The Demographic, Economic and Health Fabric of Mining Communities in British Columbia, Canada

by

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ABSTRACT

A significant number of communities in British Columbia (BC) are founded on mineral development and are subject to variable economic boom-and-bust cycles with implications for sustainability and community health. There were three main objectives of this multi-method PhD dissertation. The first was to quantitatively examine community level indicators describing economic, sustainability, and demographic characteristics (gained from Canadian Census data) of 31 BC rural resource based communities (with a focus on mining communities) during a period of time (1991 to 2001) when BC resource sectors experienced an economic downturn. The second was to assess the relationship between exposure to declining economic conditions and acute cardiovascular disease, chronic cardiovascular disease, and mental health outcomes in 29 BC rural resource-based using Statistics Canada Labour Force Survey data and Ministry of Health data over the same time period, again with a focus on mining. The third objective was to qualitatively investigate the experiences of health and social service providers using interviews, with respect to community health issues and the boom-bust mining cycle in a Northern remote coal mining community in British Columbia. During the decade under study, demographic and economic indicators indicated that mining communities were dependent on, and vulnerable to, economic activities and identified the need to strategize the sustainability of mining communities in British Columbia. Health data indicated that declining and bust economic conditions had a significant negative impact on the prevalence of acute cardiovascular disease and mental disorders in mining communities. Qualitative data revealed that the mining boom-bust cycle had negative effects on community health issues, and community health service provision. This dissertation concludes by proposing strategic opportunities aimed at the enhancement of mining community health and sustainability for policy-makers, communities, the mining industry and researchers to consider.

PREFACE

The main body (Chapters 2 to 5) of this thesis is comprised of four co-authored manuscripts for publication. The following details specific contributions, the manuscript submission details and author lists associated with each chapter:

Chapter 2: A version of Chapter 2 has been submitted for publication: **Shandro** J.A., Koehoorn, M., Scoble, M., Ostry, A., Veiga, M.M., and Gibson N. 2010a. Economic and demographic conditions in British Columbia mining communities: A comparison over time and with other resource communities.

Contributions: I am the first author of this manuscript. I completed the majority of the literature review, compiled and analyzed the data, proposed discussions and conclusions, and wrote the manuscript. Co-authors include individuals associated with the original Canadian Institutes of Health Research (funding agency for this research) Mining and Community Health grant (Principal Applicant: Dr. Mieke Koehoorn; Co-applicants: Dr. Malcolm Scoble, Dr. Aleck Ostry, and Dr. Nancy Gibson) who provided a portion of the literature review, and the methodology used for data collection and analysis, and my research supervisors (Dr. Marcello Veiga and Dr. Mieke Koehoorn), who along with grant members provided feedback to the manuscript and assisted in the final product.

Ethics: Research associated with this chapter was conducted with approval from the UBC Behavioural Research Ethics Board, Ethical Certificate # B05-0942.

Chapter 3: A version of this chapter will be submitted as a manuscript.

Contributions: I am the first author of this manuscript. I completed a portion of the literature review, assisted in the compilation and analysis of the data (guided by Dr. Mieke Koehoorn), and wrote the manuscript. Co-authors include those associated with the original Canadian Institutes of Health Research (funding agency for this research) Mining and Community Health grant (Principal Applicant: Dr. Mieke Koehoorn; Co-aaplicants: Dr. Malcolm Scoble, Dr. Aleck Ostry, and Dr. Nancy Gibson) who provided a portion of the literature review, and the methodology used for data collection and analysis. My research supervisors (Dr. Marcello Veiga and Dr. Mieke Koehoorn), committee members (Dr. Malcolm Scoble and Dr. Jeannie Shoveller) along with grant members provided feedback to the manuscript and assisted in the final product.

Ethics: This research was conducted with approval from the UBC Behavioural Research Ethics Board, Ethical Certificate #: B05-0942.

Chapter 4: A version of this chapter has been submitted: **Shandro**, J.A., Veiga, M.M. Shoveller, J., Scoble, M., and Koehoorn, M. 2010. Perspectives on community health issues and the mining boom-bust cycle.

Contributions: I am the first author of this manuscript. I completed the literature review, developed the methodology (with guidance from Dr. Mieke Koehoorn and Dr. Jeannie Shoveller), collected and analyzed the data (with guidance from Dr. Mieke Koehoorn and Dr. Jeannie Shoveller), and wrote the manuscript with guidance from co-authors who provided feedback to the manuscript and assisted in the final product. The co-authors of this manuscript were my research supervisors (Dr. Marcello Veiga and Dr. Mieke Koehoorn) and committee members (Dr. Jeannie Shoveller and Dr. Malcolm Scoble).

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Chapter 5: A version of this chapter has been published by the Canadian Institutes of Health Research: Shandro, J.A., Koehoorn, M., and Scoble, M. 2010. Bridging Mining Community Health and Sustainability, Canadian Institutes of Health Research 2010 Knowledge Translation Casebook. Available online at: http://www.cihr-irsc.gc.ca/e/41594.html, and in the Proceedings of the V International Conference on Mine Closure, Santiago, Chile, November 23-26, 2010.

Contributions: I am the first author of this manuscript. I assisted in development of the Mining and Community Health Knowledge Translation grant (Principle Applicant: Dr. Mieke Koehoorn), that was successfully funded by CIHR under the supervision of Dr. Mieke Koehoorn. In this chapter, I completed the literature review, developed the Knowledge Translation Action Plan with Co-supervisor Dr. Mieke Koehoorn, carried out KT activities (as guided and supervised by Dr. Mieke Koehoorn) with Dr. Mieke Koehoorn and Dr. Malcolm Scoble. I wrote the manuscript with guidance from co-authors who provided feedback to the manuscript and assisted in the final product. The co-authors of this manuscript were my research supervisors (Dr. Marcello Veiga and Dr. Mieke Koehoorn) and committee member/ original CIHR Mining and Community Health grant co-applicant Dr. Malcolm Scoble.

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LIST OF ABBREVIATIONS

AMEBC	Association of Mineral Exploration BC
BC	British Columbia
CAF	Community Adjustment Fund
CIHR	Canadian Institutes of Health Research
CSD	Census Subdivision
DI	Diversity Index
EIA	Environmental Impact Assessment
GMI	Global Mining Initiative
HIA	Health Impact Assessment
ICD-9	International Classification of Disease, 9th edition
ICMM	International Council on Mining and Metals
ID	Income Dependency Index
IFC	International Finance Corporation
IIED	International Institute for Environment and Development
LFS	Labour Force Survey
KT	Knowledge Translation
MABC	Mining Association of British Columbia
MAC	Mining Association of Canada
MEMPR	Ministry of Energy, Mines and Petroleum Resources
MMSD	Mining, Minerals and Sustainable Development project
NETHRN-BC	New Emerging Team for Health in Rural and Northern British Columbia
OECD	Organisation for Economic and Co-operation and Development
TSM	Towards Sustainable Mining
TSX	Toronto Stock Exchange
UNCED	United Nations Conference on Environment and Development
VI	Vulnerability Index
WCC	Western Canadian Coal
WCED	World Commission on Economic Development
WD	Western Economic Diversification Canada
WHO	World Health Organization
WMI	Whitehorse Mining Initiative

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I would also like to acknowledge my thesis supervisory committee members: Dr. Malcolm Scoble, Dr. Jeannie Shoveller, and Dr. Bern Klein. Your time, energy, and commitment to this work have been paramount to its completion, and you have all influenced the direction I am heading with future research and career endeavors.

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DEDICATION

To Donn Shandro, my Dad.

This wouldn't have happened without your support,
And I think often of how it took us away.

I can't say thanks in this life – but I'll have a beer at 4 pm, in the backyard in Dawson, on a sunny day with Joel, once it's all done…and think of you.

With love,

Janis

1 Introduction

1.1 Problem Statement: Mining and Communities

Mining, mineral processing, metal refining, and the trade of mining resources have played important roles in human life (Madigan, 1981), in forming the global economy and in the advancement of cultures (Nriagu, 1996). While mineral development has been ongoing in locations around the globe, including Canada, for thousands of years (Cranstone, 2002); the formalization of the mining sector in Canada represents a relatively new occurrence. For example, the first organization to be initiated by Parliament was the Geological Survey of Canada in 1877 (Wright and Czelusta, 2002). Mining is also recognized as playing an important role in the development of Canada, and is considered to be more responsible for development of frontier areas than any other resources activity (Neil et al, 1992). Despite its relatively short existence, the Canadian mining industry has developed into a global leader. As examples, the latest statistics identify Toronto, the largest Canadian metropolitan centre, as the global hub for mining finance; and the Toronto Stock Exchange (TSX) handles approximately 81% of worldwide mining equity transactions and is the leading global destination for exploration spending (The Mining Association of Canada, 2009). Canadian mining firms are involved in approximately 4600 projects located around the globe and are dominating global exploration spending (The Mining Association of Canada, 2009). Within Canada, there are over 800 (as of 2008) established mining projects and an estimated 351,000 Canadians employed in mineral extraction or associated sectors (smelting, refining, and manufacturing) (The Mining Association of Canada, 2009). Many Canadian mining projects are located in the Western Canadian province of British Columbia (BC); BC ranks third in terms of value of mineral production by province in Canada (behind Saskatchewan and Ontario) (The Mining Association of Canada, 2009).

Vancouver, the largest city in BC, is considered to be the global mining exploration centre, housing more than 850 mining and exploration company offices, and over 400 mining consultants and service providers (The Mining Association of Canada, 2009).

Today, it is estimated that over 115 communities are associated with mineral development in Canada (Natural Resources Canada, 2010). Mining communities in general can differ in geography, cultural, and political, environmental and social contexts (Veiga et al, 2001). Mining communities in Canada can include those that are purposefully built to support mineral development, communities located in proximity to a mineral development property, Aboriginal communities, and communities that are associated with Fly-in Fly-out operations (Veiga et al, 2001). They can range in size from a city (such as Sudbury, Ontario) to a small rural/remote town (such as Daniel's Harbour, Newfoundland) (Neil et al, 1992; Veiga et al, 2001). It is not uncommon for one mine to be associated with multiple communities, and to have a varied relationship with them (Veiga et al, 2001).

Many Canadian mining communities are situated in rural and remote regions (Canadian Institute for Health Information, 2006; Randall and Ironside, 1996), are economically reliant on this industry (Neil et al, 1992; McAllister et al, 1999), and are perceived to benefit from mining activities (Mining Association of Canada, 2009). Examples of benefits could include direct employment, ancillary economic activity, the development or enhancement of infrastructure and/or transportation corridors, and water and power supply (Veiga et al, 2001). In BC, operating mines have provided billions of dollars worth of investment, over 25,000 jobs, and provided high salaries and benefits to communities and their residents across the province. In addition over $1 million in funding has been allocated to rural and First Nations communities for mining education and skills training (Ministry of Energy, Mines and Petroleum Resources, 2007).

While the potential benefits that mining can bring to a community are substantial, it is also widely recognized amongst the mining industry, financial institutions, governments, researchers, and non-governmental organizations that mineral development can also negatively impact communities in a significant manner. At the community level, mining has been associated with: *variations in income and employment* (Strangleman, 2002); *loss of traditional values and livelihoods* (Oxfam, 2009); *substance abuse* (Lightfoot et al., 2009; Miranda et al, 1998; North Slave Metis Association, 2002; Sosa and Keenan, 2001; Oxfam, 2009; Campbell, 2000; Emberson-Bain, 1994; Yukon Conservation Society and Yukon Women's Council, 2000); *sexually transmitted infections* (Zhang et al., 2010; Desmond et al, 2005; Clift et al, 2003; Palmer et al, 2002; Ijsselmuiden et al, 1990; Miranda et al, 1998; Campbell et al, 1997; Jochelson et al, 1991); *exposure to harmful substances* (Singh and Pal, 2010; Goldberg M., 2009; Reid A. et al., 2008; Zhang et al., 2008; Asante et al., 2007; Luus, 2007; Glorennec, 2006; Wickre et al., 2004; Cohen and Velho, 2002; Malcoe et al., 2002Au et al., 1998 ; Au et al., 1995; Koike, 1992; Carruthers and Smith, 1979); *increases in cancer* (Hendryx et al., 2008; Pearce et al., 2008; Nawrot et al., 2006); *depression* (Slack and Jensen, 2004; Avery et al., 1998; Robinson and Wilkinson, 1998); *respiratory illness caused from air pollution from mining activities* (Coelho et al., 2007; Pless et al., 2000; Ernst et al., 1986; Singh et al. 2010; Pratt, 1990); *bioaccumulation of heavy metals* (Mackenzie and Kyle, 1984; Gallacher et al., 1984; Diaz Barriga et al., 1993; Gulson, 1996; Yui et al. 1998; Cook et al., 1993; Jung and Thornton 1997; Harnly et al., 1997); *domestic violence* (Sosa and Keenan, 2001; Oxfam, 2010; Emberson-Bain 1994; Yukon Conservation Society and Yukon Women's Council, 2000); *mental health issues among women* (Sharma and Rees, 2007); *prostitution* (Miranda et al, 1998; Campbell, 2000; Oxfam, 2009); *a lack of accommodation, variations in school enrollments, increased motor vehicle accidents; and demographic changes* (Petkova et al, 2009); *gambling* (Yukon

Conservation Society and Yukon Women's Council, 2000); *family disconnect* (North Slave Metis Association, 2002; Sharma and Rees, 2007; Yukon Conservation Society and Yukon Women's Council, 2000); *human rights abuses* (Ballard and Banks, 2003; MMSD, 2002; Handelsman et al., 2003); *and conflict* (Switzer, 2001; Collier & Hoeffler, 1998).

While the above literature review may initially seem exhaustive, the majority of research- based reported community-level impacts are: specific to a single community/case study; focused on workers; characterize environmental exposures to harmful substances, and accumulation of heavy metals; and utilize only one research method (there is a lack of multi-method studies investigating mining-community impacts). There is a deficiency of research-based studies, within the Canadian and global context, that focus on community-level economic, health, and social characteristics of mining communities. There is also an absence of holistic, multi-method studies, or investigations focused on how mining communities have fared over time, and in relation to fluctuating economic markets. Finally, little information pertaining to communities in British Columbia; a site of active mining since the mid 1800's where almost all communities in the province hold a history of mining activity, and at some point have supported the industry (Taylor, 1978) is available. The objective of this dissertation is to address these research gaps by investigating the economic, demographic, and health fabric of mining communities in British Columbia, Canada; with a secondary objective of providing evidence to inform the inclusion of a broader set of community health indicators for mine planning.

1.2 Research Objectives

There were three main objectives of this multidisciplinary, multi-method study:

1. Investigate how BC mining communities compared with other BC resource based communities in terms of their social, economic, and health fabric over a decade (1991-

2002) marked by a downturn in main BC resource-based industries (mining and forestry) through:

- A quantitative analysis of community-level demographic and economic characteristics derived from Statistics Canada Census Data (1991, 1996, and 2001 census collections); and
- A quantitative analysis of annual community-level age-sex adjusted health rates for acute cardiovascular disease, chronic cardiovascular disease, and mental disorders using Ministry of Health data (annual data from for 1992-2002).

2. Gain deeper insight into mining community health issues associated with the boom-bust cycle from the perspective of community health/social service providers through:
    - A qualitative investigation, guided by grounded theory techniques, in a Northern remote British Columbian coal mining community.
3. Contribute research findings in a meaningful way to the mining industry's efforts to minimize community impacts, and maximize community benefits associated with mineral development activities by engaging the BC mining industry, community leaders, and health care providers in British Columbia, by:
    - Sharing research findings;
    - Discussing the importance for developing community level health and sustainability indicators that can be incorporated into mine planning/impact assessments;
    - Reporting on the need for interdisciplinary strategies to effectively mitigate impacts of boom-bust cycles on communities; and
    - Highlighting the importance of mine closure planning.

1.3 Research Justification

Mineral development projects require a considerable amount of planning, and financial, governmental and public support. In addition, rich ore deposits have fixed locations, limiting the ability to simply choose an operational site. As each potential mine is unique in geographic, geologic, environmental, political, social, and cultural setting, these parameters in turn influence the design, layout, size, type, and overall planning of an operation. Mines also have a finite life. Once the ore of value has been extracted from the earth, there is no replacing it. Mine life depends entirely on the ore present and the technological and financial feasibility of extracting it and involves several stages. It is generally viewed that projects that undergo large time lags between stages have a significant risk of project failure; global prices for mineral commodities can directly affect the success of a mine project (Russell, 1999). Low commodity prices may also result in unexpected closure, either temporarily or permanently (Cranstone, 2002). Therefore, a successful mine plan is essential for each operation. As there are a vast array of factors to consider during planning a mining corporation relies on not only individuals skilled in mining engineering or mineral processing; the collaboration of many disciplines including: Earth Sciences, Environmental Sciences, Ethics, Business, Engineering and Design, Social Sciences, and Basic Sciences is required. The mining industry is also heavily reliant on communities. Communities provide homes, extracurricular activities and infrastructure support to mine employees and their families. In addition, communities can serve as a base for fly-in fly-out operations and for supportive industries such as environmental consultants.

Internationally, recognition of the sustainability of mining communities began with the definition of sustainable development in the landmark report entitled *Our Common Future* as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987, Chapter 2, pg 1.). In continuance, the *United Nations Conference on*

Environment and Development (UNCED), held in Rio de Janeiro in June of 1992, resulted in the production of a brief document (commonly known as *The Rio Declaration*) affirming 27 principals intended to guide sustainable development. Specifically the first principal outlines that "*Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature*" (United Nations Environment Programme, 1992, pg 1.). Within the mining sector, people questioned:

> "*Will the industry be a critical and important contributor to a sustainable future or will it become, in reality or perception, a relic of a declining industrial age*?"(Littlewood and Wells, 2000 pg 1.)

In recognition that mining is inseparable from sustainable development, and in order to assume a leadership role in the incorporation of sustainable development principals, the Global Mining Initiative (GMI) was borne. The GMI represented nine of the largest mining and metals corporations. Launched in 1999, with the objective of preparing the sector for the *World Summit on Sustainable Development* held on the 10th anniversary of the UNCED conference in 2002, the GMI gave rise to the Mining, Minerals and Sustainable Development (MMSD) project (Littlewood and Wells, 2000). This independent consultation and research project was led by International Institute for Environment and Development (IIED) in an effort to catalyze change within the mining industry. These developments were followed by the reorganization of an international mining representation to form the International Council on Mining and Metals (ICMM). In 2002, the GMI and the MMSD project both concluded with the GMI sponsoring an international conference *Resourcing the Future* where ICMM companies signed the *Toronto Declaration*. This declaration committed ICMM to continue efforts started from the MMSD project.

Today, the ICMM is a representation of 19 companies and 30 national and regional mining associations. Its main function is to address core sustainable development challenges faced by the industry. In 2008, the ICMM developed a sustainable development framework that member companies have committed to implement (ICMM, 2008). The framework involves 10 principles developed in accordance with other global standards (examples include the Rio Declaration, the Global Reporting Initiative, the Organization of Economic and Co-operative Development (OECD) Guidelines for Multinational Enterprises, the social and environmental Safeguard Policies of the International Finance Corporation, the OECD Convention on Combating Bribery, ILO Conventions 98, 169, 176, and the Voluntary Principles on Human Rights and Security) (ICMM, 2008). Table 1-1 highlights ICMM Principals and descriptors that are associated with the health and well-being of mining communities.

In the Canadian context, one of the first strategic opportunities that targeted the sustainability and well-being of mining communities was The Whitehorse Mining Initiative (WMI). A priority of the WMI was to establish a cooperative, collaborative framework for dealing with various issues (including community impacts) related to mining in Canada. In the 1994 WMI accord, the WMI leadership council acknowledged that "*Mining is the economic mainstay of many communities in Canada*" (WMI, 1994, pg 24), and that "*the dependence of these communities on mining activity makes them more vulnerable to economic fluctuations than other communities with more diverse economic bases* (WMI, 1994, Pg 24)". They also recognized that "*when mines come to the end of their economic life and close, the socio-economic dislocation can be significant*." (WMI, 1994, pg 24). Specifically, in 1994, the WMI envisioned the ability of Canadian mining firms to:

- Produce the maximum practicable mining related socio-economic benefits for communities; and

- Integrate mine life cycle plans with community economic development plans in order to minimize the consequences of mine closure on workers (WMI, 1994).

Table 1-1. ICMM Principles for Sustainable Development Performance that are associated with the health and well-being of mining communities

Principle	Associated Descriptor
#2: *Integrate sustainable development considerations within the corporate decision-making process*	"*Implement good practice and innovate to improve social, environmental and economic performance while enhancing shareholder value*" (ICMM, 2008, pg 9)
#3: *Implement risk management strategies based on valid data and sound science*	"*Consult with interested and affected parties in the identification, assessment and management of all significant social, health, safety, environmental and economic impacts associated with our activities*" (ICMM, 2008, pg 10)
#9: *Contribute to the social, economic and institutional development of the communities in which we operate*	"*Contribute to community development from project development through closure in collaboration with host communities and their representatives*" (ICMM, 2008, pg 11) "*Encourage partnerships with governments and non-governmental organizations to ensure that programs (such as community health, education, local business development) are well designed and effectively delivered*" (ICMM, 2008, pg 11) "*Enhance social and economic development by seeking opportunities to address poverty Report on our economic, social and environmental performance and contribution to sustainable development*" (ICMM, 2008, pg 11).

The WMI was quickly followed by an update to the Canadian governments Mineral and Metals Policy in 1996 where commitment was made to "*maintaining or enhancing the quality of life and the environment for present and future generations*" (Government of Canada, 1996, pg 5). The WMI and previously described events also influenced the Mining Association of Canada's (MAC) *Towards Sustainable Mining* (TSM) initiative that also recognized community impacts. The main objective of this directive is "*to responsibly meet society's needs for minerals metals*

and energy products" (Mining Association of Canada, 2004, pg 1.). The need to contribute to communities in a positive way was highlighted as TSM Guiding Principles. Specifically, MAC expressed the need to "*Be responsive to community priorities, needs and interests through all stages of mining exploration, development, operations and closure",* and to "*provide lasting benefits to local communities through self-sustaining programs to enhance the economic, environmental, social, educational and health care standards they enjoy"* (Mining Association of Canada, 2004, pg 1.).

In British Columbia, the current Government's *Mining Plan*, identifies a focus on communities, First Nations, and sustainable development stating "*This Plan will support: strong, enduring relationships between the mining industry, communities and First Nations; the development and implementation of a made-in-British Columbia approach to sustainable exploration, mining and communities*" (Ministry of Energy, Mines and Petroleum Resources, 2005, pg 11). In addition, the Mining Association of British Columbia (MABC) in collaboration with MEMPR have identified "*enhancing the potential for creating economic, social, and cultural benefits for local communities or regions*" as a key criterion to evaluate sustainability in their annual Mining and Sustainability Award (MABC, 2009).

