INDOOR MOULD, DUST MITE AND ENDOTOXIN EXPOSURE IN ABORIGINAL HOUSING IN BRITISH COLUMBIA: AN ASSESSMENT IN THE HEILTSUK FIRST NATION COMMUNITY

by

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ABSTRACT

Concerned with mould exposure in reserve housing, the Heiltsuk First Nation participated in a CIHR-funded research project to assess residential indoor air quality. Biological particles including moulds, dust mites and endotoxins, and questionnaires based on health status and home environment for 43 homes were studied to understand exposure risks (determinants of exposure). The Heiltsuk were partners in this research project. They consented to the initiative and implementation of the project, shared their knowledge and were the trainers and the trainees – examples of self-determination. Odds Ratios ($\alpha = 0.05$) were applied to air and dust samples and compared with the questionnaires. The geometric mean (GM) for indoor airborne mould concentration was 509 CFU/m$^3$ (range 7 – 18,582 CFU/m$^3$). In bedroom carpet samples, dust mite protein, DerP1, levels ranged 0.1 – 150 µg/g (GM 15 µg/g). In other rooms, levels ranged 0.1 – 55 µg/g (GM 1.3 µg/g). DerP2 levels ranged 0.1 – 180 µg/g dust (GM 14.7 µg/g) for bedroom samples and 0.1 – 110 µg/g (GM 2.1 µg/g) in other rooms. An association was found between bedroom dust samples and mite sensitization levels (> 2.0 µg/g) for DerP1 (OR 5.5; 95% CI 1.194 – 25.517; $P = 0.029$) and DerP2 (OR 10.1; CI 0.922 – 111.247; $P = 0.058$). An association was also found between levels of mould concentrations and reported respiratory treatment (OR 8.2; CI 1.977 – 34.431; $P = 0.04$) but not with levels of dust mite concentrations.

Indoor to outdoor fungal ratios exceeding unity were associated with reported asthma symptoms (OR 4.0; CI 1.040 – 15.381; $P = 0.44$), allergy symptoms (OR 4.5; CI 1.138 – 17.965; $P = 0.03$) and carpet age (OR 4.5; CI 1.252 – 16.171; $P = 0.021$). Thus dust mite allergens in the bedrooms and the levels of mould concentration in the homes, especially when amplified, indicate a health risk. A significant determinant of exposure to mould was carpet age, which was identified both by analysis of samples and by communicating with the Heiltsuk. These data will contribute to population and public health promotion and baseline data. Heiltsuk self-determination catalyzed community engagement in education, remediation, and health promotion programs.
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A NOTE ABOUT TERMINOLOGY

The term 'aboriginal' refers to organic political and cultural entities that stem historically from the original peoples of North America. The term includes the First Nation, Inuit and Métis peoples of Canada.

(Section 35(2) of the Constitution Act, 1982)

This study took place in a First Nations community. The term First Nation is used interchangeably with aboriginal, where aboriginal is used in the citation and general information context only.
ACRONYMS, NOMENCLATURE AND SYMBOLS

ACGIH  American Conference of Governmental Industrial Hygienists
Aerosol Airborne solid or liquid substance
AEWG Aboriginal Ethics Working Group
AFN Assembly of First Nations
Antigen Anti-body generating substance that can cause an immune response
Alopy Exaggerated immunological reaction to antigens
\( a_w \) Water activity
ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers
BC ACADRE British Columbia Aboriginal Capacity and Developmental Research Environments
bioaerosols Biologically derived particulate matter
CBD Convention on Biological Diversity
CBR Community Based Research
CBPR Community Based Participatory Research
CFU/m\(^3\) Colony forming units per cubic meter of air
CIHR Canadian Institute for Health Research
CMHC Canada Mortgage and Housing Corporation
CO\(_2\) Carbon Dioxide
Determinants of exposure Multiple factors that influence the presence of mould which helps to aid the identification and suggestions of controls
DIA Department of Indian Affairs
EHO Environmental Health Officer
EU Endotoxin Units
FNESC First Nations Education Steering Committee
FNHC First Nations Health Council
FNLC First Nations Leadership Council
FNS First Nations Summit
GM Geometric Mean
GSD Geometric Standard Deviation
HETFC Heiltsuk Environmental Task Force Committee
HHHC Hailika'as Heiltsuk Health Center
HHD Heiltsuk Housing Department
HRPA Heiltsuk Research Protocol Agreement
HTC Heiltsuk Tribal Council
Hygiene Study and promotion of health
Hypersensitivity an exaggerated immune response
IAPH Institute for Aboriginal Peoples Health
IAQ Indoor air quality
IIPR Indigenous Intellectual Property Rights
INAC Indian and Northern Affairs Canada
IT Indoor Temperature
LAL Limulus Amoebocyte Lysate
\( \text{Ln} \) Natural log (base e)
L/min Litres per minute
LOD Limit of Detection
M\(^3\) Cubic meter
MEA Malt Extract Agar
MMS Moisture Measurement System
MOU Memorandum of Understanding
Mycotoxins Toxic organic compounds which can produce a wide range of acute and chronic effects
MVOC's Microbial Volatile Organic Compounds
NISI Native Inspection Services Initiative
OCAP Ownership, Control, Access, Possession
OR Odds Ratio
PAR  Participatory Action Research
PFW  Pyrogen Free Water
PHO  [Office of] Provincial Health Officer
PPM  Parts per million
RCAP Royal Commission on Aboriginal Peoples 1996
RH   Relative humidity
SD   Standard Deviation
Sterile Mycelia Fungal colonies that did not produce spores
TFNHP Tripartite First Nations Health Plan
TLV  Threshold Level Value. Air concentrations of substances that can produce a health effect (Macher, 1999)
UN   United Nations
UNDI United Nations Development Index
VCH  Vancouver Coastal Health
VOC's Volatile organic compound: A highly evaporative, carbon-based chemical substance, which produces noxious fumes; found in many paints, caulks, stains, and adhesives.
WHO  World Health Organization
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I raise my hands in great respect to the Heiltsuk Housing Department, Heiltsuk Tribal Council, Heiltsuk Environmental Task Force Committee, the Heiltsuk construction workers, the Hailika’as Heiltsuk Health Center, the Heiltsuk Hemas, and especially the Heiltsuk participants who contributed their time and resources to this project. This has been the most unique experience. I have learned the values of community, and especially about Heiltsuk kindness. I am grateful to the Heiltsuk Tribal Council for welcoming me into their meeting and inviting me back to share more information. Thank you, elected Chief Ross Wilson, for your time and your support for this project and my work. I am very grateful to Louisa Willie of the Hailika’as Heiltsuk Health Center for providing me with the great comfort of a home while I visited the community. You went above and beyond my expectations.

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journey for me and no one could ask for a better team to help a student through their academic endeavor.

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DEDICATION

To my parents and brothers, for all their love throughout my life-long learning journey.

To the Heiltsuk people, whose incredible kindness will never be forgotten.

This thesis is also dedicated to current and future First Nations, Inuit and Métis following their own life-long learning journeys.
CO-AUTHORSHIP STATEMENT


I conducted the majority of the research and wrote this thesis; however it was part of a large collaborative effort. This project was initiated by discussions between Dr. E.M. Jovel (supervisor) and Chief Ross Wilson (Heiltsuk). The Heiltsuk Housing Department, Heiltsuk Tribal Council, Heiltsuk Environmental Task Force Committee, the Hailika’as Heiltsuk Health Center, and Heiltsuk participants contributed time, knowledge and resources to help shape this project. Dr. E.M. Jovel, Dr. K.H. Bartlett and C.R. Menzies assisted in study design. Dr. K.H. Bartlett contributed significant guidance for statistical data analysis.
CHAPTER 1 – INTRODUCTION

1.1 First Nations Peoples’ Determinants of Health

According to the oral tradition of First Nations people, the settlement in British Columbia (BC) began with the arrival of sky-born beings and transformations of ancestral animals (Shaepe, 2001). Paleoanthropologists and geneticists say that modern humans arose 200,000 years ago in Africa and further suggest that people crossed to the Americas via the Bering Strait 20,000 to 15,000 years ago (Shreeve, 2006). Regardless of what is thought to be true, aboriginal roots lie beyond the limits of memory and reside in time immemorial (Schaepe, 2001). Today, there are 11 major aboriginal language families across Canada, and seven of them are in British Columbia (BC).

There are 203 First Nation communities, lending a richness of culture, art, language, traditional knowledge, technologies, and values that positively contribute to the social foundation of BC. However, the health and wellness of the aboriginal population in BC continues to be poorer than the rest of BC’s population on nearly every health indicator and across age groups and genders (Vancouver Coastal Health, 2008). Although there is considerable interest in the health status of all aboriginal people, relevant data are only available for Status Indians¹ (PHO, 2007).

First Nations on and off reserve face high incidence of compromised mental wellness, circulatory diseases, respiratory diseases, diabetes, obesity, and mortalities (PHO, 2007). The number one reason for day surgeries among First Nations children in BC is dental treatment, while the leading causes of death are suicide, accidental poisoning, motor vehicle accidents, and injury (PHO, 2007). Although trends are decreasing, premature mortality of status First Nations, whether during infancy or later in life, are at greater rates than other BC residents (PHO, 2007).

¹ ‘Status Indians’ are those who are entitled to receive the provisions of the Indian Act. Non-status Indians are those who do not meet the criteria for registration or who have chosen not to be registered (PHO, 2007). The Indian Act gave federal officials the authority to create Indian Bands which remain under the administrative supervision and control of the federal Indian and Northern Affairs Canada (Tennant, 1990).
Risk factors compromising health and well-being cannot be explained by genetics alone as they are also rooted in socio-economic disparities and cultural disruption (PHO, 2007). The impact of colonization on aboriginal people left generations of people with a drastically reduced population, changes to their rights and title to the land, social and political disruption, and suppressed cultural practices through assimilation policies (Aboriginal Healing Foundation, 2006; Waldram et al., 1995). Examples of government assimilation initiatives include:

1. The "Gradual Civilization Act" was a bill passed by the 5th Parliament of the Province of Canada (1857). It defined "Indians" as British subjects and wards of the government, not citizens of the land (Carlson, 1997). Three criteria for citizenship included:
   
   a. Literacy requirements. As people of the oral tradition, it was difficult to adapt to the government's literacy requirements (Carlson, 1997).
   
   b. Free from Debt. When a major feast or potlatch was held, the host always borrowed from their relatives to ensure enough food was available. The hosts then become indebted. In this way all who participated were by definition "in debt" and ineligible for Canadian Citizenship (Carlson, 1997; Tennant, 1990).
   
   c. "Good Morals." Slavery and polygamy were defined as immoral. To become citizens, traditional activities and practices were abandoned (Carlson, 1997).

2. The Anti-Potlatching Law (1884 - 1951) was an act that made it illegal for aboriginal people to gather together in a ceremonial dance, funeral, marriage, naming ceremony, or any other kind of traditional gathering (Carlson, 1997).

3. No Lawyers (1929-1951): it was illegal for any lawyer to work for an aboriginal person or organization in a suit against the federal government (Carlson, 1997).
One significant assimilation policy was the implementation of the residential school system in Canada, causing an intergenerational legacy of health disparities (Aboriginal Health Foundation, 2006). The purpose was to "kill the Indian in the child". "The treatment of aboriginal children in the residential schools is a sad chapter in Canadian history and has caused great harm and has no place in our country" (Harper, 2008). In BC there were 16 residential schools operated by the Government of Canada, and under the control of the United Church, the Anglican Church, and the Roman Catholic Church (Brasfield, 2001). They operated from 1863 to 1984, when St. Mary's Residential School in Mission, BC was finally closed (Woods, 2001). Across Canada, attendance for every aboriginal child between the age of seven and 15 became mandatory in 1920 (Brasfield, 2001). This in effect separated children from their families. The ultimate purpose of the residential school system was to assimilate aboriginal people into western society and culture (Aboriginal Healing Foundation, 2006). Many will describe their experience as psychologically and emotionally abusive, resulting in a long-term post-traumatic stress disorder, and a major disruption in culture and communities.

When Shirley turned 16, her mother, at great personal sacrifice, sent Shirley a store-bought dress to celebrate her coming of age. The nuns saw the dress as an attempt to make Shirley "look like a whore." When she defended her mother she was slapped and strapped and made to stand facing one of four punishment posts in the middle of the building for three days with only bread and water for food.


This trans-generational trauma continues to impact the health and well-being of aboriginal people in Canada. During the same period, similar policies were implemented in Australia, New Zealand and the United States (Ralph et al. 2006).

For many years, aboriginal people struggled to have their rights recognized. In the late 1880's, political awareness and organization emerged with a specific set of aboriginal political demands for recognition of aboriginal rights and title for treaties, and for self-government (Tennent, 1990). In the 1920's, Maori Chiefs Deskaheh Cayuga and W.T. Ratana sought the support of the League of Nations but both were turned away (Grand Chief Edward John, 2008). After over 21 years of negotiations and lobbying by
Indigenous people and their supporters, the United Nations General Assembly finally adopted the United Nations Declaration on the Rights of Indigenous Peoples on September 13, 2007 (Grand Chief Edward John, 2008), which provides guiding principles for ensuring the health and well-being of Indigenous people worldwide. On this historic day, the Declaration was adopted by a vote of 144 ‘yes,’ four ‘no,’ and 11 abstentions; Canada, the United States, Australia and New Zealand voted against the adoption (United Nations, 2008).

Aboriginal people are now the fastest growing community in Canada (Statistics Canada, 2006) and today’s generation faces health disparities and socio-economic inequities (PHO, 2007; Health Canada, 2006; Romanow, 2002; Royal Commission on Aboriginal Peoples, 1996). The United Nations (UN) releases annual reports and includes a section on the human development index (UN, 2008). It ranks countries based on three basic human needs: health, education, and poverty or level of income. Aboriginal people in Canada ranked 76th out of 174 Nations when the Assembly of First Nations applied the UN Development Index (Assembly of First Nations, 2006). Non-aboriginal Canadians ranked 4th (UN, 2008). Among First Nations, the unemployment rate is greater than 50% (Assembly of First Nations. 2006) and the average income is less than half the Canadian average (Indian and Northern Affairs Canada, 2007). Aboriginal high school graduation rates are currently at 48%, but unfortunately only 8% of the aboriginal students are successfully completing Math 12, and only 33% complete English 12 (First Nations Education Steering Committee, 2008).

On November 2006, First Nations Leadership Council (Grand Chiefs Edward John (Akile Ch’oh) and Stewart Phillip (Penticton Indian Band), Regional Chief Shawn Atleo (Ahousaht First Nation), Chief Judith Sayers (Hupacasath First Nation), Chief Robert Shintah (Ts’kw’aylaxw), Chiefs Linda Price (Ulkatcho) and Dave Porter (Kaska Dene), and the Province of BC (Premier Gordon Campbell)) signed the First Nations Health Plan Memorandum of Understanding in support of the bilateral Transformative Change Accord: First Nations Health Plan that recommends the establishment of a First Nations Health Council. On June 2007, the Government of Canada (The Honourable Tony Clement, federal Minister of Health) signed Canada’s first Tripartite First Nations Health Plan with the goal of improving the health and well-being of First Nations in BC, closing the gaps in health between aboriginal people and other British Columbians, and
ensuring First Nations are fully involved in decision-making regarding the health of their people. In this 10-year trilateral agreement, all three parties have committed to action in four priority areas: governance, relationships and accountability; health promotion, disease and injury prevention; health services; and performance tracking (First Nations Leadership Council and Province of British Columbia, 2006). On May 21, 2008, the tripartite partners signed a Memorandum of Understanding (MOU) to work together in developing a comprehensive approach to improve housing for First Nations communities, individuals and families both on and off reserve (FNS, 2008).

"Nothing is more important to First Nations individuals than having a healthy, high-quality environment in which to live. For too long our people have lived in substandard, unhealthy homes which affect our physical and emotional well-being. We need a comprehensive, strategic action to address the critical housing crisis First Nations in BC are facing."

(Chief Judith Sayers, FNS, 2008).

1.2 Housing and Health of Coastal First Nations

The traditional homes of BC coastal First Nations people were medium to large sized cedar plank houses, where extended families and generations would share space (Perry, 2003; Shaepe et al., 2001; Carlson, 1997). Drawn from church and government sources, Perry (2003) presents archival descriptions of First Nations housing. In 1792, French explorer Etienne Marchand commended the houses he found – “What instinct, what genius, it has required to conceive and execute solidly...those edifices, those heavy frames of buildings of fifty feet in extent by eleven in elevation” (Perry, 2003). Methodist missionary Thomas Crosby reports that longhouses fostered immorality and disease – “…sometimes one hundred feet long by thirty wide, made of split cedar boards fastened together with poles and withes and strips of strong bark, and occupied by as many as a dozen families, only separated from each other by low partitions” (Perry, 2003).

The traditional homes were designed with a large open space for dwelling, social and cultural gatherings, and adequate storage for preserved foods (e.g., fish and berries), fishing tackle, and ceremonial gifts (Shaepe et al., 2001; Carlson, 1997; Tennent, 1990). Crosby describes a building with a floor of soil, platform beds, little natural light, multiple fire pits for each family, and poor ventilation (Perry, 2003). The
Department of Indian Affairs (DIA) in the 1930’s began replacing the traditional homes with pre-planned reserve houses, which reduced the numbers of family members who could live together (Perry, 2003; Shaepe et al., 2001). Current housing designs now fall short of essential qualities, which have disrupted social organization, cultural value, and family needs (Shaepe et al., 2001). Approximately 28.5% of aboriginal households in BC are in core housing need, compared to 15.3% of the general population (Province of BC, 2007). The aboriginal population in British Columbia is disproportionately less likely to be home owners than the general population, and is more likely to live in older homes (Province of British Columbia, 2007). Half the homes require repair and half require regular maintenance (Province of British Columbia, 2007).

To address disparities, the 1996 Royal Commission on Aboriginal Peoples (RCAP) concluded that there was a need for a comprehensive strategy to improve the socio-economic and health status of Aboriginal communities and individuals over the next 20 years. Despite federal and provincial government initiatives to provide better quality housing, the living conditions of First Nations on and off reserve have consistently been below national standards and have remained unchanged (Statistics Canada, 2006; Waldram et al., 1995; CMHC, 2001). Ministerial Loan Guarantees allow individuals and communities to secure housing loans on-reserve; however, the Minister seeks guarantees from the First Nation that they will reimburse payments to an approved lender (Province of British Columbia, 2007). This added burden places financial stress on other important community social programs that are generally underfunded.

Research involving airborne mould spores, dust mites, and endotoxins have taken place in some Canadian aboriginal communities including the Baffin Region, Nunavut (Kovesi et al., 2006), the Elsipogtog Reserve (Berghout et al., 2004), in three First Nations communities in BC: Halalt, Chemainus, and Penelakut (Mazey, 2002), and in Manitoba (community unknown; Wilson, 1999). In my thesis, I focus on mould, dust mite and endotoxin exposures and how they affect health and housing in the Heiltsuk First Nation community.
1.3 Bioaerosols, Health and Determinants of Exposure

Organic house dust can either be airborne (a bioaerosol) or settled biological particles consisting of organic and synthetic particles such as fabric fibers, food particles, insect parts, animal dander, pollen, bacteria, mould, and dust mites and their feces. Particle characteristics (e.g., size, density and shape of the substance), and environmental parameters (e.g., air currents, relative humidity and temperature) affect air dispersal and settlement of a bioaerosol (Stetzenbach, 1997).

Examples of environmental exposures include: bioaerosols such as moulds, dust mites, endotoxins from certain bacteria, algae, pollen, animal dander, and viruses; and chemicals including off-gassing substances from paints, varnish, glue, and carpets.

Some sources and substrates of organic house dust include skin particulates, dandruff, furnishings, pets, plants, air conditioning systems, moist surfaces, and water damaged building materials. Dwelling occupants can also contribute to create suitable environmental conditions for moulds, dust mites and bacterial growth through daily activities (e.g., showers/baths and air drying cloths indoors). These activities and conditions may increase exposure of bioaerosols and biological particles and are referred to as ‘determinants of exposure’ (Burstyn and Teschke, 1999; Bartlett, 1999).

