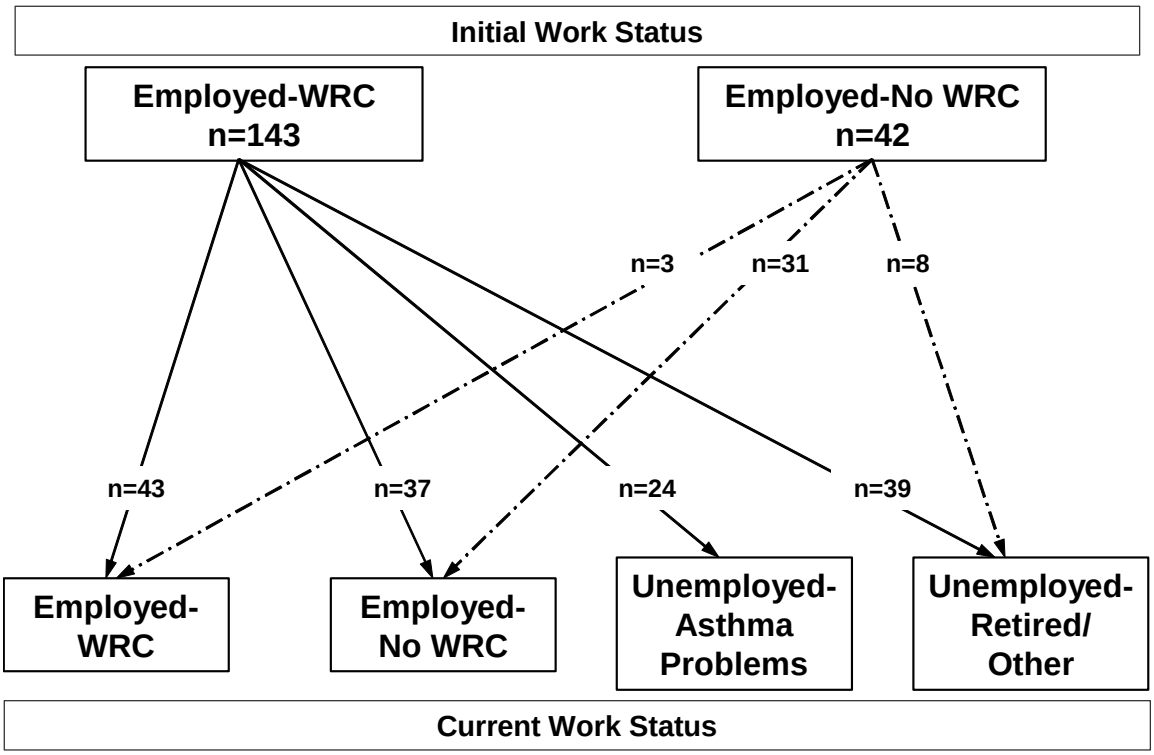
Table 23. Acute respiratory symptoms within the last 12 months of western red cedar (WRC) asthmatics by initial work status

Respiratory Symptoms	Initial Work Status			
	Working		Not working (n=25)	p-value*
	WRC (n=143)	No WRC (n=42)		
Wheeze anytime	57(39.9%)	12(28.6%)	13(52.0%)	0.15
Woken with chest tightness	52(36.4%)	5(11.9%)	9(36.0%)	0.01
Dyspnea during day	43(30.1%)	8(19.0%)	12(48.0%)	0.04
Woken by dyspnea	44(30.8%)	7(16.7%)	11(44.0%)	0.05
Woken by cough	39(27.3%)	8(19.0%)	9(36.0%)	0.30
Asthma-like symptoms	91(63.6%)	19(45.2%)	17(68.0%)	0.07

* Significance testing based on chi-square testing for comparison of proportions.

The change in work status over the follow-up period from the initial year after diagnosis for employed subjects (n=185) is shown in Figure 1. For three of the workers, no information on initial work status was available. Of the subjects who continued working with red cedar after diagnosis, 30.1% remained in exposed jobs at follow-up, 25.9% switched to jobs without exposure to red cedar, and 16.8% eventually quit due to problems with their asthma. By comparison, the majority of workers (73.8%) who began working in unexposed jobs within one year of diagnosis remained in unexposed jobs and none had quit work due to problems with asthma.