In addition to sustainable development strategies, directives have started to incorporate social considerations within the Environmental Impact Assessment (EIA). The EIA is the primary process used to decide whether a mine project is granted authorization to begin, and to mitigate potential impacts (Environment Canada, 2000; Kwiatkowski & Ooi, 2003). Canada's Mineral and Metals Policy identifies that mineral project development involves taking into account assessed risks, as well as economic, social and legal concerns (Government of Canada, 1996). While the Canadian Environmental Assessment Act is verbally limited to environmental issues

(Government of Canada, 1992), provincial legislature recognizes the inclusion of health in the EIA process under different acts and requirements (Health Canada, 1999). For instance, if the development project is located near communities, additional information associated with social and/or health impacts may be required as enforced by the provincial legislature, the Canadian Environmental Assessment Agency, or other federal bodies such as Health Canada (administrator of the Canadian Health Act) (Canadian Environmental Assessment Agency, 2007).

As each mine is unique and there are no clear guidelines or policies in place provided by the Canadian Environmental Assessment Agency, each EIA application has the potential to vary in scope, issues, and integration of social and health impacts. In Canada, the determinants of health (Federal, Provincial and Territorial Advisory Committee on Population Health, 1994; Health Canada 2007; Figure 1-1) have been included in the assessment of the health and socio-economic impacts, as detailed in the *Canadian Handbook on Health Impact Assessment* (Health Canada, 1999). While not all determinants will require detailed review, developers are encouraged to consider them all (Kwiatkowski & Ooi, 2003). While it has been recognized that *"impacts of development activities can occur at several social scales, including individuals, families, communities, Aboriginal peoples, cultures, and society as a whole",* it is the perception that *"the social dimension is subjective, qualitative, difficult to measure, and there are diverse views by the various players and stakeholders"* (Natural Resources Canada, 2003, pg 11; Natural Resources Canada, 2010).

As a result of the flexibility in the interpretation of the impact assessment process, mining organizations (including the ICMM and IFC) generally ignore health determinants in the guidance documents available to their associated companies. Nonetheless, health determinants as

part of a Sustainable Development framework (Figure 1-1) highlight the need to consider community health as a central focus within impact assessments and sustainable development strategies.

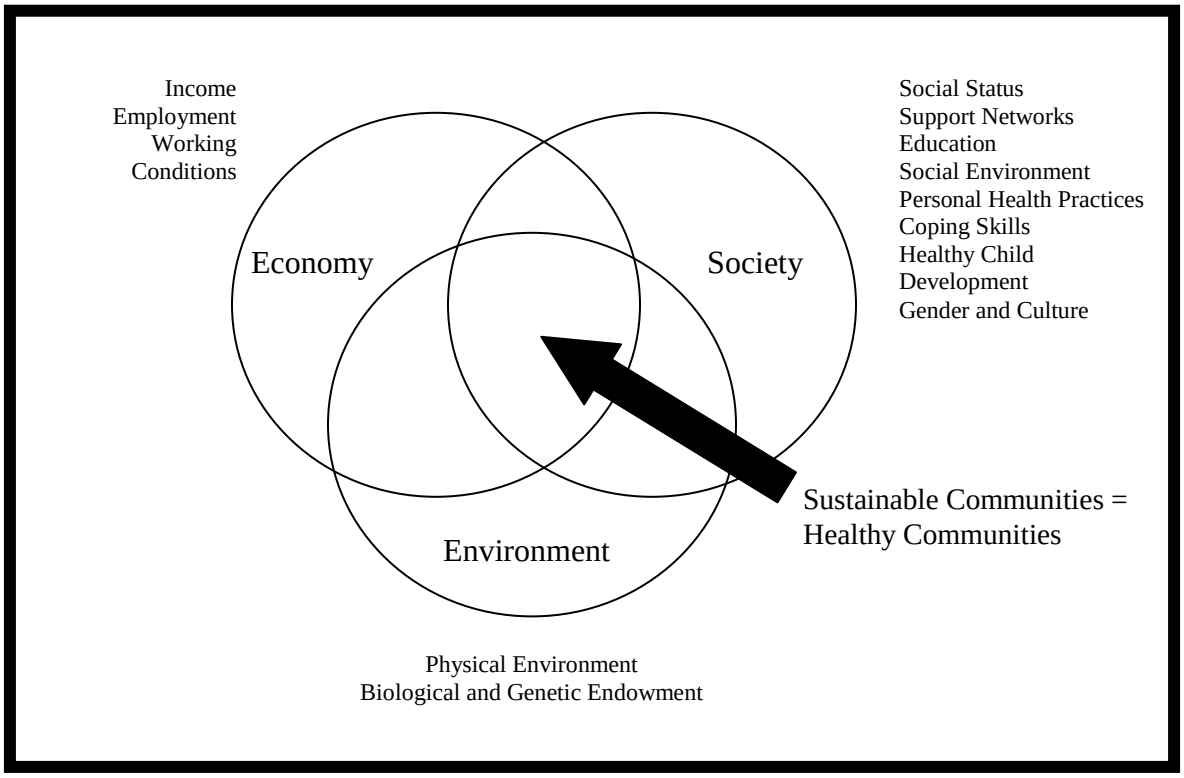

Figure 1-1. Adaptation of the Sustainable Development and Health framework (adapted from Health Canada, 2007). The three pillars of sustainable development are within the circles and associated determinants of health are listed outside the circles.

As demonstrated, there has been a strong commitment made to communities by industry and government, and this has only increased over the last five years. However, there still remains a lack of research into community-level issues to support evidence-based decision making in the impact assessment process; and to develop sufficient indicators and methods for the mining industry and governments to adequately characterize, plan for, and mitigate community impacts. This is especially the case within the realm of community health. Nevertheless, the mining sector and governments have demonstrated a commitment to minimize community-level impacts

resultant from mineral development, and have started to recognize the importance of community health (ICMM, 2010). To pursue this paradigm shift and momentum within industry, it is the aim of this dissertation to provide evidence to contribute to this process.

1.4 Thesis Structure

This manuscript-based thesis consists of six chapters (the first representing this introductory chapter). Chapters 2, 3, 4, and 5 are based on manuscripts that either have been or will be submitted to a peer-reviewed academic journal for publication. Chapter 6 provides an overall discussion and conclusion of study findings. The relationship between research objectives and chapters is demonstrated in Figure 1-2. Specific research questions are highlighted in Table 1-2.

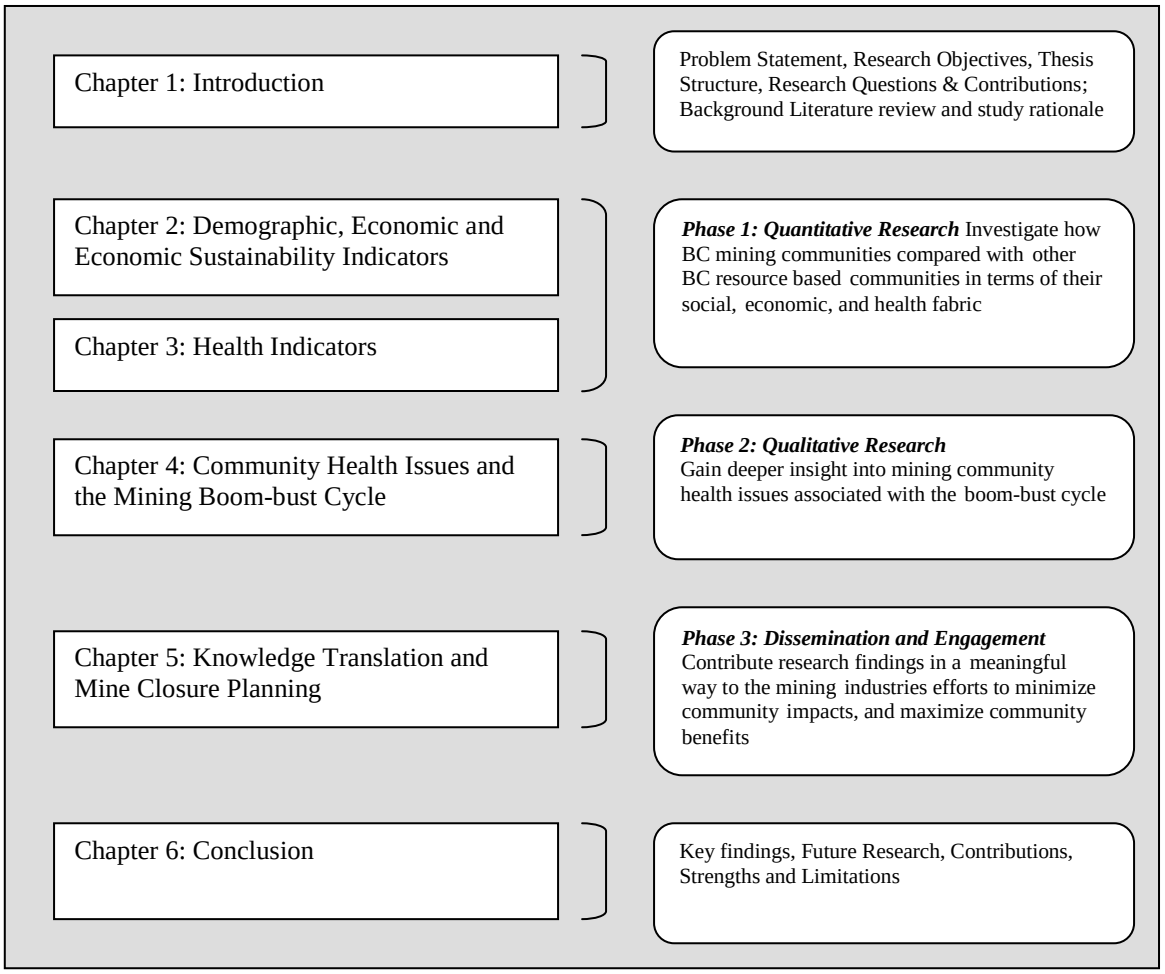

Figure 1-2. Dissertation objectives and chapters.

Table 1-2. Overview of research questions.

Chapter	Research Question
2	How do mining communities differ from other resource based communities in British Columbia in terms of their socio-demographic, economic fabric over a specific period of time (1991-2001)?
3	What is the relationship between community-level health outcomes of cardiovascular disease and mental disorders and community-level exposure to economic conditions among residents of BC mining communities? How does this compare to residents of other BC resource-based communities?
4	What are the experiences of health and social service providers in a remote mining community, with respect to community health issues and the boom-bust cycle of mining? How can the mining sector contribute to enhancing community health?
5	Can researchers engage in knowledge translation activities with mining communities? What can we learn from the process?

Chapter 2: Demographic, Economic, and Economic Sustainability Indicators

Chapter 2 examines community-level indicators (derived from Canadian Census data) describing demographic, economic, and economic sustainability characteristics of 31 BC resource based communities (with a focus on mining communities) during a period of time (1991 to 2001) when resource sectors experienced an economic downturn. During this decade, mining communities differed significantly from other resource-based communities. On average, mining communities experienced higher incomes (from all sources), higher industry-specific salaries, and greater industry-specific employment in comparison to other resource communities. However, although all study communities demonstrated high economic vulnerability to industry downturns, mining communities were found to be more dependent on mining (than other communities were on

comparison resource sectors) and less diverse in terms of economic opportunities. During the study period, a reduction in resource employment affected most study communities; however, mining communities experienced a greater relative reduction in industry specific employment (from mining) and overall male employment over time. They also experienced population loss. In contrast, other resource communities were more stable or experienced population growth. As the current economic crisis is now affecting BC resource communities, this chapter concludes by proposing strategic opportunities aimed at the enhancement of mining community sustainability for policy-makers, communities, the mining industry to consider.

Chapter 3: Health Indicators

Chapter 3 presents an investigation into the relationship between community-level health outcomes (prevalence and incidence rates of heart disease and mental disorders) and community-level exposure to economic conditions among residents of BC resource based communities with a focus on mining communities. The purpose of this study was to investigate the relationship between community-level exposure to changes in economic conditions and the incidence and prevalence of mental disorders and cardiovascular disease in resource-based communities in British Columbia (BC) from1991 to 2001, a period marked by an economic downturn that impacted BC mining and forest-based industries.

The investigation relied on Labour Force Survey (LFS) and Census data, and health records from the British Columbia Ministry of Health (MoH). British Columbia resource based communities (n=29) were identified and further categorized as mining or other-resource using LFS Data. Individuals residing in the 29 study communities during the study years from 1991 to 2002 were identified from the MoH provincial (universal) health registry. MoH physician visits and hospitalizations for cardiovascular disease and mental disorders among community residents

were defined using diagnostic codes recorded in the health records. Age and sex adjusted prevalence and incidence rates were calculated for each community and compared from 1991 to 2002. In addition, the development of a boom-bust economic change indicator defined using Census data and industry/government documents allowed for yearly assessment of community-level exposure to economic conditions. The relationship between exposure to economic change and rates of acute and chronic cardiovascular disease and mental disorders across the 29 study communities was investigated using a generalized linear model (stratified by type of community, and adjusted for the effect of the community).

Findings indicate an impact on the prevalence rates for acute CVD during periods of economic decline (rate increased by 13.1 cases per 1000 population, $p<0.0001$ as compared with stable periods) and bust conditions (rate increased by 30.1 cases per 1000 population, $p<0.0001$ as compared with stable conditions) and mental disorders (rate increased by 13.2 cases per 1000 population, $p=0.0001$) in mining communities during declining economic conditions as compared to steady periods of mining employment. This is not observed in other resource-based communities. Study results demonstrate little impact on chronic cardiovascular conditions or on incidence rates. This chapter concludes by highlighting implications for the mining industry to consider.

Chapter 4: Community Health Services and the Mining Boom-bust Cycle

Chapter 4 describes an exploratory qualitative investigation, guided by a grounded theory approach, into community health issues and the boom-bust mining cycle from the perspective of health and social service providers in a remote Canadian coal mining community. It begins by highlighting commitments mining companies and government have made to the health of mining communities; and identifies a lack of incorporation of health in mining strategies, with an

international, Canadian and British Columbian focus. This chapter continues with a description of the study setting (Tumbler Ridge, BC) and defines the qualitative research method used. This chapter identifies five main community health issues associated with the boom-bust cycle from the perspective of community health/social service providers. Specifically, the chapter calls for attention to family health, women's health, mine worker's health issues. It also illuminates the need to address mental health and addictions issues, and highlights the challenges faced by health service providers in both booming and busting economies. Chapter 4 concludes by providing recommendations as to how the industry can enhance community health made by this underrepresented, important stakeholder group.

Chapter 5: Knowledge Translation, Stakeholder Engagement, and Mine Closure

Chapter 5: This chapter focuses on the knowledge translation process undertaken by the researcher to share research findings presented in Chapters 2 and 3 with mining communities and decision makers; and to explore the inclusion of mining community health in sustainability planning. The mining and community health project represents a collaborative research project between the N. B. Keevil Institute of Mining Engineering and the School of Population and Public Health at the University of British Columbia, Canada, and was supported by the Mining Association of British Columbia and the Canadian Institutes of Health Research. As part of the study, researchers engaged various mine and community stakeholders associated with the project to discuss findings and to introduce the concept of working towards a collaborative mining community sustainability plan. Chapter 5 focuses on the results from the stakeholder engagement with the northern remote coal mining community of Tumbler Ridge, Canada, which is to date the last community in British Columbia to be developed for the purpose of supporting coal mining. It highlights the community of Tumbler Ridge as a case study for how mine closure can impact

communities. It also presents a model for stakeholder/community engagement that can be used or adapted for mine closure planning.

Chapter 6: Concluding Chapter

The final chapter of this dissertation summarizes key findings from this investigation, and addresses the main research questions as presented in the first chapter. It also presents recommendations for future studies. Finally, this chapter describes contributions that are academic and applied in nature. Research questions and contributions are summarized in Table 6-1.

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2 Economic and Demographic Conditions in British Columbia Mining Communities: A Comparison over Time and With Other Resource Communities[1]

2.1 Introduction

Approximately 30% of Canada's population resides in rural, remote and Northern regions (du Plessis et al, 2002). Many of these communities are under stress and are only beginning to be recognized as unique with respect to their size and distance to urban centres; and the social, health and economic challenges faced by their residents (Reimer, 2009; The Rural Think Tank, 2005). Thus, the well-being of Canadian rural communities is becoming a priority for governments and for researchers. Perhaps in response, the Canadian Government has recently highlighted the need to strengthen the economic prosperity and social cohesiveness of rural communities; issues that are of particular importance now when many of these communities are feeling the full effects of the current economic downturn. Accordingly, funds have been allocated, through the Community Adjustment Fund, to assist rural communities strongly impacted by the global economic recession (Department of Finance Canada, 2009) as many of these communities are dependent on natural resource development, and are thus linked to global economic trends.

Natural resource development has played an integral role in determining the Canadian fabric and has helped shape its social, economic and political landscape. Many communities and towns in

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Canada were, and continue to be, built on the wealth of resource extraction; and in many instances, resource industries are the sole reason for the existence of a community (Hayter and Barnes, 1990). The historical pattern associated with discovery of natural resources, including community formation to facilitate extraction, resource depletion, and community disappearance has been well documented; this pattern has existed since the Canadian fur trade in the 16th century through to the Newfoundland cod fishery in the 20th century (Hayter and Barnes, 1990). As resource based communities are generally considered to be geographically isolated (Randall and Ironside, 1996), they are considered home to a portion of Canada's rural population. In 1996, over 25 percent of employment in rural communities was based in resource industries (Stedman, 2004). Today, the sustainability of these communities, particularly those that are remote and linked with resource commodity trade, is at risk (Reimer, 2009).

In Canada, and in the province of BC, many rural communities have been founded on, and are economically dependant on mining (Taylor, 1978; Canadian Institutes for Health Information, 2006); a continued key economic driver for this province. BC encompasses the largest part of the Canadian Cordillera, a mountain belt rich in minerals and coal (Taylor, 1978). As such, BC is a major producer of coal (66% of Canada's total production), silver (50%), copper (40%), gold, lead, zinc, and molybdenum (MABC, 2009). The mining industry in BC is represented by two associations: The Mining Association of British Columbia (MABC) and the Association of Mineral Exploration BC (AMEBC). MABC is one of the province's oldest industry associations and was established in 1901 to represent the interests of the mining industry. AMEBC, established in 1912 represents individuals, companies, and organizations involved in mineral exploration. Mineral resources are provincially managed by the Ministry of Mines, Energy, and Petroleum Resources (MEMPR), Mining and Minerals Division.

In BC, as in many other parts of the world, mining communities were historically built and populated exclusively to satisfy the workforce needs of mining operations. Mining camps, evolved into "company towns" in the 19th century, and generally lacked overall development plans; at this time very few companies could make commitments to long-term community development. Residential areas were secondary to the industrial operations (Robson, 1989). By the mid-1940's governments became partners in mine development and participated in the delivery of physical infrastructure and social services to communities (Robson, 1989). The company town evolved into a planned "mining town". Some mining communities in BC evolved to secure a diversified economy after their mining operations were permanently closed, some managed to survive with later subsequent renewed mining development, while others were completely decommissioned once mining operations ceased. The 1970's represented a backlash for most resource communities in BC, with several towns downsizing and decommissioning (Robson, 1989). The 1980's represented an era of significant renewed industry and government investment towards the development of infrastructure and communities associated with the northeast and southeast coalfields in BC, (e.g. Tumbler Ridge and Elkford respectively). Despite government mining initiatives (through tax cuts and exploration incentives), the 1990's marked a challenging time for the BC mining industry.

At the turn of the century, commodity prices increased and new mining projects began to emerge into the permitting phase. In 2008, gross BC mining revenues equaled $8.4 billion, the industry employed 7607 people (PricewaterhouseCoopers, 2009), and 54 mines were in production (10 metal, 9 coal, and 35 industrial minerals) (MEMPR, 2008). Although 2008 was considered a successful year for the BC mining sector, the global economic crisis began to impact the industry on a national and global level. For example, prompted by the drop in global base metal demand, Canadian sales of metal products decreased by 37.6% in September 2009 from September 2008

levels (Statistics Canada, 2009). The lending crisis left many BC mining and exploration companies struggling to secure financing; and sharp declines in commodity prices compounded financial problems. Operating mines closed and mine expansion plans and new projects were suspended or cancelled. Mining companies also experienced drastic declines in stock prices, in some cases exceeding 90 percent. It has been reported that all companies are now engaged in serious cost-control measures (The BC Mining Economic Task Force, 2009). In response to the economic downturn, the BC government introduced new tax credits, and announced the creation of a new economic mining task force (MABC, 2008) to advise the BC government on how to assist the mining sector during the current economic crisis (The BC Mining Economic Task Force, 2009). Governments also recognized that single industry Canadian regions, such as those associated with mineral development, were hardest hit by the economic crisis (Conference Board, 2009).

2.2 The Economic Health and Sustainability of Mining Communities

The economic health and sustainability of mining communities in rural and remote locations are essential for national economic and social development, and for the health and well-being of residents of these places. This has been recognized by MABC, AMEBC, MEMPR, and the Mining Association of Canada (MAC). For instance, MABC and MEMPR identified "*enhancing the potential for creating economic, social, and cultural benefits for local communities or regions*" as a key criterion to evaluate sustainability in their annual Mining and Sustainability Award (MABC, 2009a). MAC in 2004 developed the framework 'Towards Sustainable Mining (TSM) Guiding Principles' including a definition of sustainable development as presented in the 1987 Brundtland Commission; "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Bruntland, 1987). The TSM framework also indicated that MAC members will "*provide lasting benefits to local*

communities through self-sustaining programs to enhance the economic, environmental, social, educational and health care standards they enjoy" (MAC, 2004, pg 1.). Finally, within the current BC Government's *Mining Plan*, the first "cornerstone" identifies a focus on communities and First Nations stating "*This Plan will support: strong, enduring relationships between the mining industry, communities and First Nations; the development and implementation of a made-in-British Columbia approach to sustainable exploration, mining and communities*" (MEMPR, 2005 pg 11.).

The challenge for the BC mining sector is to achieve the committed sustainability sentiments as outlined by MABC, MAC and MEMPR, through the insurance of "*a lasting legacy of sustainability and community well-being coupled with avoidance of environmental degradation and social dislocation*" (Veiga et al, 2001, pg 192). This is especially the case given there is a lack of research evidence related to community sustainability indicators for rural and remote communities associated with resource activities. To highlight the importance of continued commitments to mining community sustainability, and as a contribution towards the enhancement of mining community well-being this specific paper describes a collaborative research project between the Norman B. Keevil Institute of Mining Engineering and the School of Population and Public Health at the University of British Columbia. The study investigated how the last significant downturn in the mining sector (that occurred during the 1990's) affected BC mining communities and analyzed community level demographic and economic characteristics derived from Statistics Canada Census Data (1991, 1996, and 2001 Census collections). As a comparison, the study also investigated other BC resource communities during this time period (Forestry, Oil and Gas, and Agriculture). The majority of other BC resource study communities were associated with the forest sector, an industry that also experienced a downturn during the study period. It is hypothesized that mining communities will have more

adverse demographic, economic, and sustainability indicators compared to other resource based communities. Mining is a finite resource based activity, linked to global economic trends that are highly cyclical in nature, and thus presents unique challenges for associated communities.