1.3.1 Moulds

Fungi are one of five kingdoms of life (Monera, Protoctista, Plantae, Animalia and Fungi; Kwon-Chung et al., 1992; Graveson et al., 1994). The fungal kingdom is thought to contain over a million species, of which about 80,000 have been named and about 600 species cause some form of human disease (Woodcock, 2007). There are two large groups of fungi, Basidiomycetes and Ascomycetes, with over 100,000 species that account for approximately 25% of the earth’s biomass (Raven et al., 1999; Kwon-Chung et al., 1992; Graveson et al., 1994). Fungi are important for ecosystem functioning, and along with bacteria are the principal decomposers of organic material such as carbohydrates, fats, and oils (Raven et al., 2003). Fungi are heterotrophic organisms lacking chlorophyll and come in the form of toadstools (e.g., Agaricus, the common pizza mushroom), puffballs, truffles, smuts, rusts, and moulds.
Moulds (Kingdom Fungi) are a collection of spores (reproductive cells) and mycelia (absorbs organic compounds; vegetative reproduction), which often appear as fuzzy or powdery colonies (Van Loo et al., 2004). Mould spores are naturally occurring and make up the largest portion of all bioaerosols in both indoor and outdoor environments (Hardin et al., 2003; Chapman et al., 2003). Spores are produced in hyphal compartments called sporangia and are generally released and disseminated in the air from one location to another by air currents, wind, insects, water, animals, and people. Spores, which range in size between 0.5 – 30.0 µm in diameter, vary in shape, color, surface structure, and are produced at different densities (Stetzenbach, 1997). Airborne spores settle on a surface, germinate and grow into new mycelia, and form a new mould colony if environmental conditions are adequate (moisture, an energy source, a supply of mineral nutrients, oxygen, a suitable temperature, and protection from ultraviolet light; Van der Kamp, 1998). Moulds flourish on water damaged materials, at high humidity and at temperatures of 20° – 40° C (Abba, 2003). Psychotrophic moulds Compared to bacteria and viruses, moulds tend to colonize a wider variety of substrates because of their lower moisture requirements (Stetzenbach, 1997).

Mould is ubiquitous in normal indoor and outdoor environments, thus some exposure is inevitable in everyday life (Park et al. 2008). However, elevated exposure levels may occur indoors in buildings with humidity problems, either due to climate or local water damage (Garrett et al., 1998; Verhoeff et al., 1995; Su et al., 2005). Aspergillus and Penicillium are the most common moulds found in residential housing in north-central North America (Dharmage et al., 1999). Approximately 270 species of fungi were isolated from house dust in Wallaceburg, England and the most common were Cladosporium, Aspergillus and Penicillium (Dales et al., 1991). No residential indoor space is naturally sterile and free from bioaerosol contamination, thus mould spores at low concentrations can be treated as acceptable (Gorny, 2004).

### 1.3.2 Mould and Health

For centuries, the role of buildings in causing or exacerbating human diseases has been understood by doctors and public health workers, including Hippocrates (Greek Father of Medicine) and Biblical Israelites (Wu et al., 2007). Major
epidemiological and biological studies support a link between exposure to dampness and excess mould growth and the development of respiratory symptoms (Hope, 2007; Su et al., 2005; King, 2002; Koskinen et al., 1999; Rylander et al., 2000; Neilson, 2003).

Three types of mould exposure include inhalation, ingestion, and contact of/with spores, conidia, and mycelia components, and toxic agents including β-(1→3)-D-glucans, microbial volatile organic compounds (MVOC’s) and mycotoxins (Abba, 2003; Chapman et al., 2003). Allergens are generally found in the cell wall, membrane plasma, and cytoplasm of these mould components and agents (Gorny, 2004).

Whether a person is affected by mould exposure may depend on the type of mould, sensitivity to mould, spore load in the living space, colony growth, duration of exposure, type of exposure (Forintek, 2002), and health of the individual. To date, very few airborne genera (i.e. Alternaria, Aspergillus, Cladosporium, Botrytis, and Penicillium) have been implicated in allergic asthma, and allergic alveolitis (Woodcock, 2007). Aspergillus and Penicillium have a spore size (5 μm) within the respirable range, unlike other moulds which have much larger spore sizes (Woodcock, 2007). Also, some fungi such as Aspergillus fumigatus can germinate and colonize the sinuses and airways (Woodcock, 2007). Young children, the elderly, and those with compromised immune systems or chronic illnesses are generally more vulnerable to the effects of mould exposure. Other health complications increasing the risk of exposure include acquired immunodeficiency syndrome, cancer, diabetes, and alcoholism (Chapman et al., 2003). Although controversial, there are several symptoms alleged to stem from exposure to indoor mould. These include cognitive and memory difficulties, recurring cold and flu symptoms, diarrhea, and hair loss (Abba, 2003; Chapman et al., 2003).

Cladosporium, Penicillium, and Aspergillus have been associated with allergic respiratory disease, infection, chronic sinus and pulmonary diseases, chronic fatigue syndrome, lethargy, and migraines (Chapman, 2006). Other effects include asthma, dermal irritations, hypersensitivity pneumonitis, and mucous membrane irritations (Dales et al., 1991; Stetzenbach, 1997; Chapman et al., 2003; Frew, 2003; Bush et al., 2006). Health practitioners recognized infection, allergy, and toxicity as health outcomes caused by mould (Abba, 2003; Chapman et al., 2003). For example, Aspergillus, Fusarium and Mucor can cause infections on the skin or on mucous membranes (i.e.
nostrils, lips, ears, genital area, anus; Chapman et al., 2003). Yang and Johanning (1997) reported that the percentages of the population affected by mould allergies vary from 2-18%. Because mould allergies are less understood, this is likely an underestimate as allergies are generally linked to other allergens including pollen, grass, cats, and dogs. Ingestion toxicity is a concern due to the mycotoxins and volatile organic compounds (VOCs) released from moulds. Aspergillus fumigatus is a toxic mould that typically colonizes water damaged materials. It is linked to sinusitis, allergic bronchiopulmonary aspergillosis (a rare disease found in asthma patients where spasms occur in the bronchi (airway), and/or increases mucous production causing the airway to subsequently collapse), and other allergies. Opportunistic infections caused by A. fumigatus are called mycoses and are secondary complications that occur in patients with weakened immune systems (e.g., complicated diabetes mellitus, some forms of cancer, HIV; Yang and Johanning, 1997).

All fungi produce chemicals and secondary metabolites that are necessary for their survival, nourishment, and propagation (Chapman et al., 2003). Depending on what moulds are consuming at the time, they will release a different profile of organic solvents (e.g., alcohols, ketones, esters, hydrocarbons) called MVOCs that produce a musty, earthy odor (Graveson, 1994). These are only released while the mould is living (Dalton, 2004). β-(1→3)-D-glucans are found in the cell walls of mould and their inhalation causes symptoms (airway inflammation, asthma, and atopy) of the upper respiratory tract (Douwes, 2005; Rylander and Lin, 2000; Gehring et al., 2001).

Mycotoxins are toxic secondary metabolites produced by a variety of fungi. They function as toxins against plants, bacteria and other fungi, and cause a range of acute and chronic systemic effects in humans and animals (Nielson, 2003). To date, over 350 fungal species have been identified to produce over 400 different mycotoxins (Kuhn et al., 2003; Gutarowska et al., 2007). Ten mycotoxins have been identified as carcinogenic in laboratory animals, or associated with human cancer in epidemiological studies (Hendry, 1993).

The following common indoor mould species produce mycotoxins: Alternaria sp., Aspergillus flavus, A. fumigatus, A. niger, A. ochraceus, A. ustus, A. versicolor, Chaetomium globsum, Memnoniella echinata, Penicillium brevicompactum, P.
chrysogenum, *P. expansum*, *P. polonicium*, *Trichoderma* sp., and *Stachybotrys chartarum*. *Penicillium* and *Aspergillus* species both produce small quantities of mycotoxins, especially when compared to *S. chartarum* (Frisvad et al., 2004; Ciegler et al., 1970; Graveson, 1994; Nielson, 2003; Sweeney et al., 1998). Mycotoxic moulds cause impairment of the human immune system, which may lead to acute or chronic damage to the liver, kidneys, gastrointestinal tract, heart, and central nervous system.

1.3.3 Determinants of Exposure to Mould

The increasing prevalence of asthma development suggests an important environmental component (Simpson et al., 2006). Homes built in the past 15-20 years are based on a building code for winter conditions of central Canada, not the soggy, wet conditions of the west coast (Pynn and McCullough. Jan 2, 2001). “Instead of building test houses, we’re building test houses and living in them” (Pynn and McCullough. Jan 2, 2001.). These designs resulted in airtight houses leading to moisture accumulation and consequently to mould contamination and exposure (Pynn and McCullough. Jan 2, 2001).

The problem of indoor mould incidence first came to the attention of the Canadian federal government in 1988 (Pynn and McCullough, 2001). The national building code adopted by the provincial government at that time was devised in response to the energy crisis of the 1970’s and has only seen minor adjustments since (Pynn and McCullough, 2001). Building design and selection of construction materials used for building interiors (e.g., dry wall and plastics) went through a revolution in the 1970’s (Dalton, 2004; Barrett, 1998). These changes included new materials that allowed more water to condense inside wall cavities, but also prevented wall cavities from drying out, which create appropriate conditions for the growth of indoor moulds (Kilburn and Hayes, 2002). Drywall is made from paper and cornstarch with an interior core of calcium sulfate. When exposed to water or high relative humidity, the interior absorbs moisture and the paper provides sufficient nutrients for fungal growth and proliferation (Bartlett, 1999).

Douglas-fir was an exterior building material traditionally used to frame buildings because it had a high percentage of heartwood, which is relatively nutrient poor. However, current lumber markets have replaced Douglas-fir with spruce or pine and
both have a higher percentage of sapwood, which is nutrient rich and ideal for fungal growth if not treated or protected from weathering (Bartlett, 1999).

Airborne mould spores can easily find a way into the interior space through fresh air intakes, open windows and doors, and/or by being tracked in on the soles of our shoes (Graveson et al., 1994). Indoor airborne spores can come from either outdoor or indoor organic sources such as plants, plant debris or garbage (Abba, 2003). Housing design and structural conditions can contribute to elevated spore loads, which cause adverse health effects. When there are moisture accumulations, there will be mould incidence. Each day, a house can take in approximately 30 litres of water (CMHC et al., 2006) depending on the number of occupants and their daily activities (see Table 1.1).

Table 1.1 Factors contributing to indoor moisture production (litres/day).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Moisture Production (litres/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four people</td>
<td>5</td>
</tr>
<tr>
<td>Damp basements / crawlspace</td>
<td>3 – 8</td>
</tr>
<tr>
<td>Bathing / showers</td>
<td>2 – 10</td>
</tr>
<tr>
<td>Firewood, per cord</td>
<td>1 – 3</td>
</tr>
<tr>
<td>Washing floors, laundry</td>
<td>2 – 5</td>
</tr>
<tr>
<td>Cooking</td>
<td>1 – 5</td>
</tr>
<tr>
<td>Plants (each)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: CMHC et al., 2006.

Once water has accumulated, moisture will surface and/or penetrate substrates such as carpets, walls, ceilings, and window frames providing suitable substrates for mould growth. If sufficient water activity ($a_w$) is present, moulds, bacteria and dust mites are able to complete lifecycles, reproduce and consume organic components of dust (Gravesen et al., 1994; Douwes et al., 1998a).

Water activity ($a_w$) is the moisture available in hygroscopic and porous materials. It is calculated and presented as the ratio of the vapour pressure exerted by water in the material to the vapour pressure of pure water at the same temperature and pressure (Graveson et al., 1994; Flannigan et al., 2002; Macher, 1999; Gomey, 2004). An $a_w$ value below 0.55 causes DNA denaturation or biological inactivity (Gomey, 2004).
minimum $a_w$ value of 0.65 has been shown to initiate mould growth when appropriate amounts of nutrients are present (Flannigan et al., 2002). Moulds thrive when the $a_w$ value approaches 1.0. Based on different $a_w$ values of a material, different moulds will appear as primary colonizers ($a_w < 0.8$), secondary colonizers ($a_w = 0.8 - 0.9$) or tertiary colonizers ($a_w > 0.9$; Grant et al., 1989; Neilson, 2003). Mycotoxin production in indoor environments occurs when surface water activity exceeds 0.9 (Neilson, 2003). Table 1.2 presents moulds included in each colonization classification.

Table 1.2 Moulds included in each colonization classification: primary, secondary and tertiary colonizers.

<table>
<thead>
<tr>
<th>Primary Colonizers</th>
<th>Secondary Colonizers</th>
<th>Tertiary Colonizers</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. versicolor [1,2]</td>
<td></td>
<td>Phialophora sp. [2]</td>
</tr>
<tr>
<td>Penicillium aurantiogriseum [2]</td>
<td></td>
<td>Stachybotrys chartarum var. atrum [1,2]</td>
</tr>
<tr>
<td>P. chrysogenum [2]</td>
<td></td>
<td>Ulocladium sp. [1,2]</td>
</tr>
<tr>
<td>P. commune [1,2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. expansum [1,2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. griseofulvum [2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paecilomyces variotti [2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willemia sebi [2]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[2] Burge et al., 1997; Flannigan and Miller, 2002; Grant et al., 1989; Graveson, 1994; Neilson et al., 2003; Yang and Johanning. 1997; Gorney, 2004

1.4 Dust Mites

Depending on geography and climate, house dust mites provide the predominant inhalant allergens in many parts of the world (Zock et al., 2006). Common dust mites include *Blomia tropicalis*, *Euroglyphus maynci*, *Dermatophagoides microceros*, *Dermatophagoides farinae*, and *Dermatophagoides pteronyssinus* (Arlain, 1999). The latter two are the most frequent and more widely distributed (Fernandez-Caldas et al., 2006). Dust mites have pincers, no visual organs, four pairs of legs, one body region
and are invisible to the naked eye (Arlain, 1999). At 23°C, the mite life cycle lasts on average 34 days (Arlain et al., 1999).

1.4.1 Dust Mites and Health

House dust mites are an important source of indoor allergens (Cieslak et al., 2007). Mites have been reported to produce feces weighing up to 200 times their body weight (Hamilton et al., 1992; Arlain, 1999). Mite feces are allergenic and are responsible for hypersensitivity reactions, chronic or perennial rhinitis, allergic asthma, atopic dermatitis, and vernal conjunctivitis (Pennanen et al., 2007; Cho et al., 2006; Fernandez-Caldas et al., 2006). Allergic sensitization has been identified as a risk factor for persistent asthma (Platts-Mills et al., 1997; Cho et al. 2006; Grad, 2000; Nelson, 2000). It is suggested that children who become allergic to foreign proteins (e.g., dust mite allergens) in their homes are at increased risk of asthma and continued exposure contributes to morbidity (Celedon et al., 2007; Platts-Mills et al., 1992). The development of asthma is not found to be related to mite allergen exposure in the first years of life, but allergy sensitization has been correlated with mite allergen exposure (Lau, 2000). However, in the form of a bioaerosol, quantities and size (> 10μm diameter) suggest that a relatively small number of particles (i.e. 200) are inhaled per day (Platts-Mills, 1997).

1.4.2 Determinants of Exposure to Dust Mites

Dust mites feed on detritus of animal or vegetable origin and live in close association with their food sources (e.g., beds, living rooms, bedrooms, carpets, upholstery) such as skin scales and animal dander (Redlich, 1997). It has been estimated that humans shed approximately 1 gram per day (Hamilton et al., 1992). Conditions such as ambient relative humidity and temperature play a crucial role in mite survival, prevalence and densities (Hart, 2007; Fernandez-Caldas et al., 2006; Zock et al., 2006). Increases in prevalence and density have been found during periods of higher relative humidity while decreases are reported during long dry winters (Platts-Mills et al., 1997). Mites are also more commonly found in water-damaged buildings (Pennanen et al., 2007). Dermatophagoides pteronyssinus is more susceptible to
desiccation than *D. farinae*, especially during cold winters and in heated homes (Zock *et al.*, 2006).

### 1.5 Endotoxins

Endotoxins are strong pro-inflammatory and immune-stimulatory components of the outer cell membrane of gram-negative bacteria (Giovannangelo *et al.*, 2007). Endotoxins are found in gram-negative bacteria such as Enterobacteriaceae, Pseudomonadaceae, and Rhodospirillaceae, but not in the cell walls of gram-positive bacteria, mycobacteria, or fungi (Liebers, 2006). Recognition that house dust contains endotoxins dates back to 1964 (Thorne *et al.* 2005).

#### 1.5.1 Endotoxin Exposure and Health

Endotoxin exposure has both positive and negative health effects. Endotoxin exposure is regarded as beneficial because it is believed that it can contribute to the development and stimulation of the immune system. For example, endotoxin exposure has been reported to reduce cancer rates among agricultural workers (Lang, 2000), and has been associated with reduced risk of allergic sensitization (Simpson *et al.*, 2006; Gehring *et al.*, 2004).

However, exposure to endotoxins in workplaces has been linked to fever, cough, shortness of breath, wheezing, headache, nose and throat irritation, chest tightness, acute airway flow restriction, and inflammation (Liebers, 2006). Exposure to elevated levels of house dust endotoxin has been shown to increase the risk and severity of asthma symptoms (Douwes *et al.*, 2005; Park *et al.*, 2006; Thorne *et al.*, 2005) and decrease the risk of allergic sensitization in others (Simpson *et al.*, 2006). Exposure to >100 endotoxin units (EU)/mg of dust during the first year of life has been associated with increased risk of wheeze (Park *et al.*, 2006).

Response to endotoxin inhalation may differ between individuals by genetics or degree of tolerance (Simpson *et al.*, 2006). There is clear evidence of different effects of domestic endotoxin exposure on allergic sensitization, eczema, and wheeze in children with different genotypes (Simpson *et al.*, 2006).
1.5.2 Determinants of Exposure to Endotoxins

Exposure to endotoxins is common, due to indoor sources such as pets, pests, humidifiers, and kitchen compost bins (Thorne et al., 2005). In general, pets and vermin are associated with high endotoxin levels in house dust (Heinrich et al., 2001). Keeping pets and having more than four people living in the home were consistently associated with up to 1.7-fold higher endotoxin concentrations in mattress and floor dust (Giovannangelo et al., 2006). Materials such as carpets and upholstery are primary sources of endotoxin exposure and could serve as secondary sinks (Redlich, 1997).

1.6 Research Hypothesis, Goals and Objectives

Poor indoor air quality is an important public health risk worldwide (Wu et al., 2007). People in modern societies spend more than 90% of their time in indoor environments and more likely in homes (Wu et al. 2007). “For too long the Indigenous people of this country have been deprived of the fundamental human right to decent, affordable housing” (Grand Chief Edward John, FNLC, 2008). It is therefore important that the home is safe and sustainable to live in.

**Hypothesis**: On-reserve housing conditions and characteristics are associated with airborne mould spore concentrations, and elevated levels of dust mite and endotoxin exposure.

Despite the advances of modern epidemiology, the field remains limited in generating the kind of findings that can be translated into programs or policies to improve health (Leung et al., 2004). The goal of this research is to contribute baseline data by air sampling for mould incidence and abundance on the Heiltsuk reserve and to propose a draft provincial work plan.

Biological particles including dust mites and endotoxins in carpet dust were collected, and conditions and characteristics of the home were investigated to determine exposure risks.
My objectives were to:

1. Establish a relationship with the Heiltsuk community by meeting with Tribal Council members, Housing Department staff, Health Center staff and the community (Responsibility);

2. Obtain Tribal Council support and community/individual consent for the project (Relevance and Responsibility);

3. Abide to Heiltsuk Nation’s rules and guidelines for researchers (Respect);

4. Promote capacity development initiatives (Reciprocity);

5. Sample for mould and house dust in participant houses (Relevance);

6. Conduct statistical analysis to help identify determinants of exposure (Relevance);

7. Present results to the Heiltsuk Tribal Council, the Housing Department, the Hailika’as Heiltsuk Health Center and the participants (Responsibility); and

8. Invite participants and other community members to assist in the interpretation of results during the dissemination process (Respect and Reciprocity).