Figure 1: Change in work status for Western Red Cedar (WRC) asthmatics who were initially employed.



5.5 WRC Exposure

5.5.1 Years worked with WRC since diagnosis

The number of years worked with WRC since diagnosis and number of years since last exposed to WRC were categorized into <5, 5-15 and > 15 years and evaluated for an exposure-response relationship with chronic and acute symptoms. Statistically significant differences were observed for breathlessness at own pace and for asthma-like symptoms according to years worked with WRC and for years since exposed to WRC. However, there was no clear exposure-response relationship; rather, the prevalence of breathlessness at your own pace was 15.4%, 38.3% and

31.3% for <5, 5-15 and >15 years of exposure to WRC respectively. For years since last exposure to WRC, the corresponding percentages were 28.6%, 42.5% and 17.5%.

5.5.2 Current and recent work exposure to WRC

Comparisons were made of working conditions between groups who were currently exposed to WRC or who had been exposed to WRC in their most recent job. Statistically significant differences were seen for primary work area (Table 24). Both those who had quit working due to problems with asthma and those who were exclusively working with WRC had the greatest percentage working in sawmills, shingles or planer mills. There were no differences between groups in the typical work patterns which could influence exposure to WRC, For instance, for all groups it was most common to work less than 5 feet from the saw cutting surface.

Table 24. Job characteristics of those currently working or recently exposed to western red cedar (WRC)

Characteristic	Currently exposed to WRC		Last job exposed to WRC		p-value*
	100% WRC† (n=22)	<100% WRC (n=25)	Quit due to Asthma (n=27)	Retired/Other (n=32)	
Type of industry:					0.17
Sawmill	19(86.4%)	17(68.0%)	24(88.9%)	22(68.8%)	
Other wood industries	2(9.1%)	5(20.0%)	3(11.1%)	9(28.1%)	
Other	1(4.5%)	3(12.0%)	0(0%)	1(3.1%)	
Primary work area:					0.02
Sawmill/shingle/planer	19(86.4%)	16(64.0%)	24(88.9%)	21(67.7%)	
Decking/Fencing/Furniture manufacturer	0(0%)	1(4.0%)	3(11.1%)	1(3.2%)	
Carpentry/Construction	2(9.1%)	2(8.0%)	0(0%)	6(19.4%)	
Other	1(4.5%)	6(24.0%)	0(0%)	3(9.7%)	
Hours worked per week (± SD)	40.0±0	43.7±18.6	40.0±2.4	42.8±10.9	0.51
Work done inside/under cover	18(81.8%)	21(84.0%)	23(85.2%)	23(71.9%)	0.56
Work in saw area	14(63.6%)	16(64.0%)	21(77.8%)	22(68.8%)	0.67
Hours per week worked on saw (± SD)	35±10.2	31.3±14.4	36.1±16.8	32.4±12.4	0.72
Distance from cutting surface:					0.81
<5 ft	9(64.3%)	10(62.5%)	15(75.0%)	16(72.7%)	
<20 ft	4(28.6%)	4(25.0%)	2(10.0%)	3(13.6%)	
≥20 ft	1(7.1%)	2(12.5%)	3(15.0%)	3(13.6%)	
Vented saws	13(92.9%)	10(62.5%)	17(85.0%)	13(59.1%)	0.06
Work in sanding area	5(22.7%)	7(28.0%)	4(14.8%)	13(40.6%)	0.16
Hours per week worked sanding (± SD)	26.0±13.4	22.6±17.2	27.0±22.5	24.2±15.1	0.97
Distance from cutting surface:					0.50
<5 ft	2(40.0%)	5(71.4%)	3(75.0%)	10(76.9%)	
<20 ft	2(40.0%)	1(14.3%)	0(0%)	3(23.1%)	
≥20 ft	1(20.0%)	1(14.3%)	1(25.0%)	0(0%)	
Vented sanders	4(80.0%)	5(71.4%)	1(33.3%)	8(61.5%)	0.58
Work in planer area	10(45.5%)	8(32.0%)	8(29.6%)	14(43.8%)	0.54
Hours per week worked planing (± SD)	34.2±12.2	22.9±16.5	37.1±7.6	26.1±12.6	0.09
Distance from cutting surface:					0.71
<5 ft	5(50.0%)	4(50.0%)	6(75.0%)	10(71.4%)	
<20 ft	4(40.0%)	2(25.0%)	1(12.5%)	2(14.3%)	
≥20 ft	1(10.0%)	2(25.0%)	1(12.5%)	2(14.3%)	
Vented planers	10(100%)	6(75.0%)	6(85.7%)	9(64.3%)	0.19