2.4 The Research Method

This study relied on retrospective existing data (Statistics Canada Census and Labour Force Survey) to identify mining and other resource-based communities in BC and to construct community-level demographic and economic indicators that were measured over time from 1991 to 2001.

2.4.1 Defining Mining and Comparison Communities

Based on Census data, study communities were defined geographically by census subdivision boundaries (CSD) and using Labour Force Survey data. In keeping with the current practice of defining resource communities as a function of economic dependency (Stedman et al., 2004; Randal and Ironside, 1996), 15 communities in BC were identified as mining communities using the following criteria: 1) Mining was the most common economic activity at one point in time during the study period (highest percentage employment income across all possible economic activities) and 2) the presence of an active mine/mine processing plant within the CSD at one point in time during the study period. For comparison purposes, 16 other resource-based communities (CSDs) were also identified. The criteria used to identify these comparison communities were: 1) A different resource activity (aside from mining) was the most common economic activity in the community (e.g. n=13 forestry, n=1 oil and gas, n=2 agriculture) and 2) at lease one comparison community was chosen within the same census division as a mining community. Among the 31 study communities, population size ranged from 350 to 16,035 residents over the study period. During the follow-up period, two comparison resource based

communities were present within the same Census division as that of a mining community, resulting in a study sample of 15 mining and 16 comparison communities.

2.4.2 The Study Period 1991 to 2001

Mining: The first three years of the study period (1991 to 1993) were marked by a decrease in exploration expenditures, mining revenues, and employment within the mining sector (MEMPR, 1992a; MEMPR, 1994). Low metal markets, increased regulation, increased global competition and a lack of risk financing were all contributing factors to this depression (MEMPR, 1992b). In 1995, the industry experienced a brief revitalization, spurred generally by higher metal and coal prices, a weaker Canadian dollar, the introduction of a BC government industry tax cut, and the launching of Explore BC (the BC Government provided approximately $3.5 million in exploration grants) (MEMPR, 1995). The BC government underwent some significant transformations during this period by temporarily integrating the Ministry of Energy, Mines and Petroleum Resources with the Ministry of Employment and Investment (Ministry of Employment and Investment, 1996). In 1996, exploration activities began to decline, and by 1998 sharp decreases were felt through exploration expenditures and mineral production. Globally, the mining and mineral exploration industries faced restrained activities as low metal and coal prices were coupled with an economic crisis in Asia (Ministry of Energy and Mines, 1999). The 1990's ended with a continued difficult period of time for the mining industry; existing metal mines for the most part continued production, however, Highland Valley Copper mine, BC's largest metal mine suffered a five month shutdown. Low prices for coal and most metals continued into 2000, and resulted in the closure of the Quintette Coal Mine in Tumbler Ridge, BC. In 2001 after over a century of production the Sullivan mine in Kimberly, BC was permanently closed due to ore exhaustion.

Comparison Sectors: The majority of comparison communities were associated with the forest industry. This sector has undergone enormous transformations over the past few decades in BC. Prior to the study period, the forest sector experienced a major economic depression, in which more than 23, 000 people lost their jobs. This downturn repeated during the study period with the permanent loss of approximately 6,000 additional BC forest sector jobs (Lusch, 1998; Beatty and Hamilton, 1998 as cited in Markey and Pierce, 1999). Rural and northern communities were strongly impacted during the 1990's as many small sawmills located in these regions disappeared with the consolidation and centralization of the forest industry (Ostry et al., 2001). The BC forest sector continued to undergo significant changes as the American soft-wood lumber tariff placed a considerable amount of strain on industry (Markey et al., 1999). The study period was marked by the introduction of a variety of new Forest Practice Codes aimed at improving the BC sector (Markey et al., 1999). However, the new policy changes limited the access and control that rural and northern communities previously had over their local forest resources (Stedman et al., 2004; Stedman et al., 2005). Other comparison industries involved in this study included the oil /gas and agriculture sectors. Over the study period oil and gas development steadily increased in the northeastern region of BC, and agriculture remained a consistent economic opportunity in the south-central region.

2.4.3 Indicators

In Canada, detailed census data is collected every five years at a fine geographical level by Statistics Canada (http://estat.statcan.gc.ca). In addition, detailed Labour Force Survey (LFS) data is collected monthly and provides estimates of employment (and unemployment) (www.statcan.gc.ca). Select Census and LFS data describing the economic conditions and demographic composition of each community was collected at the CSD level for the 31 study communities, measured for 1991, 1996 and 2001 Census time periods.

Economic Indicators

Economic indicators were derived from Census data and LFS data, and included community-level measures of income (average employment income for all persons with employment income by work activity, average male employment income, average female employment income), industry specific annual salaries (this indicator derived from LFS data and was estimated for each community using the total number of people employed in each specific industry and total industry specific income contributions), and unemployment rates (male and female).

Indices of Economic Sustainability

This study assessed three community-level indirect economic indices called Indices of Economic Sustainability. These Indices were developed using LFS data and were aggregated at the community level. The construction of these indices (described in detail below) was based on methods originally developed by Horne for the purpose of estimating community economic impacts resultant from changes in local economies (with a focus on the BC forest sector) (Horne, 2004). These indices have been constructed for the 31 study communities to estimate community economic impacts over time and include: The Income Dependency Index (ID), Diversity Index (DI) and Vulnerability Index (VI). The ID, DI and VI have been used by the BC Ministry of Management Services to measure the degree of overall economic stability or security of a BC community on major industries (Horne, 2004).

The Income Dependency Index (ID) measures a community's reliance on a particular industry relative to all other industries for direct income. Each dollar of community income was uniquely allocated to one of 19 employment sectors (including mining and mineral processing, forestry and logging, oil and gas, and agriculture). Dependency on mining was calculated as a percentage of mining income in relation to total community income for study mining communities. For

comparison communities, the income dependency index was calculated based on the dominant (highest community income) resource sector in each community (e.g. forestry, oil and gas, or agriculture). ID values range from 0 to 100%, where 100% would represent a community entirely dependent upon one sector. In investigating the ID, it is important to note the ID is a measure which demonstrates a share of total community income that a specific industry sector provides to a community. Importantly, an increase (or decrease) in the ID does not mean the absolute amount of income provided by a given sector has increased, rather that its share of income relative to other sectors has increased (or decreased) (Horne, 2004).

The Diversity Index (DI) is a measure of economic diversification for a particular community. The 31 community specific IDs were calculated using the following formula:

$$DI = 100 \times \quad SD_{ldc} - SD/SD_{ldc}$$

Where SD is the standard deviation of the 19 dependency values for each community and SD_{ldc} is the standard deviation for the least diversified case possible (i.e. a constant value representing a community that is found to be dependent on only one sector). The DI ranges from 0-100 and a score of 0 would be calculated if the community was entirely dependent on one sector. At the other extreme, the DI would be 100 in a local area equally dependent on each of the 19 defined employment sectors (Horne, 2004).

The Vulnerability Index (VI) provides a measure of the magnitude of the vulnerability of each community to potential downturns in their respective dominant sector (Horne, 2004). The VI was developed using ID and DI data for each study community. The first step in calculating the VI is to multiply each community's ID on their respective dominant resource sector by (100 minus DI). This product is then standardized to a scale ranging from 0 to 100 for comparison purposes. (Horne, 2004). A high value suggests that a decline in the dominant economic sector would

result in the respective community experiencing greater economic difficulties than those communities with a lower VI value.

Demographic Indicators

Demographic indicators were derived from Census data (http://estat.statcan.gc.ca) and included measures of population change (from 1986 to 1991, 1991 to 1996 and from 1996 to 2001), marital status (percentage of community population who were legally married, single, separated, divorced, or widowed), and education (percentage of community population with completed education including secondary school certificate, trades certificate, diploma or university degree). Variables were measured for 1991, 1996 and 2001 Census time periods.

2.4.5 Data Analysis

The Economic Indicators, Indices of Economic Sustainability and Demographic Indicators were constructed for study communities at the three Census time points (1991, 1996 and 2001), enabling a comparison over time and between mining and other resource based communities. SAS 9.1.3 (SAS Institute Inc., 2002) was utilized to analyze data. Independent t-tests were conducted to compare the means of economic and demographic values between community types and within community types over time at a significance level of $p<0.05$.

2.5 Results

2.5.1 Economic Indicator Results

Economic Indicator results are summarized in Table 2-1. Over the study period, the estimated average employment income (from all sources) increased for all study communities, and was consistently higher in mining communities (e.g. in Census year 1991 *mean*=$28,295) than in comparison communities (e.g in Census year 1991 *mean*=$23,250). T-test results indicate there

was a significant difference in the estimated employment income (from all sources) between mining and comparison communities for Census years 1991 and 1996, and a non-significant difference in 2001. Male average employment income (from all sources) was also higher in mining communities (e.g. in Census year 2001 *mean*=$42,326) than in comparison communities (e.g. in Census year 2001 *mean*=34,831). T-test results indicate a significantly higher difference in male income for all Census years (1991, 1996 and 2001) for mining compared to other resource communities. In addition, the average female employment income (from all sources) was slightly higher in mining communities (e.g. in Census year 1991 *mean*=$14,738) versus comparison communities (e.g. in Census year 1991 *mean*=$14,204). T-test results indicate a significant higher difference in female income (from all sources) for mining compared to other resource based communities for Census years 1991 and 1996, and a non-significant difference for Census year 2001. The gap between male and female average incomes was greater in mining communities (Figure 2-2) than other resource based communities.

A comparison of estimated industry-specific annual salaries within sampled communities identified mining as the highest paid resource employment opportunity (e.g. In Census year 2001 *mean*=$58,523) compared to other resource sectors in comparison communities (e.g. In Census year 2001 *mean*=$38,419). T-test results denote a significant difference in estimated industry-specific annual salaries between mining and comparison communities for all Census years.

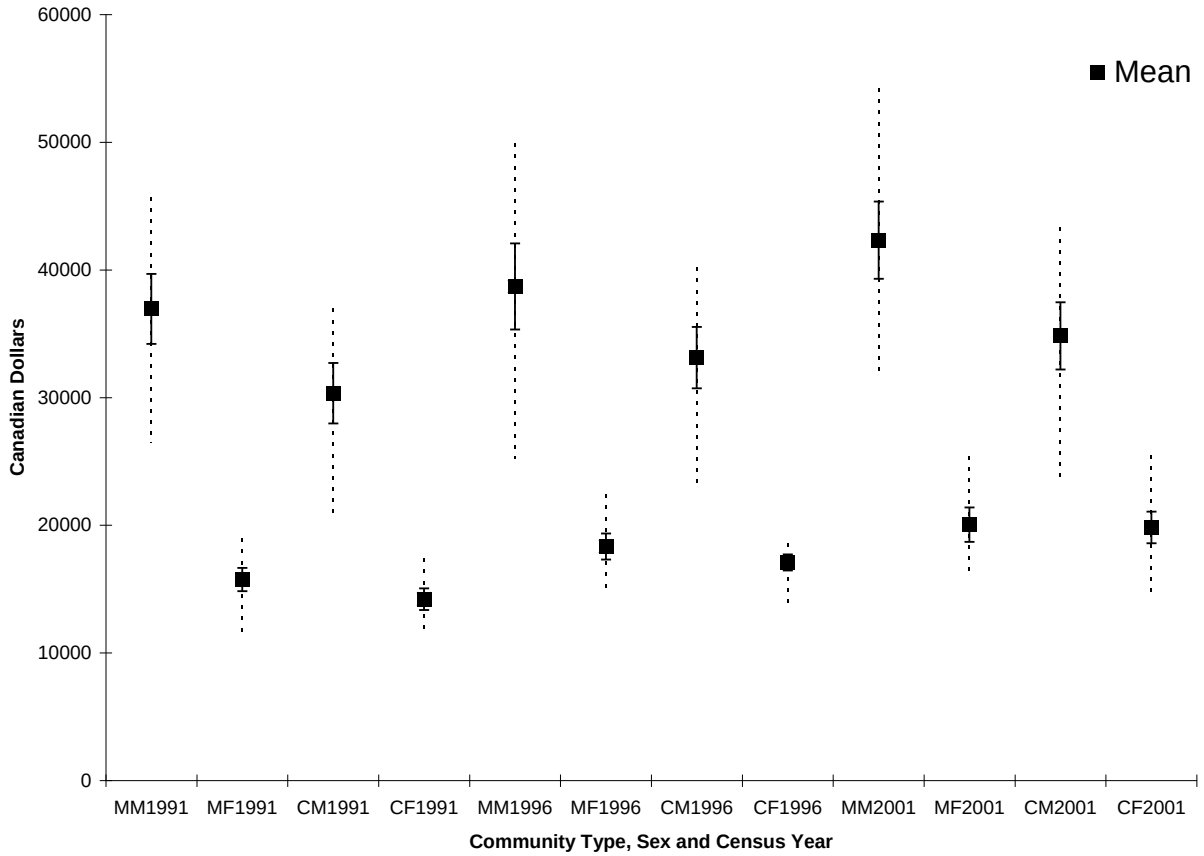

Figure 2-1. Average mining community male (MM), mining community female (MF), comparison community male (CM) and comparison community female (CF) community-level employment income from all sources. Solid square represents the mean, solid bar lines represents upper and lower 95% confidence intervals, dashed line represents value range amongst study communities.

Mining communities benefited from mining employment early in the study period but the economic recession in the 1990's resulted in reduced mining employment opportunities. For example, in 1991, the mean percentage of employed people in the mining industry was 33% in mining communities. This decreased to 23% in 1996 and 22% in 2001. Comparison communities also experienced a decrease in resource employment (the decrease was present in communities reliant on the forest sector) over the study period; however, the decline was more gradual. The percentage of people employed in comparison industries was on average 17% in 1991; this decreased slightly to 16% in 1996 and to 15% in 2001. T-test results indicate a significant

difference in industry specific employment (%) for Census year 1991, and non-significant differences for Census years 1996 and 2001, between mining and comparison communities.

At the start of the study period (1991 and 1996 Census years), mining communities had lower male unemployment rates (e.g. In Census year 1991 *mean*=7.8) in comparison to other resource-based communities (e.g. In Census year 1991 *mean*=11.5). These rates increased in both community types over time but to a greater degree in mining communities. T-test results indicate a significant difference in male unemployment rates in Census year 1991 and a non-significant difference in Census years 1996 and 2001, between mining and comparison communities. Average Female unemployment rates however, were found to be higher in mining communities (e.g. In Census year 2001 *mean*=12.4) than comparison communities (e.g. In Census year 2001 *mean*=8.9) throughout the study period; although these differences were not statistically significant.

Table 2-1. Comparison of Community-Level Economic Indicators among BC Mining (n=15) and Comparison Resource (n=16) Communities.

	Mining	Comparison	
	Mean (min, max)	**Mean (min, max)**	**p-value***
Average Employment Income (From all sources, CAD)			
1991	28,295 (21180, 35942)	23250 (16930, 27311)	**0.0022**
1996	30,177 (22693, 38286)	25847 (19638, 30533)	**0.0038**
2001	32,305 (25747, 41483)	27790 (20819, 33347)	**0.0024**
Average Male Employment Income (From all sources, CAD)			
1991	36954 (26531, 45637)	30339 (20601, 36888)	**0.0038**
1996	38702 (25322, 49829)	33120 (23039, 40125)	**0.0123**
2001	42326 (32099, 54153)	34831 (23715, 43240)	**0.0010**
Average Female Employment Income (From all sources, CAD)			
1991	15738 (11749, 18888)	14204 (11516, 17332)	**0.0400**
1996	18337 (14749, 22339)	17081 (13950, 18512)	**0.0457**
2001	20040 (15951, 25356)	19821 (14408, 25453)	0.8139
Estimated Industry Average Annual Salaries (From all sources, CAD)			
1991	43482 (33915, 55734)	30235 (13409, 37928)	**<0.0001**
1996	50838 (42407, 57317)	37727 (13520, 46831)	**<0.0001**
2001	58523 (51629, 66908)	38419 (20583, 50115)	**<0.0001**
Male Unemployment Rate (%)			
1991	7.8 (1.6, 15.3)	11.5 (4.3, 17.7)	**0.0115**
1996	10.2 (1.5, 31.7)	12.9 (8.7, 22.2)	0.2438
2001	12.4 (2.3, 35.2)	14.2 (6.0, 36.5)	0.5894
Female Unemployment Rate (%)			
1991	15.3 (5.1,26.2)	12.4 (6.3,24.3)	0.1161
1996	10.5 (0, 25.5)	9.0 (0, 12.7)	0.4501
2001	12.4 (4.9, 33.3)	8.9 (1.8, 19.8)	0.1078
Industry Specific Employment (%)			
1991	32.7 (11.0, 62.0)	17.3 (6.0, 32.0)	**0.0031**
1996	22.8 (10.0, 54.0)	16.2 (7, 26)	0.0928
2001	21.5 (6.0, 53.0)	15.4 (6.0, 25.0)	0.0937

*Bold p-values represent a significant difference between mining and comparison communities at the 0.05 level for each year.

2.5.2 Indices of Economic Sustainability Results

Indices of Economic Sustainability results are summarized in Table 2.2. Overall economic sustainability indicator data indicates that mining communities had higher ID scores (e.g. in Census year 1991 the *mean ID* score=51) than comparison communities (e.g. in Census year 1991 the *mean ID* score=23). However, despite being more dependent overall, dependency

improved (the *ID* decreased) in mining communities by the end of the study period, whereas comparison communities became more dependent (the *ID* increased) on comparative resource sectors (Forestry and Oil and Gas). T-test results indicate a significant difference in the *ID* measure for all Census years between mining and comparison communities, suggesting that mining communities were more dependent on mining than comparison communities were on their associated resource sectors over the study period.

In terms of the DI (diversity index), mining communities consistently scored lower than comparison communities. For instance, the greatest difference between mining and comparison communities in terms of economic diversity occurred in 1991: The *mean DI* score=49 for mining communities and the *mean* DI score=70 for comparison communities (a higher score indicates more (positive) diversity). Over time, diversity increased in mining communities compared to 1991, although the 2001 *DI* value for mining communities was lower than the 1996 value, suggesting some loss in prior progress. Comparison communities experienced an overall increase in diversity through the study period. T-test results indicate a significant difference in the DI measure for all Census years between mining and comparison communities, suggesting that mining communities were less diverse in terms of economic opportunities than other sample communities over the study period.

The VI (vulnerability index) scores were higher in mining communities compared to the other resource based communities, although all resource based communities were found to have a relatively high vulnerability index. For example, in 1991 mining communities had a *mean VI* score of 100 (all communities were completely vulnerable). Other resource based communities in 1991 had a *mean VI* score of 82. Over the study period, the *VI* score for mining communities declined, where as in comparison communities the *VI* increased between 1991 and 1996, and

then declined in 2001. T-test results denote a significant difference in the VI measure for Census year 1991 and a non-significant difference in 1996 and 2001 between mining and comparison communities, signifying that mining communities were more vulnerable to economic downturns at the beginning of the study period than comparison communities.

Table 2-2. Comparison of Community-Level Indices of Economic Sustainability among BC Mining (n=15) and Comparison Resource (n=16) Communities.

	Mining	Comparison	
	Mean (min, max)	**Mean (min, max)**	**p-value***
Income Dependency Index (ID)			
0 to 100 score			
(higher indicating worse dependency)			
1991	51 (20, 86)	23 (5, 46)	**0.0002**
1996	39 (15, 75)	24 (6, 41)	**0.0131**
2001	39 (17, 77)	22 (5, 32)	**0.0047**
Diversity Index (DI)			
0 to 100 score			
(higher indicating better diversity)			
1991	45 (0, 76)	70 (40, 88)	**0.0025**
1996	59 (16, 76)	74 (52, 88)	**0.0289**
2001	57 (12, 80)	76 (68, 88)	**0.0053**
Vulnerability Index (VI)			
0 to 100 score			
(higher indicating worse vulnerability)			
1991	100 (100, 100)	82 (22, 100)	**0.0182**
1996	97 (22, 100)	92 (32, 100)	0.3577
2001	97 (54, 100)	88 (27, 100)	0.2137

*Bold p-values represent a significant difference between mining and comparison communities at the 0.05 level.

2.5.3 Demographic Indicator Results

Demographic Indicator results are summarized in Table 2.3. Overall, comparison communities achieved population growth in 2 out of 3 Census time periods (between 1986 and 1991; and between 1991 and 1996). Conversely, mining communities experienced population decline in 2 out of the 3 Census time periods (between 1991 and 1996; and between 1996 and 2001). To exemplify this point, in the 1991 Census year, 7 out of 15 mining communities experienced

population loss. The average population decline for these communities was 5%. In 1996, 10 mining communities experienced an average decline of 11%. In 2001, all study mining communities experienced population loss with an average decline of 11%. Importantly, communities associated with mine closure incurred larger population losses; a coal mining community in the Northeastern BC lost 51% of its population as a result of mine closure in 2000 and a metal mining community in Northwestern BC lost 45% of its population post mine closure in 1992. Comparison communities fared much better during the study period with respect to population loss. Only 4 out of 16 comparison communities experienced decline with an average decline in 1991 of 3%. In 1996, only one comparison community experienced a decline of 0.5%, and in 2001 9 comparison communities experienced a decline of an average 6%. T-test results indicate a significant difference in population change (%) between mining and comparison communities, for 1996 and 2001 census records with mining incurring larger population losses, and a non-significant difference for the 1991 census record.

Mining communities also had a higher percentage of married residents in 1996 and 2001 Census years (1996 *mean*= 58.1%; 2001 *mean*=56.2%), as compared to comparison communities (1996 *mean*=53.6%; 2001 *mean*=51.1%). T-test results denoting a significant higher percentage of married residents in mining communities for 1996 and 2001 Census years, and a non-significant difference in 1991. Over the study period, the percentage of married residents decreased in both mining and comparison communities. Mining communities also reported on average, a higher percentage of residents who had completed some form of education (including Secondary Certificate, Trades Certificate, College Diploma/Certificate, and University Degree) within community populations (e.g. in 2001 *mean*=53.0%) than comparison communities (e.g. in 2001 *mean*=47.6%). The total percentage of educated residents also increased in both community

types over the decade under study. T-test results suggest the higher percentage of educated individuals in mining communities is significant.

Table 2-3. Comparison of Community-Level Demographic Indicators among BC Mining (n=15) and Comparison Resource (n=16) Communities.