The Four R’s (Respect, Reciprocity, Relevance, and Responsibility) illustrate values regarded as fundamental for the implementation of research goals and objectives among aboriginal people. This model has been adapted from Kirkness and Barnhardt (1991).

Social relevance was an important part of this research, therefore community participation and self-determination were part of the research process. This was achieved by working with the Heiltsuk based on research protocols and ethics defined by the Heiltsuk Cultural Education Center Guidelines for Researchers, University of British Columbia’s (UBC) Institute for Aboriginal Health research ethics protocol, and Canadian Institute for Health Research Ethics Guidelines, Policy 6. The Four R’s: Respect, Relevance, Reciprocity and Responsibility (Kirkness and Barnhardt, 1991) are
values used as a contextual guide in this research. The following section illustrates the use of these values as incorporated in my research.

1.6.1 Relevance: Housing in the Heiltsuk Community

Both reserve and off-reserve housing, and particularly the lack and poor quality thereof, are to this day a central issue in contemporary First Nations experience and politics (Auditor General of Canada. 2006; Perry, 2003). Cover stories highlight the issue and raise public awareness: “The rot of corruption on Indian reserves” (McLean and Steel, 2001) and “A new crisis for natives: mouldy homes: Ottawa spends millions on renovations and relocations” (Pynn and McCollough, 2001).

The housing conditions are regarded as fundamental to improving the health status of aboriginal people (Auditor General of Canada, 2006). These conditions are compounded in BC by geography and climate.

Waglisla lies in the center of the temperate rainforest with environmentally wet conditions during all seasons. These wet conditions have a direct impact on the housing crisis in our community. Our people have been severely affected by mould exposure and in a number of extreme cases have had to move from their homes due to fungal growth, until the homes were renovated. (Chief Councelor, Ross Wilson 2005. pers.com.).

1.6.2 Reciprocity: Research with the Heiltsuk

Research can provide useful information about health and social matters; however, it is also evident how disillusioned aboriginal people often feel about academic research not benefiting their communities (Vedan, 2006). It is important for the researcher to study and understand the mould issue from an aboriginal perspective. Researchers should also acknowledge the different ways of knowing, giving equal weight to scientific expressions of knowledge (Fletcher, 2003). Therefore, ethical principles and protocols recognized by the Heiltsuk community were integrated and implemented into the research process. This is discussed in Chapter 2.
1.6.3 Respect and Responsibility: A Common Vision for Health Promotion

Indoor mould, dust mite and endotoxin exposures and their effect on the quality of life and health of coastal First Nations peoples of BC had not yet been researched at the time I conducted my study. Currently, baseline information is scant and collaborative research is essential. In Chapter 3, I report on airborne mould concentrations, organic components found in carpet dust samples (dust mite and endotoxin allergens and ergosterol), and the Heiltsuk peoples’ responses to questionnaires/open-ended conversations. It is the goal of the Tribal Council and the Housing Department to use these data to engage the community in jointly planning remediation, education and health promotion programs. In Chapter 4, I discuss conclusion and recommendations related to housing policy implications.
1.7 References


Canadian Institutes for Health Research. 2007. CIHR guidelines for health research involving Aboriginal people. Her Majesty the Queen in Right of Canada, Ottawa, Ontario.


CHAPTER 2 – WORKING FOR AND WITH HEILTSUK FIRST NATION

2.1 Introduction

Aboriginal people speak of their history, sociology, psychology and politics of imperialism and colonialism as an epic story telling of devastation, painful struggle and persistent survival (Smith, 1999). Aboriginal people face great challenges because they live within political and social conditions that perpetuate extreme levels of poverty, chronic ill health and poor educational opportunities (Smith, 1999). Although there are improvements in numbers of aboriginal people in higher education and economic development, Kindergarten to Grade 12 education, high levels of unemployment, poverty, and health status continue to pose challenges (Assembly of First Nations, 2006).

Research within late-modern and late-colonial conditions continues and brings exploration and discovery but it also at times brought exploitation and appropriation (Smith, 1999). Extensive health related research around the world appears to have little impact on overall well-being of populations (Cochrane, et al. 2008).

Therefore, research methods must be compatible with community understanding of collaboration, ethics and protocols. Community-based participatory research (CBPR), community-based research (CBR), and participatory action research (PAR), are emerging research orientations and methodologies applied more frequently in health research, which set out to change traditional western scientific methodologies. This is achieved by decolonizing traditional research methods by centering aboriginal concerns and worldviews, and understanding research outcomes from an aboriginal perspective and for an aboriginal purpose (Smith, 1999).

2.2 Western Knowledge and Health Research

The globalization of western knowledge affirms the western perspective is the centre of legitimate and civilized knowledge (Smith, 1999). Traditionally, research
involving aboriginal people has not included consultation and collaboration when defining the research question and the process:

*The gathering of information and its subsequent use are inherently political. In the past, aboriginal people have not been consulted about what information should be collected, who should gather that information, who should maintain it, and who should have access to it. The information gathered may or may not have been relevant to the questions, priorities and concerns of aboriginal peoples. Because data gathering has frequently been imposed by outside authorities, it has met with resistance in many quarters.*


Health research is generally initiated, paid for and carried out by non-aboriginal people from universities, government and industry (Cochrane et al., 2008; Schnarch, 2004). Researchers have legal obligations to their funding agencies, which can include publication and property rights to data. Researchers publicize or potentially profit from sensitive cultural information provided by aboriginal peoples. This results in research outcomes that are not accessible, understandable, or relevant and has often had little effect on health policy. Furthermore, aboriginal people and their cultures are largely subjects and objects of study (CIHR, 2007), rather than collaborators.

Some ethical problems have arisen from traditional methods of research relating to information management and intellectual property rights (Brant Castellano, 2004; Schnarch, 2004; Israel et al., 1998). For example, blood samples originally taken from members of the Nuu-chah-nulth in BC for arthritis research were later used for genetic anthropology research without their consent (Chartrand, 2005).

Recurring grievances involving aboriginal people’s Traditional Ecological Knowledge worldwide are the result of misunderstanding or appropriation, especially by bio-prospectors for commercial production of medicines (Moran et al., 2001). In response to this worldwide concern, the United Nations (UN) Earth Summit (Rio de Janeiro, Brazil) adopted the Convention on Biological Diversity (CBD) in 1992, which addressed sovereignty over access to biodiversity and resources. The treaty recognizes Indigenous Intellectual Property Rights (IIPR) and self-determination to regulate activities in their own communities and territories (Moran et al., 2001). However, as previously stated, Canada voted against adopting the *UN Declaration on the Rights of*
Indigenous Peoples. The minority Conservative government of Canada is concerned that the wording of Article 26, "Indigenous peoples have the rights to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired," has great implications for addressing lands and resources, such as existing settled land claims and existing treaties in Canada (Jim Prentice, CBC Radio 1 News, 2007).

2.3 Aboriginal Health Research

Western research paradigms are changing and aboriginal people and other disenfranchised communities worldwide continue repositioning themselves from marginalization to empowerment. Upon the insistence of aboriginal organizations and communities, researchers do research for and with aboriginal peoples rather than on them (Fletcher, 2003). Community-based research has evolved significantly since the 1970's, especially in education, development, social sciences and health (Fletcher, 2003; Elias et al., 2004; Rifkin, 2003). Traditional research paradigms (e.g., western science research methods) have slowly shifted in response to aboriginal political autonomy, as aboriginal people exercise increased authority over events that take place within their communities (Cochrane et al., 2008; Leung, 2004; Brant Castellano, 1993).

Aboriginal people and their communities have the right to self-determine the level of participation when research is conducted in their communities. Self-determination includes aboriginal control of the research process. Research that is conducive to self-determination should endeavor to engage people and communities in all phases of research, from the definition of the question to the dissemination of the results. Study results reinforce the importance of consultation, community involvement, consent, and appropriate dissemination of research findings (Cochrane, 2008; Fletcher, 2003; Brant Castellano 1993, 2004; O'Fallon et al., 2002; Leung, 2004; Schnarch, 2004).

Communities, aboriginal organizations, universities and colleges, and some government offices are now engaged in transforming research to reflect ethical and self-determined research. These include: University of BC's (UBC) Institute for Aboriginal Health and BC Aboriginal Capacity and Developmental Research Environment (BC ACADRE), Kahnawake Schools Diabetes Prevention Project, Section 6 in Tri-Council...

I facilitated the creation of a community partnership for my research project to allow the community to participate in the definition of the question, implementation, and dissemination of results. The research process was guided by the Heiltsuk Cultural Education Center Guidelines for Researchers. Four fundamental values were used to guide the research project: *Respect, Relevance, Reciprocity and Responsibility*. The Four R's model is based on aboriginal teachings and values, as defined by Kirkness and Barnhardt (1991). The model has been adapted by the BC ACADRE to promote health research and healing solutions:

1. **RESPECT** is demonstrated toward aboriginal Peoples' cultures and communities by valuing their diverse knowledge of health matters and toward health science knowledge that contributes to aboriginal community health and wellness;

2. **RELEVANCE** to culture and community is critical for success of aboriginal health training and research;

3. **RECIPROCITY** is accomplished through a two-way process of learning and research exchange. Both community and university benefit from effective training and research relationships; and

4. **RESPONSIBILITY** is empowerment and is fostered through active and rigorous engagement and participation.

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\(^3\) OCAP are principles of Ownership, Control, Access and Possession, which was coined by the Steering Committee of the First Nations Regional Longitudinal Health Survey (1998) within the context of self-determination in research and data management.
Based on researcher-community consultation and participation, my research goal was to investigate indoor mould, dust mite, and endotoxin exposure, and associated home characteristics using research protocols shown in Figure 2.1.
2.4 Collaborative Research with Heiltsuk First Nation

2.4.1 The Heiltsuk People

The Heiltsuk Nation is comprised of proud descendants of the Heiltsuk Tribal Groups; 'Wúyalitxu, Yísdaítxv, Wúiítxv, 'Qvuqva'áitxv and 'Xáixáis. The Heiltsuk relationship to their land is ancient, complex and sacred (Heiltsuk Tribal Council, 2005). Oral tradition, physical evidence and continued use and occupancy reveal at least 55 permanent villages and hundreds of traditional camps throughout the territory over the past 9700 years (Heiltsuk Tribal Council, 2005; Cannon 1996; Carlson, 1979). The Heiltsuk people speak Hailhzaqvla, the Heiltsuk language.

Today, the Heiltsuk people live off the central coast of BC in an island village called Bella Bella, traditionally known as Waglisla (Appendix I). According to a 2006 census report, the total population living on reserve was 1,066 with 393 total dwellings (BC Stats, 2007). The number of off-reserve Heiltsuk is unknown. Heiltsuk territory
encompasses approximately 16,770 km² of land and an additional 19,000 km² of near-shore and off-shore areas extending into international waters (Heiltsuk Tribal Council, 2005). There are mild winters (December: Min 1°C; Max 6°C; Mean 3°C), cool summers (July/August: Min 10°C; Max 18°C; Mean 14°C) and rainfall that can exceed three meters per year (The Weather Network, 2008; Schoonmaker et al., 1997). South-east winds are predominant from October to April, with northern winds between May and September (The Weather Network, 2008).

Anthropological studies confirm that the Heiltsuk have had, for generations, a sophisticated culture with well defined ceremonial and social systems for governance (Jones, 1996). ‘Gv’ilás is a set of Heiltsuk customary laws of governance that embodies values, beliefs, teachings, principles, practices and consequences (Heiltsuk Tribal Council, 2005). Highly developed technologies included the construction of immense cedar longhouses and canoes, complex fishing and hunting equipment and strategies, production of intricate ceremonial regalia, spinning and weaving of local plants and animal fibers, and a variety of methods for processing and preserving perishable foods (Jones, 2002).

Today, Heiltsuk governance remains sophisticated and offered my project team the opportunity to develop and work within collaborative, multi-level partnerships inclusive of the Heiltsuk Tribal Council (HTC), the Heiltsuk Housing Department (HHD), the HaIlika’as Heiltsuk Health Center (HHHC), and the Heiltsuk Environmental Task Force Committee (HETFC).

2.4.2 Community Consent

My research proposal, “Effects of Indoor Mould Exposure on the Health of Aboriginal Peoples in British Columbia”, was based in the UBC Institute for Aboriginal Health (UBC IAH) with the input and numerous discussions with Chief Ross Wilson about the situation and need for research. The project was funded by the Canadian Institutes for Health Research (CIHR), Institute for Aboriginal People’s Health (IAPH), and the research ethics protocols were approved by UBC’s Research Ethics Board. After the funds were received, a meeting was held with the Heiltsuk Tribal Council, Brenda Brown (Manager, Heiltsuk Housing Department), and Louisa Willie (Health Director, HaIlika’as Heiltsuk Health Center) to seek their advice, discuss community
engagement, and to strategize the implementation of the research plan. A community forum was also organized to provide the background of the project, such as the burden of disease, and to motivate community interest, seek participants, and more importantly, to listen and learn from their experience.

2.4.2.1 Connecting with the Community

I traveled to Bella Bella as an advocate for UBC’s Faculty of Science at the Bella Bella Community School Career Fair. I had two purposes for this visit. My first purpose was to share my experience and interest in science with the Heiltsuk youth at their annual career fair. Approximately 20 students attended my workshop, which was successful in creating dialogue and curiosity about the field of science. My second purpose was to build relationships with the housing authorities and to discuss the background and significance of my research. I met Ralph Humchitt, (Manager, Heiltsuk Public Works Department) and scheduled a meeting to discuss the opportunity to work in the community.

Community-based research can benefit from the participation of all ages in a given community. Often children are not asked to participate, but they can be a great source of information. At the career fair I met a young Heiltsuk girl who pointed to my research poster and asked, “What’s that?” I explained that I was going to study mould that can be found inside the home. In her words she stated “My auntie has mould all over her window and she has asthma too.” She continued to ask many questions. Those questions prepared me in developing questions for my home surveys and my analysis. This was a valuable contribution and it taught me to respect informal authority at all levels of contact.

2.4.2.2 Presentations

I met with seven members of the Heiltsuk Environmental Task Force Committee who are also members of the Heiltsuk Tribal Council. I provided a 20-minute presentation that was followed by a 30-minute question and discussion period. We discussed mould exposure and the burden on health, recruitment of participants, informed consent, a mould and dust mite sampling strategy, data analysis and dissemination of information. I provided council members with an information package that included the correspondence letters, research methodology, sample data collection
forms, sample consent forms and a questionnaire. I also presented them with the UBC Behavioral Research Ethics Review Board application (August 2004). They responded with their support by providing me with consent to work with the community, and they presented me with the Heiltsuk Cultural Education Centre Research Protocol Agreement (HRPA) to use as a guideline for rules of conduct.

2.4.2.3 Community Forum

The relevance of mould incidence and health outcomes was demonstrated at the community forum. This forum allowed my team to understand the social and health implications of the research. Thirty-five community members attended the community meeting and they spoke of their frustration over housing conditions including poor indoor ventilation, poor conditions of carpets, high relative humidity, substandard construction materials, poor storage facilities for building materials, and the problem with southeast prevailing winds weathering the sides of their homes. It was an invaluable exchange of knowledge (reciprocity) and contributed to building relationships with those interested in the study.

2.4.2.4 Community Consent

The Heiltsuk empower themselves in the research process by implementing protocols and guidelines through the Heiltsuk Cultural Education Centre (Guidelines for Researchers/Access to Information). Their evaluation of research proposals is based on the following questions and understandings:

1. Will it be useful? Will the research product or process be of any practical benefit or use to Heiltsuk? The Heiltsuk Tribal Council put forward their resolution that the project was important for the community.

2. Does the proposal provide clear and acceptable guidelines for informed consent or participants? Are vocabulary and technical terms understandable to persons who are asked to give consent? Are there clear provisions for confidentiality and ability to ask questions and withdraw at anytime? After reviewing the consent form, Heiltsuk Tribal Council was satisfied with the provisions and rights of the participants.
3. Are the right questions being asked? After reviewing the Home Respiratory Questionnaire (Appendix III), the Heiltsuk Tribal Council and Brenda Brown were satisfied with the content of the survey questions.

4. Is there an opportunity for Heiltsuk employment in the design and conduct of research at the local level? There was a commitment within the research proposal that Community Research Assistants would be employed.

The guidelines stipulate that, in exchange for accepting and abiding by the rules, Heiltsuk Nation will support the researcher with, firstly, permission to conduct research on reserve and within its broader traditional territory, and secondly, with the pertinent resources it can offer (Heiltsuk Cultural Education Center). The rules and guidelines are intended to ensure that the basic concern of respect for the Heiltsuk is demonstrated in the research process.

Satisfied that the research protocols and processes were consistent with their own guidelines, Chief Ross Wilson and Ralph Humchitt gave consent to work side-by-side with the Heiltsuk Housing Department, the Heiltsuk Tribal Council, the Heiltsuk Environmental Task Force Committee, the Hailika’as Health Authorities and Heiltsuk community members. It is the goal of the Heiltsuk Tribal Council and Housing Department to assess the data and determine how to address the issue (Brenda Brown, Housing Department Manager, 2004, pers. com.).

It was now my research team’s responsibility to follow the policies set forth by the Heiltsuk Guidelines for Researchers/Access to Information and be mindful of ethical and cultural protocols recognized by the community and the UBC Institute for Aboriginal Health.

2.4.3 Relationship Development

An integral part of building relationships within the community is engaging in casual encounters and dialogue with the local people. I found opportunities to talk to the Heiltsuk by taking daily walks through the village and shopping at the local grocery store. I regularly rented videos from the local video store, and ate out at the local restaurant on pizza nights. They have a keen interest in knowing who the newcomers
are and were never shy to introduce themselves or extend invitations for meals and community activities.

During my time in Bella Bella, I regularly visited elders Carmen Humchitt Sr., Mary Hunt, and Stanley George. I also spent time at the fishing dock, a central hub for many community members. I had unique opportunities to attend community gatherings, including two memorial gatherings and a fundraising event for victims of Hurricane Katrina (August 2005). I travelled with other community members to remote beaches of Kva‘i (Koeye) River, an approximately 2-hr boat ride from Bella Bella village, where a summer science camp for First Nations youth was taking place. I witnessed the youth telling stories about their ancestors and the land through songs and dance. I witnessed the historic formal announcement of the Heiltsuk Land-Use Plan – Qn q̓ı̓ts sasmats 7ns7ats (translation: “For Our Children’s Tomorrows). This plan was intended to assert their rights and title to their traditional territory. I also witnessed the celebration of the provincial government’s recognition and reconciliation of Hakai Luxvbalis Conservancy Area with the Heiltsuk, which was the first of its kind in the Central Coast that recognizes the need for direct involvement of the Heiltsuk in new tourism opportunities and conservation. Approximately 50 Heiltsuk community members travelled in large fishing boats for a 2-4 hour ride to this culturally significant land area, to celebrate the co-management agreement.

While developing a relationship with the community through these experiences, the Heiltsuk learned about whom I am, how I carry myself and my willingness to learn and accept guidance. They then decided whether I am trustworthy and whether they will participate with me in my work. This was extremely helpful in recruiting participants for the study, because it provided a means for them to talk about their experiences with indoor mould exposure. Relationship building is an important step in research because the researcher gains better cultural awareness of the people, which is fundamental in recognizing and acknowledging differences. This will ensure cultural safety of the Heiltsuk, or any other community engaged in a research program. This can be facilitated by taking workshops or courses with culturally appropriate curricula. However, conversations with community members and participation in community events had a more profound effect on my learning and understanding of the Heiltsuk.
2.4.4 Community Collaboration

Collaboration and implementation in health research gives aboriginal people the inherent right to self-determination. They may choose at what level they would like to collaborate. There existed a spectrum of participation and interaction by the Heiltsuk people. The Heiltsuk Tribal Council, and Ralph Humchitt and Brenda Brown of the Heiltsuk Housing Department, contributed significantly to the design and implementation of the research by reviewing my proposal and providing continuous feedback. Brenda had an open-door policy and was always available in a timely manner to help. She hired a local community member to assist in communications, recruitment strategies, and organization of community meetings. The community played a role in developing my understanding of mould in their community. At the community forum, the Heiltsuk attendees collectively analyzed and determined the issues that needed to be considered. Subsequently, through the Heiltsuk Housing Department, the Hailika'as Heiltsuk Health Center and advertisements on the local community television channel, community members made their interest in the formative data collection process known. Finally, an important level of participation is the capacity enabling initiative. I hired two community field research assistants through project funding and trained them to collect and manage data. I also appointed one volunteer field coordinator to schedule the home visits.