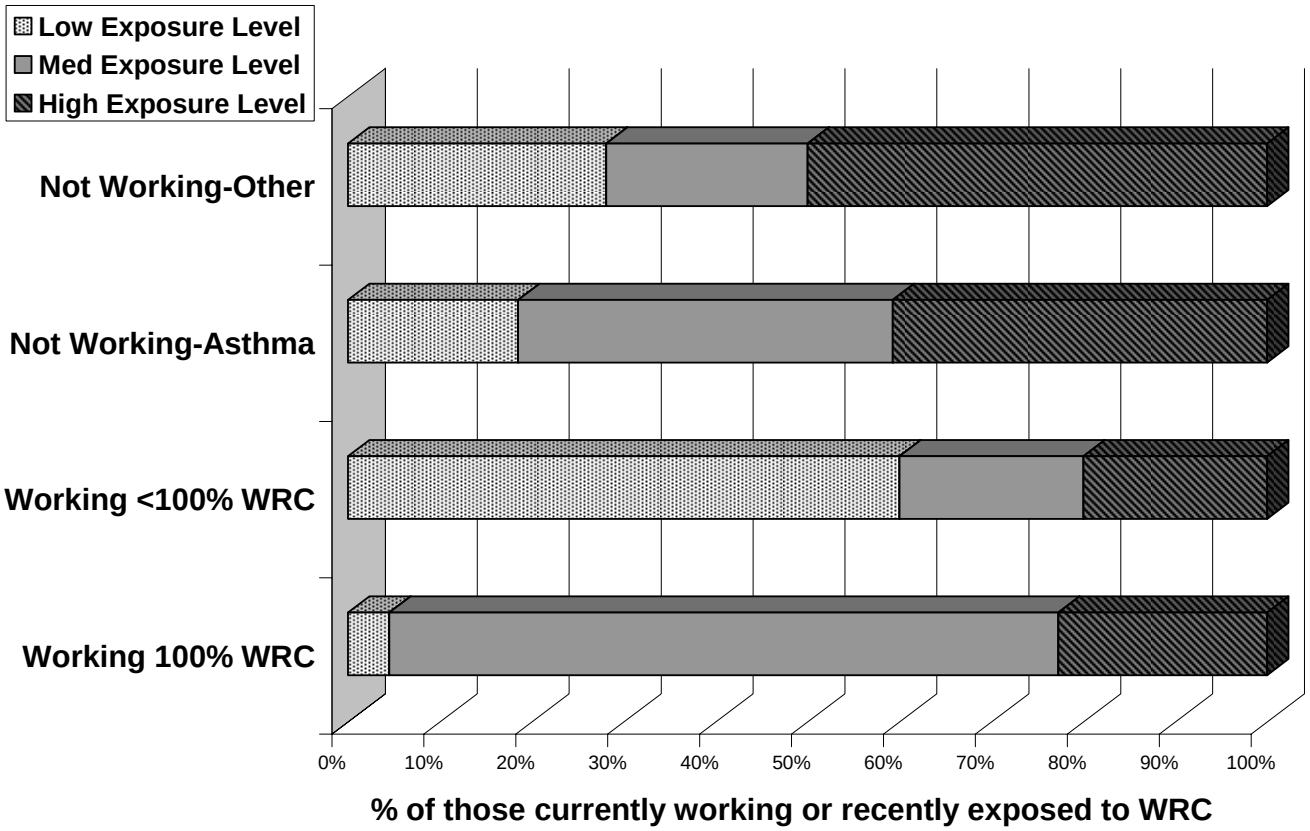
Clean up dust debris	12(54.5%)	13(52.0%)	15(55.6%)	22(68.8%)	0.56
Hours per week (± SD)	6.5±4.6	7.3±5.1	6.6±5.0	8.2±5.9	0.77
Type of method used:					
Vacuum	4(33.3%)	5(38.5%)	6(40.0%)	5(22.7%)	0.67
Shovel	8(66.7%)	9(69.2%)	14(93.3%)	14(63.6%)	0.22
Broom	11(91.7%)	11(84.6%)	14(93.3%)	19(86.4%)	0.86
Compressed air	6(50.0%)	2(15.4%)	4(26.7%)	4(18.2%)	0.17
Operate mobile machinery	6(27.3%)	8(32.0%)	8(29.6%)	3(9.4%)	0.15
Enclosed in machinery	2(9.1%)	1(4.2%)	0(0%)	1(3.1%)	0.43
Work in booth/enclosure	2(9.5%)	0(0%)	1(3.7%)	2(6.9%)	0.49