	Mining	Comparison	
	Mean (min, max)	**Mean (min, max)**	**p-value***
Population Change (%)			
1991	3.8 (-10.7, 34.1)	5.2 (-5.7, 15.1)	0.7107
1996	-5.7 (-44.5, 8.4)	7.70 (-0.5, 21.7)	**0.0030**
2001	-10.6 (-51.0, -2.7)	-0.6 (-13.4, 14.3)	**0.0158**
Married (%)			
1991	66.0 (48.0, 75.5)	62.9 (52.3, 69.9)	0.1669
1996	58.1 (51.4, 67.6)	53.6 (47.0, 63.2)	**0.0126**
2001	56.2 (49.0, 63.4)	51.1 (49.0, 63.4)	**0.0042**
Completed Education (%)			
1991	48.1 (42.5, 59.2)	40.8 (34.1, 47.4)	**0.0001**
1996	51.1 (44.6, 61.2)	45.4 (40.3, 53.4)	**0.0024**
2001	53.0 (43.4, 63.2)	47.6 (38.3, 64.4)	**0.0143**

*Bold p-values represent a significant difference between mining and comparison communities at the 0.05 level.

2.6 Discussion

The presentation of the three sets of Census derived indicators along side one another provides a holistic, and detailed view of how these communities have fared over the decade under study (1991 to 2001). Overall, mining communities experienced higher overall incomes from all sources, and higher income and employment rates from their dominant resource sector (mining) as compared to other BC resource communities (dominant resource sectors included forestry, oil and gas, and agriculture). Mining communities were also potentially viewed as attractive destinations for families and educated individuals through the study period. In contrast, although comparison communities were found to be also highly vulnerable to industry downturns, they were less dependent on their dominant resource sector and were economically more diverse than mining communities (as indicated by the Indices of Economic Sustainability). The differences

between mining and other resource communities in terms of the Indices of Economic Sustainability were greatest in the 1991 census data. Improvements over time for mining communities with respect to dependency and diversity decreased the gap by 2001, although mining communities consistently had less positive economic indicators than other resource based communities. Mining communities consistently had a high vulnerability index although the difference between mining and comparison communities also narrowed over time. However, this was mainly due to an increase in vulnerability among the other resource based communities (resulting from increased economic dependency on forestry, and oil and gas over the study period in comparison communities). Assessed alone, mining community Indices of Economic Sustainability are suggestive of potential improvements with respect to community level economic stability, and may indicate that these communities are on the road to becoming more sustainable (as the diversity index has increased in a positive manner over the time period). Economic diversity, after all is a sought after trait for the survival of a one industry town. However, Horne cautions on the reliance of the diversity index as a sole method for assessing the prosperity of a given community: *"A one-industry town that loses its industry probably has increasing diversity as it struggles to avoid becoming a ghost town"* (Horne, 2004 p.42.).

Inclusion of economic and demographic indicators allows for the presentation of a different reality and highlights the advantage comparison communities had over mining based communities during a study period marked by an economic downturn that impacted forest and mining sectors. For example, forest sector comparison communities underwent a gradual decline in forestry related employment, and this decline did not significantly impact community populations. On the other hand, mining communities experienced a greater decline in mining employment and this coincided with population loss, (substantial loss when mine closure occurred), and an elevation in male unemployment rates. Finally, the opportunities present for

women residing in all resource-based communities should be given attention. For example, in 1991 when employment with the mining industry was the highest, and male unemployment rates were low within mining communities, the mean female unemployment rate was at its peak; approximately double the mean 1991 male unemployment rate. Also, the overall female income (from all sources) throughout the study period was also considerably lower than male income (from all sources) in all sample communities, although this difference was greater in mining communities.

In considering the study results, it is important to recognize, that all industries associated with study communities differ significantly in their operations, and use of natural resources. Mining is a non-renewable resource based activity (unlike forestry and agriculture, but similar to oil and gas); and thus the differences between mining communities and other resource based communities (given forest-based communities dominated the comparison study sample) is not surprising. It is possible, with a larger comparison study sample (equal number of communities representing the four sectors), differences between all community types would be present. As the focus of this research has been to contribute to the sustainability of rural/remote mining communities, to assist in explaining research findings, it is necessary to briefly review the nature of the mineral development sector.

Exploration and mineral development activities are totally dependant on environmental, geologic, economic, and technologic circumstances. If a mine is developed, the operational life is also dependant on these factors. In addition, these conditions affect the availability of additional mining jobs once the mine closes. If mining employment is no longer available within a given region, many of those employed need to relocate to find further employment with the mining sector (and associated communities will undoubtedly lose a portion of their population). This is

the nature of the industry. However, as aforementioned, the need to contribute to communities beyond the life of the mine has been well recognized; and ideally, a sustainable mining community should benefit from mineral development post mine closure. Local governance and community capacity building have been identified as important first steps towards reaching this goal (Veiga et al, 2001). It is therefore recommended that associated communities, mining companies and governing bodies collaborate in the development of a community sustainability plan. Such collaboration will give local communities a chance to envision future prospects for their community, and to work with an industry that can assist them in achieving their community planning goals; the presence of mining within a community does provide an economic boost. A collaborated community sustainability plan also demonstrates to governing bodies the required community consultation was a meaningful and engaging process, and can maximize company-community relations. The alternative could lead to more companies endorsing the Fly-in Fly-out (or Long Distance Commuting) model (Shrimpton and Storey, 1992, p. 190) in mineral development plans, which would significantly reduce the economic benefits mining brings to northern rural communities.

2.7 Conclusion

This study investigated how BC resource based communities faired during the last downturn that impacted the mineral and forest sectors. During this period of time (1991 to 2001), the nature of the downturn and resultant community changes differed greatly between mining and other resource based communities. Comparison communities became more dependent on the forest and oil and gas sectors and more vulnerable to industry downturns over time. However, they enhanced their economic diversity. These communities did experience a slight decline in forest sector employment, although this did not coincide with population loss. Mining communities on the other hand, were highly dependent on mining, lacked community diversity, and were

economically vulnerable to industry downturns. This vulnerability was demonstrated when reduced employment with the mining sector coincided with losses (significant in some cases) in community populations and increases in unemployment rates. These findings reinforce the need community sustainability strategic planning, and ideally, for the benefit of mining communities in BC, and globally, this process should be imbedded within mineral development applications and mine impact assessment procedures.

Since the study period, major changes have occurred in BC resource sectors. For example, the Mountain Pine Beetle Infestation has had a devastating impact on the BC Forest Sector and associated communities, and the Oil and Gas boom presently occurring in Northeastern BC has dramatically altered many rural, once agricultural-based communities. Although these changes have not been captured in these analyses, this study is presented as a platform for consideration and discussion, and research findings outlined above do set the context for the need to for communities, governments and corporations to strategize the enhancement of rural community sustainability.

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3 Mental Health and Cardiovascular Disease Rates and Declining Economies in British Columbia Resource-based Communities[2]

3.1 Introduction

Traditionally, epidemiology studies have focused on the identification of individual-level risk factors for disease. However, given the importance of broader determinants of health that may arise from social structures, physical or cultural environments, and the context within which individuals live their lives, epidemiology is increasingly focusing on investigations of the impact of the broader social determinants on health. The different contexts have been described as "macro-pathways" that mediate or modify individual health in populations (Halfon and Hochstein, 2002). Several macro-pathway models have been proposed to explain how various determinants associated with economic, social, physical, cultural, and other environments, including at the community-level, produce different population health outcomes (Brunner and Marmot, 1999; Evans et al., 1994; Hertzman et al., 2001; Evans and Stoddard, 1990). The existence of the macro-pathways in these models is supported by research on the relationships between economic change and the distribution of morbidity and mortality in populations; in particular, studies have demonstrated an association with cardiovascular and mental health outcomes (Ostry, et al., 2006).

Investigations into the relationship between economic change and health outcomes have focused on the effects of unemployment, job insecurity and economic instability. For instance, a recent study of rapid workplace expansion for 24,036 Swedish workers (across many industries) found

[2] A version of the chapter will be submitted to a peer-reviewed journal

a statistically significant increase in both long-term sickness absences and hospital admissions associated with the rapid expansion of workplaces (Westerlund et al., 2004). Rapidly increasing unemployment has also been associated with increased all-cause mortality rates among workers (Martikainen and Valkonen, 1996), and high neighbourhood unemployment rates in London (UK) have been associated with poor self-rated health (Stafford et al., 2004). A study in the British Columbia (BC) sawmill industry (Ostry et al., 2002) found that workers who remained employed in sawmills during extensive restructuring were approximately 50% more likely to report poor health than those who were re-employed elsewhere. In other words, health status was better for workers who, under pressure of massive industry downsizing and change, left the sawmill industry and obtained re-employment elsewhere.

Studies on employees (including blue collar and white collar industries) have established that psychological stress induced by industry instability has a negative effect on mental health (Ostry et al, 2006; Domentighetti et al., 2000; Ferrie et al., 2001; Friis et al., 1998; Ostry et al., 2007). Job insecurity has also been shown to act as a chronic stressor whose effects intensify with increasing exposure over time (Heaney et al., 1994). A 1994 study of mental health outcomes among miners in the United Kingdom found higher rates of psychological distress and morbidity in miners two years after a mine closure compared to working miners and to workers in other professions (Avery et al., 1998).

Several recent articles have also pointed to the effect of socioeconomic context on heart disease mortality after adjusting for individual-level indicators. Literature reviews found consistent relationships between socioeconomic measures of education, income, occupation, employment status, and living conditions and cardiovascular disease, (Kaplan and Keil, 1993; Terris, 1996; Terris, 1999). Neighborhood economic context has also been shown to influence heart disease

mortality and risk factors (Diez-Roux et al., 2004; Franzini and Spears, 2003; Hart et al., 1997; Waitzman and Smith, 1997). For, example, living in economically disadvantaged neighbourhoods increased the risk of cardiovascular death by 50% after adjustment for individual risk factors in a population-based study of elderly men in the US (Diez-Roux et al., 2004). Although it is evident that economic changes affect local economies (and in particular, workers), many cross-sectional studies have focused on worker health. In addition, longitudinal studies have generally investigated community-level characteristics measured at a single point in time in relation to changes in health. Overall, there is a lack of research relating changes in community-level economic indicators to population health in communities reliant on natural resource development over time.

Natural resource development has played an integral role in determining the social, economic and political landscape in Canada, and has played an integral role in shaping the rural Canadian economy. In 1996, over 25 percent of employment in rural communities was based in resource industries (Stedman, 2004). The social, health and economic challenges faced by rural communities are increasingly being recognized in Canada (The Rural Think Tank, 2005). As well, the health and well-being of Canadian rural communities is becoming more of a priority for governments and for health researchers as higher mortality and morbidity rates (for most but not all health outcomes) have been observed in residents of remote and rural communities in comparison to Canadians living in urban centers (Canadian Institute for Health Information, 2006; Ostry, 2009). In the western province of BC, many rural and remote communities have been founded and are economically dependant on mining (Taylor, 1978; Canadian Institute for Health Information, 2006; Randall and Ironside, 1996), a continued key economic driver for the province. According to Shandro et al., (2009, 2010a), many BC mining communities are

vulnerable to the mining boom-bust cycle, that still characterizes and defines economic dynamics in Northern BC (Shandro et al.,2010b; Shandro et al., 2010c).

The purpose of this paper is to report on the relationship between community-level exposure to declining economic conditions and community-level health outcomes (prevalence and incidence rates of heart disease and mental disorders) among residents of BC resource-based communities with a focus on mining communities. The study is retrospective, mainly covering the decade of the 1990's that marked a major recent economic downturn impacting BC resource sectors (mining and forestry). It is hypothesized that individuals living in BC mining communities during periods of economic decline will have an increase in community-level rates of heart disease and mental disorders as compared to stable economic periods and that the effect might be greater in mining communities compared to other resource-based communities. The rationale for this hypothesis stems from associated research findings that identified these study mining communities as highly dependant on mining, lacking in economic diversity, and vulnerable to severe population fluctuations over the same study period (Shandro et al., 2009; Shandro et al., 2010a).

3.2 Methodology

3.2.1 Data Sources

Data for this retrospective study for 29 resource-based communities[3] in British Columbia (University of British Columbia Ethical Review Certificate # B05-0942) was drawn from administrative data from Statistics Canada, BC Ministry of Health data and the BC Vital Statistics Agency. Ministry of Health and Vital Statistics data were accessed via

[3] This study originally included the same 31 communities as described in Chapter 2. However, health data for two other resource-based communities was unavailable, and thereby resulted in the exclusion of two communities.

PopulationDataBC (www.popdata.bc.ca), one of the richest data sources available for health services and health research with population-based data (from 1991 onwards) for virtually all BC residents (Chamberlyne et al., 1998). Specifically, this investigation relied on existing data from a) Statistics Canada Labour Force Survey (LFS) Census data to identify mining and other resource-based communities in BC, b) LFS data to identify community level economic and employment conditions, and c) health contact data (physician visits, hospitalizations, deaths) accessed via PopulationDataBC to construct yearly, community-level rates of cardiovascular disease and mental disorders. The follow-up period was defined as 1991 to 2002 based on the availability of health outcome records at the time of the study.

3.2.2 Study Sample

This was a community-level analysis of rates of disease so the study sample consisted of 29 resource-based communities in the province of British Columbia. Fifteen of the study (mining) communities relied mainly on mining and the fourteen (other resource-based) communities consisted of similar communities but based on other types of resource extraction and processing (mainly forest products). For the purposes of this study, Census Subdivisions (CSDs) were used to geographically define study communities that were further classified as mining or other resource-based. Mining communities (n=15) were identified using the following criteria: 1) Mining was the most common economic activity at one Census point in time during the study period (highest percentage employment income across all possible economic activities) based on Statistics Canada's Labour Force Survey data; and 2) there was an active mine/mine processing plant within the CSD at one point in time during the study period based on government and industry documents. Other resource-based communities were identified using the following criteria: 1) A resource activity (aside from mining) was the most common economic activity in the community (e.g. n=12 forestry, n=1 oil and gas, n=1 agriculture) at one point in time during

the study period using the LFS data; and 2) At least one other resource-based community was chosen within the same census division as a mining community to ensure a matched comparison (two mining communities and one other resource-based community were in the same Census Division resulting in a 15 to 14 ratio of communities).

3.2.3 Outcome Measures

Rates of Cardiovascular and Mental Disorders

Yearly, community-level health rates were constructed as the number of residents with cardiovascular disease or mental health within each follow-up year, divided by the total number of residents in each community for that year. Total number of residents in each of the study communities was available from the Ministry of Health Registry file by using postal code of the resident mapped to the community CSDs. The Registry file is a yearly registration of individuals eligible for health benefits in the provincial health care system. As a universal health care system, the registry is considered comprehensive at the population level for BC residents. Health data available via PopulationDataBC included the provincial Medical Services File (physician and specialist billings), the Hospital Discharge File and the Vital Statistics Mortality File. These records were linked across databases at the individual-level by PopulationDataBC in order to identify unique cases of cardiovascular disease or mental disorders. Personal information was removed from the merged file and a research data file was released to the researchers with an anonymous study identifier.

The health data files included up to a 5-digit International Classification of Disease, 9th edition (ICD-9) diagnostic codes in the hospitalization and vital statistics records and a 3-digit ICD-9 codes in the medical services records until March 31st, 2002 (Practice Management Information Corporation, 2003). Diagnostic codes were selected over procedure codes, as they offer more

specific and sensitive coding for identifying disease. Two broad categories of cardiovascular disease were used for this study (Friesinger, 1999; Levy, 1999): acute coronary syndrome which includes acute myocardial infarction, unstable angina or other acute forms of ischemic heart disease (ICD9 410 or 411) and chronic coronary syndrome which includes stable angina pectoris, other chronic forms of ischemic heart disease, or arteriosclerotic cardiovascular disease (ICD9 413, 414, 429.2). These particular health outcomes were selected as they have been demonstrated to be influenced by environmental, cultural, economic conditions through stress mechanisms. Individuals under the age of 15 were excluded from the cardiovascular outcome definitions.

Mental disorders were defined as depression (ICD9 296.0-296.9, 300.4-300.49, 311.0-311.99), anxiety disorders (ICD9 300.0-300.9), acute/chronic stress reactions (308.0-309.99), or suicide (ICD9 E950-E959). These non-organic/non-congenital mental disorders were also selected as they are impacted by stress (including economic stressors).

By combining health data files, all cases of cardiovascular disease or mental disorders were captured on a yearly basis by the presence of 1) a hospitalization with the aforementioned diagnostic codes as the 'primary diagnosis' or 'most responsible diagnosis' with a separation date in that year; or 2) at least two physician or specialist visits within a 12 month period with the study diagnostic codes (Hertzman et al., 1999) and the first of the two visits occurring in that year; or 3) a vital statistics death record with a study diagnostic code and a death date in that year.

Age and sex standardized annual incidence (number of new cases divided by the population at risk) and prevalence rates (number of existing cases) for the study outcomes were calculated per 1,000 population by study community. We were interested if the effect of economic cycles on

individuals living in mining communities, through physiological stress-related reactions, may trigger the onset of underlying disease (incidence) or may aggravate existing disease (prevalence). Rates were constructed for the three broad categories: Acute CVD, Chronic CVD and Mental Disorders.

Boom-Bust Indicator

In order to assess exposure to economic conditions, a community-level economic indicator was constructed by the research team for each study community for each year during the study period. This indicator was based on the number of people employed within the dominant industry (mining or other resource-based) using Labour Force Survey (LFS) data and government/industry documents in each community. In Canada, detailed LFS data provides estimates of employment (and unemployment) ***(www.statcan.gc.ca)*** at the CSD level. LFS data describing employment conditions for each community was extracted for the 29 study communities for the 1991, 1996 and 2001 Census time periods. Study years were identified as being "stable", "in decline", or in a "bust" cycle. A community was identified as: "stable" if the level of industry-specific employment remained the same or increased from one Census window to the next. A community was identified as "in decline" if employment decreased between Census time periods, or "bust" if there was a decline in industry employment between Census windows in conjunction with a cessation of industry operations such as plant suspension or closure as identified through the evaluation of industry specific data gained from BC government/industry annual reports.

3.2.4 Data Analysis

Data was entered into SAS v. 9.1 (SAS Institute, Cary, NC) for storage, management and analysis. Rates were normally distributed across communities over the entire study period. A generalized linear model (Proc GLM-SAS Institute Inc., 2003) was used to investigate the relationship between community-level exposure to economic change and community level rates of cardiovascular disease and mental disorders across the 29 study communities, stratified by resource community type (mining versus other resource-based). This procedure is used to analyze data within the framework of general linear regression models (continuous measure of cases or rates) using the method of least squares, adjusting for covariates (SAS, 2008). The analyses were conducted for incidence and prevalence cases separately. The GLM models were adjusted for the effect of community and corrected for the correlation of rates within communities (i.e. repeated measures over time).

3.3 Results

3.3.1 Study Sample

Among the 29 study communities, the number of residents per community ranged from 487 to 14,420 over the study period. Table 3.1 summarizes demographic characteristics for mining and other resource-based communities. On average, the percentage of males and females and the distribution by age was similar between the mining and other resource-based communities. A more detailed description of community-level demographic and economic characteristics for this study period can be found in Shandro et al., 2009 and was provided in Chapter 2.

Table 3-1. Study community characteristics.

	Mining Communities (n=15)		Other Resource-based Communities (n=14)	
	1991 Census Year	2001 Census Year	1991 Census Year	2001 Census Year
Total Population	59,975	50,675	64,950	68,970
Distributions	(%)	(%)	(%)	(%)
Male (overall)	51	50	50	50
0-14 years	12	11	12	11
15-64 years	34	34	33	33
65+ years	5	6	5	6
Female (overall)	49	50	50	50
0-14 years	12	9	11	10
15-64 years	32	33	32	33
65+ years	6	8	6	8

3.3.2 Economic Conditions in Mining and Comparison Communities

Over the study period three communities experienced stable economic conditions for the entire study period (all were other resource-based); 19 communities (15 were mining communities, four were other resource-based) transitioned from a stable period at the beginning of the study period, to a period of economic decline; two communities transitioned from declining conditions in the beginning of the study period to a stable period (both were other resource-based); five communities experienced economic decline for the entire duration of the study period (all were other resource-based); and four mining communities in addition to periods of economic decline, were also exposed to bust conditions (due to mine closures).

3.3.3 Cardiovascular Disease and Mental Disorder Rates in Study Communities

A total of 319 yearly health rates were calculated for each of the three study outcomes of acute and chronic cardiovascular disease and for mental disorders (29 communities by 11 years of follow-up for each community). The mean rates were compared descriptively for mining and

other resource based communities by the economic periods defined as stable, decline or bust. Prevalence rates are summarized in Table 3.2, and incidence rates are summarized in Table 3.3. As seen in Table 3.2, the mean yearly prevalence rate of acute cardiovascular disease was similar between mining and other resource-based communities, but other resource-based communities had slightly higher mean yearly prevalence rates of chronic cardiovascular disease and mental disorders.

In mining communities, we observed that the mean yearly prevalence rate for acute cardiovascular disease and mental disorders were higher during decline and bust periods as compared with stable periods; whereas the rate for chronic cardiovascular disease was lower. In other resource-based communities, the yearly prevalence rate for acute and chronic cardiovascular disease was higher during periods of decline versus stable periods, and the rate for mental disorders was lower for decline periods as compared to stable periods. Changes in incidence rates (Table 3.3) across stable, decline, and bust periods were less pronounced than changes in prevalence rates for all health indicators (acute and chronic cardiovascular diseases and for mental disorders).

Table 3-2. Comparison of age- and sex- adjusted cardiovascular and mental disorder prevalence rates across stable, in decline, and communities in a bust cycle (n=29 communities).

Health Indicator	MINING COMMUNITIES (n=15) Mean Yearly Rate per 1000 (sd)			
	Study Period	Stable Periods	Decline Periods	Bust Periods
Prevalence				
Acute Cardiovascular Disease	61.7 (26.3)	51.6 (21.2)	65.7 (27.1)	62.6 (29.3)
Chronic Cardiovascular Disease	12.2 (4.9)	13.1 (5.5)	11.9 (4.6)	11.9 (5.1)
Mental Disorders	46.3 (19.6)	37.1 (17.0)	50.7 (19.3)	43.5(19.3)

Health Indicator	OTHER RESOURCE-BASED COMMUNITIES (n=14) Mean Yearly Rate per 1000 (sd)			
	Study Period	Stable Periods	Decline Periods	Bust Periods
Prevalence				
Acute Cardiovascular Disease	61.3 (21.9)	59.7 (14.4)	62.3 (25.7)	*
Chronic Cardiovascular Disease	15.8 (7.1)	13.9 (3.9)	17.1 (8.4)	*
Mental Disorders	52.1 (21.1)	53.3 (19.2)	51.3 (22.3)	*

*Other resource-based communities did not experience plant closure during the study period.

Table 3-3. Comparison of age- and sex- adjusted cardiovascular and mental disorder incidence rates across stable, in decline, and communities in a bust cycle (n=29 communities).