2.4.5 Capacity Enabling

Reciprocity and capacity enabling is accomplished through a two-way process of learning and research exchange in gaining knowledge, skills and confidence. As part of capacity enabling initiatives, I announced a call for applications for two Community Research Assistants. Fourteen community members applied and all were invited for an interview so that I could gain experience on how to be an interviewer, and they could gain experience on how to be an interviewee. From September to October 2005, I worked with a team, which included two Community Research Assistants (Mary Vickers and Ted Gladstone) and one Community Research Assistant Volunteer (Bernadine “Bunny” Grant).

The community research assistants contributed to the success of the project. The community members had a strong interest in the health concerns shared by other
members. We shared our knowledge based on different and complimentary backgrounds. I contributed a scientific perspective and they contributed their community, cultural, and social perspectives. The Community Research Assistants and volunteer had an opportunity to further their professional development. More importantly, they provided a fundamental connection, enhancing the collaboration between the community and researchers. As they were familiar faces among participants, the research assistants provided comfort and trust during our first time meetings. As a researcher, I was able to learn about local protocols that otherwise would have been overlooked, ignored, and disrespected due to lack of understanding and knowledge about them.

2.4.6 Communicating Research Results

I returned to the community with the indoor air quality information I previously sampled from their homes. This is an important research effort because it accommodates the perspectives of the Heiltsuk involved in the research and also ensures that the results are made known to the community. I met with the Heiltsuk Environmental Task Force Committee to present the findings. They contributed important interpretation of the data and questioned significant mould issues found in some of the homes. I then returned back to each participant home and spoke about my findings. Heiltsuk perspectives about their indoor air quality helped to translate research results that are relevant to policy and programming development and change. This step is also important because in enables individuals and the community to respond to the issue and guide them in their efforts.

2.5 Conclusions and Recommendations

Researchers are viewed with skepticism by many aboriginal people worldwide. Therefore, meaningful community collaboration and defined research ethics protocols are integral to the research process (Cochran et al., 2008; CIHR, 2007; Leung, 2004; Fletcher, 2003; Rifkin, 2003). Its importance is rooted in preventing potential harm towards a community. Research ethics protocols shift the balance of power from the researcher to the community resulting in a reciprocal relationship.
Based on my experience, I recommend all researchers use their common sense and conduct their behavior to reflect cultural competency and cultural safety in the community with which they work. Ignorance and racism is not tolerated. Attention must be paid to aboriginal history (Fletcher, 2003) and its impacts on aboriginal social determinants of health. People who conduct research in areas that touch on the lives of aboriginal peoples should be prepared to approach their work as a small piece of a much larger community effort for development and renewal (Fletcher, 2003).

Working with aboriginal people is a matter of governance, relationships and accountability. These guiding principles were recommended for inclusion in the BC Tripartite First Nations Health Plan. It states that the health jurisdiction of individual First Nations and their individual mandated health organizations must be upheld and respected. This entails transparency, fiduciary obligations, equitable, balance of First Nations representation in committees and working groups, and informed consent (First Nations Health Council, 2007). There exists a significant social paradigm shift in addressing both public health (e.g., Tripartite First Nations Health Plan, 2007) and research methodologies (e.g., community ethics and protocol), which has great implications for aboriginal self-governance. Lou Demerais, the Executive Director of the Vancouver Native Health Society (2008) stated: "There is nothing, nothing to be afraid of with having us [aboriginal people] collaborate with you. We are actually here to make it easier for you. We will make the decisions for you."4

Ownership (collective ownership of group information), control (over research and information), access (management of their data) and possession (physical possession of data) are research principles advocated by First Nations in Canada and were first coined by the Steering Committee of the First Nations Regional Longitudinal Health Survey (OCAP; Schnarch, 2004). These principles are discussed in the context of self-determination in research (Schnarch, 2004), which is a prerequisite to self-governance (Marie Anderson, 2007, pers. com.). Aboriginal self-governance is a social determinant of health. Capacity enabling within the context of research provides a learning opportunity for not only the researcher, but for the community. Community members on a research team learn about environmental health and possibly decide to

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continue their education to prepare for aboriginal governance of public health issues and health programs. There is a shortage of health care professionals and para-professionals worldwide, and this is particularly acute for aboriginal communities (WHO, 2006; FNHC, 2007; Assembly of First Nations, 2007). This is also true in the case of Environmental Health Officers (EHO's).

EHO's serving First Nations communities in BC are employed by Health Canada and visit communities to assess health and safety risks. Community-based EHO's could not only provide assistance to housing occupants on a regular basis, but more importantly, they could provide local employment and relieve the expanded scope of duties for community housing department managers. A community-based EHO, either working for one community or for a region of communities, is an important strategic provision to address aboriginal housing safety and sustainability.

The benefits of community-based research not only include life enhancing moments, but it also strengthens the research collaboration and relationships with the Heiltsuk. Collaborative inquiry creates an opportunity to think together, where no one individual "knows the answer" (Smith, 1999). David Suzuki (2003) says that science has a terrible weakness, which is rooted in its methodology. Scientists focus on a fragment of nature that they isolate, control and measure (Suzuki, 2003). The insights we acquire are a fractured mosaic of bits and pieces without knowing how it relates to an integrated whole or its context (Suzuki, 2003). Further, as a researcher, there is a chance that my unconscious social and cultural biases and values will manifest itself in the research analysis (Suzuki, 2003). In this study, Heiltsuk knowledge was accounted for, which shaped data analysis outcomes. Brenda Brown, the Community Research Assistants, and the Heiltsuk community were all integral members of this research effort for providing their insight, knowledge and community context. Without them and the 43 participants, I would not fully understand the impact and circumstances of poor indoor air quality and how it affects those who live with it.
2.6 References


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CHAPTER 3 – MOULD, DUST MITES AND ENDOTOXINS: EXPOSURE ASSESSMENT IN HEILTSUK HOUSING

3.1 Introduction

Housing conditions are used as social determinants of population health and well-being (WHO, 2004; Assembly of First Nations, 2005; Shaw, 2004). First Nations housing and infrastructure in some Canadian communities have been compared to third world conditions, contributing to the socio-economic crisis (Assembly of First Nations, 2005).

Because housing plays an important role in how social, economic and cultural factors shape health, addressing inadequate housing conditions on reserve is important.

(Brenda Brown, Housing Department Manager, 2005. Pers. com.).

Substandard quality of reserve housing in Canada continues to be an important issue in contemporary First Nations experience and politics (Perry, 2003). Factors such as structural failure due to poor construction, lack of plumbing, poor ventilation, inefficient heating and insulation, overcrowding and electrical deficiencies have resulted in a cycle of stress and sickness, placing an additional burden on the already strained Canadian health care system (Assembly of First Nations, 2005; Public Health Agency of Canada, 2007). Previous studies on aboriginal housing on reserves in Canada and the United States have described mould spores, dust mites, and endotoxins as predominant allergens (Berghout et al., 2005; Kovesi et al., 2006; Mazey, 2002; Surdu et al., 2006; Wilson, 1999). These epidemiological studies indicated that exposure to these allergens is associated with increased risk for asthma, chronic obstructive pulmonary disorders including emphysema or bronchitis, and possibly sudden infant death syndrome. Other health effects due to exposure are described in Chapter 1. In this chapter, I quantify airborne mould concentrations, house dust mites, and endotoxins. I then compare those results to available guidelines of exposure. To reduce the health and financial burden due to mould, dust mite and endotoxin exposures, it is necessary to identify the reasons these conditions are problematic. Therefore, I used a questionnaire to obtain health

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5 A version of this chapter will be submitted for publication. Osterberg, P., Jovel, E.M., Bartlett, K.H., Menzies C.R. Indoor Mould, Dust Mite and Endotoxin Exposure in Aboriginal Housing in British Columbia: an Assessment in the Heiltsuk First Nations Community.
status and home environment information, and the data were used to identify possible determinants of exposure. Further, policy recommendations to improve indoor air quality for public health are provided and recommendations to minimize exposure are presented and discussed.

3.2 Methodology

To estimate the magnitude of mould, dust mite and endotoxin exposures in reserve housing, Heiltsuk participants volunteered through informed consent, and my research team visited their homes to measure the selected parameters. Air and dust samples were collected and related information was obtained using respiratory questionnaires and open-ended conversations. I implemented standard sampling protocols and survey forms used in previous studies (Bartlett, 1999; Bartlett et al., 2004; Nak'azdli First Nation, 2004; Chan-Yeung et al., 1995) and those published by the American Conference of Governmental Industrial Hygienists (1999). It was agreed that the data collected would be held in co-ownership with Heiltsuk First Nation, and sensitive (cultural and traditional) knowledge was determined to be released only with community consent through the Heiltsuk Tribal Council (Jovel et al., 2007). Figure 3.1 describes activities and parameters measured in each home: air sampling, comfort parameter measurements, dust sampling and questionnaire/interview.

Figure 3.1 Flow chart of fieldwork activities: air sampling for airborne mould concentrations; comfort parameter measures of relative humidity, temperature, and carbon dioxide (CO2); carpet dust sampling for dust mites, endotoxins, ergosterol; and questionnaire/open-ended interview covering demographics, health status, home environment and air pollution.
3.2.1 Heiltsuk Participation Enrollment

Through the Heiltsuk Housing Department, the Hailika’as Heiltsuk Health Center and advertisements on the local community television channel, 43 participants voluntarily enrolled in this study. All participants were Heiltsuk community members living in homes where indoor mould growth and poor housing conditions were suspected to be a current problem or where problems were reported in the past. No specifications were made based on whether participants felt their health problems were caused by mould exposure in the home. Community participants were provided with information about the pre-scheduled visits, which included sampling methodologies and rationale, and the importance and reasons for administering the questionnaire. I suggested that the first visit could take 1.5 hrs and a second visit would take 1 hr.

3.2.2 Informed Consent

A template consent form (UBC, 2005; Appendix II) was used to outline participant rights and obligations. This form explained the purpose, research method, potential risks, confidentiality, handling of records, and remuneration/compensation. The consent form outlining the research background and participant rights was reviewed with the interviewees. One copy of the consent form was presented to the participant and a photocopy was stored by the Heiltsuk Housing Department. Interviewees understood that their participation would be on-going, voluntary, non-paid and that they could withdraw from the study at any time (UBC, 2005).

3.2.3 Room Selection

In collaboration with the participants, two rooms from each home were selected based on the following criteria: 1) where the participant was most concerned (worst-case scenario), and 2) where they spent most of their time. Forty-three homes were assessed for bioaerosol and settled particulate exposures. The total number of sampled rooms ($n = 81$) included: 27 basements, 34 bedrooms, 14 living rooms, two kitchens, two bathrooms, one laundry room and one carport.
3.2.4 Air Sample Collection and Analysis

Aerosol sampling and analysis procedures followed Bartlett (1999) and Bartlett et al. (2004). In each room, a disposable Petri dish filled with 45-46 ml malt extract agar (MEA ingredients per liter: maltose, 12.75 g; dextrin, 2.75 g; glycerol, 2.35 g; peptone, 0.78 g; and agar 15.0 g; BBL Becton Dickinson and Company, Cockeysville, MD) was placed in a sterilized Andersen N-6 sampling head (Graseby Anderson, Atlanta, GA) (Bartlett et al., 2004; Bartlett, 1999; Burge et al., 1999; Dillon et al., 1996). Isopropyl alcohol was used both before and after taking and air sample. The Andersen N-6 was connected to an air pump (GAST, General Electric Corp., Benton Harbor Michigan) and placed on a tripod in the middle of each room at an approximate height of 65 cm above the floor or ground level. This impaction method separates the mould spores in the air stream and forces their deposition onto the MEA surface (Buttner et al., 1997). The air pump drew 28.3 litres of air per minute (L/min) for five minutes. The total air volume collected was 141.5 litres (5 min x 28.3 L/min). The Limit of Detection (LOD) refers to the minimum concentration that is detected with reasonable certainty for a given analytical procedure (Perkins, 1997). For this sampling method, LOD was determined by dividing 1000 L/m³ of air by 141.5 litres (LOD = 7.1; multiplication factor converts to 7.1 CFU/m³). I assigned a value of half the LOD to samples <LOD to account for a large geometric standard deviation (Park et al., 2008). A control plate was taken into the field and treated identically to the sample plates, but was not opened (Bartlett, 1999; Bartlett et al., 2004). The indoor samples were collected between 09:00-17:30 hrs. Outdoor air samples were also collected for baseline data. The air samples and control were placed in shipping boxes packed with Styrofoam and cold packs to keep the samples cool during daily air transport to the laboratory. Samples arrived at UBC within 12-48 hrs from the time of sampling. Samples were shipped to the UBC Environmental Bioaerosol Exposure Laboratory. The Petri dishes were incubated at room temperature and exposed to seasonally variable light/dark cycles (Bartlett, 1999; Bartlett et al., 2004). Approximately 4-5 days after the sample was taken, colonies were counted using a stereoscopic microscope. All fungal colonies were identified to the genus level, but Aspergillus colonies were identified to the species level. Mycotoxin producers are most commonly found in this group. Further, colonies that did not have conidial structures or spores were grouped together as “sterile mycelia” (Bartlett, 1999). Colony counts were
adjusted for the probability of more than one spore entering one of the 400 sieve holes using the positive hole correction table (Andersen, 1958).

3.2.5 **Home Respiratory Questionnaire**

The questionnaire used to study determinants of exposure included questions about demographics, health status (e.g., history of allergies and other respiratory diseases), home environment (e.g., moisture and water damage in the homes, mould growth), and dust pollution (Appendix III). The parents or guardians who were most familiar with a child/baby or elder's health completed the questionnaires.

3.2.6 **Analysis of Dust Mite Allergens, Endotoxin, and Ergosterol**

3.2.6.1 *Carpet Dust Sample Collection and Storage*

I collected dust samples from carpets and floor coverings using protocols based on Chan-Yeung *et al.* (1995). I collected carpet dust samples using a portable Hoover Vacuum Cleaner (7.5 amp motor) with a sock attachment inside the wand. The sock captures particles of mould spores and ergosterols (a biomarker for fungal biomass), dust mites and feces (proteins Der p1, Der p2), and endotoxins from Gram-negative bacteria. The pore size of the sock attachment was approximately 10-15 μm in diameter. To standardize the amount of dust collected, 1 m² was vacuumed for 5 min. The vacuum wand attachment was sterilized with isopropyl alcohol both before and after taking a carpet dust sample. The samples were enclosed in plastic Ziploc® bags, stored and shipped at refrigerator (4°C) temperature until analyzed. One sample was shipped to UBC Aboriginal Health and Natural Products Chemistry Laboratory for dust mite allergen analysis, and one sample was shipped to the UBC Environmental Bioaerosol Exposure Laboratory for endotoxin and ergosterol analysis.

3.2.6.2 *Enzyme Linked Immunosorbent Assay (ELISA)*

Der p 1 and Der p 2 are two purified allergen proteins produced in the gut and excreted by house dust mite *D. pteronyssinus* (Platts-Mills *et al.*, 1997). To quantify Der p 1 and Der p 2 allergen proteins present in settled dust samples, a two-site monoclonal antibody based enzyme-linked immunoassay (mAb-ELISA) was applied using a standard procedure (Indoor Biotechnologies Inc, Charlottesville, VA) and are described
in Luczynska et al. (1989). Reagents were purchased from Sigma Chemical Co., St. Louis, MO. Briefly, individual 96-well microlitre plates were coated overnight with monoclonal antibodies to Der p1, and Der p2 allergens, respectively. Plates were washed with PBS-Tween and non-specific reactive sites blocked with BSA-PBS-Tween. Serial double dilutions of standards and test samples were added to wells and incubated for 1 hr at room temperature. The control curve dilutions are from 250-0.5 ng/ml Der p 1. 20 μl Der p 1 standard was pipetted into 180 μl 1% BSA PBS-T into wells A1 and B1 of the ELISA plate. 100 μl was then transferred across the plate into 100 μl 1% BSA PBS-T diluents to make 10 serial doubling dilutions. Various blanks were used as negative controls. Blank controls were included in duplicate on every plate, with 4 control (PBS-T) wells, using 24 microtiter wells and leaving 72 wells for samples. We used 4 doubling dilutions for each dust sample (1/10, 1/20, 1/40, 1/80), where 18 samples can be tested on a plate. The blank control has no antigen. The outer walls were not used to avoid edge effect. Plates were washed and biotin-conjugated antibody to antigens was added and incubated. After washing the plates, Streptavidin-peroxidase was added and incubated. Color was developed using ABTS (2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) in citrate buffer and absorbance was read on an ELISA reader at 405 nm.

3.2.6.3 Limulus Amoebocyte Lysate for Gram Negative Bacterial Endotoxin Levels

Endotoxin content was measured using a kinetic Limulus Amoebocyte Lysate (LAL) assay, 192 Test Kit, as described by Bio-Whittaker (Kinetic-QLC, Walkersville, MD) (Thorne et al. 1997). The kinetic LAL test is the most accepted assay for detecting and quantifying endotoxin (Lang, 2000). The lysate reacts with the endotoxin. In the presence of endotoxin, a lysate proenzyme is activated, which in turn acts on a substrate to release a colored product. The rate of color change over time is proportional to the amount of endotoxin in the sample. The color change is quantified against a standard curve, and the biologic activity is expressed as endotoxin units (EU). Concentration is measured in EU per milligram of dust (EU/mg) (Cambrex BioScience Walkersville). The samples were prepared by weighing 0.1 g of fine dust and placed in

6 *Limulus* is the genus of the extract source *Limulus polyphemus* (Horseshoe crab); Ameobocyte refers to the blood cells of the Horseshoe crab. Polyphemus was a great Cyclops in Homer's Odyssey (700 BC) who lived in a cave and trapped Greeks inside. His father was Poseidon (God of Sea and Horses, and was also known as the earth-shaker).
a conical test tube filled with 10 ml of pyrogen free water (PFW), and shaken for 60 minutes. The tubes were then transferred to a sonicator bath and sonicated for 60 minutes. Each tube was vortexed and then centrifuged at 1000 x g for 15 minutes at 20°C. 100 µl standards, PFW water blank and, 1:50 and 1:100 dilutions of samples (in duplicate) were pipette into 96 well microtitre plates and incubated at 37°C for 15 minutes in a microplate reader. The microplate reader settings were: Kintetic (time=1:15; interval = 30 sec) L1 = 405; Automix ON; OD min = 0; OD max = 2; Vmax. R² of the standard curve is at least 0.995, otherwise, data was rejected.

3.2.6.4 Gas Chromatograph Spectrometry to Measure Ergosterol

Ergosterol (24β-methylcholesta-5,7,trans 22-trien-3β-ol) is a sterol in the cell membranes of inhalable mycelia, spores and vegetative cells of most filamentous fungi (Pasanen et al., 1999; Miller et al., 1997; Hippelein et al., 2004). It plays a major architectural and functional role in membrane fluidity and cell growth (Hippelein et al. 2004). Currently, there are no known health effects, but ergosterol is measured to detect, quantify and analyze for a possible relationship with air samples of mould. In this study, ergosterol content was measured by gas chromatograph spectrometry and is expressed in units of micrograms per gram of dust (µg/gram).