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

† 100% WRC – working only with WRC and not other woods

Statistically significant differences were found in the estimates of level of exposure to WRC. A greater percentage of subjects exposed to WRC in their most recent job before quitting due to asthma or other reasons, had higher estimated exposures to WRC dust than those currently working with WRC. However those working only with WRC were rarely assigned a "low" exposure level (Figure 2). There were no significant exposure-response relationships between respiratory symptoms and estimated current or more recent exposure to WRC or for cumulative exposure for jobs held since diagnosis.

Figure 2: Qualitative estimates of exposure level* by western red cedar (WRC) work exposure groups



* $p<0.01$

No significant differences were seen among groups in personal protection practices or equipment use (Table 25). Those that had quit due to problems with asthma tended to have the lowest percentage of subjects that did not use any type of respirator. The prevalence of symptoms was not associated with the use of respirators (data not shown). On the one hand, symptomatic individuals were expected to be more likely to use respirators; on the other hand symptoms may have improved as a result of respiratory use. Multiple logistic regression analysis did show a greater risk of asthma-like symptoms with more hours spent cleaning up debris (OR 1.4; 95% CI 1.0-1.9) and a lower risk of symptoms with use of a respirator (OR 0.2; 95% CI 0.03-0.8).

Very few subjects had learned about the potential hazards of WRC in their training. Generally, most subjects learned about the risks of being exposed to WRC after diagnosis. This underscores the importance of raising awareness through education during training and throughout

employment about the potential health risks associated with exposure to WRC as well as the protective measures to minimize and preferably, avoid exposure.

Based on a study done on Danish furniture workers, suggestions made to minimize wood dust exposures included: ensuring effective local exhaust ventilation on all woodworking machines, increasing use of sanding robots, cleaning machines and work pieces by vacuum and not compressed air, ventilation with supplementary fresh air and good support from management in order to ensure improved hygienic practices in the workplace (53).

Table 25. Personal protection of those currently working or recently exposed to western red cedar (WRC)