Health Indicator	MINING COMMUNITIES (n=15) Mean Yearly Rate per 1000 (sd)			
	Study Period	Stable Periods	Decline Periods	Bust Periods
Incidence				
Acute Cardiovascular Disease	15.0 (6.0)	15.3 (6.8)	14.2 (4.8)	17.9 (8.2)
Chronic Cardiovascular Disease	5.8 (2.9)	7.3 (3.6)	5.1 (2.0)	6.2 (3.5)
Mental Disorders	18.5 (7.3)	20.3 (7.9)	18.1 (6.6)	16.6 (8.3)

Health Indicator	OTHER RESOURCE-BASED COMMUNITIES (n=14) Mean Yearly Rate per 1000 (sd)			
	Study Period	Stable Periods	Decline Periods	Bust Periods
Incidence				
Acute Cardiovascular Disease	14.8 (4.7)	15.0 (4.3)	14.7 (4.9)	*
Chronic Cardiovascular Disease	7.1 (3.8)	5.9 (2.1)	7.8 (4.4)	*
Mental Disorders	20.6 (8.8)	22.2 (9.8)	19.5 (7.9)	*

*Other resource-based communities did not experience plant closure during the study period.

3.3.4 Relationship between Economic Conditions and Health Outcomes

Results from the GLM models adjusted for community, to investigate the relationship between community-level exposure to economic change (periods of boom, bust or stable) and community level rates of cardiovascular disease and mental disorders across the 29 study communities, stratified by community type (mining versus other), are summarized in Table 3.4.

Prevalence

Acute Cardiovascular Disease: In mining communities, a statistically significant increase in the yearly community-level prevalence rate by 13.0 cases per 1000 population for acute cardiovascular disease was observed during periods of economic decline compared to stable periods. A statistically significant increase in the prevalence rate by 30.1 cases per 1000 was also seen during bust periods (marked by mine closure). In other resource-based communities, a smaller increase in the acute cardiovascular disease rate was observed (4.5 cases per 1000) during decline periods, compared to stable economic periods. This difference was not statistically significant.

Chronic Cardiovascular Disease: In mining communities, there was no significant change in the rate of chronic cardiovascular disease across economic comparison periods (decrease of 1 case per 1000 residents for bust and decline compared to stable periods). Other resource-based communities demonstrated a slight increase in the prevalence of chronic cardiovascular disease conditions by 1.2 cases per 1000 during decline compared to stable periods.

Mental Disorders; The prevalence rate of mental disorders in mining communities increased by a statistically significant amount during decline economic periods by 13.2 cases per 1000 compared to stable periods. Rates also increased during bust periods by 5 cases per 1000,

although this increase was not statistically significant. In contrast, the rate in other resource-based communities decreased by 9.4 cases per 1000 during decline compared to steady periods; the decline was statistically significant.

Incidence:

Acute Cardiovascular Disease: We observed slight, statistically non-significant decreases in the incidence rate of acute cardiovascular disease during decline periods as compared with stable periods for both mining and other resource-based communities (decrease by 1.2 cases per 1000). A small statistically non-significant increase in the incidence rate of acute cardiovascular disease by 1.6 cases per 1000 was observed for bust periods, as compared to stable periods in mining communities.

Chronic Cardiovascular Disease: Statistically significant changes were observed for the incidence of chronic cardiovascular disease in mining communities during decline versus stable periods of mining employment (2.2 fewer cases per 1000) and during decline versus bust periods (1.9 fewer cases per 1000). In other resource-based communities no change was observed.

Mental Disorders: Statistically significant decreases in the incidence of mental disorders was observed for decline periods versus stable periods in mining (decrease by 2.4 cases per 1000) and in other resource-based communities (decrease by 8.7 cases per 1000). A decrease in the incidence of mental disorders by 4.5 cases per 1000 was also observed in mining communities for bust periods as compared to stable periods, and this decrease was also statistically significant.

Table 3-4. Relationship between community-level exposure to economic change and community-level rates of cardiovascular disease and mental disorders.*

		Mining Communities (n=15)		Other Resource Communities (n=14)	
Health Indicator	**Economic Conditions**	Change in Rate	p-values	Change in Rate	p-values
Prevalence					
Acute Cardiovascular Disease	Decline vs Stable	**13.0**	**<0.0001**	4.5	0.28
	Bust vs Stable	**30.1**	**<0.0001**	NA	NA
Chronic Cardiovascular Disease	Decline vs Stable	-1.1	0.39	1.3	0.13
	Bust vs Stable	-1.2	0.06	NA	NA
Mental Disorders	Decline vs Stable	**13.2**	**<0.0001**	**-9.4**	**0.004**
	Bust vs Stable	5.0	0.20	NA	NA
Incidence					
Acute Cardiovascular Disease	Decline vs Stable	-1.2	0.18	-1.2	0.26
	Bust vs Stable	1.6	0.38	NA	NA
Chronic Cardiovascular Disease	Decline vs Stable	**-2.2**	**<0.0001**	0.1	0.88
	Bust vs Stable	**-1.9**	**0.04**	NA	NA
Mental Disorders	Decline vs Stable	**-2.4**	**0.02**	**-8.7**	**<0.0001**
	Bust vs Stable	**-4.5**	**0.03**	NA	NA

*Bold p-values represent a significant difference between economic periods at the 0.05 levelModels adjusted for community and for repeated measures within community.

3.4 Discussion

In the period under study (1991 to 2002), we observed that deteriorating economic conditions characterized by a decrease in community-level industry-specific employment had a negative impact on the prevalence of acute cardiovascular disease and mental disorders in mining communities and chronic cardiovascular disease in other resource-based (mainly forestry) communities.

While there are few multi-community studies that have investigated the relationship between economic conditions in mining communities and health outcomes over time, results from this exploratory study are consistent with findings from other studies on the impact of the economic environment on the health of residents of British Columbian communities that are primarily based on resource extraction and processing. For example, in studies conducted in Northern BC, the influx of transient resource-based workers, with high disposable incomes, has had a demonstrated negative impact on the health, especially of already vulnerable residents, in two northern BC communities (Goldenberg et al., 2008a; Goldenberg et al., 2010; Shandro et al., 2010d). In a study in a northern BC community experiencing an oil and gas boom Goldenberg et al. (2008a, 2009a, 2009b, 2010) also identified an acute lack of important basic health services. And, in a coal mining community located in northeastern BC Shandro et al. (2010d) has documented the overextension and heavy burden placed on existing health services by the needs of an ever-expanding mining workforce. As well, in a research program devoted specifically to understanding the relationship between adverse social and economic conditions and the health of rural and northern British Columbians, Ostry and the New Emerging Team for Health in Rural and Northern British Columbia (NETHRN-BC) have demonstrated the links between adverse economic conditions in some of these communities and adverse health outcomes among

residents (Ostry et al., 2002; Ostry et al., 2009a; Ostry et al., 2010; Nelson et al., 2010; Ostry, 2009b; Ostry, 2009c; Ostry, 2003; Ostry 2001; Ostry 2000a; Ostry 2000b).

In addition to supporting evidence, the 1990s decade witnessed a major economic collapse for mining in BC. While the same decade was difficult for forestry communities, economic and socio-demographic data indicate this period of time was less difficult than it was for mining communities (as demonstrated in Chapter 2; Shandro et al., 2010). A detailed review of the study period, and additional contextual information, helps to explain the differences in health outcomes between mining and other resource-based communities and the differences in prevalence and incidence rates.

For the mining sector, the first three years of the study period (1991 to 1993) were marked by a decrease in exploration expenditures, mining revenues, and employment (Ministry of Energy, Mines, and Petroleum Resources, 1992a; Ministry of Energy, Mines, and Petroleum Resources, 1994). Low metal markets, increased regulation, increased global competition and a lack of risk financing were all contributing factors to this decline (Ministry of Energy, Mines, and Petroleum Resources, 1992b). In 1995, the industry experienced a brief revitalization, spurred generally by higher metal and coal prices, a weaker Canadian dollar, the introduction of a BC government industry tax cut, and the launching of Explore BC (the BC Government provided approximately $3.5 million in exploration grants) (Ministry of Energy, Mines, and Petroleum Resources, 1995). The BC government underwent some significant transformations during this period by temporarily integrating the Ministry of Energy, Mines and Petroleum Resources with the Ministry of Employment and Investment (Ministry of Employment and Investment, 1996). In 1996, exploration activities began to decline, and by 1998 sharp decreases were felt through exploration expenditures, and mineral production. Globally, the mining and mineral exploration

industries faced restrained activities as low metal and coal prices were coupled with an economic crisis in Asia (Ministry of Energy and Mines, 1999). The 1990's ended with a continued difficult period of time for the mining industry; existing metal mines for the most part continued production, however, Highland Valley Copper mine, BC's largest metal mine suffered a five month shutdown. Low prices for coal and most metals continued into 2000, and resulted in the premature closure of the Quintette Coal Mine in Tumbler Ridge, BC. In 2001 after over a century of production, the Sullivan mine in Kimberly, BC was permanently closed due to ore exhaustion.

The majority of other resource-based communities were dependent on forestry activities (n=12), although one study community relied on oil and gas (n=1) and another on agriculture (n=1). Over the study period oil and gas development steadily increased in the northeastern region of BC, and agriculture remained a consistent economic opportunity in the south-central region. On the other hand, the forest sector has undergone enormous transformations over the past few decades in BC. Prior to the study period, the forest sector experienced a major economic depression, in which more than 23, 000 people lost their jobs. This downturn continued during the study period with the permanent loss of approximately 6,000 additional BC forest sector jobs (Beatty and Hamilton, 1998 as cited in Markey and Pierce, 1999). Rural and northern BC communities were strongly impacted during the 1990's as many small sawmills located in these regions disappeared with the consolidation and centralization of the forest industry (Ostry et al, 2001). The BC forest sector continued to undergo significant changes as the American soft-wood lumber tariff placed a considerable amount of strain on the industry (Markey et al., 1999). In addition, the study period was marked by the introduction of a variety of new Forest Practice Codes aimed at improving the BC sector (Markey et al., 1999). However, these policy changes

limited the access and control rural and northern communities had previously had over their local forest resources (Stedman et al., 2004; Stedman et al., 2005).

While forest-based industries have undergone significant changes, these resource-based communities experienced more gradual declining employment conditions in comparison to mining communities. Other resource-based communities in our study also demonstrated more stability within their populations, and in many cases, experienced population growth (Shandro et al., 2009; Shandro et al., 2010a;). In addition, over the study period the ratio of people employed in resource industry to community residents was greater in mining communities than in other resource-based communities; BC mining communities were observed to be economically more dependant on mining than other resource-based communities were on comparison sectors; mining communities had lower community economic diversity and were found to be more vulnerable to economic downturns than other resource-based communities (Shandro et al., 2009; Shandro et al., 2010a); and stress and mental disorders were community health impacts reported by health care providers in a Northern BC mining community as being prominent during declining economic conditions that preempted mine closure (Shandro et al., 2010d).

Economic conditions as captured by industry employment in this study also identify that the nature of mineral development projects have been starkly different than other sectors over the study period. Mine suspensions and closures occurred rapidly, and closures coincided with dramatic community-level changes within short time frames (Shandro et al., 2009; Shandro et al., 2010a). To exemplify this point, many study mining communities experienced population loss and in some cases drastic reductions in populations (over 50% population loss) were observed post mine closure (Shandro et al., 2009; Shandro et al., 2010a;). In contrast, other resource-based communities observed no periods of plant closure. Also the combination of the

economic decline observed in most mining communities and the low availability of alternative economic options present in study mining communities (Shandro et al., 2009; Shandro et al., 2010a) mean that residents of mining communities are likely acutely aware that declining conditions threaten livelihoods. These key characteristics lead to the expectation that mining communities could be experiencing increased stress, and thus have a higher prevalence of mental health and acute cardiovascular disease compared to other resource-based communities.

In contrast to prevalence rates, incidence rates were not adversely affected by economic conditions in the study communities. It is possible that during periods of economic decline individuals who are at risk for new cases of disease (generally the younger population demographic) relocated elsewhere to find work resulting in the observed decrease in the rates, albeit small decreases that were not statistically significant. Therefore, these potential new cases were not captured. It is also possible that there was insufficient follow-up time or latency period to capture the effects of the economic cycles on the onset of new disease such as cardiovascular outcomes, the effect of which may not been seen until decades after living through economic cycles in mining communities. Finally, it is also possible that the impact of economic change within a community is felt more by those who already have underlying conditions, symptoms, and prior health history, and thus declining conditions may aggravate existing, prevalent cases of illness and disease.

As the focus of the research study was on mining communities, it is important to highlight the implications of these findings for the mining sector. Internationally, in Canada, and in British Columbia, the mining industry has committed to the well-being of associated communities. As examples, the International Council on Mining and Metals (ICMM), a representation of 19 mining companies and 30 national and regional mining associations aims to "*Implement good*

practice and innovate to improve social, environmental and economic performance while enhancing shareholder value" (ICMM, 2008, pg 9) and "*Enhance social and economic development by seeking opportunities to address poverty; Report on our economic, social and environmental performance and contribution to sustainable development*" (ICMM, 2008, pg 11). The Mining Association of Canada in their Towards Sustainable Mining initiative has expressed the need to "*provide lasting benefits to local communities through self-sustaining programs to enhance the economic, environmental, social, educational and health care standards they enjoy"* (Mining Association of Canada, 2004, pg 1.). In addition, the British Columbia Ministry of Energy, Mines and Petroleum Resources has pledged to "*support: strong, enduring relationships between the mining industry, communities and First Nations; the development and implementation of a made-in-British Columbia approach to sustainable exploration, mining and communities*" in their BC Mining Plan (Ministry of Energy, Mines and Petroleum Resources, 2005, pg 11). However, determinants of health outside the realm of the physical environment have only been recently highlighted as important considerations during the assessment of potential health impacts associated with mineral development (ICMM, 2010). It is therefore the hope that this study strengthens the importance of health determinants within the economic and social dimension, and highlights the need for recognizing, planning for, and mitigating potential impacts mining operations can have on communities; especially in rural and remote locations where economic dependency on mineral development is generally high.

3.5 Conclusion

We observed that declining economic conditions had a negative impact on the age-sex adjusted prevalence rates of acute cardiovascular disease and mental disorders in mining communities, many of which were located in rural and Northern BC. Specifically, acute cardiovascular disease and mental health prevalence results were worse for mining versus other resource-based

communities and these outcomes illuminate how deteriorating economic environments can impact health through stress pathways. Our findings suggest that these health outcomes require attention by industry and government in their planning and mitigation for potential health impacts as a result of industrial development, especially given the current global economy. The recent recognition of the importance of community health by mining sector leaders (ICMM, 2010) may help to reduce the burden of mental disorders and cardiovascular disease within mining communities.

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4 Perspectives on Community Health Issues and the Mining Boom-Bust Cycle[4]

4.1 Introduction

Today, governments, non-governmental organizations, communities, and mining organizations expect mining companies to plan for and mitigate health impacts associated with development projects. The mining sector has recognized the importance of health and has made specific commitments to enhancing the health of associated communities. For instance, the International Council on Mining and Metals (ICMM) identify in their Sustainable Development Framework that corporate members are committed to implement and measure their performance against ten principals. Under Principal 5: *Seek continued improvement of our health and safety*, the ICMM identifies this to include implementing *" a management system focused on continual improvement of all aspects of operations that could have a significant impact on the health and safety of our own employees, those of contractors and the communities where we operate*" (ICMM, 2008, pg10.). These commitments follow the recognition that "*beyond work related diseases, few endeavours attempt to prevent diseases that affect the wider community or to consider the community's broader well-being"* (MMSD, 2002, pg. xx)*;* and that "*Ensuring that improved health and education or economic activity will endure after mines close requires a level of planning that has too often not been achieved"* (MMSD, 2002 pg. xvii). The following section highlights literature related to community health and the mining sector as developed by international organizations over the past decade.

[4] A version of this chapter has been submitted: **Shandro**, J.A., Veiga, M.M. Shoveller, J., Scoble, M., and Koehoorn, M. 2010. Perspectives on community health issues and the mining boom-bust cycle.

The most comprehensive report available to date related to mining community health is the literature review of worker and community health and mining by Stephens and Ahern (2002) as part of the Mining, Minerals and Sustainable Development (MMSD) project. This review identifies the focus of mining community health research as historically focused on community exposure to environmental toxins (Stephens & Ahern, 2002). The final report of the MMSD project *Breaking New Ground* reports community health as an important parameter in their chapter on Local Communities and Mines (MMSD, 2002 Chapter 9, pg 203). However, the description of community health issues is limited to four paragraphs, and there lacks a detailed description of issues a mining company can/should address in impact/sustainable development/community relations planning (MMSD, 2002). In 2003, the International Finance Corporation (IFC) limits their definition of potential health affects to changes in nutritional status, mortality and morbidity, HIV and other communicable diseases, endemic diseases, impacts of in-migration on health services and associated infrastructure, and environmental (exposure) – health impacts (IFC, 2003 pg. 12). More recently, the IFC released a guidebook to introduce the Health Impact Assessment (HIA) procedure with main objectives of: providing guidance to associated corporations in relation to the HIA process; and assisting in assessing potential impacts to community health as a result of project development. However, the HIA process as outlined by the IFC is limited to environmental health areas, and does not mention health issues associated with other determinants of health (IFC, 2009).

Health impacts such as changes in nutritional status, rates of communicable diseases or illness from environmental exposure are important issues for the mining industry to consider, plan for and mitigate. However, as the mining sector is now engaged in directives that commit to sustainable development and corporate social responsibility, it is necessary to update the concept of community health, and incorporate this into mine planning. The World Health Organization

(WHO) defines health as "*a state of complete physical and mental and social well-being and not purely the presence or absence of disease*" (WHO, 1948, pg 100) and "*the extent to which an individual or a group is able, on the one hand, to realize aspirations and to satisfy needs, and on the other, to change or cope with the environment*" (WHO, 1986, pg 1.). Recently, the mining sector published an important document regarding the health of communities: the International Council on Mining and Metals (ICMM) Good Practice Guidance on Health Impact Assessment (ICMM, 2010). This guidebook represents the first reference material produced by the mining sector that describes health beyond the presence and absence of disease or environmental exposures and includes other factors that impact health (ICMM, 2010). Commonly referred to as determinants of health, these factors can include: income and social status, social support networks, education, employment and working conditions, social environments, physical environments, personal health practices and coping skills, healthy child development, biology and genetic endowment, health services, gender, and culture (Health Canada, 2004).

This paper describes the results of an exploratory qualitative investigation into community health issues and the boom-bust mining cycle from the perspective of health and social service providers in a remote Canadian coal mining community. The study is based on the assumption that experiences and perceptions of health and social service providers are integral to understanding how the mining boom-bust cycle may affect community health issues. To begin, the Canadian/British Columbia mining context is briefly described with a focus on the commitment made to communities. The next section provides a socio-economic description of the study community; Tumbler Ridge, BC. This is followed by a detailed explanation of the study's method including data collection and analysis, and presentation of main findings. The final section discusses the results and highlights policy implications for the mining sector, governments and researchers.

4.2 Study Setting

4.2.1 Health Commitments to Mining Communities in Canada and in British Columbia

In Canada, the health of rural/remote mining communities has garnered little attention, although rural communities in general have become a priority for governments, researchers, and industry. This is especially the case since the global economic recession has left few rural communities unscathed, as many are dependent on natural resource development. To exemplify this point, the Canadian Government recently recognized the need to strengthen economic prosperity and social cohesiveness in rural communities. As such, $1 billion (CAD) over two years has been allocated, through the Community Adjustment Fund (CAF), to assist rural communities that are heavily reliant on resource-based industries, including mining (Department of Finance Canada, 2009), Western Economic Diversification Canada (WD) is the responsible governmental institution for delivering CAF funds in British Columbia, and to date, a total of 1092 CAF applications have been submitted to CAF, exceeding $2 billion (CAD) through WD (Western Economic Diversification Canada, 2010). In Northern BC, an additional 477 CAF applications were submitted for a total of $685 million in program funding. The Northern Development Initiative Trust is an additional example of a current funding strategy targeting the sustainability of northern and rural communities in British Columbia. BC mining municipalities such as Logan Lake, Granisle, Stewart, and Tumbler Ridge have all applied for, and received funds from this initiative (Northern Development Initiative Trust, 2008).

Within the mining sector, additional commitments have been made to communities. For example, in 2004, The *Towards Sustainable Mining* framework developed by the Mining

Association of Canada (MAC), representing many Canadian companies indicated that MAC members will "*provide lasting benefits to local communities through self-sustaining programs to enhance the economic, environmental, social, educational and health care standards they enjoy*" (MAC, 2004, pg. 1). In the western Canadian province of British Columbia (BC), the Government committed to supporting "*strong, enduring relationships between the mining industry, communities and First Nations; the development and implementation of a made-in-British Columbia approach to sustainable exploration, mining and communities*" in their 2005 Mining Plan (MEMPR, 2005, pg. 11). To recognize achievements in the field and sustainable development, the Mining Association of British Columbia (MABC) and MEMPR identified "*enhancing the potential for creating economic, social, and cultural benefits for local communities or regions*" as a key criterion (MABC, 2009). While the commitments made by MAC, MABC, and MEMPR are strong, mining communities in Canada and BC are at present applying for and requiring financial assistance from federal and provincial sources. In addition, many mining communities in British Columbia have demonstrated economic vulnerability, demographic instability (Shandro et al, 2010), and negative health impacts (Shandro et al, 2010) as a result of declining economic and employment conditions. The community of Tumbler Ridge, the last Canadian locale to be developed solely for the purpose of coal mining, is an example of where industries and governments commitments are not being fulfilled.

4.2.2 The Community

Coal, in Canada and in BC, represents an important commodity; BC produces approximately 73% of Canada's coal (Natural Resources Canada, 2009), and coal represents 51% of the total provincial mineral production (MEMPR, 2009). Tumbler Ridge, is a remote coal mining community in northeastern BC, located in proximity to four operating mines. Last year (2009) coal mines in the Tumbler Ridge region (there were three operating mines in 2009) produced

approximately 2,936,000 t representing 14% of the total coal produced in BC (Ministry of Energy Mines and Petroleum Resources, 2009). Tumbler Ridge is located approximately 1200 kilometers northeast of Vancouver, the largest city in BC. The municipality of Tumbler Ridge, along with the nearby communities of Chetwynd, and Dawson Creek, belong to the Peace River Regional District (District of Tumbler Ridge, 2009).

To date, Tumbler Ridge represents the last community in BC to be developed under the *Instant Towns Policy* (Campbell, 1965) to support the extraction of 100 million tonnes of metallurgical coal destined for Japan. Planning for Tumbler Ridge began in 1976, following applications to develop two open pit coal mines (the Bullmoose Mine and the Quinette Mine). Size and infrastructure requirements for the proposed projects and town development required a partnership between the provincial government and mining corporations. The provincial government was responsible for town site planning and infrastructure of public areas, contributing an unprecedented one billion dollars towards this effort. Companies were responsible for mine development and construction of employee housing within the town site (District of Tumbler Ridge, 2005). Incorporated on April 9, 1981, inhabitation and mining in the Tumbler Ridge area began shortly after in 1983. By incorporation, both of the first two coal mines in the Tumbler Ridge area were in operation.