The following procedure for the analysis of ergosterol (Method Version: SOEH-SOP # A.00.02, 2003) was obtained from the University of British Columbia School of Occupational and Environmental Hygiene (SOEH, 2006, pers.com.). The Agilent Technologies GC/MSD 5973 and the Varian Saturn 2000 Ion Trap are instruments used to detect ergosterol-TMS derivative. The trimethylsilyl derivative of ergosteral yields a unique mass spectrum.

To prepare the stock solutions, we weighed and recorded precisely an amount of ergosterol crystals into an aluminum boat (range 0.01 to 0.02 g). It was then transferred into a 50 mL volumetric flask, topped up to volume with toluene and mixed well. The internal standard was 7-Dehydrocholesterol (Sigma-Aldrich # D-4429; lot 71K2510; 93.4% purity). The sample was prepared by weighing the dust mass, and placing the sample in 8 mL culture tubes. Each sample was spiked with 50 µL of the internal standard. A solution of 10% KOH/Methanol was added, so that the dust was
submerged. The tubes were then incubated in a dry block heater at 80°C for 90
minutes, and removed to allow to cool to room temperature.

The sample was extracted 2 times with pentane and washed twice with a 2 mL
volume of 10% KOH/Methanol and decanted. Then, 2 mL of pentane was added to
each tube, capped tightly and placed in a Rotamax mixer and mixed for 5 minutes
(agitation speed of 10). After mixing, the pentane (upper phase) was transferred to a
clean test tube and evaporated to dryness under a stream of nitrogen gas.

Derivatization reagents were added to each tube. First, Pyridine (15 µL) was
added and then 50 µL of (N)-bis(trimethylsilyl) trifluoroacetamde (BSFTA; Aldrich
Catalogue No.39, 485-8 derivatization grade in 1.0 mL X 10 vials). The tubes were
heated to 60°C for 30 minutes and removed to cool to room temperature. 500 µL of
toluene was added and vortexed. The derivitized extracts were transferred to GC vials
for analysis.

The Gas Chromotographic Parameters (Varian and Agilent Technologies
GC/MS) were as follows: Column Type: PTE-5, HP-5 or DB-5, 0.25 m.m. I.D. x 30
meters, 250 microns film thickness. GC Oven Temperature Program: 95°C (1 min hold)
to 310°C @ 15°C/min hold for 6.5 minutes. Injection Port Temperature: 290°C. Splitless
Injection Time: 0.50 minutes. Interface Temperature: 290°C. Injection Amount: 1.0 µL.

3.2.7 Comfort Parameter Measurements

Indoor temperature (IT), ambient relative humidity (RH) and carbon dioxide (CO₂)
are typical measurements in air quality investigations (Bartlett et al., 2004) and are
reported to play a role in determining occupant comfort (ANSI/ASHRAE, 1981; Levin,
1995). RH levels have been correlated with fungal concentration and CO₂ level can be
an indicator of ventilation efficiency (Redlich et al., 1997). Outdoor temperature, RH,
and CO₂ were also measured for baseline data. A Q-trak (TSI Inst.) was used to
measure comfort parameters in the following units: degrees Celsius (°C) for
temperature, percentages (%) for RH, and parts per million (ppm) for CO₂
concentration.
3.2.8 Statistical Analysis

3.2.8.1 Indoor and Outdoor Airborne Fungal Concentrations

For each air sample, I calculated the airborne fungal concentration [AF]. The following is an example of how the calculations were implemented.

\[
\text{total liters of air pumped} = \text{measurement duration} \times \text{pump flow rate} \\
= 5 \text{ min} \times 28.3 \text{ L/min} \\
= 141.5 \text{ liters}
\]

\[
\text{total volume of air (} V_a \text{)} = \frac{\text{total liters of air pumped}}{\text{liters of air per m}^3 \text{ of air}} \\
= \frac{141.5 \text{ liters}}{1000 \text{ liters per m}^3} \\
= 0.1415 \text{ m}^3
\]

\[
\text{airborne fungal concentration} = \frac{X}{V_a} \quad (X = \text{number of colonies counted}) \\
= \frac{28.5 \text{ CFU}}{0.1415 \text{ m}^3} \\
= 201.6 \text{ CFU/m}^3
\]

3.2.8.2 Descriptive Statistics for Indoor and Outdoor Mould Concentrations

The geometric mean (GM) and geometric standard deviation (GSD) are descriptive statistics used for data sets with a large distribution of values, because arithmetic mean emphasizes extreme datum values. A quick test may be used to determine whether the data are skewed. If the ratio of the highest to lowest datum exceeds 20, one should expect skewed or non-normal data (Perkins, 1997). The highest concentration measured in this study was 18,583 CFU/m\(^3\) and the lowest concentration was 3.6 CFU/m\(^3\). The ratio is 1:5161.

I analyzed data using SPSS 14.0 for Windows (Leadstools Tech. Inc., Chicago). Frequency tables and ranges for all variables were checked and all entries were rechecked once for accuracy of transcription. All reported \(P\)-values were obtained using statistics tested against a preset significance level of \(\alpha = 0.05\). Student t-test was used to analyze air and dust samples and to make comparisons with comfort parameter
measurements.

Indoor-outdoor ratios of fungal measurements were calculated by dividing the indoor concentration of each room by the outdoor concentration. By calculating ratios, it could be determined whether fungal amplification was evident in the room. If the ratio was greater than 1, possible sources and/or house conditions may be contributing to the higher indoor fungal concentrations.

3.2.8.3 The Odds Ratio

The odds ratio was developed for the fields of epidemiology and medicine to examine the risk of exposure to conditions that may result in a disease (Dawson-Saunders et al., 1990). In my study, the odds ratio refers to the odds that a home occupant is exposed to bioaerosols (the risk factor) divided by the odds that a control is exposed (Dawson-Saunders et al., 1990). Odds ratio tests and proportions, using Pearson Chi-square analysis, were applied to air and dust samples and compared with comfort parameter measurements and variables describing the home and occupant health.

3.3 Results

3.3.1 Airborne Mould Concentrations

I sampled 81 rooms in 43 homes (n = 81). Two air samples (n = 2; one bedroom and one living room) were below the LOD (7.1 CFU/m³) and were assigned half the LOD value (3.6 CFU/m³). Among the rooms sampled, 13 fungal genera were identified. The GM for the indoor airborne mould concentration was 508.9 CFU/m³ (GSD 4.7; range 3.6 – 18,583.0 CFU/m³). The GM for outdoor airborne mould concentration was 347.6 CFU/m³ (GSD 2.4; range 35.2 – 2591.5 CFU/m³).
Table 3.1  Summary of GM, GSD and range for indoor and outdoor airborne mould concentrations.

<table>
<thead>
<tr>
<th>Room</th>
<th>Number of Samples (n)</th>
<th>Indoor CFU/m³&lt;sup&gt;A&lt;/sup&gt; GM&lt;sup&gt;B&lt;/sup&gt; (GSD&lt;sup&gt;C&lt;/sup&gt;)</th>
<th>Range CFU/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total indoor recovery from MEA</td>
<td>81</td>
<td>508.9 (4.7)</td>
<td>3.6 – 18,583.0</td>
</tr>
<tr>
<td>Total outdoor recovery from MEA</td>
<td>30</td>
<td>347.6 (2.4)</td>
<td>35.2 – 2591.5</td>
</tr>
<tr>
<td>Basement</td>
<td>27</td>
<td>547.1 (5.5)</td>
<td>7.1 – 18,583.0</td>
</tr>
<tr>
<td>Bedroom</td>
<td>34</td>
<td>424.8 (4.1)</td>
<td>3.6 – 18,583.0</td>
</tr>
<tr>
<td>Living room</td>
<td>14</td>
<td>794.4 (4.4)</td>
<td>3.6 – 18,583.0</td>
</tr>
<tr>
<td>Other rooms&lt;sup&gt;D&lt;/sup&gt;</td>
<td>5</td>
<td>200.1 (3.2)</td>
<td>28.2 – 678.6</td>
</tr>
<tr>
<td>Carport</td>
<td>1</td>
<td>7420.0</td>
<td></td>
</tr>
</tbody>
</table>

A colony forming units per m³ of air  
B geometric mean  
C geometric standard deviation  
D kitchen/laundry/bathroom

In decreasing order of occurrence, the fungal genera most commonly identified in the basement samples were *Cladosporium* sp. (96%) > *Penicillium* sp. (93%) > yeast (70%) > sterile mycelia (67%) > *Aspergillus fumigatus* (33%) = *Mucor* (33%). The ranking order is similar for the bedroom and living room samples with the additional presence of *Acremonium* sp. (11%). *Cladosporium* sp. and sterile mycelia were found in all five samples collected in kitchens, bathrooms and laundry rooms. Fungal genera present in the outdoor samples were sterile mycelia (97%) > *Cladosporium* sp. (90%) > yeast (83%) > *Penicillium* sp. (62%) > *Acremonium* sp. (21%) > *A. fumigatus* sp. (10%).

Fungal genera in 10% or more of the total samples collected (n = 81) are shown in Table 3.2 and Figure 3.3. Positive Samples indicate the percentage of total samples in which fungal genera were present.
Table 3.2  Indoor and outdoor GM, GSD and range concentrations of fungal genera in each room sampled.

| Fungal Genera      | Basement CFU/m³ GM (GSD) | Bedroom CFU/m³ GM (GSD) | Living room CFU/m³ GM (GSD) | Other CFU/m³ GM (GSD) | Outdoor CFU/m³ GM (GSD) | % Positive Samples | % Positive Samples | % Positive Samples | % Positive Samples | % Positive Samples |
|--------------------|--------------------------|-------------------------|-----------------------------|-----------------------|------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
|                    | % Positive Samples       | % Positive Samples      | % Positive Samples          | % Positive Samples    | % Positive Samples     | Samples              | Samples          | Samples          | Samples          | Samples          |
| Total Recovery from Collected Air Samples | 415 (4.01) | 188 (7.98) | 403 (3.3) | 200 (3.2) | 356 (2.3) | 100 | 100 | 100 | 100 | 100 |
| Cladosporium sp.   | 92.3 (7.6) | 92.3 (3.5) | 78.2 (2.6) | 53.7 (4.2) | 93.5 (4.7) | 96 | 94 | 92 | 100 | 90 |
| Penicillium sp.    | 276.7 (6.6) | 106.8 (5.7) | 241.8 (6.4) | 48.9 (2.2) | 30.2 (3.7) | 93 | 94 | 92 | 80 | 62 |
| Yeast              | 26.2 (2.7) | 25.9 (2.2) | 18.8 (1.9) | 50.7 (1.4) | 31.9 (2.1) | 70 | 77 | 77 | 80 | 83 |
| A. fumigatus       | 62.4 (1.9) | 47.7 (8.1) | 71.9 (6.3) | 7.4 (1.0) | 11.9 (2.2) | 33 | 37 | 38 | 40 | 10 |
| Sterile Mycelia    | 60.9 (2.3) | 48.4 (2.5) | 158.9 (6.2) | 49.9 (2.3) | 119.6 (3.5) | 67 | 71 | 69 | 100 | 97 |
| Mucor sp.          | 19.8 (2.2) | 14.1 (2.7) | 39.6 (3.8) | ____ | ____ | 33 | 34 | 31 | ____ | ____ |
| Acremonium sp.     | ____ | 14.0 (1.5) | ____ | ____ | 26.5 (2.4) | 11 | ____ | ____ | ____ | 21 |
Figure 3.2 Indoor and outdoor GM concentrations (CFU/m3) of fungal genera identified in 10% or more of the total number of samples collected: *Cladosporium* sp., *Penicillium* sp., Yeast, *Aspergillus fumigatus*, Sterile Mycelia, *Mucor* sp. and *Acremonium* sp.

3.3.1.1 Exposure Guidelines

To date, there are no threshold limit values (TLV) for mould exposure (Wu et al., 2007; Chapman, 2006; Peden et al., 2006; Abba 2003; Gorny, 2004). The following guidelines were used to analyze the data:

1. Absolute Comparison. The available baseline outdoor concentrations presented in Table 3.3 were compiled by the EMLab™ database (2006). Data from Washington State is chosen because climatic conditions are relatively similar.

---

7 TLV refers to air concentrations of substances and represents conditions that can produce a health effect (Macher *et al.*, 1999).
Table 3.3  Typical outdoor levels for *Cladosporium* and *Penicillium/Aspergillus*; low, medium, and high values represent the 2.5%, 50%, and 97.5% percentile values of the concentration, when that genus is detected (EMLabTM, 2006).

<table>
<thead>
<tr>
<th>Fungal Genus</th>
<th>Low  (CFU/m³)</th>
<th>Medium (CFU/m³)</th>
<th>High  (CFU/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cladosporium</em> sp.</td>
<td>27</td>
<td>373</td>
<td>4587</td>
</tr>
<tr>
<td><em>Penicillium</em> sp./Aspergillus sp.</td>
<td>40</td>
<td>267</td>
<td>3128</td>
</tr>
</tbody>
</table>

When I compared the average concentrations of *Cladosporium* sp. and *Penicillium* sp./Aspergillus sp. found indoors in my study (Figure 3.2 and Table 3.3), the concentrations were within the low to medium range compared with baseline outdoor concentrations from Washington State.

2. **Relative Comparison.** Indoor and outdoor comparisons of mould concentrations (ACGIH/Guidelines for the Assessment of Bioaerosols; ACGIH, 1989) and Health Canada/Indoor Air Quality in Office Buildings: A Technical Guide/1995a:

   i. Indoor/outdoor <1 = OK if similar taxa;

   ii. The normal air mycoflora is qualitatively similar and quantitatively lower than that the mycoflora of outdoor air. Health Canada further describes criteria including: the confirmed presence of one or more fungal species occurring as a significant percentage of a sample in indoor air samples and not similarly present in concurrent outdoor samples.

   iii. Significant numbers of certain pathogenic fungi should not be present in indoor air (e.g., *Aspergillus fumigatus*, *Histoplasma* and *Cryptococcus*).

A quantitative and qualitative analysis using the Student t-test indicated the following⁸. *Cladosporium* sp. was found equally in both indoor and outdoor samples and at similar concentrations, and was a prevalent group found in all rooms of the home. *Penicillium* sp. was found more often inside the homes (93%) compared to outdoors

---

⁸ $H_0$: Indoor concentrations are qualitatively and quantitatively lower than outdoor air concentrations; Reject $H_0$ if $P < 0.05$ (only 5% likely).
(62%) and at significantly higher concentrations ($P < 0.05$). *A. fumigatus* and *Mucor* sp. were also found more often indoors and at higher concentrations compared to outdoors. *Mucor* sp. was not found in the outdoor samples suggesting an indoor source of exposure.

Of greatest concern is *A. fumigatus*. This opportunistic pathogen was found in 33 rooms (41%). It is a tertiary colonizer, which indicates moisture and water problems in the homes.

Table 3.4  Range and occurrence of *A. fumigatus* (range; indoor count and percentage; and outdoor count and percentage).

<table>
<thead>
<tr>
<th>Range</th>
<th>Number of Samples (%) containing <em>A. fumigatus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indoor Count (%)</td>
</tr>
<tr>
<td></td>
<td>$n = 81$</td>
</tr>
<tr>
<td>$&lt; 31 \text{ CFU/m}^3$</td>
<td>13 (16)</td>
</tr>
<tr>
<td>$31 - 100 \text{ CFU/m}^3$</td>
<td>10 (12)</td>
</tr>
<tr>
<td>$100 - 600 \text{ CFU/m}^3$</td>
<td>5 (6)</td>
</tr>
<tr>
<td>$4023 \text{ CFU/m}^3$</td>
<td>1 (carport)</td>
</tr>
<tr>
<td>$17500 \text{ CFU/m}^3$</td>
<td>1 (child's room)$^b$</td>
</tr>
</tbody>
</table>

$^A$ 31 CFU/m$^3$ is based on the maximum concentration found in eight outdoor samples (9% of total samples taken)

$^B$ Mushroom growth in room reported immediately

The concentration of *A. fumigatus* in a carport sample (4023 CFU/m$^3$; Table 3.4) was due to water damage. *A. fumigatus* was also found in the living room upstairs (593 CFU/m$^3$). *A. fumigatus* (17,500 CFU/m$^3$) in a sample taken from a child's bedroom was also due to water damage resulting from rainfall penetrating the exterior sheathing indicative of building envelope failure.

An association was found between levels of mould concentrations and reported respiratory treatment (odds ratio [OR] 8.2; 95% confidence interval [CI] 1.977 – 34.431; $P = 0.04$). Indoor:outdoor fungal ratios exceeding unity were associated with reported asthma symptoms (OR 4.0; CI 1.040 – 15.381; $P = 0.04$) and allergy symptoms (OR 4.5; CI 1.138 – 17.965; $P = 0.03$) and carpet age (OR 4.5; CI 1.252 – 16.171; $P = 0.021$).
3.3.2 Dust Mites, Endotoxin and Ergosterol Quantification

Fifty-two dust samples from carpet or floor coverings were analyzed for dust mites, endotoxins and ergosterol. Eight basement samples, 31 bedroom samples and 13 living room samples were checked against baseline data.

3.3.2.1 Dust Mites

Der P1 levels ranged 0.1 – 150 µg/g (GM 15 µg/g) for bedroom samples and 0.1 – 55 µg/g (GM 1.3 µg/g) for other rooms sampled. Der P2 levels ranged 0.1 – 180 µg/g dust (GM 14.7 µg/g) for bedroom samples and 0.1 – 110 µg/g (GM 2.1 µg/g) in other rooms. An association was found between bedroom dust samples and mite sensitization levels (> 2.0 µg/g) for DerP1 (CI 1.194 – 25.517; \( P = 0.029 \)) and DerP2 (OR 10.1; CI 0.922 – 111.247; \( P = 0.058 \)).

3.3.2.2 Endotoxins

Endotoxins were detected in 100% of the samples \((n = 52)\). The GM for endotoxin in the house dust samples was 71.9 EU/mg (GSD 2.6; range 10.9 – 518.0 EU/mg).

3.3.2.3 Ergosterol

Ergosterol was detected in 95% of the samples \((n = 49)\). The GM for ergosterol was 4.52 µg/gram (GSD 2.0; range 1.43 – 21.5 µg/gram).

3.3.2.4 Comfort Parameters (Relative Humidity, Temperature, Carbon Dioxide)

Indoor temperatures averaged 19.2 °C (SD 1.9; range 15 – 23 °C). Indoor temperatures (IT) were within the recommended range (ASHRAE standard 55-1981) of 23.1 – 26.4 °C during summer conditions.

The mean indoor RH was 67.4% (SD 8.7; range 50.8 – 89.9). The mean outdoor RH was 58.3% (SD 6.7; range 37.8 – 70.5). ASHRAE standard 62-1989 specifies that indoor RH should be maintained between 30% – 60%. The number of rooms failing to meet RH guidelines was 21 (78%) for basements, 26 (76%) for bedrooms, 12 (86%) for living rooms, and 5 (100%) for bathrooms and laundry rooms.
Average indoor CO₂ levels were 1042.6 ppm (SD 419.5; range 191 – 2332). Average outdoor CO₂ was 418.4 ppm (SD 43.3; range 178 – 526). CO₂ measurements indicated that 70% of rooms exceeded the recommended limit of 800 ppm (Redlich et al. 1997).

3.3.2.5 Questionnaire

Of the 43 households, I administered 33 questionnaires with interviewees (76%). The interview process allowed interviewees to speak freely about their homes and themselves. Two participants chose open-ended conversations and six participants were unavailable to complete the questionnaire at the time of sampling. Questionnaires were not administered for one vacant home and one business.

The geometric mean (GM) age of the occupants was 30 years (GSD 3.0; range 2 – 83 years). There was an average of three occupants in each home (GSD 1.7; range 1 – 6 people) with an equivalent average number of rooms (GSD 1.3; range 2 – 5 rooms). Of the respondents, 47% reported having respiratory conditions predominantly related to allergies and asthma.