Characteristic	Currently exposed to WRC		Last job exposed to WRC		P-value*
	100% WRC (n=22)	<100% WRC (n=25)	Quit due to Asthma (n=27)	Retired/Other (n=32)	
Used respirator	13(59.1%)	14(56.0%)	22(81.5%)	23(71.9%)	0.18
Respirator type: Paper mask	9(40.9%)	11(44.0%)	19(70.4%)	16(51.6%)	0.26
Other mask	4(18.2%)	3(12.0%)	3(11.1%)	7(22.6%)	
None	9(40.9%)	11(44.0%)	5(18.5%)	8(25.8%)	
Change clothes	2(9.5%)	3(12.0%)	5(18.5%)	8(25.0%)	0.43
Wash work clothes (#/wk ± SD)	3.9±1.7	3.4±1.8	4.2±1.7	3.0±1.7	0.06
Coffee/meal breaks:					0.08
In lunchroom-separate building	0(0%)	3(12.0%)	3(11.1%)	1(3.2%)	
In lunchroom-same building	17(81.0%)	13(52.0%)	23(85.2%)	20(64.5%)	
Outdoors	4(19.0%)	7(28.0%)	1(3.7%)	9(29.0%)	
In work room	0(0%)	2(8.0%)	0(0%)	1(3.2%)	
Wood dust in break area	17(81.0%)	16(64.0%)	24(88.9%)	24(77.4%)	0.19
Made aware of WRC hazards:					0.53
Throughout employment	3(14.3%)	2(8.0%)	5(18.5%)	3(9.4%)	
In training	1(4.8%)	0(0%)	0(0%)	1(3.1%)	
After diagnosis	7(33.3%)	15(60.0%)	13(48.1%)	20(62.5%)	
Never	10(47.6%)	8(32.0%)	9(33.3%)	8(25.0%)	

* Significance testing based on chi-square testing for comparison of proportions and one-way analysis of variance for comparison of means.

6.0 IMPLICATIONS: FUTURE RESEARCH ON OCCUPATIONAL HEALTH

This long-term follow-up study, averaging 17.8 years since diagnosis was successful in recruiting 213 participants who had been initially diagnosed as early as 1970. The participation rate for those who could be contacted was very good at 70.5%. However, the study power was not optimal as available contact information was no longer current and traceable for a large segment of potential participants (n=195). As a result, between group comparisons, especially

for subgroup analyses such as the employed subjects, showed few statistically significant differences. Loss of follow-up may introduce selection bias such that the study sample may not be considered to be representative of all patients with western red cedar asthma. However, other than ethnicity, there were no statistically significant differences between the study subjects and non-participants who would have qualified for the study based on age.

The telephone interview format was chosen to allow the maximal number of participants throughout British Columbia, at less disruption, rather than including only those subjects who lived in the Vancouver area or who were willing to travel to the Vancouver Hospital site. Having bilingual interviewers facilitated the participation of Punjabi speaking subjects and therefore avoided inconsistency in response when using surrogate respondents. The success of the strategy is illustrated by the relatively large percentage of subjects with East Indian ethnicity who participated in this study.. In previous studies of WRCA patients from BC, subjects who were fluent only in Punjabi were either excluded or were accompanied by a family member that would act as an interpreter.

The questionnaire-based interview was appropriate for eliciting personal information and historical description of work characteristics, as well as the principal outcomes of symptoms and quality of life scores. However past information was subject to errors in recall and symptom reporting was subjective. Laboratory testing using spirometry and methacholine challenge testing for degree of bronchial hyperresponsiveness, although more costly, would allow for more objective evaluation of current respiratory health.

Prospective studies are valuable for determining long-term outcomes. Having information collected at diagnosis improves upon a cross-sectional design which is subject to a number of biases. Our finding that it is not just removal from exposure, but having gainful employment that resulted in better quality of life, is important. Coincident with better quality of life were respiratory symptoms which were lowest in prevalence for those working but unexposed. Removal from exposure to red cedar appeared to be beneficial only if there was alternative work in unexposed jobs. However further research is needed to gain insight into what distinguished those that could keep working yet be exposed to red cedar and those that had to quit due to problems with asthma. The latter group all had been working after diagnosis in exposed jobs, and

the estimated exposure to red cedar for those not employed was relatively higher. If fact, none of the subjects employed in an unexposed job had quit work due to asthma.

An alternative explanation is that there is a selection effect in which those with less severe asthma at the outset were able to continue employment and have better quality of life in the long term. Support for this hypothesis is that those who eventually quit work due to asthma on average had lower lung function at diagnosis. However there were no differences in characteristics and severity of asthma between those who stayed exposed, switched to unexposed jobs or quit work at the outset. Although observation studies, such as this follow-up study, provide useful information, carefully designed qualitative research and intervention studies would allow for better understanding of how best to promote good quality of life and respiratory health in the long term for those diagnosed with western red cedar asthma.