A large proportion of the community's population was employed at the Quintette and the Bullmoose Mines. For example, in 1991, 57% of the total number of employed people in Tumbler Ridge worked in the mining sector (Statistics Canada, 1991). Declining coal prices and the subsequent collapse of global coal resulted in premature closure of the Quintette Mine in 2000 (Jen, 2000), prompting a decline in mining employment by over 400% (Statistics Canada, 1991; Statistics Canada 2001). The smaller Bullmoose Mine closed shortly after, due to ore

exhaustion (Jen, 2003). As a result of the Quintette and Bullmoose mine closure, many people departed from Tumbler Ridge to pursue other economic opportunities (District of Tumbler Ridge, 2005). The first Census population record for Tumbler Ridge in 1986 was 4,387 residents (BC Stats, 1988). In 2001, coinciding with closure of the Quintette Mine, the population plummeted to 1,851 (BC Stats, 2001). In July 2002, an attempt to sustain the community was made through an innovative housing transfer and sale. Houses in Tumbler Ridge were previously owned by mining corporations, and as a contribution to the sustainability of the community, these homes were put up for sale at well below assessed values. This led to approximately 900 sales of vacant homes, many were purchased "*sight unseen*" (District of Tumbler Ridge, 2005 pg 5). A large proportion of homes were purchased by retirees (District of Tumbler Ridge, 2005), and relocation of these individuals radically shifted the demographic composition of the community. Post housing sale, the community began to diversify into the tourist sector, and attracted oil and gas, wind power, and forestry development.

Despite economic diversification, an elevation in coal prices and increased demand for metallurgical coal has renewed interest in coal properties in the Tumbler Ridge region, and mining today has become the dominant employer once again. In addition to the four operating mines, there are three mine projects in the Environmental Assessment process, and three in the exploration/development stage. The population has rebounded to an estimated 3,500 with a future projection of over 6,000 (District of Tumbler Ridge, 2010). In addition, housing is in high demand: rental properties are coveted, and homes once purchased when the Quintette Mine closed for approximately $25,000 are now selling for $199,000 (District of Tumbler Ridge, 2010). The altered demography of the community has posed additional challenges. The original development of the town seemingly lacked consideration of needs for aged or disabled populations. As examples, all residential homes had stairs, no elevators were installed in service

buildings, automatic doors and transportation options were non-existent, and support services were designed for a younger demography (District of Tumbler Ridge, 2008).

As of October 2009, all health and related services were available at one location. Services included: family practice run by two physicians, 24 hour emergency services (through a diagnostic and treatment centre) serviced by three nurses and the two family physicians (with one physician available from Dawson Creek), mental health and addiction counseling, Safe Home Project, Women's Crisis, public health, home care, X-ray and laboratory services, massage therapy, optometry, and visiting specialists.

4.3 Study Design and Methods

This exploratory study was informed by qualitative research methods. The study design assumes that experiences and perceptions of health and social service providers are essential to understanding how the mining boom-bust cycle may affect community health. Qualitative research has proven to be of value in the field of health and policy (Sofaer, 1999). While it was guided by a grounded theory approach (Glaser and Strauss, 1967, Corbin and Strauss, 2008), the final aim of the analysis did not include the development of a theoretical model. Rather, data gathered from interviews was used to generate rich descriptions of mining community health issues. The University of British Columbia Behavioural Research Ethics Board provided approval for this study.

4.3.1 Recruitment and Sampling within the Community

Participants were selected purposefully (Corbin and Strauss, 2008) and met the following criteria: participants were employed in the community health or social service sector and had worked in their respective position long enough as to have experienced a boom or bust in mining

activity. Key health and social services in the community were identified and administrators of these services were invited to participate in the study in order to provide insights into general community health impacts.

Within the community a total of 13 potential participants that met the recruitment criteria were identified. These individuals held positions as hospital administrators, physicians, nurses, mental health and addictions counselors, women's health counselors, crisis outreach workers, health consultants, and community policy makers who had strong knowledge of the mining sector and general community health issues (such as municipal mayors). Of the 13 candidates, three were unavailable, and ten were recruited and interviewed. Interviews were conducted with four men and six women; seven health care providers and three social service providers. Of the ten participants, six had spent over a decade in the Tumbler Ridge area and were employed during the closure of the Quintette and Bullmoose mines. One social service provider had previously been employed with the Quintette mine and had played an important role in developing community health and mine workers health programs (such as mine site addiction counseling and the community transition house for abused women).

4.3.2 Data Collection

Data collection involved field work, observations, and interviews with health and social service providers. Fieldwork activities included: informal conversations with mining industry representatives and local policy makers; visiting local health authorities; attending a regional mineral development forum; reading local newspapers and histories of Tumbler Ridge and the surrounding Peace River Region; and participating in a workshop between mining industry representatives, local health care providers, and community leaders to discuss mining community health and sustainability (Shandro et al, 2010). Various governmental, academic, mining, and

community documents associated with Tumbler Ridge were also collected and read. In addition, informal conversations with mining industry and community representatives were held.

Interviews (n=10) were semi-structured; this style of interviewing elicits participant viewpoints (Creswell, 2003) and facilitates comparisons across interviews (Cohen and Crabtree, 2006). Interviews were conducted by the first author (JS) who had training[5] in qualitative data collection. The interviews consisted of open-ended questions and were of a conversational nature. They focused on general community health issues and health issues specific to men and to women as related to the boom and bust cyclical nature of mining. Participants were also asked to provide their opinion on how the mining industry could contribute towards improving community health. Each participant provided informed consent, including permission to audiotape the interview. Interviews took place in Tumbler Ridge, in the interviewee's office or meeting room, or via telephone. Each interview lasted between 45 and 60 minutes. Observations and additional field notes were recorded during and after the interview. Member checks were conducted in real time (during the interview) and in follow up to ensure accuracy of data and interpretation.

4.3.3 Data Analysis

Utilizing grounded theory techniques, this study involved simultaneous and sequential collection and analysis of data using inductive, constant comparison methods (Corbin and Strauss, 2008). In following this approach, data analysis began with the completion of the first interview (Glaser & Strauss, 1967; Corbin and Strauss, 2008). Interviews were transcribed verbatim and field notes

[5] In October 2008, Janis Shandro attended the 9th Advances in Qualitative Methods Conference and the 14th International Qualitative Health Research Conference, in Banff, Alberta. At these venues she completed five training courses in qualitative research including: Coding & Categorization of Qualitative Data: Laying the Foundation for Effective Data; Developing Inclusive Research Samples; Community-Based Participatory Research; Accounting For Selected Social Determinants of Health in Qualitative Health Research; and Making A Convincing Argument With Qualitative Data.

synthesized with transcripts. Interview transcripts were reviewed and data analyzed using open coding and the constant comparison method (Corbin and Strauss, 2008) to identify emergent themes that described community health issues in Tumbler Ridge.

4.4 Results

Health issues related to the mining boom-bust cycle that were described by interview participants have been organized under the following themes: Family Health, Women's Health, Mental Health and Addictions, Mine Workers Health, and Health and Social Services. The final section of the results reports on the recommendations health and social service providers had for the mining industry to consider. Each theme is detailed in the following sections and includes participant quotes to illustrate important aspects of the theme that are identified by interview and transcript line number (e.g. I1L25 would be interview #1, line 25 on transcript).

4.4.1 Family Health

"*Family is so important for one's health*" (I2L200). Most participants identified family as being key to the health of the overall community and to individuals during boom and bust periods. Working conditions at the mine during boom times and stress during bust times were key factors affecting the family and were attributed to divorce, violence, and stress. Family was also considered by participants to extend beyond the nuclear family to include others involved in the mining community. For many interviewed, the notion of family went beyond immediate relations, "*there is a network of people that know each other; generations of families have moved here*" (I2L149). For people that did not have kin in the community, "*your neighbors and your friends become your family"* (I3L284); "*you became family with each other, no one was born here"* (I3L279). All participants identified closeness with one another; and related this to mining having brought them together.

Participants recounted that for many families in the community at least one parent works at the mine and this parent was usually the father/husband. Almost all participants identified the mining shift rotations as stressful for both parents. They identified that for mothers, there were difficulties securing child-care, meaning many stayed at home with their children. With the long shift rotations "*It's a disconnect when he's away*" (I1L202). For fathers, *"When you get up at 5 to go to work and you get home at 8:30, when you're doing a daytime shift, you're exhausted; you eat and go to sleep. There is not any connection on that kind of shift with the family and what's going on with the family…"* (I2L182).

All participants identified bust periods as stressful for families. There were financial hardships, the process of moving a family to a different community to find new employment, and uncertainty about the future. Bust periods were also identified by participants as particularly difficult times for families who stay in the community. Many men embarked on long distance commuting which contributed additional strain for the nuclear family. This employment option, often referred to as fly in fly out operations, typically entails two weeks away working at a remote location, and two weeks of time off when the worker can return home. *"It's just very tough having a family, and having to move, when you don't want to move. And then you had the other folks that were staying regardless, listen we're prepared to wait one or two or three years for things to come back, and they're hoping they made the right decision, and that in itself is stressful. And there is no income for a few years"*(I8L251)

Family counseling services were available in Tumbler Ridge during the operations of the Quintette and Bullmoose mines. However, with the decline in population that occurred as a result of mine closure, this health service was eliminated by the Northern Health Authority. Although

the population has rebounded, as of October 2009, family counseling services have not been reinstated.

4.4.2 Women's Health

The health of women in the community was a prominent topic amongst participants in relation to the boom-bust cycle. A range of issues were described that relate to women's health, including maternity and sexual health, domestic violence, and a lack of employment opportunities (while employment itself is not a health outcome; it has been recognized as an important determinant of health. [Health Canada, 2004]).

During boom times it was described that there "*"were more men than women, more std's, more pregnancies."* (I6 L533). Many participants associated the mining boom with the fact that "*We've got a huge increase in maternity cases here and we're having to send them out for fairly simple maternity care"* (I10L141). While there is a Diagnostic and Treatment (D&T) Centre in Tumbler Ridge, pregnancy is not a health issue that health service providers are able to manage as the D&T Centre does not have overnight beds, and is not equipped to perform surgical procedures. Many interviewees identified the lack of maternity health services for expectant mothers, and the isolation of Tumbler Ridge has compounded this situation to be extremely stressful: "*your ideal situation we're an hour and a half from Dawson Creek, in good weather, and so if you try and deliver here, and something unexpected goes wrong, and you need your c-section, you have an hour to two hours from actually, and that's in the first world these days, that's considered too long".* (I8L223).

It was also reported by three participants that *"there is a fairly live and well violence against women happening in Tumbler Ridge"* (I4L419) during both boom and bust times. It was

described that in more cases than not, women tend to remain in the abusive relationship. "*Say I have a woman who wants to leave and abusive relationship. The way it stands now, is she basically needs to leave the community. Because we don't have a transition house*" (I2L109).

The municipality of Tumbler Ridge does have a Safe Home program; a service that provides abused women a safe place to stay. However, the service is only available for a couple of days, after which the woman must make alternative arrangements. During the 1990's, Tumbler Ridge had a transition house (that was previously funded by Teck Cominco), however this service was lost with the closure of the Quintette Mine. This situation is exacerbated by the fact that as of October, 2009 the community also did not have a social worker (this position was also eliminated by the Northern Health Authority with the closure of the Bullmoose and Quintette mines), who has the authority to process income assistance forms. As a result, there are no formal, provincial or corporately sponsored programs that assist women to transition out of an abusive relationship, or to gain financial independence, in order to leave the community or relationship.

In addition, interviewees identified the lack of employment opportunities available to women in the community. "W*omen tend to work in the home. There are lots of women working at the mine, but they don't have children. Daycare is hard to find with mining hours. The day care is only 8-5. There isn't a lot of 8-5 jobs*" (I2L153); For women employment in the mining sector may come with its own challenges: "*The women who are working at the mines, sexual harassment is still very prevalent from what they tell me…They just learn how to sluff it off…*" (I2L140).

4.4.3 Mental Health and Addictions

Mental health and addictions were described by 9 out of 10 participants as being an important health issue during both boom and bust times. Six participants interviewed were practicing health/social service providers in Tumbler Ridge during the closure of the Quintette and Bullmoose mines. They indicated that for residents that remained, it was an emotionally challenging time. Specifically, mine closure coincided with increased reporting of stress, anxiety, depression, and alcoholism: *"the appropriate response um for a community that's facing death and for people that are having to unexpectedly relocate, I mean you get all sorts of increases in stress related issues, psychological related issues, depression issues, um people knowing that their insurance is going to run out, so they come in quickly to get, to ask you for a three month prescription, so that they're still covered".(I8L247)*

In 2004, mining returned to the Tumbler Ridge region, and mineral development activities have steadily increased. Coinciding with the increase in mining, participants identified that "*the counseling department* is *always busy*" (I6L 539). They also identified that drug use and addictions were "*not as big an issue back then* (referring to the first round of mines mainly operating from 1983 to 2000) *as they are now. There wasn't crack, and there wasn't meth and there wasn't these other things that we now have*." (I3L247).

Participants also reported that drugs have played a critical role in the crisis of young families in Tumbler Ridge, and indicated that crisis calls are received on a daily basis for drug-family related issues.

4.4.4 Miner's Health and Safety

In addition to family health, mental health, and addictions issues, three participants who have been working in the Tumbler Ridge health sector for over a decade, identified that the nature of mine related injuries have changed. It was the perception that the "*mining nature of some of the emergencies coming in are more significant and severe now*" (I4L386). In addition, it was reported that "*there is an impetus by the industry to not allow the employees to actually leave the work site to go for health care* (due to the length of shift time), *so what is happening is we have people coming in quite ill at the end of the shift where they should have been seen earlier"* (I4L411). These participants also questioned the skill or confidence level of mine site first aid staff, as some of the miners injuries brought to the emergency services centre were not felt to be appropriate emergency situations, and should have been handled by a first aid attendant. They also expressed concern about the level of health and safety training miners received, and indicated that most of the significant injuries were amongst young males. One participant identified concern about the lack of health services available to the injured or aging miner. It was reported during one interview that the average age of a miner in Tumbler Ridge is 55 years old, and no physiotherapy or occupational therapy services as of October 2009, were available within the community to assist in rehabilitation needs as these position were also cut by the Northern Health Authority after the closure of Quintette and Bullmoose Mines.

4.4.5 Health and Social Services

As highlighted in the above sections, many health concerns outlined by health/social service care providers are associated with the lack of specific services available within the community. All participants identified that both boom and bust times have strained health services. As a result of mine closure, and the subsequent decrease in population, health services were cut rapidly by the Northern Health Authority. *"It has been extremely challenging for the residents of tumbler*

especially the long term who stayed, because with that comes knowledge and we went from boom to bust to boom so quickly. The resources provincially and federally are certainly not there in a timely fashion, to accommodate those changes." (I3L221)

Three main issues emerged from the data in respect to the challenges faced by health service as a result of the boom-bust mining cycle. The following quotation clearly defines the first issue:

"The health care, the basic services are always there, but you're dealing with different age demographics when you have your boom, you're dealing with a lot of younger people, young families, new families, children, and when we have the bust we dealt with more seniors. Seniors came to this community based on the availability of cheap housing, so the basics are covered, but they lack services that were not covered here initially"(I1L24). As Tumbler Ridge is a small, northern, isolated community, many of the health and social services required for an aging population are simply not available. All participants reported on this issue as being an on-going critical issue for the health of seniors (who when relocating to the community played an integral role in sustaining the community).

The second issue is the relationship between a booming community and community health services. All participants identified that the mining boom cycle has strained available health services to an unprecedented level. *"The problem was we had this big influx of people that need these services more than ever, and yet the services were never brought up to the levels they were before and its always tricky to get them back to those levels again." (I10L100)*

There was also great concern for fellow workers and their personal health status as many are working or on call 24 hours a day, 7 days a week. Seven participants reported that they feel

overworked, but that there is no other option, as they are the only service provider (or one of two) in the community who can lend assistance. *"And, we used to have 6 or 7 nurses in town, but now with the same population, now we have 2. So we have 2 emergency nurses, so just one on one off at any one point in time. So that's catastrophic and this is the risk, and I'm not going to mention their exact ages, but they are both over 50, ones in the mid 60's, you know, could be a retirement age if she chose to. And, there's certainly the risk of burning out there for them." (I8L394)*

4.4.6 Contributing to Community Health

Health and social service providers had four general recommendations as to how the mining industry could contribute to improving community health in Tumbler Ridge. These recommendations include:

Employee Screening

Although challenging under current laws, three participants identified that the mining sector should strengthen the employee screening process for addictions and one participant identified they should also enhance their screening for pre-employment injuries. *"Drug testing is important. We know there are a lot of folks going to work* (to the mine) *every day whether it's on wake ups or other things*" (I3L373).

Enhance Contact and Collaborate with Health/Social Service Care Providers

Two participants (one of which was in a higher administrative position), recommended that mining corporations and the health authority need to strengthen their relationship. *"Whenever a new mine or any industry moves into the region it would be nice to have a courtesy call." (I4L445)*

They also identified the need to educate the mining industry on available services, and suggested a strengthened relationship could lead to benefits for both industries. Examples given included the suggestion that the mine and health authority could engage in joint training, revolving around healthy living, workplace safety, nutrition, with a focus on a preventative approach, rather than a prescriptive perspective.

Assist Health Services

Four participants recommended that assistance to health services, whether it be financial, or the provision of health personnel at the mine site, or targeting hiring practices as means to bring qualified health personnel to the community (i.e. considering a spouses occupation if all other factors are equivalent between job candidates) would be paramount in elevating the burden on health services that was occurring (as of October, 2009).

"Encourage the mining industry should hire an occupational health nurses – have people on site to take care of minor health needs, this would reduce stress on services after hours. And when they are recruiting, look at spouses and how they can contribute to the community" (I5L524)

Invest in the Health of your Workers, Families and Communities

Five participants recommended that as the community provides a home for the employees working at the mine, the mines could improve their role within the community. It was identified that community programs that target addictions and family counseling would be very helpful. It was also suggested that mining corporations take a serious look at the shift schedule, as the current shift length and a rotation was not viewed as beneficial for workers, families or the community. It was recommended they also take more of a leadership role.

"Restructure what your position is in the community. What are my responsibilities as an industry? What do I owe this community? This is where all of my workers live. What is it that I can do to improve the lifestyle and the retention of people within the community? And that can be done a number of ways. And I believe, if you have a mining corporation, and we have a couple or three of them here in town, that I think together they could change a whole lot of things that are going on in our community that aren't right. And do it in a sincere way. Right now, the biggest problem is booze and drugs. Take an honest look at it; it's your employee that you're investing in. How he lives in his 12 hours off are just as important to you as how he spends his 12 hours at work. And if you start to adopt some of those kinds of thinking, you can make a pretty good community. But if you continue to go down the road of always saying well it's not my problem, what did you do as an industry? You didn't do anything." (I9L595)

4.5 Discussion

While this study was focused on one northern, remote, Canadian coal mining community, the qualitative methodology provides for a thick, rich description of the experiences of health and social service providers, that allows for the transfer of research findings to different contexts (Corbin and Strauss, 2008), including other mining communities. Research findings suggest that there are distinct community health issues associated with the boom and bust cycle of mineral development, and represent the overall perceptions of interviewed health care and social service providers in the community of Tumbler Ridge; many whom have been employed since the early 1990's and experienced the closure of Quintette and Bullmoose Mines, and the subsequent opening of new mines. During boom times, health and social service providers in the Northern remote mining community of Tumbler Ridge have seen an increase in pregnancies, sexually transmitted infections, and mine related injuries. There was also a problem with unequal

employment opportunities (an important determinant of health) for women, thereby further disadvantaging them. Community health issues that were reported for bust times, include mental health issues such as depression and anxiety. Overarching themes that were reported during both boom and bust periods include family stress, violence towards women, and addiction issues (both on and off the job site). Health and social services have also been negatively impacted during boom and bust periods. At present, they are reportedly overburdened, understaffed, and in some cases important services required for the health of the community are lacking all together (e.g., sexual and reproductive health services as demonstrated in a BC oil and gas community) (Goldenberg et al, 2010; Goldenberg et al, 2008a; Goldenberg et al, 2008b; Goldenberg et al, 2008c). In summary, data from this qualitative study identified stress as a key mining-health issue that persisted, albeit for different reasons and factors, throughout the mining economic cycle across both boom and bust periods.

Cyclical economic periods have generally resulted in fluctuations in population levels, often leading to shortages in housing, education, and health services during boom periods (Petkova et al., 2009; Ednie, 2003). In the Australian context, 12 hour shifts and continuous rosters have also been reported to negatively impact families and mining communities (Brereton and Forbes, 2004). Mining boom and bust periods have been associated with increased levels of substance abuse (Miranda et al, 1998; North Slave Metis Association, 2002; Sosa and Keenan, 2001; Oxfam, 2010; Campbell, 2000; Emberson-Bain, 1994; Desmond et al. 2004; Yukon Conservation Society and Yukon Women's Council, 2000) and gambling (Yukon Conservation Society and Yukon Women's Council, 2000); and family instability, abandonment and divorce, and child neglect (Yukon Conservation Society and Yukon Women's Council, 2000; Sosa & Keenan, 2001; North Slave Metis Association, 2002). Demanding schedules and shift work, which are typical of mining occupations, often result in less time for families and traditional

activities in periods of "boom". Childcare problems can be further exacerbated if both parents work (Sosa & Keenan, 2001).

Findings from this research indicate that community health impacts associated with mineral development are occurring (at least in the community of Tumbler Ridge from the perspective of health and social service providers), and to date, a concise legal framework in Canada, and internationally is lacking to prevent or minimize health and social issues associated with development (Clark & Clark, 2005). There are some considerations of these issues embedded within health and social impact assessments, and in Canada, their inclusion is often amalgamated with the EIA process. In Canada, the EIA is the primary method used to decide whether a mine project is granted authorization to begin, and to mitigate potential impacts (Environment Canada, 2000; Kwiatkowski & Ooi, 2003). It is an exhaustive effort, and in some instances generates thousands of pages for review. Importantly, findings from this research study challenge the effectiveness of the EIA process in mitigating community health impacts. Using Mine EIA certificates and applications in the Tumbler Ridge region as examples: in the 128 commitments made by Western Canadian Coal (WCC) in the EIA certified Wolverine Coal Project (certified in 2005), not one commitment mentions the mitigation of potential community health impacts for Tumbler Ridge (Environment Assessment Office, 2005). In the 2008 EIA certificate for the Hermann Mine, WCC addresses issue #89 *Increased demand on health and emergency services* by committing to "*participating with agencies charged with the responsibility of monitoring and managing the quality of community care*" (Environment Assessment Office, 2008, pg 13.) and will support "*health needs of mine workers through the Employee Assistance Program which provides professional counseling for employees and dependants on various areas of concern including drug and alcohol issues*" (Environment Assessment Office, 2008, pg 13.). In the current EIA application for the Roman Mine by Peace River Coal (application made March 29,

2010), the exact same commitments, word for word, are made (Peace River Coal, 2010, pg 18-53). However, as this research indicates, the mitigation measures identified by WCC were not adequate, and this makes Peace River Coal's abilities to adequately minimize community impacts through the EIA process questionable. As such, it seems as though the EIA is a regulatory process involving "saying the right thing", but lacking a process for ensuring that the proponent carries through with commitments (e.g. monitoring community health as it relates to the presence of mining).