Table 3.5 Summary of questionnaire responses showing questions asked and the percentage of “yes,” “no,” or other category responses. Categories include Home Environment; and Dust and Air Pollution in the Home.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Home Environment</strong></td>
<td></td>
</tr>
<tr>
<td>1. Working exhaust fan over the cooking stove?</td>
<td>No 18.8</td>
</tr>
<tr>
<td></td>
<td>Yes 81.2</td>
</tr>
<tr>
<td>2. When cooking, do you use the exhaust fan?</td>
<td>All of the time 61.5</td>
</tr>
<tr>
<td></td>
<td>Some of the time 30.8</td>
</tr>
<tr>
<td></td>
<td>None of the time Never 7.7</td>
</tr>
<tr>
<td>3. Does the exhaust fan take cooking fumes outside?</td>
<td>No 50.0</td>
</tr>
<tr>
<td></td>
<td>Yes 42.3</td>
</tr>
<tr>
<td></td>
<td>Don’t know 7.7</td>
</tr>
<tr>
<td>4. Is there a working exhaust fan in the bathroom?</td>
<td>No 59.4</td>
</tr>
<tr>
<td></td>
<td>Yes 34.4</td>
</tr>
<tr>
<td></td>
<td>Don’t have a fan 6.2</td>
</tr>
<tr>
<td>5. Does the exhaust fan take bathroom moisture outside?</td>
<td>No 18.2</td>
</tr>
<tr>
<td></td>
<td>Yes 54.5</td>
</tr>
<tr>
<td></td>
<td>Don’t Know 27.3</td>
</tr>
<tr>
<td>Questions</td>
<td>Percentage (%)</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>6. Do windows in your home fog up (have condensation) during the heating</td>
<td></td>
</tr>
<tr>
<td>season?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>21.9</td>
</tr>
<tr>
<td>Yes</td>
<td>75.0</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>3.1</td>
</tr>
<tr>
<td>7. Is any part of the basement floor damp or wet?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>53.6</td>
</tr>
<tr>
<td>Yes</td>
<td>46.4</td>
</tr>
<tr>
<td>8. Is the land around your house wet or swampy during any time of the</td>
<td></td>
</tr>
<tr>
<td>year?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>35.5</td>
</tr>
<tr>
<td>Yes</td>
<td>58.0</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>6.5</td>
</tr>
<tr>
<td>9. Has there ever been water damage to your house or its contents?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>56.3</td>
</tr>
<tr>
<td>Yes</td>
<td>40.6</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>3.1</td>
</tr>
<tr>
<td>10. Has there been any water damage within the last 12 months?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>62.0</td>
</tr>
<tr>
<td>Yes</td>
<td>33.3</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>4.7</td>
</tr>
<tr>
<td>11. Has there ever been mould or mildew on any surface, other than food,</td>
<td></td>
</tr>
<tr>
<td>inside the home?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>25.8</td>
</tr>
<tr>
<td>Yes</td>
<td>67.7</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>6.5</td>
</tr>
<tr>
<td>12. Has there been mould, mildew or any fungal growth in the last 12</td>
<td></td>
</tr>
<tr>
<td>months?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>65.2</td>
</tr>
<tr>
<td>Yes</td>
<td>30.4</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>4.4</td>
</tr>
<tr>
<td>13. Does your house ever smell mouldy?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>34.4</td>
</tr>
<tr>
<td>Yes</td>
<td>65.6</td>
</tr>
<tr>
<td>14. Do you consider your home to have poor ventilation?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>15.6</td>
</tr>
<tr>
<td>Yes</td>
<td>81.3</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>3.1</td>
</tr>
<tr>
<td>15. How old is the oldest carpet or rug in the room that you use most at</td>
<td></td>
</tr>
<tr>
<td>home curing the day?</td>
<td></td>
</tr>
<tr>
<td>Less than two years old</td>
<td>3.2</td>
</tr>
<tr>
<td>2 to 5 years old</td>
<td>9.7</td>
</tr>
<tr>
<td>6 to 10 years old</td>
<td>6.5</td>
</tr>
<tr>
<td>More than 10 years old</td>
<td>64.5</td>
</tr>
<tr>
<td>Don’t have a carpet or rug</td>
<td>16.1</td>
</tr>
<tr>
<td>16. How old is the oldest carpet or rug in your bedroom?</td>
<td></td>
</tr>
<tr>
<td>2 to 5 years old</td>
<td>9.7</td>
</tr>
<tr>
<td>6 to 10 years old</td>
<td>9.7</td>
</tr>
<tr>
<td>More than 10 years old</td>
<td>67.7</td>
</tr>
<tr>
<td>Don’t have a carpet or rug</td>
<td>12.9</td>
</tr>
<tr>
<td>17. How often do you vacuum your home?</td>
<td></td>
</tr>
<tr>
<td>Four times or more/month</td>
<td>88.5</td>
</tr>
<tr>
<td>One to three times per month</td>
<td>7.7</td>
</tr>
<tr>
<td>Less than once per month</td>
<td>3.8</td>
</tr>
</tbody>
</table>
Sixty-eight percent of the home occupants reported having visible mould growth at one time while 30% of them reported having visible mould growth within in the last 12 months. From my inspection, 26 rooms (31%) had visible mould growth. Eighty-one percent reported that they considered their homes to have poor ventilation. In kitchens, 81% reported that there was a working kitchen fan above the stove but only 50% of the fans ventilated to the outdoors. In bathrooms, 59% reported that their fan did not work. Seventy-five percent reported that condensation was an issue during the heating season.

In my research, 68% of interviewees reported having carpets greater than 10 years old and 88% reported vacuuming four or more times per month. Only 12% reported that dust was a constant issue in the home.

The Heiltsuk people suggested that the major problems contributing to poor indoor air quality included: poor ventilation, old carpets, substandard building codes and inspections. It was also reported that the southeast prevailing winds rapidly weather the outside of their homes, causing water damage to the roof and inside wall cavities. Forty percent of interviewees reported having water damage in the past and 33% reported water damage in the past 12 months.

### 3.4 Discussion

Results demonstrate that dust mite allergens in the bedrooms, and the levels of mould concentration in the homes, especially when amplified, indicate a health risk. A significant determinant of exposure to mould was carpet age, which was identified both by analysis of samples and by communications with the Heiltsuk. An association was also found between levels of mould concentrations and reported respiratory treatment.
(OR 8.2; CI 1.977 – 34.431; \( P = 0.04 \)) but not with levels of dust mite concentrations as expected. It should be kept in mind that there are other identified risk factors that could result in respiratory conditions including: genetic predisposition, prenatal factors, infections, tobacco smoke, diet, obesity and environmental air pollution (Surdu, 2006). Other health risk factors in indoor home environments include: biological infectious agents such as bacteria and viruses, and antigens from house dust mites, rodents, cockroaches, pollen, and animal dander (Wu et al., 2007). These exposures should also be considered when exploring root causes of compromised health.

3.4.1 Airborne Mould Exposure

Environmental factors play a major role in the incidence of moulds. A major review indicated a strong association between dampness levels in the dwellings and health effects (e.g., for cough, wheeze and asthma) on the occupants (Park et al., 2008; Menzies et al., 2006). Indoor dampness issues occur when moisture is not properly ventilated, or when the housing structure is not well insulated (e.g., windows). However, moisture issues can also occur because of natural environmental conditions. The village of Waglisla (Bella Bella) is noted for its dampness due to the abundant rainfall and mild temperatures.

There are no official standards for indoor airborne mould concentrations, but levels above the range of 150 – 1000 CFU/m\(^3\) are sufficient to cause health problems (Etzel, 2003; Flannigan et al., 2002; Mukherjee and Moudgil, 2006). For mould, conditions for naturally ventilated rooms should reflect concentrations and compositions for outdoor mould flora (Bartlett et al., 2004). In my study, Cladosporium was the most prevalent mould measured and reflected outdoor levels on average (Table 3.2; Figure 3.2). Leaves are the preferred habitat of Cladosporium. Exposure to Cladosporium has been associated with asthma and hay fever (Rhodes, 2008). Penicillium constituted a significant percentage of indoor air samples and was not similarly present in concurrent outdoor samples (\( P < 0.05 \)). This is evidence of a fungal amplifier as discussed by Health Canada (1995a). My study also showed that A. fumigatus is of concern. There were two homes that had significant A. fumigatus growth where water damage was the cause.
Moisture and ventilation problems in reserve housing were both observed and reported by interviewees and the Heiltsuk community. Bathrooms had mould growth on the ceilings due to poor moisture ventilation. This is most likely attributed to improperly working fans or extraction ventilation systems, not using the fans or ventilation system, or not leaving the fans or ventilation system on long enough to extract the moisture from a shower. Other factors that may also inhibit increased ventilation include outdoor temperature, noise, comfort, energy costs, window and door conditions, or cultural and personal habits (Public Health Agency of Canada, 2007).

Forty-six percent of the participants reported having damp or wet basements. Basements are not usually places where people spend extended periods of time. However, air circulates throughout a home and it is suggested that basements may provide a source of microbial contamination to living spaces (Mahooti-Brooks et al., 2004). Results from my research showed similar fungal types present in both the basement and a room sampled upstairs, and at relatively higher concentrations. Mould incidence in the basements that were sampled could be an important source of exposure throughout the dwelling due to the effects of negative pressure. Negative pressure tends to draw moist exterior air in through cracks or openings in the foundation and may facilitate fungal growth and subsequent migration of fungal material throughout the house (Mahooti-Brooks et al., 2004). Wet soil conditions adjacent to the home may also explain the high fungal concentrations detected in basements. Fifty eight percent of the interviewees reported this condition, which was due to poor drainage and flooding, and these were significant factors compromising their housing safety and sustainability.

3.4.2 Ergosterol Content in Settled Carpet/Floor Covering Samples

The GM for ergosterol was 4.52 μg/gram (range 1.43 – 21.5 μg/gram). In other studies of settled house dust, ergosterol concentrations ranging 0.7 – 45 μg/g have been reported (Pasanen et al. 1999). Studies found a weak correlation between airborne mould concentrations and ergosterol amounts (Hippelein et al., 2004). I found no correlation between ergosterol amounts and airborne mould concentrations in my study.
3.4.3 Dust Mite Allergen Exposure

Contrary to expectations, I found no correlation between dust mite and airborne mould concentrations. However, my results did indicate that GM concentrations were higher than those found in other studies. This is may be due to the characteristic long, wet climatic conditions of coastal BC. Mites flourish in warm and damp environments where they feed on protein rich organic substances and mould (Pennanen et al., 2007). A case control study on the east coast with the St. Regis Mohawk tribe (Sardu et al., 2006) reported a Der P1 concentration range of 0.05 – 11.15 µg/g of dust (GM 0.25 µg/g) in living room samples and 0.05 – 10.52 µg/g (GM 0.38 µg/g) in bedroom samples. A study on Elsipogtog reserve (New Brunswick, Canada: Berghout et al., 2005) reported a GM of 1.94 µg/g (range 0.53 – 4.60 µg/g).

A level of ≥ 2 ug/g dust has been found to be a risk factor for sensitization and a level of ≥ 10 ug/g dust is the level associated with the exacerbation of asthmatic attacks (Platts-Mills et al., 1992; Hamilton et al., 1992; Etzel, 2003; Belanger et al., 2003; Matheson, 2005). Early exposure to ≥ 2 ug/g dust mite allergen was associated with 2-fold increased odds of sensitization to dust mite (OR 2.1; 95% CI 1.1 – 6.3) (Celedon et al., 2007). A strong association is reported between exposure to ≥ 10 µg/g house dust mite in infancy and asthma at age 11 years among children with parental history of asthma or hay fever (Celedon et al. 2007). I found that 38% of the samples were below 2 ug/g (containing either low concentrations or none of the allergens for which they were tested) and 37% were above 10 ug/g, suggesting an increased risk for sensitization.

3.4.4 Endotoxin Exposure

In my study, the GM for endotoxin in the house dust samples was 71.9 EU/mg (range 10.9 – 518.0 EU/mg). One study indicated that a GM of 16.1 EU/mg (95% CI 14.3 – 18.1) was not found to be associated with history of allergic disease, nor parental smoking (Simpson et al., 2006). A national study of endotoxin concentrations in United States housing reported a GM of 35.3 EU/mg in bedrooms and 63.9 EU/mg in family rooms (Thorne et al., 2005). Their study demonstrated that household endotoxin exposure is a significant risk factor for increased asthma prevalence. Another study in Boston reported a GM of 79.6 EU/mg (range 26.2 – 241.6) settled dust endotoxins
(Horick et al., 2006). Although endotoxin was not found to be a significant risk factor for respiratory prevalence in this study, other studies indicate its importance to occupant health outcomes.

Horick et al. (2006) questioned to what extent the amount of endotoxin present in settled house dust reflects individual exposure. Their study in Boston reported a GM of 93.1 EU/mg (range 27.7 – 1249.0) settled dust endotoxins and airborne endotoxin GM concentrations of 0.81 EU/m³ (range 0.23 – 5.87). They found a much stronger association of wheeze with airborne endotoxin than with dust samples, and it is suggested that airborne measurements may be important in identifying the true magnitude of its health effects and should be considered in indoor air quality assessments.

3.5 Conclusions and Recommendations

3.5.1 Housing Policy and Regulation Interventions

Housing safety, sustainability and affordability is a national and global issue, but it is particularly acute for Canadian First Nations communities. My study concludes that levels of moulds, dust mites and endotoxins should be reduced in Heiltsuk reserve housing because they pose a health risk. While not within the scope of my study, other housing environmental health indicators should also be considered. These include: extremes of indoor air temperatures, accidents, accessibility, affordability, food safety, hygiene and sanitation, fire safety, water supply, pests and infestations, crime and fear of crime, and noise indicators (WHO, 2004).

All relevant stakeholders need the following prerequisites for action: education through dialogue, information capacity and knowledge dissemination. Dialogue through regional forums will allow First Nations to reinforce the claims they have been voicing for a long time. Improved knowledge and understanding is needed to recognize why the status quo does not work and transformative change is necessary. Information to educate government agencies about First Nations perspectives on transformative change is available from the First Nations Housing Action Plan (Assembly of First Nations, 2005). Another important element is the availability of information and research capacity. A First Nations housing and infrastructure database is needed to provide First
Nations with the ability to determine the real scope of the housing and infrastructure situation, identify core needs and pinpoint opportunities to increase returns on investments (Assembly of First Nations, 2005).

Relevant stakeholders should include the Treasury Board, Canada Mortgage and Housing Corporation (CMHC), Indian and Northern Affairs Canada, Health Canada First Nations and Inuit Health (BC), Ministry of Health, the First Nations Leadership Council, Assembly of First Nations, First Nations housing organizations, First Nations housing and health departments, housing product manufacturers, builders, engineers, architects, maintenance staff and especially First Nations communities.

In BC, today’s political climate provides an opportunity to address governance, relationships, accountability, health promotion/disease, injury prevention, health services and performance tracking through the Tripartite Agreement on the First Nations Health Plan. In May 2008, the Government of Canada, Province, and the First Nations Leadership Council signed a Memorandum of Understanding (MOU) to include First Nation Housing, both on and off reserve, as part of the BC 10-year First Nations Health Plan agenda. Although a positive step, the MOU does not explicitly recognize complete transfer of jurisdiction and control of housing and infrastructure activities and funding. The terms *self-determination* or *self-government*, which promote community empowerment, do not appear in the MOU (2008).

The Assembly of First Nations (2005) proposes that to achieve the vision of a First Nations controlled housing and infrastructure system, three key concepts are required at the forefront: *sustainability* of funding and services, *jurisdiction* over housing and infrastructure and *coordination* of programs and services. Sustainable funding is required to fulfill the Government of Canada’s treaty, aboriginal, and fiduciary obligations in the area of housing and infrastructure (AFN, 2005). There are steps that housing occupants can take, but with affordability problems, and over-crowding due to a rapidly growing population without corresponding increases in housing allocation (AFN, 2005) there is only so much an individual or family can do. Community empowerment has been shown to be the critical factor in developing economic self-sufficiency and tackling social problems (Champagne, 2008; Wahbe *et al.*, 2007; Assembly of First Nations, 2005; Waldram *et al.*, 1995; Boldt, 1993; Tennent, 1990). Therefore aboriginal
jurisdiction over housing is an important prerequisite for action. Coordination of programs will address service gaps and streamline funding and information to maximize results (AFN, 2005). Without these improvements, the housing backlog and the future needs for adequate shelter cannot be met.

3.5.2 Community Intervention

Defining a housing safety and sustainability action plan, and addressing resource and capacity needs are both essential for community intervention. This can be achieved by using the oral tradition, a culturally appropriate and effective tool that has been demonstrated through the success of the Gathering Wisdom for a Shared Journey in Vancouver BC 2007 & 2008. These health forums to address First Nations health in BC were facilitated in a World Café where forum participants discussed public health issues in talking circles and were recorded. A province-wide forum on First Nations housing may include the following topics, but should not be limited to: education about housing safety, moisture/water contributors, housing maintenance, building codes, program infrastructure, culturally appropriate unit types, capacity to manage housing programs, financial capacity, economic capacity, local capacity to construct housing, capacity for housing inspection, access to serviceable and affordable land, programs to promote home ownership, and cultural issues as they relate to housing (The Government of BC, 2007). A forum would inform strategic approaches required for community intervention to address First Nations housing in BC using First Nations community voices.

One significant intervention measure taken by the Heiltsuk housing department was that they will no longer install wall-to-wall carpeting, which was found in my study to be a significant determinant of exposure to mould. However, area rugs are recommended for occupant comfort and dust control. Dust becomes easily airborne from hard flooring because it cannot trap dust like a carpet can. Maintaining an area rug is much easier than wall-to-wall carpeting, because one can wash it when needed and hang to dry outdoors. It can also be easily replaced at a reasonable cost. The scientific context provided in my study compliments what the Heiltsuk knew before the time of sampling. Evidence from both can be used to influence policy.

Education is important for aboriginal self-actualization, which is a prerequisite for self-determination, and subsequently self-government (Marie Anderson, 2007, pers.
com.). With the support of the Heiltsuk Tribal Council, Brenda Brown, the Heiltsuk Housing Department manager, made an important decision and commitment to educational and intervention measures. She invited home inspectors from the Native Inspection Services Initiative (NISI; administered by the Canada Mortgage and Housing Corporation (CMHC) initiative for a full week of indoor air quality workshops. These workshops were designed for the general public, construction workers, and band council. These four NISI inspectors were from the territories of the Nisga’a, Haisla, Wetsuwetan and Nlaka’pmux. They travel to First Nation communities in BC, networking and sharing their knowledge, solutions and strategies for addressing the housing crisis in their own communities. By building upon this coastal network, communities pursue opportunities for empowerment and equity in health improvements.

3.5.3 Individual Interventions

Recommendations to achieve healthy home environments will also require individual action where relevant and possible. Water and/or moisture damage and ambient relative humidity are important contributors to mould growth, thus, the source of water and moisture must be identified and eliminated. In March 2007, the Minister of Health, pursuant to subsection 55(3) of the Canadian Environmental Protection Act (1999) issued new guidelines regarding the presence of mould in residential indoor air, regardless of the species. In cases where mould odors and growth occur, the new guidelines recommend:

1. To control humidity and diligently repair any water damage in residences to prevent mould growth;

2. To clean thoroughly any visible or concealed mould growing in residential buildings; and

3. To remove mould contaminated materials.

Humidity levels on the northwest coast of BC average 93.6% in September (Environment Canada, 2008). There are also activities that take place in the home that
can contribute to indoor moisture production, and those were discussed in Chapter 1 (See Table 1.1).