7.0 POLICY AND PREVENTION

A number of recommendations can be drawn from this follow-up study of WRCA subjects.

1) Better protective health measures in the workplace should be instituted, such as engineering controls, in order to reduce exposure to WRC and subsequently the development and deterioration of WRCA among workers. Because severity of asthma at diagnosis were worse for the group that eventually quit employment due to asthma, preventing the development of western red cedar asthma, or failing that, early detection and treatment of the disease is essential for a better prognosis.

2) Education and risk communication strategies aimed at prevention are important to institute when hiring and at periodic times during employment. The majority of WRCA subjects did not recall ever being made aware of WRC hazards or not until they were diagnosed.

3) The group of workers who stayed employed but avoided exposure to western red cedar had the best outcomes for respiratory health and quality of life. Workers diagnosed with WRCA should be offered re-training on other unexposed jobs with monetary compensation, preferably within the same company. Of those who continued to work

with western red cedar after diagnosis, 16.8% eventually quit due to problems with asthma. In contrast none of the workers who were in unexposed jobs quit due to problems with asthma. Where workers continue to be exposed to WRC, attempts to minimize exposure though workplace redesign and personal protection should help prevent intolerable symptoms which may result in unemployment and subsequent reduction in income.

4) WRCA patients should be monitored regularly by a chest physician for optimal control of the disease. The prevalence of respiratory symptoms well as the use of medication were generally lower for the unexposed group of workers in comparison to those exposed to red cedar at work..

5) Quality of life is an important but often overlooked measure of health. Evaluation of patients' health should incorporate repeated administration of an accepted quality of life instrument to detect changes over time.

6) A more comprehensive follow-up including physiological testing is recommended. This would help guide practices in medical management of western red cedar asthma, and potentially will advance a comprehensive patient follow-up program within the claims system. Currently, the Workers' Compensation Board of British Columbia does not have a program to follow-up workers with occupational asthma (even in those cases where workers continue to be exposed to red cedar dust). Yet, workers with pneumoconiosis have follow-up examinations once every few years for reassessment. A follow-up program would allow for appropriate management of the disease, reducing the risk of irreversible damage to the lungs and thereby preventing permanent disability and the ensuing financial and emotional hardship that inevitably occurs. Instituting a medical surveillance program to further allow for early detection and prevention of the disease would be ideal.

7) Unfortunately WRCA is not just a disease of the past. Due to current economic challenges the wood industry may consider the option of combining cedar and sawmill operations. This will result in exposure to red cedar dust for previously unexposed sawmill workers. The consequence may not only be an increase in new claims for WRCA, but also this may adversely affect claimants who had been successfully

avoiding exposure to western red cedar dust. Those subjects who were currently working in mills where a combination of cedar and other woods were processed generally had worse quality of life scores and a greater prevalence of respiratory symptoms than other employed groups.

8.0 DISSEMINATION AND KNOWLEDGE TRANSFER

The results of this study have been presented at two scientific conferences. An abstract entitled the "Long-term impact of western red cedar asthma on quality of life" was accepted for a poster discussion session by the American Thoracic Society International Conference held in San Diego, CA in May, 2005. The abstract was published in the American Journal of Respiratory and Critical Care Medicine in April 2005 and the presentation was given by Dr. Helen Ward.

An abstract entitled the "Long-term impact of western red cedar asthma on respiratory symptoms" was accepted by the Canadian Association for Research on Work and Health, for a conference which was held at UBC in May, 2005. An oral presentation using PowerPoint slides was given by Virginia Taliadouros.

A manuscript on the study findings is being submitted to the European Respiratory journal with Dr. Helen Dimich-Ward as lead author.

9.0 ACKNOWLEDGEMENTS

We would like to thank the Workers' Compensation Board of British Columbia for funding this study through the Research Secretariat. We appreciate the support from Mr. Al Dewar, Director of Health and Safety for the BC Coastal Group of Weyerhaeuser and Mr. Jim Parker, Health and Safety Director of the Industrial, Wood and Allied Workers of Canada, Local 2171. We also would like to acknowledge the cooperation of the participants of the study.