As findings suggest the current EIA process in Canada may represent an inadequate method of minimizing or mitigating community health impacts. The onus is therefore on the company to proceed with development projects using ethical decision making and best practices guidance from the ICMM, IEED, IFC, the World Bank, and the United Nations. These organizations are attempting to guide the mining industry to consider health in their sustainable development/corporate social responsibility strategies. The recommendations made by health and social service providers in this paper are therefore perhaps the most valuable to those guiding mining policy, as they stem from individuals who are professionals and experts in the field of community health. To summarize their recommendations on how the industry could contribute towards the enhancement of community health, the path forward is simple: Communicate and collaborate with the health sector in your development and closure planning, and contribute to the health of your workers, their families, and the communities in which you operate in a meaningful way.

4.6 Conclusion

In conclusion, the size of the study community, as well as the exploratory nature of this study limited the sample size to 10 health/social service providers. The study took place in a Northern, remote, Canadian, community that was developed purposefully to support coal mining, and focused on how health and social service providers perceive the mining boom-bust cycle to affect community health. This paper reports on the perceptions that the mining boom-bust cycle has negatively impacted health outcomes for the residents of this community, and these perceptions are demonstrated through illustrative quotations. This paper also reports on recommendations health and social service providers had for the mining sector to enhance the health of this community. Specifically, the mining industry at large, community planners, impact assessors, and policy makers should focus on: Mitigating negative impacts to family structures by reassessing current mining shift rotation schedules; Ensuring women have access to appropriate health care services (such as transition housing and maternity care) and opportunities for important determinant of health issues (such as employment and child care options); Enhancing drug and alcohol policies and support services at the mine site and in the community at large; Increasing safety training opportunities for miners and ensure adequate rehabilitation services are available in case of injury; and guaranteeing your companies presence is not overburdening important health services by taking an active role in participating in community health provision (through funding health services) and by collaborating with the appropriate government authorities to ensure adequate funding has been allocated to support the increased demand on health and service delivery your company will place. As this study also suggests that commitments made by the industry and governments to communities are, at least in the northern Canadian context, falling short; consideration of these issues is imperative.

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5 Bridging Mining Community Health and Sustainability[6]

5.1 Introduction

In the Western Canadian province of British Columbia (BC), mining and mineral exploration are key economic drivers; and the BC mining industry is demonstrating commitment to sustainable development, and recognizing the importance of community well-being. For instance, the Mining Association of British Columbia (MABC) and the Ministry of Energy, Mines and Petroleum Resources (MEMPR) have identified "enhancing the potential for creating economic, social, and cultural benefits for local communities or regions" as a key criterion to evaluate sustainability in their annual Mining and Sustainability Award (MABC, 2009). In addition, in the current BC Government's Mining Plan, the first "cornerstone" identifies a focus on communities and First Nations stating "This Plan will support: strong, enduring relationships between the mining industry, communities and First Nations; the development and implementation of a made-in-British Columbia approach to sustainable exploration, mining and communities"(MEMPR, 2005 pg. 11). As such, researchers associated with the Mining and Community Health Projects (described in Chapters 2 and 3) felt that it would be very timely and valuable to:

- Highlight the importance of community health for the BC mining sector; and,
- Present research findings from a newly completed project to policy makers, communities, and the mining industry for reflection as they strategize on the advancement of sustainable mining communities.

[6] A version of this chapter has been published by the Canadian Institutes of Health Research: Shandro, J.A., Koehoorn, M., and Scoble, M. 2010. Bridging Mining Community Health and Sustainability, *Canadian Institutes of Health Research 2010 Knowledge Translation Casebook*. Available online at: http://www.cihr-irsc.gc.ca/e/41594.html, and in the Proceedings of the V International Conference on Mine Closure: Shandro, J., Veiga, M.M., Scoble, M., and Koehoorn, M. 2010. Strategic planning for mine closure: Community sustainability experiences in Northern British Columbia, Canada. *Mine Closure 2010: Proceedings of the 5th International Conference on Mine Closure*, 227-237.

A successful application for funding was granted by the Canadian Institutes for Health Research (CIHR; End-of-grant Knowledge Translation: Meetings, Planning, and Dissemination Activities) to accomplish the above objectives. This purpose of this paper is to describe the Knowledge Translation (KT) process used by University of British Columbia investigators to engage research-associated stakeholders. Specifically, the paper highlights the development and theory behind KT, the KT strategy employed in this project, and reports on outcomes of the KT process as of November 2010.

5.1.2 The CIHR Knowledge Translation Model

The process of stakeholder engagement to share research findings within the population health field is commonly referred to as Knowledge Translation (KT). Traditionally, the interaction between health researchers and stakeholders took a uni-directional approach, and there was an identified lack of success in health knowledge uptake by research stakeholders. This lack of success was attributed to the reality that stakeholders and researchers inhabit completely different worlds, with different languages, and cultures (Caplan, 1979; Lomas, 1997). Thus, with aims of improving the uptake of health research knowledge towards improving the health of Canadians, the Knowledge Translation (KT) model was developed by CIHR (CIHR, 2009; Figure 5-1).

The CIHR KT model is a process used by health researchers to communicate and engage with individuals, communities, or institutions (collectively referred to as stakeholders) associated with research projects, with the main objective of yielding beneficial health outcomes for society. CIHR defines this process as dynamic and iterative, with the aim of improving the health of Canadians, enhancing the effectiveness of health services and products, and a strengthened

health care system. The model takes into consideration that interactions between researchers and stakeholders are complex, and may vary considerably in the level of engagement required. This is dependent on the nature of the research, the research findings, and the specific needs of the stakeholder (Canadian Institute for Health Information, 2001). Importantly, it has been recognized that the application of KT can have profound implications for all stages of research, and is now encouraged early on in the research process (CIHR, 2009).

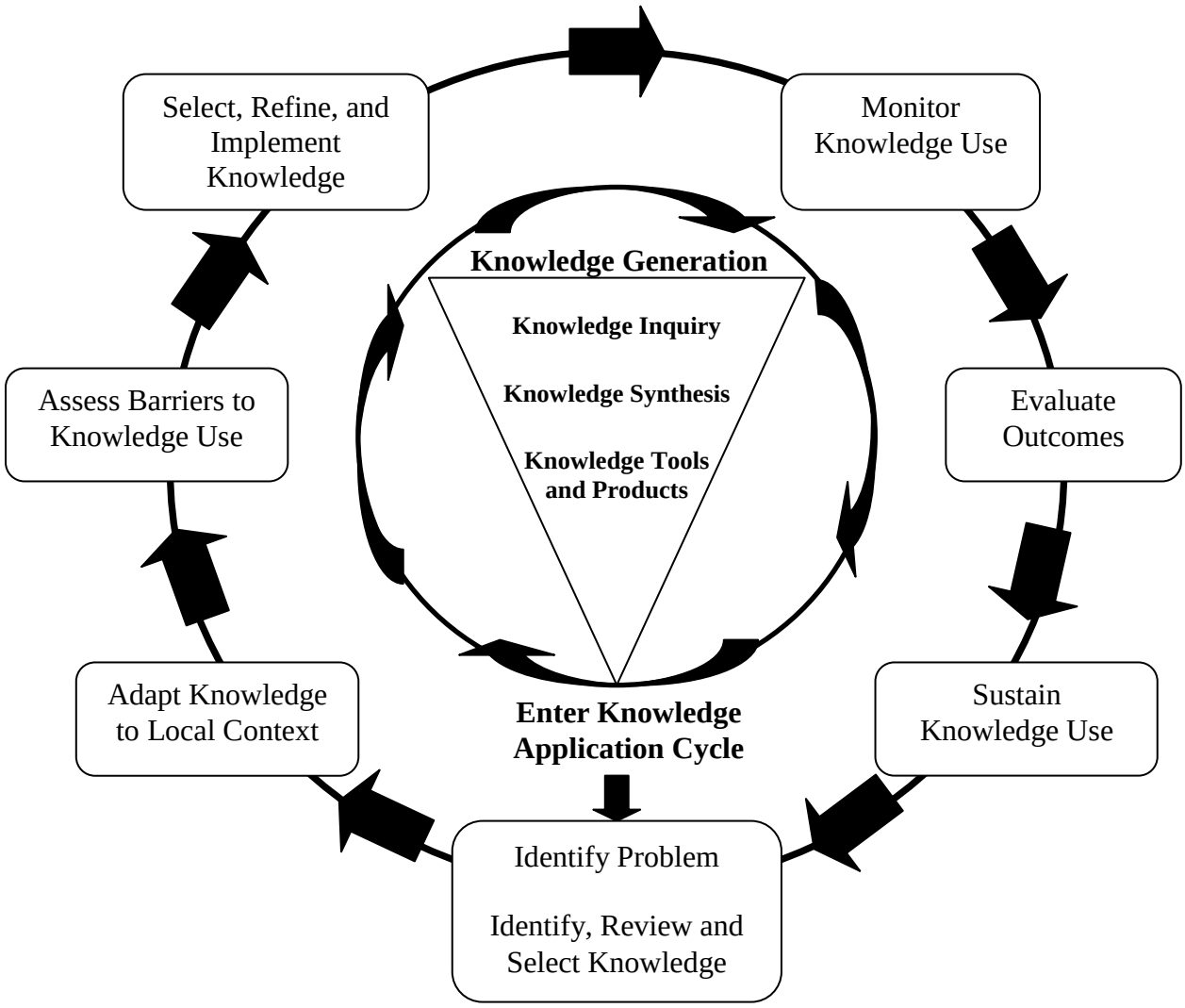

Figure 5-1. The Canadian Institutes of Health Research Knowledge Translation model (adapted from Graham et al., 2006).

Partnerships form the heart of KT, and in order to achieve the objectives set out by the model, it is essential to consider and develop relationships with the full range of potential partners at the regional, national, and international level that may enhance knowledge uptake and application. Important relationships with other researchers across or within disciplines; policy makers and planners; health care providers; the general public including the media, educators, non-governmental organizations, and volunteers; and the private sector have been identified as important (CIHR, 2009).

5.1.3 The CIHR Mining and Community Health Knowledge Translation Project

Findings from the "Mining and Community Health project" (represented by Chapters 2 and 3 in this dissertation), funded by the Canadian Institutes of Health Research (CIHR) and lead by researchers with the School of Population and Public Health and the Norman B. Keevil Institute of Mining Engineering at the University of British Columbia, drove the development of the Knowledge Translation project.

The Mining and Community Health project investigated community-level economic, socio-demographic, and health characteristics of British Columbia rural resource-based communities with a focus on mining over a period of time (1991 to 2002) marked by an economic downturn that negatively impacted the BC mining sector (Shandro et al., 2009). The study included Canadian census data (capturing community-level economic and demographic information) and community-level annual rates of mental illness and cardiovascular disease. Findings revealed that mining communities were more dependent on the mining industry than other BC resource-based communities were on their resource industries. They were also less diverse in terms of economic opportunities. Women lacked equal employment and income opportunities in all of the resource-based communities, but this inequality was greater in mining communities.

Specifically, there was a large discrepancy between male and female incomes, and females had higher unemployment rates. Importantly, all mining communities associated with mine closure experienced drastic reductions in populations post-closure. In contrast, other resource-based communities had stable populations or experienced population growth. During times of decreased mining employment, acute cardiovascular disease and mental disorder prevalence rates significantly increased in mining communities, whereas this was not observed in other resource-based communities (Shandro et al., 2009).

5.3 Methodology: The KT Strategy

The objective of the KT strategy was to share the above research findings in hopes that these findings could lead to the collaborative identification of key indicators that would contribute to the enhancement of mine planning and impact assessing, in order to effectively mitigate future community impacts resultant from mineral development.

5.3.1 KT Participants

In keeping with KT theory that dissemination must target a variety of audiences (Canadian Institute for Health Information, 2001); and in terms of having an impact on mine and community planning, and health services, the following groups were targeted for KT:

- Municipalities of study mining communities;
- Mining industry leaders including representatives from the Mining Association of British Columbia;
- The mining sector, community health care providers, and municipal governmental representatives from one mining community (Tumbler Ridge, BC), as a pilot project;
- Representatives from the Ministry of Energy, Mines, and Petroleum Resources; and
- The academic community

5.3.2. KT Activity Plan

A multi-pronged KT approach was subsequently developed in the hope that by presenting knowledge (specific messages targeted to each group) in different forms and at multiple times, this methodology would enhance the likelihood of the use of research findings in evidence based decision making by the various leaders (Canadian Institutes of Health Information, 2001). The activity plan took advantage of three KT opportunities to engage research stakeholders (described in detail in Figure 5.2) as outlined by CIHR (Canadian Institutes of Health Research, 2003): the production of plain language summaries (Activity#1- Report), the placement of research findings into the context of community norms (Activities#2- Outreach Visits), and to make decisions and actions informed by research findings (Activity#3- Interactive Educational Meeting).

The first activity included the production of a 1:3:25 research summary report. This style of report is typically directed towards decision makers, and generally is written in clear language (in comparison to peer-reviewed journal articles) enabling the applicability to broader audiences (community leaders, health care providers, and mining industry representatives). The style of the research summary report was presented in the following recommended format for stakeholders (Canadian Health Services Research Foundation, 2001): one page summarizing the main findings and conclusions of the research project; three pages acting as the executive summary, briefly summarizing background information; and twenty five pages presenting the research in non-academic language describing the context, implications, research approach, results, additional resources, knowledge gaps and possible solutions. Research reports can be extensive, and time consuming to read. The Mining and Community Health KT report ensured that main research findings were highlighted upfront in a clear and concise manner. Unlike peer-reviewed journal articles, the research summary report was written in non-academic language, and is thus

suitable for many different audiences. The research summary report was widely distributed to study mining community municipal leaders (*n*=15), the Mining Association of British Columbia, the BC Ministry of Energy, Mines and Petroleum Resources. As well, the report was circulated to health services, mining industry and community leaders in Tumbler Ridge, BC (*n*=9), a pilot community selected for more in-depth KT activities. The KT report has also been posted on the Norman B. Keevil Institute of Mining Engineering and the UBC Centre for Health and Environment Research websites.

Outreach Visits also formed a critical component of the KT strategy undertaken in this project and involved researchers meeting with different stakeholder groups independently. This format for engaging research stakeholders provided a mechanism for building trust between researchers and knowledge users, a fundamental component of KT (Straus and Leung, 2010). The format of the outreach visits generally consisted of a short presentation, followed by a facilitated dialogue. For the Mining and Community Health KT project, this interactive activity involved meeting representatives from each stakeholder group to discuss tailored topics. It was anticipated that different target audiences would have different needs in regards to the research knowledge, and the delivery of separate visits to different audiences helped to ensure their needs were met. Dialogue during visits allowed for target groups to voice thoughts, concerns, and potential solutions, and provided the framework for the development of an interactive educational meeting (Mining and Community Health Workshop).

A focal event during the Mining and Community Health KT project was an interactive educational meeting that took the form of a community workshop held in Tumbler Ridge, BC in November 2009. Workshops are interactive venues that bring people together who have a common interest, and have been identified as a preferred format for knowledge dissemination by

community based organizations (Dobbins et al., 2007). They can also be useful in the facilitation of stakeholder introductions, problem solving, and solution development. The format, venue, and content of the workshop was developed as a result of the outreach visits. The aim of the workshop was to engage community leaders in a discussion on the inclusion of community-level health and sustainability indicators in mining impact assessments and the development of some strategies to mitigate the impact of the boom and bust mining cycles on community health. Workshop participants included two representatives from local mining corporations (Peace River Coal and WCC), the municipal economic development officer, and two local health service providers**.** This half-day workshop provided a venue to bring community leaders from different disciplines (mining, health, and policy) together for perhaps the first time. The objective of the workshop was to have a facilitated dialogue on: the research findings, community sustainability, potential indicators of sustainability and health that could be included in industry impact/planning assessments, and to develop a strategic plan for addressing community changes during boom and bust cycles of mining activities (Shandro et al., 2010).

5.4 Results of the KT Process: The Need for Strategic Mine Closure Planning

The KT process resulted in the wide dissemination of the research summary report. This report acted as a catalyst for bringing industry, community, government and academic stakeholders together to have discussion about mining and community health. Recommendations made in the summary report were also validated by the Mining and Community Health Workshop participants, and by industry representatives (including representatives of the Mining Association of British Columbia). In addition, throughout the KT process (especially during the Mining and Community Health Workshop in Tumbler Ridge, BC), the topic of mine closure planning continuously emerged. Specifically, the following points were highlighted by workshop participants:

- Mine closure resulted in the near-death of the community of Tumbler Ridge. It took an enormous amount of perseverance, dedication, and creativity by remaining community leaders and members to ensure the continued existence of the community.
- The impact of mine closure on Tumbler Ridge municipal services was severe (Social and Health Services). Due to population reductions, these services were reduced, and positions were cut. At present, the population has rebounded (partially as a result of renewed interest in coal mining in the region), however; these important health and social services have yet to be reinstated.
- Despite the severe impacts that mine closure had on the community of Tumbler Ridge a decade ago, the well-being of the municipality post-mining (Mine Closure Planning) is not an issue that the mining sector or community leaders have planned for. KT stakeholders agreed that a Mining Community Sustainability Plan would be an appropriate platform, although there was disagreement as to who is responsible for this plan.

In addition to these issues raised by workshop participants, all KT participants have acknowledged the total lack of sustainability planning as it relates to communities and mining on the parts of governments, communities, and industry. As a first step, researchers were invited to propose a framework for such a plan. Participants also suggested that the process of developing a community sustainability plan would be of value for mining companies in the early phases of planning for a mineral development. The municipality and health care providers supported this suggestion as the process would reinforce early engagement between a mining company and the community. One of the lead researchers (M. Scoble) subsequently applied for, and received additional research funds from the Natural Sciences and Engineering

Council of Canada (NSERC) to address the complexities of the mining community sustainability planning process.

As of November 2009, KT funds were exhausted. However, KT activities targeting the mining sector continue to date. In October 2010, Mrs. Shandro was invited by the Ministry of Energy, Mines and Petroleum Resources to present research findings at the head office in Victoria, BC. In November 2010, presentation of research findings occurred at the 5th International Conference on Mine Closure, and an abstract has been accepted to present findings at the 4th International Forum for Sustainable Development Indicators in the Mineral Industry in June 2011.

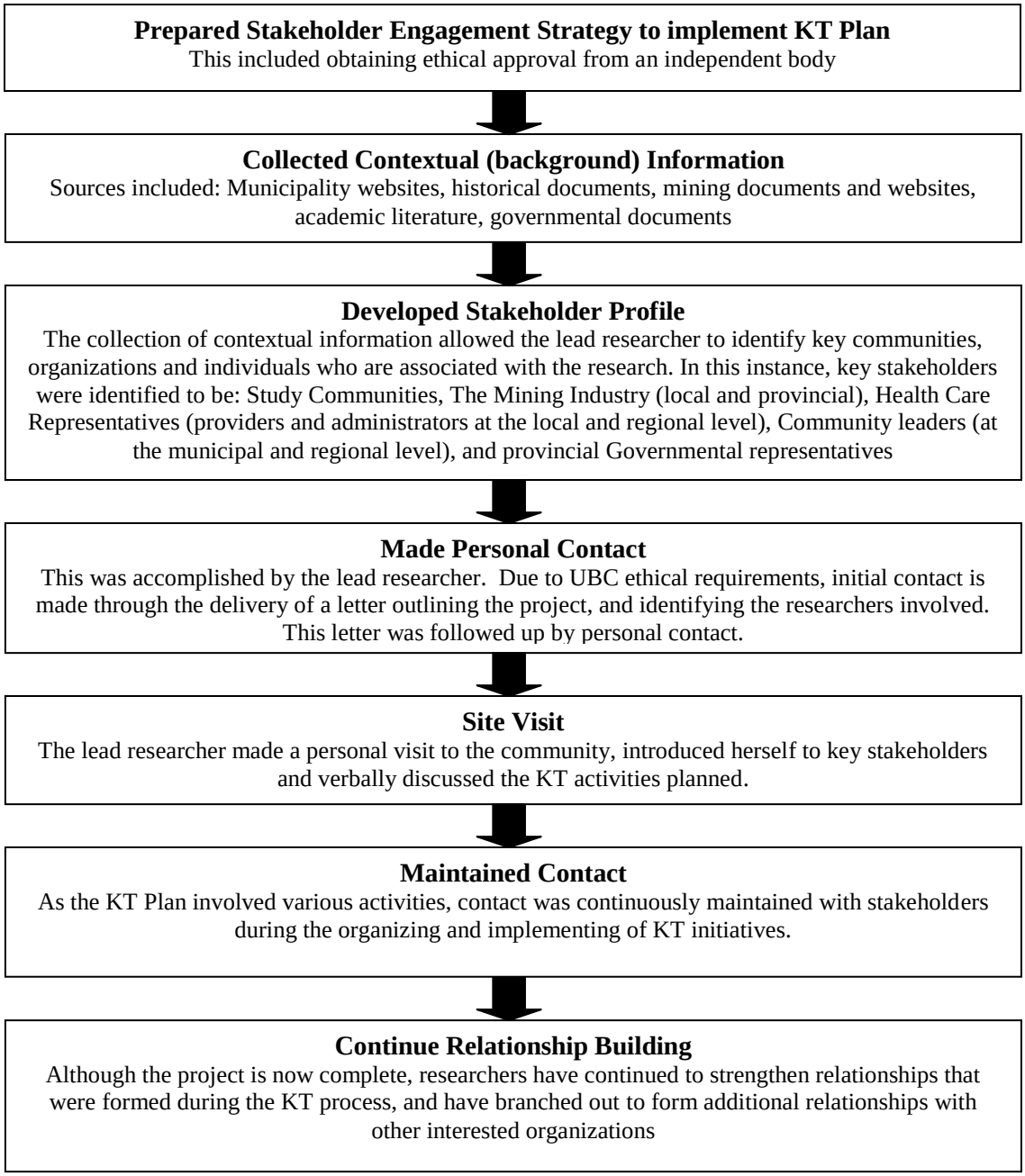

Figure 5-2. Knowledge Translation stakeholder engagement process used by UBC researchers.