Given the natural climatic conditions in Bella Bella, controlling humidity can be challenging, however, home occupants should be aware of all sources of moisture and moderate their activities if and when possible (e.g., keep bathroom vent on after a shower until the air feels dry; take shorter, cooler showers; cover pots of boiling water). Properly functioning ventilation in the bathroom and the kitchen is essential. Home occupants can check the suction strength of bathroom or stove vent by holding a piece of toilet paper or paper towel in front of an operating air intake (Holmes, 2006). If the paper does not cling to the vent, the vent is not functioning properly and can be fixed by either the home occupant, or, for more complicated mechanical problems, the housing maintenance crew. The housing occupant or the maintenance crew can also check for proper ventilation flow to the outdoors by placing a plastic bag over the vent outtakes. If the bag does not fill with air, air is not being ventilated to the outdoors. Dehumidifiers are helpful, but not viewed by some community members as economically viable due to already high energy costs. Heating can account for more than half of an occupant’s home energy bill, and up to one third of the heat from one’s home can escape through windows (BC Hydro, 2008). Housing in Bella Bella is generally viewed by the community as energy inefficient and costly. Window technology in Heiltsuk housing requires energy-efficient replacements to address mould and structural integrity, and decrease the burden of high energy costs.

Another action that individuals could take is to learn about healthy housing. The CMHC provides free publications about mould in housing, specifically targeting technical service providers, First Nations housing departments, band managers, health providers, trades people and home occupants. These include:

- A First Nations Occupants' Guide to Mold (CMHC et al.)

- Moisture and Air: Householder's Guide to Problems and Remedies (CMHC)

In cases where it is the responsibility of the community housing and health departments, an Environmental Health Officer or CMHC representative should use a
standardized, comprehensive reporting form that can be entered into a national
database. This will provide First Nations with the ability to determine the true scope of
the housing and infrastructure situation, and identify core needs (AFN, 2005). Because
reliable and accessible information was not available at the time of my study, Health
Canada, Indian and Northern Affairs Canada and CMHC have failed in their
performance tracking measures. Their information would provide vital data and
analytical capacity.

Important barriers to an individual's motivation are socioeconomic challenges
and knowledge about intervention measures (Wu et al., 2007). Income and affordability
problems impede the ability of a home occupant to make health-related investments
(Wu et al., 2007; AFN, 2005). Individuals must view their long-term health as an
important investment when making decisions to maintain a home. However, they are
often not home owners so there is little incentive to do the repairs themselves (Wu et
al., 2007; AFN, 2005).

Not addressing inadequate housing has profound effects on the social, economic
and individual health outcomes. Exposure to mould, endotoxins and dust mites causes
many health maladies affecting an individual's ability to live a full rich life. My
recommendation can be used to reinforce the claims that people in reserve have long
been voicing. We live in a political climate where we have the opportunity to make this
voice louder and call for attention.
3.6 References


Canada Mortgage and Housing Corporation 2004. Moisture and Air: householder’s guide. [Brochure].


Environment Microbiology Laboratory, Inc. (EMLab™). 2006. Indoor Air Quality Pocket Reference Guide. [no publisher].


CHAPTER 4 – CONCLUSIONS AND FUTURE DIRECTIONS

4.1 Conclusions

This study provides baseline data on indoor mould, dust mite and endotoxin concentrations for BC’s northwest coastal climatic conditions. It also demonstrates important relationships between housing conditions and increased levels of bioaerosols and their effects on human health. The concentration ranges of bioaerosols, which compared to available guidelines and did not meet the criteria for healthy homes, suggesting that maintenance and remediation is required. Remediation is at the forefront of the issue for this community. The Heiltsuk do not receive enough funding for mould remediation because applications dating back to 1997 have not been approved (Ralph Humchitt, Public Works Manager, 2005, pers. com.). Another important part of my study was the exploration of the social relevance and policy implications of unsafe and unsustainable housing.

My study demonstrated that dust mite allergens in the bedrooms, and the levels of mould concentration in the homes, especially when amplified, impose a human health risk. A significant determinant of exposure to mould was carpet age, which was identified both by analysis of samples and was communicated by the Heiltsuk. An association was also found between levels of mould concentrations and reported respiratory treatment, but not with levels of dust mite concentrations as was expected.

If housing safety and infrastructure sustainability for the Heiltsuk does not improve, the following will happen:

1. House conditions will further deteriorate, existing or potential water damage issues will persist and make the situation worse;
2. Health burden will persist and worsen, both physically and emotionally;
3. Financial burden will persist and worsen;
4. With a rapidly growing population, housing stock will not meet demand, forcing people out of their community and away from their families;
5. Individuals and communities will continue to be marginalized from the important issues surrounding capacity.
4.2 Recommendations

A study commissioned by the Province of BC provides pertinent information about aboriginal housing conditions, capacity assessment, housing need projections, and barriers to "closing the gap", but uses outdated census outcomes (2001) to describe the current core housing needs. The results of Statistics Canada Census (2006) regarding housing in BC were not available at the time of my study, except for the housing need in Vancouver. However, the social and health issue is well understood by First Nations people and the governments as per the Tripartite agreement (May 2006).

It is argued that First Nations self-government is key to policy and planning, and to economic self-sufficiency and improved health (Chandler and Lalonde, 1998).

First Nations are seeking a nation to nation and government to government relationship wherein First Nations have the capacity to improve their quality of life through long term, sustainable funding to fulfill the Government of Canada’s treaty, Aboriginal, and fiduciary obligations in the area of housing and infrastructure. This will allow First Nations to build a sufficient number of houses to deal with the housing backlog, and the future needs for adequate shelter for First Nations citizens living on or away from their communities.

(AFN, 2005)

The UN Development Report attests that transformative change can be achieved by restructuring socio-economic frameworks (UNDI, 2007/2008). For systemic change to be successful, funding, service programming and delivery should include First Nations input and greater coordination between First Nations, BC, and Canada (First Nations Leadership Council, 2008). We can learn from First Nations communities about their experiences in their homes and understand their perspective of why the status quo does not work. I recommend a World Café style gathering, which allows for enhanced participation by attendees. This will assist in implementing a strategy that meets the needs and capabilities of all stakeholders.

Capacity development initiatives should include training to meet health human resource targets. A recommended target for First Nations community-based Environmental Health Officers is 50 full-time employees to serve 203 communities by
2017. First Nations environmental health officers would provide the capacity required to serve occupant and housing safety through community education programs, one-on-one communications and dialogue, and educating and advocating for housing occupants. First Nations EHO’s would also provide the capacity needed for tracking and monitoring aboriginal housing on/off reserve. Native Inspection Services Initiative through the CMHC may target to train the same amount of inspectors to track and monitor construction and maintenance. Further, operations and management budgets should meet housing department needs with increased governance over housing programs. Each housing department should have a water damage monitoring tool (e.g., Protimeter Moisture Measurement System (MMS) Plus, General Electric; Manufacture item #BLD 5800LH) to identify water damage ($350 – $800/unit; $71,050 - $162,400).

Other recommendations include exceeding current building code standards and designing homes that meet occupant needs. Current housing design and construction materials are reported by the Heiltsuk community to not be suitable for coastal temperate climate. The community has talked about traditional materials such as cedar and the use of new designs including rain screen technology.

For higher-level planning, I have proposed a sample work plan, which requires further development by all relevant stakeholders (Figure 4.1). The work plan addresses long-term goals, outcomes, activities, and outputs that can be achieved in the process of improving housing safety and sustainability.
Figure 4.1 BC housing safety and sustainability proposed work plan.

Housing Health, Safety and Sustainability

**Long-Term Goals**

- Increased positive ties between all stakeholders based on recognition, respect, responsibility, reciprocity, relevance, and reconciliation
- Health Services will be more culturally sensitive, prevention-based and more often delivered by practicing First Nations Environmental Health Officers
- Enhanced wellness of First Nations individuals, families and communities through prevention and promotion

**Outcomes**

- Tripartite First Nations Health Plan Memorandum of Understanding (May 2008)
- Aboriginal Housing safety and sustainability Commission
- Enhanced short, intermediate and long-term Tripartite Strategy

**Activities**

- Tripartite dialogue, networking and collaboration between all relevant stakeholders
- Distribution and use of research and resource materials
- Participation in education and training
- Inspections and reporting of water damage, environmental and structural integrity of First Nations Homes both on and off reserve

**Outputs**

- Quarterly Reports in Health Promotion and Prevention
- BC First Nations Housing Forum and Forum Report
- Center of Excellence participation and enhancement of CMHC's Native Inspections Services Initiative
- Participation in education and training
- Inspections and reporting of water damage, environmental and structural integrity of First Nations Homes both on and off reserve
- Enhanced short, intermediate and long-term Tripartite Strategy
4.2.1 Limitations of the Study

A limitation of this study includes the participant selection method, which was neither random nor stratified (e.g. location or home age). Further, the sample included only 10% of the village homes. However, there was a representative geographic spread across the village (e.g. homes adjacent to the ocean, and adjacent to the forest boundary) and a range of exposure levels.

The limitations of sampling methodologies I used in my study include the implications of using impactor samplers and one-time grab sampling. Sampling by impaction can cause desiccation, bounce and re-aerosolization, or even death of mould spores (Gorny, 2004). This can cause inaccuracies and errors of measured airborne mould spore concentrations unless long-term weighted average measurements are taken. In my study, a one-time grab sample was taken and was not duplicated to determine variability. The variability may be due to factors that complicate exposure assessment, which are related to environmental conditions at the time of sampling. These include low humidity conditions that stimulate spore release, degree of physical disturbance during sampling, changes in wind and airflow patterns, and changes in ventilation (Neilson, 2003). However, these data contribute to baseline data and are useful as a background check for mould exposure. My study should also aid in the management of allergic disease by enabling the Heiltsuk community to communicate their concerns for mould in reserve housing.

Compared with air sampling, ergosterol quantification is less laborious and costly (Pasanen et al., 1999). Culture techniques provide information about viable spores and mycelial fragments, whereas ergosterol sampling detects viable, non-viable, and non-cultivable fungi (Hippelein et al. 2004). However, fungal species information is not yielded, which is necessary for risk assessment (Hippelein et al., 2004). Further, ergosterol content in house dust is not constant because it is dependent on various factors including culture age, growth rate, carbon and nutrient availability, temperature and oxygen (Gors et al. 2007). Much research is needed to determine the reliability of ergosterol content in house dust (Pasanen et al., 1999).

There are several limitations related to dust mite exposure analysis in my study. *Dermatophagoides farinae* (Der f1) is a relevant mite allergen in residential homes but
its concentration in the collected samples was not determined. *D. farinae* and *D. pteronyssinus* co-inhabit homes, and one usually predominates over the other (Arlain, 1999). Another limitation was that other relevant substrates such as mattresses and upholstered furniture, which are also important sources of exposure (especially mattresses since the distance between the settled dust and the breathing zone is much less), were not included in the assessment.

Research suggests that it is reasonable to assume that airborne endotoxin is a more direct and relevant measure of exposure than dust endotoxin (Horick et al., 2006). Breathing zone air samples would be more precise measures of inhaled endotoxin (Horick et al., 2006). Airborne measurements may be important in identifying the true magnitude of effects of microbial stimuli to the innate immune system and should be considered in future studies (Horick et al., 2006).

Other limitations of my study included the expense of traveling to the community, the sampling window (e.g., one year versus multi-year sampling), and seasonal variation. Bella Bella is a remote community requiring costly flights. By living in the community, the research may have been completed in a more timely and appropriate manner, and would also have reduced travel costs. The seasonal variation is also an important factor to consider. During the fall season, mould concentrations are more likely to be higher because leaves are decomposing and moisture in the air is greater than during other seasons. However, it should be noted that the west coast of BC receives continuous rainfall throughout all seasons.

Another important limitation of my study is that it does not contribute a financial analysis of renovations required for immediate remediation. I suggest that future research include such an analysis so that the community may submit a cost estimate to Indian and Northern Affairs Canada.

### 4.3 Health Research with Aboriginal People

Human health researchers have a heightened responsibility to ensure that the outcomes of their studies will benefit communities in advancing public health and policy. Community empowerment has been shown to be the critical factor in developing economic self-sufficiency and tackling social problems (Champagne, 2008; Wahbe et
al., 2007; AFN, 2005; Waldram et al., 1995; Boldt, 1993; Tennent, 1990), therefore community participation and capacity enabling is an important prerequisite for action. Collaboration is fundamental to aboriginal health research.

By engaging the community as participants, challenges such as access to people and resources can be avoided (Fletcher, 2003). However, building relationships and engaging community participation takes time, and time is of essence in any agency-funded research. However, the Heiltsuk demonstrated their commitment to collaboration to address indoor air quality issues. With increased knowledge about the health effects of poor indoor air quality for both myself and the Heiltsuk community, there is increased political and individual motivation to address the issues. Therefore, I faced no challenges, only benefits by working with the Heiltsuk. The most important benefit in working with the Heiltsuk people was the “lived” experience. The researcher learns about a culture and people, and the people will feel culturally safe within the community-based framework. Rose Sones (Tlingit) speaks about the difference between cultural competency and cultural safety.

We used to talk about tolerance, about anti-racism, about cultural competence. Today, the Assembly of First Nations uses Cultural Safety, which is a deliberate phrase. Cultural safety is not simply the “rules of engagement”. It’s not simply a tolerance of difference. A general First Nations tradition when having a meeting is to invite an elder. It is protocol in some cultures to give tobacco to the elder as a way of showing thanks. It isn’t about the “rule of giving tobacco,” it is the reflection on the cultural teaching of respect for elders who carry the history of the people. It’s about symbolism and meaning and respect for our teachings. It’s a lived experience. While there is a knowledge component to cultural safety, it is also a personal value and an organizational value. Cultural safety is a way of consciously drawing out a space for personal reflection and a willingness to learn. It’s an issue of the heart. This is why we use the phrase cultural safety, rather than cultural competency. Cultural safety is a deliberate way to rebalance the relationship.

(Rose Sones, Assistant Director, Health, Assembly of First Nations, Ottawa, November, 2007, pers. com.)

When I think of cultural safety, I think of the values taught by Kirkness and Barnhardt (1991); Respect, Reciprocity, Reverence and Responsibility, and I think of other R’s including recognition and reconciliation. It is not clearly black and white, but it seems that cultural competency applies more to something that is measurable,
quantitative, qualitative, credentials, authority, whereas cultural safety is more personal, willingness to learn, a shift in power, self-defined rather than defined by certification.

4.4 Future Directions

The political and historical context of health, healing and wellness within aboriginal communities is reflected in hard statistics, showing large disparities in health and socioeconomic status between aboriginals and other British Columbians (Statistics Canada, 2006). It has been 12 years since the Royal Commission on Aboriginal Peoples (RCAP) and there have been no significant measurable quality of life improvements (VCH, 2008; PHO, 2007; AFN, 2005).

My study focused on one community story and also focused on a relatively small sample of potential indoor environmental hazards. Important leading pathogenic fungi for persons with non-impaired immune function, Blastomyces, Cryptococcus, and Histoplasma, may find their way indoors with outdoor air but normally do not grow or propagate indoors (Hardin et al., 2003), but should not be over looked. Other hazards such as volatile organic compounds (VOC's) are emitted from materials over time and are considered to be a significant health concern (Claeson et al., 2007).

There needs to be a continuous flow of information and dialogue that will promote understanding by everyone involved. “If people are not educated, if a people are not well informed, they will get sick, because they don’t know how to fight the most common diseases” (Guevara, 2007).

Respiratory illness is the third leading cause of morbidity and mortality for First Nations in BC. Access to clean air is an absolute necessity for healthy lungs. As found in my study, mould and other indoor airborne contaminants contribute to many of the reported respiratory illnesses. The long-term effects of not addressing the issue will have a far greater impact on a health system that already struggles to meet population health needs. Furthermore, maintaining the status quo does not meet the level of support required (AFN, 2005). Current funding and infrastructure of the health system are considered inadequate to address population health needs (First Nations Leadership Council, 2008). Safe housing will decrease the pressure. Not addressing the
housing issue on reserve also places a financial burden on other community social programs (e.g., budgets for education or public works compete for housing needs).

If housing health and sustainability on and off reserve housing is not addressed, the gap in health between aboriginal people and non-aboriginal people will be difficult to close. Adequate housing is considered a fundamental human right, and is a key link to education, health, economic opportunities and employment outcomes (AFN, 2005; Loftness, 2007). Moreover, poor housing and infrastructure translate to a poor start in life leading to increased difficulties and the need for increased interventions in the long term (AFN, 2005; Public Health Agency of Canada, 2007). Children living in substandard housing will not have a fair chance to realize their potential and play a meaningful role in their community (AFN, 2005).
4.5 References


APPENDICES

Appendix I  Heiltsuk Traditional Territory Map
Appendix II  Consent Form
Appendix III  Respiratory Questionnaire
Appendix IV  Indoor Mould Survey
Appendix V   Letter of Initial Contact – April 2004
Appendix VI  Advertisement for Community Research Assistant Opportunity
Appendix VII  Behavioural Research Ethics Board Certificate of Approval
Appendix I  Heiltsuk Traditional Territory Map

Figure 5.1 Heiltsuk Traditional Territory
Appendix II  Consent Form

Purpose:
Members of our research team are inviting those interested in participating in the study of “Effects of Indoor Mould Exposure on the Health of Aboriginal People in British Columbia.” The research method includes indoor mould and house dust collection with a determination of their sources. These samples will be analyzed at our laboratory facility at the University of British Columbia. We will also document further information through an interview process. Our central goal of the research program is to identify methods of control for indoor moulds and develop preventative measures to improve the health of Aboriginal people and all Canadians. The specific objectives are:
1. Sampling household biological contaminants (e.g. bacteria endotoxins, fungi and their spores, mites and their feces) and determining their source.
2. Document potential health risk in homes with indoor mould exposure and the traditional practices that may prevent mould growth.
   Evaluate methods for the control of mould.
3. Produce and distribute educational material to minimize health effects of mould exposure and increase health promotion.

In the past, Aboriginal people may have used some traditional practices, construction materials, and housing structural designs to minimize mould exposure. However, such knowledge has never been explored or documented. This is a first attempt to document such information.

You have been asked you to participate because mould exposure has been identified in your home. Your participation and cooperation will help to support the research goals and objectives stated above. We will be happy to answer any further questions you may have about the research project.

Research Method

Sampling
If you agree to participate in this study, we will visit every 6 months for 1 year. We will conduct walk-through inspection of your home to identify the presence and degree of mould/mildew, measure indoor humidity, and collect mould and dust samples. The amount of time we will be spending in your home will be approximately half an hour.

Interview
If you agree to participate in this study, a detailed questionnaire will reflect your communication style and will include such questions needed to give significance to future laboratory-based findings. The questionnaire will request specific information on: age, education, history of allergies and other respiratory disease, personal smoking or exposure to tobacco, records of visits to a doctor, parental asthma, number of residents per unit, number of children, pets, dampness in the home, moisture damage in your home, and incidence of excessive mould growth. The interviews will be conducted in your home every six months for one year. The
interview will take between 30 and 60 minutes, though the whole process may take a bit longer.

You have your choice of how your interview is recorded. You may choose any or all of the following:

1. You agree that we may make notes from your interview from memory after the interview is finished and use the notes as part of the research.
2. You agree that we may take notes during your interview and use the notes as part of the research.
3. You agree that we may record your interview on audiotape and use the audiotape as part of the research.
4. You agree that we may record your interview in videotape and use the videotape as part of the research.

You are free to stop the interview at any point, and you may request that your interview not be used in this study. We will provide you with a copy of the record of your interview if you would like one. If there are parts of the interview record you would like removed from our records, we will remove them. You can remove the whole interview if you wish.

If you agree to participate in the research study, we will use this information to establish a database that links traditional community knowledge with other knowledge in this field including chemical or clinical studies. Analysis of the primary data may result in potential application towards further research questions and other projects between your community and UBC IAH. The investigators, co-investigators, and your community will have access to the data and results.

If you agree to participate in the research study, we will recommend that you will agree (in writing) to preserve the privacy and information throughout the course of the investigation and distribution of the results.

Potential Risks:
The information shared in the interviews may be of confidential matter (i.e. culturally sensitive) and the participant may wish to restrict the information. Another potential risk is monetary value derived from this study (i.e. preparation or product with economic potential). In both cases, appropriate legal, scientific and research ethics and protocol agreements will be established through community consultation.

Confidentiality:
You have the choice to remain anonymous in this project if you wish to. If you wish to remain anonymous, we will not use your name, and you will be given a code number. This consent form, with your real name on it, will be kept in a locked file cabinet by the principle investigator.