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11.0 APPENDICES

11.1 Invite Letter

Please accept this letter as an invitation to take part in an important study evaluating the long-term impact of western red cedar asthma on employment, respiratory health and quality of life. The study, funded by the Workers' Compensation Board of British Columbia, is being carried out by researchers of the Environmental and Occupational Lung Diseases Research Unit, associated with the Department of Medicine, and from the Department of Health Care and Epidemiology at the University of British Columbia.

A researcher will contact you by telephone during the next few weeks. Your information was extracted from the ongoing research database made available by Dr. Moira Chan-Yeung, a Co-Investigator for this study. The purpose of this phone call is to ascertain whether you would like to participate in an interview. If so, the researcher will schedule an interview at a time convenient for you. Interview materials and a consent form with stamped return envelope will be mailed to you. The subsequent telephone interview will take approximately 60 minutes and will include questions on employment history, respirator use, presence of respiratory symptoms and quality of life. Your decision to participate or not will have no effect on your standing with the Workers' Compensation Board, your employer, or medical services.

To discuss your participation in the study please contact our research office at (604) 875 – 5548.

All information you provide is strictly confidential. Only group data will be reported in any scientific publications or reports related to the study. I would like to thank you in advance for your support of this project. I hope you will accept this invitation to participate.

Sincerely,

Dr. Helen Ward — **Principal Investigator**

Dr. Moira Chan-Yeung — **Co-Investigator**

11.2 Consent Form

Title: Long-Term Impact of Western Red Cedar Asthma on Work, Health and Quality of Life

Principal Investigator: Dr. Helen Ward, UBC Department of Medicine (604) 875-4813

Co-Investigators: Dr. Moira Chan-Yeung, UBC Department of Medicine (604) 875-4122

Dr. Kay Teschke UBC Department of Health Care and Epidemiology (604) 822-2041

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Medical Consultant: Dr. Raja Abboud, UBC Department of Medicine (604) 875-4322

Funded by: The Workers' Compensation Board of British Columbia (WCB)

Purpose:

Western red cedar asthma is the most common form of occupational asthma in British Columbia, and has far-reaching effects on employees' health and ability to work. The UBC Environmental and Occupational Lung Disease Research Unit has undertaken a study to follow-up workers with western red cedar asthma. The purpose of the study is to determine long-term health outcomes and quality of life according to if, where, and when workers were employed since diagnosis. Ultimately the study findings will offer recommendations about return to work, and the effectiveness of protective measures such as respirator use for workers with western red cedar asthma.

Study Procedures:

The study will consist of a telephone interview with a researcher. The total time required for the study will be approximately one hour and 15 minutes. Interview topics will include: employment history, red cedar exposure, protective equipment use, presence of respiratory symptoms, and quality of life. For those who have been exposed to red cedar dust, questions on the type of respirator as well as consistency and frequency of use will also be asked. You have been selected because you were diagnosed with western red cedar asthma at Vancouver General Hospital since 1972.

Confidentiality:

Any information resulting from this research study will be kept strictly confidential. For all interview-based documents and computer files, code numbers only will be used. Files are kept in a locked filing cabinet in a locked office. Subjects will not be identified individually by name or by claim number in any reports of the study to the WCB. Only grouped data will be published.

Contact:

If there are questions concerning the above study, please call Dr. Helen Ward at (604) 875-4813 at any time. If there are any questions about your rights as a research subject, you may call Mr. Brent Sauder, Acting Director, Research Services, UBC, at (604) 822-8587.

Consent:

I understand that the participation of this study is entirely voluntary and that I can withdraw from the study at any time without any jeopardy to my medical care, now or in the future.

I received a copy of this consent form for my own records.

I consent to participate in this study.

Signature:_____

Name:_____

Witnessed by (signature) :_____

Witness Name:_____

Date:_____

I would like all future correspondence to be in: English ☐ Punjabi ☐

PLEASE COMPLETE THIS FORM AND RETURN IT IN THE SELF-ADDRESSED ENVELOPE. THANK-YOU.

Additional copies of this publication may be obtained by contacting:

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