5.5 Discussion

The KT approach used by UBC researchers achieved the goal of highlighting the importance of community health to the BC mining industry, and initiated a process of collaboration between the industry, community leaders and health care providers toward community sustainability

planning. However, during the Mining and Community Health Workshop, it became apparent that more work was required to fully address some of the research findings. In particular, how the mining industry intends to work with communities prior to and during mineral development; how various departments and levels of government communicate and are ready to assist mining communities in transition; and how mining communities plan for changes that will undoubtedly occur as a result of mineral developments.

Through continued KT and research activities, the research team hopes that the development of a community sustainability plan will be incorporated into the mine development application phase. This will encourage mining companies to fully engage community leaders early to promote mining community health and sustainability. With this in mind, it is important to recognize that over the past two decades, a considerable transition has occurred within the mining sector as it recognizes the impacts mine closure can have on communities. As a result, a plethora of literature now acknowledges that mine closure is an important component of the mineral development cycle; and the incorporation of sustainable development strategies within the mining sector has placed pressure on mining corporations to mitigate community impacts throughout the life of the mine and beyond.

As recent examples of these guidelines, the International Council on Mining and Metals (ICMM) has produced a Planning for Integrated Mine Closure Toolkit, to "promote a more disciplined approach to integrated closure planning and to increase the uniformity of good practices across the sector" (ICMM, 2009 pg. 6.) with aims of "achieving post-closure status that leaves behind an enduring positive legacy in the community" (ICMM, 2009 pg. 8.). The 2007 International Finance Corporation (IFC) Stakeholder Engagement guidance document, a generalized document for all industries (not mining specifically), recognizes that industry (mine) closure can

result in loss of employment, decline in economic activity (especially the case for rural and remote regions), the discontinuance of community services, and community dislocation; and that planning for closure should occur far in advance to mitigate and manage potential risks, and realize economic benefits (IFC, 2007).

There is no doubt, efforts by international organizations have been spurred by the 2002 Report of the Mining, Minerals, and Sustainable Development (MMSD) Project that stated "ensuring that improved health and education or economic activity will endure after mines close requires a level of planning that has too often not been achieved" (MMSD, 2002 pg. xvii). Within the Canadian context, The Mining Association of Canada (MAC) also acknowledged the importance of mine closure and community impacts in their Towards Sustainable Mining (TSM) initiative, with the main objective being "to responsibly meet society's needs for minerals metals and energy products" (MAC, 2004). Linkage between mine closure and the need to contribute to communities in a positive way was highlighted in the TSM Guiding Principles. Specifically, the need to "Be responsive to community priorities, needs and interests through all stages of mining exploration, development, operations and closure", and to "provide lasting benefits to local communities through self-sustaining programs to enhance the economic, environmental, social, educational and health care standards they enjoy" was expressed by MAC (MAC, 2004, pg. 1.). The concept of a Mining Community Sustainability Plan with the objectives of receiving optimum benefits from mineral development, and sustaining associated communities beyond the life of a mine is not new. Almost a decade ago, the MMSD proposed the Community Sustainable Development Plan and Integrated Planning for Closure (MMSD, 2002, pg. 400). Although it was suggested these initiatives should be formalized for projects funded by the IFC or insured by MIGA (MMSD, 2002, pg. 400), it was not clear who should initiate this process, and if this process was to be implemented, under what circumstances.

The Sullivan Mine is a case example of where mine closure planning can have beneficial outcomes for communities. The Sullivan Mine was owned and operated by Teck Cominco, in the nearby community of Kimberley, BC, Canada. The mine closed in 2001 due to ore exhaustion after 100 years of production. Prior to closure, Teck, along with the Mayor and town council, and a non-governmental organization began brainstorming community sustainability strategies (Teck Cominco Ltd., 2001; MAC, 2001; MAC, 2002). This process was a huge success, as today, Kimberley is known as the Bavarian city in the Rockies, and is an attractive destination for living and vacationing. However, sustainability and mine closure planning has yet to be fully embraced by Canadian companies operating in Canada, and it is not known if this type of planning is undertaken by Canadian companies operating globally. Also at this time, the Canadian legislature has provided a legal framework for mine closure; however, it focuses on environmental and technical issues, while societal factors lack consideration (Clark & Clark, 2005). Given the impacts mine closure has on associated communities, if mining companies do not begin to initiate this process on a voluntary level, governing bodies responsible for approving mine development projects may begin to request a community sustainability plan from mine development proponents during the application phase; perhaps as a part of the Environmental Impact Assessment permitting process.

A mining community sustainability plan should be the responsibility of all parties who have a vested interest in community sustainability (local leaders/policy makers, health care providers and industry). Such collaboration will give local communities a chance to envision future prospects for their community, and to work with an industry that can assist them in achieving their community planning goals; the presence of mining within a community does provide an economic boost. As an extension of the community sustainability plan, mining community

leaders should be prepared to facilitate the formation of a community sustainability task force as soon as a mining project has been approved. Ideally, this task force could be comprised of mining representatives, community members, and social service/health care providers. The formation of a task force ensures focus on community sustainability as priority, and has within the Canadian context, proven to be effective at implementing economic diversification and sustainability strategies (Teck Cominco Ltd., 2001; MAC, 2001; MAC, 2002).

5.5 Conclusion

Researchers at the Norman B. Keevil Institute of Mining Engineering and the School of Population and Public Health at the University of British Columbia undertook an investigation into the demographic, economic, and health characteristics of mining communities in BC, Canada. To our knowledge, this project represents the first time Canadian Census and BC Health Data has been integrated over a period of time in relation to changing economic conditions (with a focus on mining). As researchers felt findings held significant potential for mining community planning and sustainability, they used a method advocated by the Canadian Institutes of Health Research to enhance the application of knowledge gained from research to action, and to effectively engage associated stakeholders. The community of Tumbler Ridge was identified through the project as a community that had underwent significant transformations as a result of mine closure. Specifically, closure coincided with drastic population loss, and resulted in the reduced provision of health and social services. Despite renewed mining activity and population gains, this community is in need of reallocation of these important provisions and collaborative sustainability planning.

The KT activities described in this paper achieved the goals of highlighting the importance of community health to the BC mining industry, and initiated the process of collaboration between the industry, community leaders and community health care providers towards community sustainability planning for Tumbler Ridge. Overall, the KT model used to engage the community of Tumbler Ridge with research findings resulted in a positive process; however, during the Mining and Community Health Workshop, it became evident that continued efforts are needed to apply research findings. In conclusion, the impacts of mineral development on community health and wellbeing has received very little prior research, although it is well recognized by the mining sector that mine closure can affect associated communities. Based on findings from this study and through the associated KT activities, the research team has identified that collaborative efforts are needed to bring together industry, government and communities in order to recognize the priority for enhanced strategic planning that addresses community sustainability and the cyclical nature of mineral development.

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6 Conclusion

6.1 Key Findings that Address Research Questions

In this doctoral dissertation, a multi-method approach was taken to address the following research questions:

- *How mining communities differ from other resource based communities in British Columbia in terms of their socio-demographic and economic fabric over a specific period of time (1991-2001)?*
- *What is the relationship between community-level health outcomes of cardiovascular disease and mental disorders and community-level exposure to economic conditions among residents of BC mining communities; and how does this compare to residents of other BC resource-based communities?*
- *What are the experiences of health and social service providers in a remote mining community, with respect to community health issues and the boom-bust cycle of mining?*
- *How can the mining sector contribute to enhancing community sustainability and health?*
- *Can researcher engage in knowledge translation activities with mining communities? What can we learn from the process?*

These primary research questions were addressed in detail in Chapters 2 to 5. The most notable findings stemming from the dissertation as a whole are summarized below.

1. Mining makes positive economic contributions to associated communities in British Columbia.

The quantitative phase of this investigation (specifically in Chapter 2) identified that throughout the study period, the presence of mining was associated with higher overall community income from all sources, and lower male unemployment rates. Mining also provided higher wages and employed more community members than comparative industries. As such, these findings could be included as demonstrated benefits from mining within a region in mine development applications.

2. Mining communities in British Columbia were found to be economically and demographically vulnerable during the study period.

Chapter 2 also highlighted that between 1991 and 2001, mining communities were not as economically stable as other resource-based communities. Economic data indicates that mining communities were more dependent on mining than comparison communities were dependent on other resource industries. Mining communities were also found to be less diverse in terms of economic opportunities. High industry dependency coupled with low community diversity challenge communities that are facing industry downturns and can impede community sustainability post-mining.

Despite government mining initiatives (through tax cuts and exploration incentives), the study period traversed a challenging time for the BC mining industry. Low metal and coal prices, increased regulation, increased global competition, a lack of risk financing, an Asian economic crisis, and a high Canadian dollar all contributed to decreased mineral exploration activities and mineral development. As a result, BC mining communities experienced a reduction in employment within the mining industry to a greater degree than other resource-based

communities experienced in comparative industries. Decreased mining employment coincided with mining community population loss. All mining communities involved in this study recorded population decline (whereas most comparison communities reported population growth) and communities associated with mine closure incurred drastic population losses.

3. Women lacked equal opportunities in BC resource-based communities during the study period.

Between 1991 and 2001, findings outlined in Chapter 2 revealed that there was a lack of equal employment and income opportunities for women in all study communities; although this inadequacy was demonstrated to a greater degree in mining communities. Specifically, there was a large discrepancy between male and female incomes. Mining communities also held higher female unemployment rates consistently throughout the study period. In 1991, when employment within the mining industry was the highest in mining communities, the female unemployment rate was also the highest; more than double the male unemployment rate.

4. Periods of economic decline negatively impacted the prevalence of acute cardiovascular disease and mental disorders in mining communities.

Chapter 3 (also a portion of the quantitative phase) identified that over the study period (1991 to 2002), mining communities had statistically different acute CVD prevalence rates during stable economic periods (as captured through employment) compared to periods of economic decline (where an increase in the rate was observed for decline periods). Specifically, findings indicate an impact on the prevalence rates for acute CVD during periods of economic decline (rate increased by 13.1 cases per 1000 population, $p<0.0001$ as compared with stable periods) and bust conditions (rate increased by 30.1 cases per 1000 population, $p<0.0001$ as compared with stable conditions) and mental disorders (rate increased by 13.2 cases per 1000 population,

p=0.0001) in mining communities during declining economic conditions as compared to steady periods of mining employment. This relationship was not observed in other resource-based communities.

5. The mining boom-bust cycle has negatively impacted community health and the provision of health and social services in a Northern coal mining community in British Columbia.

In Chapter 4, health and social service providers reported on increases in pregnancies, sexually transmitted infections, and mine related injuries during booming mine activities. During bust times, mental health issues such as depression and anxiety were reported. Overarching community health issues prominent during both boom and bust periods include burdens to health and social services, family stress, violence towards women, and addiction issues.

6. Collaborative efforts are required to enhance mining community health and sustainability.

The key findings outlined above set the context for the following recommendations aimed at enhancing rural mining community health and sustainability. These recommendations have been selected with industry, governments, local communities, and researchers in mind. They are based on the results of this BC-wide study of resource-based communities, and were developed in conjunction with participants involved in the Knowledge Translation phase of this project (Chapter 5) and address the research question of how can the mining sector contribute to enhancing community sustainability and health:

6.2 Recommendations

Continue and enhance commitment to sustainable development

This recommendation is undoubtedly likely the most important recommendation from this dissertation, as it emerges as a common theme in all thesis chapters. The importance of community involvement and sustainability has been well recognized by governments and mining leaders in British Columbia, and in Canada. While efforts such as the annual Mining and Sustainability Award (Mining Association of British Columbia, 2009), the Towards Sustainable Mining initiated by the Mining Association of Canada (Mining Association of Canada, 2001), and the BC Governments Mining Plan (Ministry of Energy, Mines and Petroleum Resources, 2005, Pg 11.) are noteworthy, and demonstrations of industry and governments commitment; efforts are still falling short, with the described impacts occurring in Tumbler Ridge, BC described in Chapters 4 and 5, as evidence of this. Commitments made to sustainable development and mining communities in British Columbia are however, very strong, and it is important that the industry and government continue to make progress. Clearly defined inclusion of health and socio-economic considerations within legislated initiatives (such as the Environmental Impact Assessment process) or the requirement of a mining corporation to provide a social reclamation bond (in addition to the already required environmental reclamation bond) will undoubtedly enhance these efforts.

Engage Health Care Providers

Many mining companies in British Columbia have made commitments to community health in their Environmental Impact Assessment application. Given the findings in Chapter 3, and in Chapter 4, it is the recommendation that company leaders should include community health providers during mine development planning in order to strategize ways to: ensure operations do not overburden existing services (which may be under-funded, under staffed, or non-existent to

begin with; this is especially the case for rural, Northern communities), mitigate potential community health impacts such as mental disorders, cardiovascular disease, sexually transmitted infections, violence towards women, and addiction issues. In addition they can plan and prepare for increased pregnancies, and mine related injuries.

Other BC-based studies have also pointed to the importance of engaging health service providers during boom and bust periods. In a BC oil and gas community, health services are reportedly overburdened, understaffed, and in some cases important services required for the health of the community are lacking all together (e.g., sexual and reproductive health services) (Goldenberg et al, 2010; Goldenberg et al, 2008a; Goldenberg et al, 2008b; Goldenberg et al, 2008c). Hospital administrators and local health providers also hold a wealth of information as to how a community is faring pre-mining. As Canadian mining companies are generally committed to improving the well-being of associated communities, local health care professionals can identify key areas where corporations can contribute to improving community health. Community health personnel can also contribute to mine site health and safety, and can assist in the development and delivery of strategies targeting employee health and well-being. Collaboration between all individuals early in the mine planning phase will undoubtedly benefit the mining industry, their employees, and the community at large.

Plan *with* the community for closure

As it is well recognized that mining communities can undergo significant changes during the life of a mine, and post-mine closure, it is important to incorporate the process of developing a community sustainability plan into the mine planning phase. Sustainable development strategies within the mining industry have generally focused on environmental performance. However, given that associated communities are significantly impacted (positively and negatively) by the

presence of mineral development, it is our suggestion that governing bodies responsible for approving mine development projects request a community sustainability plan from mine development proponents during the application phase. Combined, planned efforts between mining corporations and a BC mining community (Kimberly, BC) has proven to be effective at implementing economic diversification and sustainability strategies in preparation for mine closure (Teck Cominco Ltd., 2001; Mining Association of Canada, 2001; Mining Association of Canada, 2002). In addition, mitigating negative community impacts as a result of closure is strongly advocated for by international mining associated organizations (International Council on Mining and Metals, 2009; International Finance Corporation, 2007).

Assist in the strengthening of community capacity

Capacity building is not a process limited to economic diversification, or improving community health. Rather, it can be viewed as a strategy for enabling communities to address any issue of priority. Building community capacity requires active participation of community members, associated individuals, and institutions. Linking with existing community structures (that assist or have the ability to assist community members), and other institutions or individuals who can provide external resources is also important.

Building capacity requires critical assessment of social, political, and economic influences that are associated with priority issues. Additional support through various resources (including time, money, leadership, volunteers, information and facilities from within and external to the community) can assist in the success of community development projects. Importantly, the process of capacity building can greatly enhance a sense of cohesion within communities; people are brought together when working towards a common goal.

Mineral development brings an array of different people into communities. Individuals working within the mining industry differ in their educational, professional, and geographical experience. As the mining industry is a mobile industry, many of these people have lived in various locations around the globe. Perhaps these people represent an untapped resource for mining community members planning sustainability strategies. In addition, the enhancing of community and regional capacity has been a key recommended strategy for the revitalization of rural communities and regions in Canada (Reimer, 2009).

Address inequities for women

The need for this recommendation stems from research findings in Chapter 2 and Chapter 4. Generally speaking, income inequalities between men and women "*in a given society may be a more important determinant of health than the total amount of income earned by society members. Large gaps in income distribution lead to increases in social problems and poorer health among the population as a whole*" (Federal, Provincial and Territorial Advisory Committee on Population Health, 1999). In Canada, there have been slight improvements in narrowing the income gap between men and women over the past three decades; however, women's median, after-tax income is still less than two-thirds of men's. Additionally, there has been a dramatic increase in the number of women with insecure, low paying, temporary part time employment (Hadley, 2001). The provision of equitable employment and income opportunities for women in BC mining communities requires the attention and initiative of community leaders, policy makers and the mining industry. The European Foundation for the Improvement of Living and Working Conditions recently published a report aimed at gender equity and identified the following recommendations as important (Oligiati and Shapiro, 2002):

- Increase the general recruitment of women

- Focus on recruiting and developing women in areas where they are under-represented (i.e. technical areas).
- Increase the number of women in management.
- Enhance the professional development of women.
- Improve flexibility and the balance between work, family and social life.
- Bringing about a change of culture to support gender equality.
- Ensure equal pay.

The facilitation of new opportunities for women living in mining communities to participate in relevant job training and/or advanced education opportunities is also critical (e.g., bursaries and scholarships could be offered by mining companies) as women with university degrees have narrowed the income gap in a more substantial manner, than those who hold a secondary school diploma (Hadley, 2001).

As these most notable findings demonstrate, the primary objectives of this dissertation have been met, and the research questions as identified in the beginning of this dissertation, and reiterated in this current chapter have been answered.

6.3 Future Research

Community-level impacts associated with mining as reported in this study could likely be addressed in the planning associated with mineral development projects. Specifically, since many observed adverse social impacts occurred during periods of economic decline or post mine closure, research focused on social reclamation would be very relevant in order to reduce and mitigate potential effects. For instance, while the issue of planning for mine closure has been well researched from an environmental reclamation perspective, little research has taken the

initiative to address the social dimensions related to mine closure such as community-level economic, social and health sustainability. As highlighted in Chapter 5, the issue of mine closure planning is a complicated process and to date, closure initiatives have focused on environmental performance. Guidance with respect to social considerations is still in its infancy.

In addition, exploratory health related findings in Chapter 3 and 4 point to the impact that mining has on health through stress-mediated pathways. Future research should focus on investigating the health of mine workers and their families in comparison to the community at large. Community-level economic data and qualitative health findings indicate that women in mining communities are particularly vulnerable, and research should also address the impacts of mineral development, and the mining economic cycle on women's health. Finally, differences between mining and other resource-based communities were noted for the period under quantitative investigation, it is important to note that this study focused on a period of time where an economic downturn gradually impacted forest sectors and more severely impacted mining sectors. It would be important to investigate how these communities have faired into the millennium where the mining industry boomed, and the pine beetle epidemic along with the BC softwood lumber crisis continued to negatively impact forest sectors; and how the latest global economic recession has severely impacted all BC resource sectors.

Finally, the last recommendation for future research lies within the realm of Knowledge Translation. While the planning of KT activities by researchers are now expected by CIHR, it has identified the strengthening and evaluation of KT processes as a priority to enhance the effectiveness of such initiatives (CIHR, 2009). Identification of key barriers and facilitators of the uptake of research knowledge by industry, governments and other associated research stakeholders to bring knowledge to action in a timely manner is likely the most pertinent directive requiring future research. This is especially the case for the mining industry.

6.4 Contributions and Claim to Originality

This dissertation has made both research and applied contributions (as highlighted in Table 6-1). It is considered that there are three main original contributions to research:

1. The multi-community longitudinal quantitative studies using Census and Health data as presented in Chapters 2 and 3 represent original approaches to:
    - Investigate demographic and economic; as well as health characteristics of mining communities in the Canadian province of BC
    - Investigate how mining communities compare to other resource-based communities in the Canadian province of BC in terms of their demographic, economic, and health fabric.

2. The use of two research methods (quantitative and qualitative methods) within the same dissertation as presented in Chapters 3 and 4 represents an original approach to investigate the health of BC mining communities.

3. Finally, the knowledge translation activities as presented in Chapter 5 represents an original approach in the diffusion, dissemination, and application of research findings that are associated with community health and sustainability in mining communities. This KT process also marks the first time that researchers, the mining industry, community leaders, and health care providers were brought together to discuss mining community health and sustainability in the province of BC.

Applied contributions include: the publication of a plain language research summary report (Shandro et al., 2009) that has been delivered to study mining communities, governments,

various facets of the BC mining sector, colleagues, and is available online at: http://www.spph.ubc.ca/sites/healthcare/files/1258418522196.pdf; the personal communication with the Mining Association President Pierre Gratton and Vice President Zoe Younger indicating support for recommendations within the summary report and indicating the potential use of these recommendations within MABC guidance initiatives for member companies; The facilitation of the aforementioned workshop (#3. original contributions to research) held in the Northern Coal mining community of Tumbler Ridge, BC in October of 2009; the presentation of research findings at the Northern BC Coal Forum in October of 2009 and the future International Mine Closure 2010 conference in November of 2010; the identification of the key demographic, economic, and health indicators as being important to mining community health and sustainability; and the invitation by CIHR to describe the KT process highlighted in Chapter 5 in CIHR's Knowledge Translation Casebook (Shandro et al., 2010), a guide produced by CIHR to support researchers and knowledge users in the development of KT strategies.

Table 6-1. Research questions and contributions.

Chapter	Research Question	Contribution (Academic)	Contribution (Applied)
2	How do mining communities differ from other resource based communities in British Columbia in terms of their socio-demographic, economic fabric over a specific period of time (1991-2001)?	Identification of key socio-demographic, economic, and sustainability differences between mining and other resource based communities	• Developed and disseminated research report summary to all study mining community leaders, the Mining Association of British Columbia, and the Ministry of Energy, Mines and Petroleum Resources
3	What is the relationship between community-level health outcomes of cardiovascular disease and mental disorders and community-level exposure to economic conditions among residents of BC mining communities?	Identification of a relationship between declining economic conditions and an increase in the prevalence of acute cardiovascular disease and mental disorders in mining communities	• Facilitated workshop that brought together the mining industry, community leaders and community health care providers to discuss research findings and sustainability planning in Tumbler Ridge, BC • Published research report summary that included a set of 6 recommendations based on research findings feedback from workshop participants
	How does this compare to residents of other BC resource-based communities?	The relationship observed in mining communities is not observed in other resource-based communities	• Met with the President of MABC (Mr. Pierre Gratton) and the Vice President Corporate Affairs (Ms. Zoe Younger) to discuss research findings. They asked if they could use our recommendations in their upcoming guidance documents for their member companies
4	What are the experiences of health and social service providers in a remote mining community, with respect to community health issues and the boom-bust cycle of mining?	Identification of 5 general health issues associated with the mining boom-bust cycle in Northern BC	• Presented research at the Northeastern BC Mining Forum in October, 2009
	How can the mining sector contribute to enhancing community health?	Identification of 4 ways in which a mining corporation can contribute to improving community health	• Adapted the Knowledge Translation model to develop a platform for mine closure planning and community engagement • Identified key indicators for inclusion in Community Impact-Sustainability assessments
5	Can researcher engage in knowledge translation activities with mining communities? What can we learn from the process?	Developed and implemented a one year Knowledge Translation activity plan associated with research findings from Chapters 2 and 3.	• Presented research findings at the Mine Closure 2010 International Conference in Vina del Mar, Chile in November, 2010.

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