You wish to remain anonymous (not have your real name used).
You do not wish to remain anonymous. Your real name may be used in this research project.

Records:
You have the right to determine what happens to the records of your interview. You may direct us to destroy the records of your interview at any time. All records of
your interview held by the principle investigator will be destroyed after five years. The retention of primary data for this length of time is required by UBC policy.

Remuneration/Compensation:
Though we much appreciate your involvement and time, there is no remuneration or compensation (payment) for participation in this project.

Contact Information:
If you have any questions about this project, would like further information, or to provide feedback, you may contact Dr. Eduardo M. Jovel, Director for the Institute for Aboriginal Health, University of British Columbia, 403-2194 Health Sciences Mall, Woodward Instructional Resources Center, Vancouver BC V6T 1Z3.

Contact for Information about the Rights of Research Subjects:
If you have any concerns about your treatment or rights as a research subject, you may contact the Research Subject Information Line in the UBC Office of Research Services.

Consent:
By signing below, you indicate that you understand that your participation in this study is entirely voluntary and that you may refuse to participate or withdraw from the project at any time. You do not surrender any of your rights by signing this form. Your signature below indicates that you have received a copy of this consent form for your own records.

Your signature indicates that you are at least 19 years old and consent to participate in this project.

_________________________________________  _________________________________
Subject: Signature                          date

_________________________________________
Printed Name of the person signing above

By signing this form, I agree to abide by your wishes as indicated above.

_________________________________________  _________________________________
Dr. Eduardo M. Jovel                          date
Appendix III  Respiratory Questionnaire

Home Respiratory Questionnaire
(Generously provided by Nak'azdli Whuten First Nation)

Date: Day: _______ Month: _______ Year: _______
To be completed by surveyor:

Interview Type?
At a public building or office, face to face .....................1
At home, face to face .............................................2
By telephone .........................................................3
Self Completed at Home ..........................................4

Community: _________________________________________

Band/Tribal Affiliation: __________________________ Reserve Number: _______

Field Interviewer Name: ___________________________________

Demographics
Person Interviewed: ________________________ Male  Female
Address: ___________________________________________

Telephone: _________________________________________
Date of Birth: Day: _______ Month: _______ Year: ______

Is this survey being completed for a child or baby?
Yes ............... 1
No ...............2

(If “No” go to question 5, if “Yes” please provide the following)
Name of Child: ________________________ Male  Female
Date of Child’s Birth Day: _______ Month: _______ Year: ______
How long have you lived at current address (# years): ________________________
What was your previous address:

Number of Years: ___________________________________
How many people live in your house?: ________________________
How many bedrooms are in your house?: ________________________
Health Status, Family History and Tobacco Smoke Exposure

1. Have you ever been told by a doctor that you have a respiratory condition?
   Yes .................. 1
   No .................. 2

1.1. What type of respiratory condition?
   Asthma .................. 1
   Bronchitis .................. 2
   Bronchiolitis .................. 3
   Emphysema .................. 4
   Allergies .................. 5
   TB .................. 6
   Pertussis .................. 7
   RSV .................. 8
   Don’t Know .................. 9
   Other

1.2. Have you ever been treated by a doctor for your respiratory condition in the last 12 months?
   Yes .................. 1
   No .................. 2
   If ‘No’ go to question 2, if ‘Yes’

1.3. Have you visited a hospital emergency room? Yes .... 1  No .... 2

1.4. Been admitted to a hospital? Yes .... 1  No .... 2

1.5. Visited a doctor’s office? Yes .... 1  No .... 2

2. How many times in the year do you get the common cold?
   Once every 2 month or more often................................. 1
   Once every 3 or 4 months ........................................ 2
   Once every 5 or 6 months ........................................ 3
   Once per year ......................................................... 4
   Rarely have a cold .................................................... 5

3. Did either of your parents have a respiratory health problem?
   Yes .................. 1
   No .................. 2
   Don’t Know ...... 9

4. Did your mother smoke tobacco when she was pregnant with you?
   Yes .................. 1
   No .................. 2
   Don’t Know ...... 9

5. Were you hospitalized before the age of two years for a respiratory illness?
   5.1. Yes .................. 1
   5.2. No .................. 2
   5.3. Don’t Know ...... 9

6. Were you exposed to second hand tobacco smoke in your home before you were five years old?
   Yes .................. 1
   No .................. 2
   Don’t Know ...... 9
7. Were you regularly exposed to wood smoke in any home, cabin, smokehouse before you were five years old?
   Yes ............ 1
   No ............. 2
   Don't Know ...... 9

8. Do you have any food allergies?
   Yes ............ 1
   No ............. 2
   Don't Know ...... 9
   (If 'No' or 'Don't Know' go to question 15, if 'Yes'
   8.1. What food(s) are you allergic to?

9. Have you ever had a respiratory illness or trouble caused by using a particular medication or drug?
   Yes ............ 1
   No ............. 2
   Don't Know ...... 9
   (If 'No' or 'Don't Know' go to question 16, if 'Yes'
   9.1. What type of medication/drug was this? (list up to three types)
   1. ______________________________________________________
   2. ______________________________________________________
   3. ______________________________________________________

10. Have you ever smoked tobacco for as long as a year? (‘Yes’ means at least 20 packs of cigarettes or 360 grams of tobacco in a lifetime, or at least one cigarette per day or one cigar a week for one year)
   Yes ............ 1
   No ............. 2
   If 'No' go to question 17, if 'Yes'
   10.1. How old were you when you started smoking? ____________ years
   10.2. Do you now smoke?
   Yes ............ 1
   No ............. 2
   If 'No' go to question 17, if 'Yes'
   10.3. Number of cigarettes per day?

   10.4. Do you now smoke inside your house?
   Yes ............ 1
   No ............. 2

11. How many hours per day (presently) are you exposed to other people’s tobacco smoke? ____________ hours

12. How many hours per day (on average) were you exposed to second hand tobacco smoke in past years?
    ____________ hours      over how many years? ________________________________

Home Environment

1. Do you use an unvented kerosene or gas heater or gas fireplace?
(Note: this is usually a portable heater that does not have a vent or exhaust to the outdoors)

1. Do you use a wood stove inside your house?
   - Yes ............... 1
   - No ............... 2
   - Don't Know ...... 9

2. Do you use a wood stove inside your house?
   - Yes ............... 1
   - No ............... 2
   - (If 'No' go to question 4, if 'Yes'
     On average, during heating season, how often does wood smoke get into the house?
     - 4 to 5 times per day or more ............................................. 1
     - 2 or 3 times per day ...................................................... 2
     - Once per day .............................................................. 3
     - 2 or 3 times per week .................................................. 4
     - Rarely ................................................................. 5
     - Never ...................................................................... 6

3. What kind of stove do you mostly use for cooking?
   - Natural Gas ................................................................. 1
   - Electric ............................................................... 2
   - Propane Gas ......................................................... 3
   - Woodstove .......................................................... 4
   - Microwave ......................................................... 5
   - Other ...................................................................... 6

4. Do you have a working exhaust fan over the cooking stove?
   - Yes ............... 1
   - No ............... 2
   - Don't have a fan ...... 9
   - (If 'No' or 'Don't have a fan' go to question 6, if 'Yes')

     When cooking, do you use the exhaust fan
     - All of the time ............... 1
     - Some of the time .......... 2
     - None of the time ........ 3

     Does the exhaust fan take cooking fumes outside?
     - Yes ............... 1
     - No ............... 2
     - Don't Know ...... 9

5. Is there a working exhaust fan in the bathroom?
   - Yes ............... 1
   - No ............... 2
   - Don't have a fan ...... 9
   - (If 'No' or 'Don't have a fan' go to question 7, if 'Yes')
Does the exhaust fan take bathroom moisture outside?
Yes ............... 1
No .................2
Don’t Know ......9

6. Does your cloth dryer vent outdoors?
Yes ............... 1
No .................2
Don’t Know ......9

7. Do windows in your home fog up (have condensation) during the heating season?
Yes ............... 1
No .................2
Don’t Know ......9

8. Do you have a basement in your home?
Yes ............... 1
No .................2
(If ‘No’ go to question 10, if ‘Yes’)
Is your bedroom located in the basement?
Yes ............... 1
No .................2
Is any part of the basement floor damp or wet?
Yes ............... 1
No .................2

9. Do you have a crawl space under your house?
Yes ............... 1
No .................2
Don’t Know ......9
(If ‘No’ or ‘Don’t Know’ go to question 11, if ‘Yes’)
Is soil exposed in the crawl space (no concrete/vapour barrier?)
Yes ............... 1
No .................2
Don’t Know ......9
Is the crawl space ventilated
Yes ............... 1
No .................2
Don’t Know ......9

10. Is the land around your house wet or swampy during any time of the year?
Yes ............... 1
No .................2
Don’t Know ......9
11. Has there ever been water damage to your house or its contents? (For example from floods, leaks, broken pipes)
   Yes ................ 1
   No ................ 2
   Don't Know ....... 9
   (If ‘No’ or ‘Don’t Know’ go to question 13, if ‘Yes’)

   Has there been any water damage within the last 12 months?
   Yes ................ 1
   No ................ 2
   Don’t Know ....... 9

12. Within the last 12 months have you had wet or damp spots on wall or ceiling surfaces inside your home?
   Yes ................ 1
   No ................ 2

13. Has there ever been mould or mildew on any surface, other than food, inside the home?
   Yes ................ 1
   No ................ 2
   Don't Know ....... 9

   If ‘No’ or ‘Don’t Know’ go to question 15

   If ‘Yes’ which rooms/areas have been affected?

   Bathroom(s)     Yes......1   No ......2
   Bedroom(s)      Yes......1   No ......2
   Living Room(s)  Yes......1   No ......2
   Kitchen         Yes......1   No ......2
   Basement        Yes......1   No ......2
   Attic           Yes......1   No ......2
   Crawl Space     Yes......1   No ......2

14. Has there been mould, mildew or any fungal growth (including mushroom growth) on any surfaces inside the home, other than food, in the last 12 months?
   Yes ................ 1
   No ................ 2
   Don’t Know ....... 9

   (If ‘No’ or ‘Don’t Know’ go to question 16, if ‘Yes’)

   Is the total area of mould greater than 10 square feet?
   Yes ................ 1
   No ................ 2
   Don’t Know ....... 9
   (Note: remind participant not to use bleach on mouldy areas)

15. Does your house ever smell mouldy? (or has someone mentioned that your house smells mouldy?)
Yes ............ 1
No ............ 2
Don't Know ...... 9

16. Do you use a portable humidifier in your home?
   Yes ............ 1
   No ............ 2
   (If 'No' go to question 18, if 'Yes' how often is it used?)
      Constantly ................................................. 1
      Frequently ............................................... 2
      Seldom ..................................................... 3
      Only when someone has a cold or the flu .............. 4

17. Do you consider your home to have poor ventilation?
   Yes ............ 1
   No ............ 2
   Don't Know ...... 9

Dust and Air Pollution in the Home

1. How old is the oldest carpet or rug in the room which you use most at home during the day?
   Less than two years old ......................... 1
   2 to 5 years old ........................................ 2
   6 to 10 years old ..................................... 3
   More than 10 years old .............................. 4
   Don't have a carpet or rug ....................... 5

2. How old is the oldest carpet or rug in your bedroom?
   Less than two years old ......................... 1
   2 to 5 years old ........................................ 2
   6 to 10 years old ..................................... 3
   More than 10 years old .............................. 4
   Don't have a carpet or rug ....................... 5

3. How old is your mattress or foam sleeping pad? (can estimate if unsure)
   Less than two years old ......................... 1
   2 to 5 years old ........................................ 2
   6 to 10 years old ..................................... 3
   More than 10 years old .............................. 4
   Don't have a carpet or rug ....................... 5

4. Do you use a feather or goose down pillow or duvet on your bed?
   Yes ............ 1
   No ............ 2
   Don't Know ...... 9

5. How often do you vacuum your home?
   Four times or more per month ................ 1
   One to three times per month .................. 2
   Less than once per month ....................... 3

6. Does your vacuum have a HEPA (high efficiency particulate air) filter?
   (Note: can check vacuum for HEPA marking)
   Yes ............ 1
7. How much are you annoyed by outdoor air pollution (from traffic, forest industry etc.) if you keep the windows open (please circle one number only)

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- Doesn't annoy at all
- Intolerable annoyance

8. How often does road dust get in your home if you keep the windows open? (During months when the roads are free from snow and ice)

- Constantly
- Frequently
- Seldom
- Never

9. Do you have a furry or feathered pet (cat, dog or bird etc.) that is allowed to stay in the house?

- Yes
- No

(If 'No' go to question 10, if 'Yes')

Is your furry or feathered pets allowed in the bedroom?

- Yes
- No

10. Have bats ever been in the attic of your house?

- Yes
- No

11. When you were near trees, grass or flowers, or when there is a lot of pollen about, do you ever have adverse respiratory symptoms? (sneezing, coughing, congestion etc.)

- Yes
- No

Don't Know

Thank-you for participating in this survey
Appendix IV  Indoor Mould Survey

Today's Date: Day: _______ Month: _______ Year: _______

Sampling Time: ______________________________________

Surveyed by: ________________________________________

Demographics

Community: __________________________________________

Band/Tribal Affiliation: __________________ Reserve Number: _______

Family Name: _______________________________________

Home Address: _______________________________________

Number of Rooms Sampled: _____________________________

Reference: This survey was modified from the original document composed by Victoria Arrandale, School of Occupational and Environmental Hygiene. The ‘Home Respiratory Questionnaire’ from the Nak’azdle First Nation community was also used.

<table>
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<tr>
<th>Location</th>
<th>Wall (N,E,S,W) Under window/Base</th>
<th>Relative</th>
<th>Temperature</th>
<th>Moisture</th>
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1. Are there any open windows? ______________________________________
2. Does the space feel well ventilated? ________________________________
3. Is there a musty odour? _________________________________________
4. Floor Material: _________________________________________________
5. Is the floor damp? ______________________________________________
6. Is there visible mould? _________________________________________
7. Describe and give approximate area of any visible mould. Tape sample if possible. ________________________________________________

8. Is there any negative or positive pressure? __________________________
9. Are there any visible water marks on the walls or ceilings? ___________
10. Do the occupants have any mould concerns? __________________________
11. Further comments:

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Re: Effects of Indoor Mould Exposure on the Health Effects of Aboriginal People in British Columbia

Dear Chief Ross Wilson:

I would like to take this opportunity to introduce our UBC research team of four faculty and one student. My name is Patricia Osterberg, Master of Science Student in the Faculty of Agricultural Sciences. I am from the Sto:lo Nation. I am participating as a co-investigator with Dr. Eduardo Jovel's research project entitled "Effects of Indoor Mould Exposure on the Health Effects of Aboriginal People in British Columbia."

Dr. Jovel is the Director for the Institute for Aboriginal Health at UBC and also Assistant Professor in the Faculty of Agricultural Sciences. He is an aboriginal person from El Salvador. He will be the principle investigator for this research project. The co-investigators include Dr. G.A. Neil Towers, Emmeritus Professor for UBC Botany, Dr. Karen H. Bartlett, Assistant Professor for UBC Occupational and Environmental Hygiene, and Dr. D.W. Cho, Research Associate for UBC Agroecology/First Nations Health. We offer you a brief research summary, which may be of interest to you and your community.

The National Aboriginal Health Organization (NAHO), Indian and Northern Affairs Canada (INAC), Assembly of First Nations (AFN) and scientific studies have identified the presence of moulds in the houses of Canadian Aboriginal people as a major health concern, therefore making this a research priority. In British Columbia, very little research is available on the impact of fungal contaminants (mould) on the quality of life and health. Health effects that may result are conjunctivitis (pink eye), allergies, hay fever, asthma, and immune system suppression.

The research project's overall goal is to improve the health conditions of Aboriginal people due to mould exposure, promote health awareness and also to identify potential anti-fungal agents that may reduce incidence of indoor mould. Indoor moulds, their sources and their health risk potentials will be investigated. Educational material will be produced, in collaboration with the Heiltsuk people, and distributed to minimize the health and safety risks due to mould exposure among Aboriginal and Non-Aboriginal people.

We are hoping that you will be interested in meeting with us during the month of July, if this is convenient for. We would like to give a brief presentation and provide you with the opportunity to ask further questions. Our team also extends an invitation to others in the community who may be interested in meeting with us and participate in discussions and initiation of the research project. You may contact any of us if you have further questions. Please see the attached "Contact List." On behalf of our research team, we look forward to meeting with you and the Heiltsuk community.

With Respect,

Patricia M. Osterberg
Master of Science Candidate, Plant Science
Appendix VI Advertisement for Community Research Assistant Opportunity

Would you like to be a Community Research Assistant?

Community Field Assistant Job Posting ~ Mid-September to Mid-October

I would like to take this opportunity to introduce myself. My name is Patricia Osterberg and I am a member of the Squiala Band from the Sto:lo Nation. As a Master of Science candidate with the Faculty of Land and Food Systems, I am participating as a co-investigator with Dr. Eduardo Jovel's research project entitled “Effects of Indoor Mould Exposure on the Health Effects of Aboriginal People in British Columbia.”

From approximately September 12th to the 30th, I will be visiting homes in the Heiltsuk community to obtain some important data. You may be aware that indoor mould in some homes has been problematic in your community. Exposure to indoor moulds can result with some unwanted health effects to the occupants, especially for our elders, our children and also those who have compromised immune systems. The most common health effects include: pink eye, allergies, hay fever, asthma, and immune system suppression.

You will join myself, Tina Campbell (research assistant from N’Laka’pamux) and Regan Chesley (Maori from New Zealand) as we visit approximately 80 homes to collect the following data:

- **Air samples** using an air sampling pump. Air contains tiny mould spores, which we cannot see. We can capture these spores onto media plates by using this pump. These samples will be sent back to our UBC laboratory where we can count the spore colonies that grow and also identify the types of moulds collected. We will then share this information with the home occupants.
- **Dust samples** using a vacuum cleaner. Mould can also grow on the dust that is captured in our carpets. We will vacuum a small area ($1m^2$) for about 5 minutes and do a laboratory analysis.
- **Completion of Questionnaires.** I have a questionnaire, which needs to be administered. Either myself, or one of you will go through a questionnaire with the participant. While the team is taking the air samples and dust samples, the questionnaire will also be done during this time.

The benefits of working with us include being in great company! You will be a part of the process to help your community obtain and maintain healthier homes and healthier lives. This work will look great on your resume which will also be accompanied with a letter of reference from the Director of the Institute for Aboriginal, Dr. E.M. Jovel. There are also future job opportunities involving this project, which will include conducting interviews with your elders and administering questionnaires with the participants. I am hoping that I can play the role as a mentor, as a person who can help you demystify the whole academic experience of university. If you are interested and driven, we will both benefit from the teachings we have to share with each other! If you have any further questions, please do not hesitate to e-mail me. I really look forward to meeting and working with my new community research assistants!
Appendix VII  Behavioral Research Ethics Review Board Certificate of Approval
Certificate of Approval

PRINCIPAL INVESTIGATOR
Jovel, E.

DEPARTMENT
College of Health Disciplines

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT
UBC Campus

CO-INVESTIGATORS:
Bartlett, Karen, Occupational & Env Hygiene; Cho, Dong, Agricultural Economics; Osterberg, Patricia, Agricultural Economics; Towers, Geourge H., Botany

SPONSORING AGENCIES
Canadian Institutes of Health Research

TITLE
Health Effects of Mould Exposure in Aboriginal Housing in BC

APPROVAL RENEWED DATE
APR 21 2006

TERM (YR(S))
1

The request for continuing review of the above-named project has been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

Approved on behalf of the Behavioural Research Ethics Board
by one of the following:
Dr. Peter Suedfeld, Chair,
Dr. Susan Rowley, Associate Chair
Dr. Jim Rupert, Associate Chair
Dr. Arminee Kazanjian, Associate Chair

This Certificate of Approval is valid for the above term provided there is no change in the experimental procedures.