Overburdened:
Understanding the Impacts of Mineral Extraction on Women's Health in Mining Communities

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EXECUTIVE SUMMARY

Overburdened is a comprehensive literature review on women, mining, and health. Evidence regarding the impact of mining, mineral extraction, and processing on the health of women and their communities is presented. The purpose of the review is to provide information to help heal and protect women, their families, and their communities from the adverse health impacts of mineral extraction through:

- Enhancing the level of knowledge about the impact of mining on women's health; and
- Developing the capacity of women in mining communities to protect themselves and their families from the effects of mining.

The World Health Organisation (WHO) defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease and infirmity."[1] This review has applied this holistic definition of health to the search for information about the impact of mining on women's health. Most academic research to date has focused on white men of working age and has (mis)represented this information as "human health."[2] The *Overburdened* literature review investigates research specific to women that provided some gender analysis of the results.

Gender-based health determinants can be classified as physical or social determinants of health. Physical determinants of women's health are dependent on women-specific physiologies of different life stages (childhood growth, menstruation, pregnancy, lactation, and menopause) and physical characteristics of women (percentage body fat, height and weight, the ability to absorb and retain nutrients) that affect susceptibility to disease.[3] Much of mining's health impact on women is also mediated by the social determinants of health, including poverty, housing, the lack of social and economic power held by most women throughout the world, and women's experience in the workplace.[4]

Women are affected by mining as individuals, as workers, and as community and family members. Health problems arise for women both from the environmental and the social impacts of mining. The environmental impact on women's health depends on a range of factors that affect the duration and kind of exposure to contaminants, such as the kinds of minerals mined, the type of mining (open pit to underground), the technology used, the size of operations, and the methods of waste disposal and water treatment used. Lands, water bodies, air, and the environment are polluted due to the release of toxic wastes, dust generated by blasting and excavation, and the dumping of mine wastes and overburden in the surrounding lands and rivers. Women may experience the environmental exposure effects of mining in a variety of ways – as workers in large-scale underground mines or small-scale gold-panning operations; by being exposed to contaminated dust, air, water, and soil; or by consuming the mining-contaminated fish, wildlife, plant food, and drinking water. Social impacts experienced by women include poverty, sexual exploitation, dislocation, family violence, and workplace harassment.[5]

This review is based on an extensive search of the epidemiological, toxicological, and community-based literature on the effects of mining specifically on women. It presents what little is

[1] World Health Organization 2003.
[2] Vahter et al. 2002.
[3] Roberts and Silbergeld 1995.
[4] Mines and Communities 2003.
[5] Mines and Communities 2003.

known about toxicological effects on women of a variety of minerals throughout the various stages of a woman's lifecycle. These minerals include cadmium, lead, copper, mercury, arsenic, and asbestos, among others. Many metals tend to be stored in bone (e.g., lead, cadmium, aluminum, and mercury) and are moved in the body in the same way as calcium. Increased metabolic requirements for calcium during growth, pregnancy, lactation, and aging can also release these metals into the blood stream causing health problems.[6] Changes to the metabolism of fat-stored toxins may occur. For this reason, women are more susceptible to certain kinds of disease, such as cadmium-caused Itai-itai disease that results in bone fractures and pain.[7] Growth and development of the foetus and of breastfeeding children can also be affected by maternally released metals.[8]

A review of the literature regarding both the toxicological and non-toxicological (e.g., accidents) health impacts for women mineworkers are presented. Contaminant exposure levels at the workplace may be high and cause both short- and long-term health effects. These effects include various types of cancer, respiratory distress, changes to the menstrual cycle, other impacts on reproductive health (including birth defects), organ damage, and skin diseases.[9]

The *Overburdened* review found that mining brings with it an ethic of exploitation that is harmful to women and families in mining communities.[10] Mining is an industry of extraction that intensively uses resources, both human and environmental, at the expense of communities. In addition to causing pollution of resources, mining uses large quantities of water and destroys land that might have been otherwise used for other purposes such as agriculture or housing. This review addresses social determinants of health and the issues of sexual exploitation, migration and displacement, addictions, and family violence, among other non-toxicological consequences of the mining industry. Women whose spouses are miners often have to deal with the stress of living in small, isolated communities, and the worry about the effects of mine contamination on themselves and their families.[11] They often must cope with depression, anxiety, community violence, poverty, addictions, and the uncertain boom-bust economic cycles that can be a reality in such communities. Mining can displace whole communities from their homes, and thus can affect cultural identity, security, subsistence, as well as contribute to malnutrition, poor health, diarrhoea, dysentery, and epidemics of infectious diseases.[12] Sexual violence, including rape, assault, and harassment, are reportedly commonly experienced by women working in and living around mines throughout the world.[13] It is likely that this ethic also affects female mineworkers, but no information on this subject was found.

In conclusion, this literature review shows that women are affected by the mining industry from work to home, at all stages of their lifecycles, by all types of mining, and in ways that include physical, emotional, sexual, and spiritual aspects of their lives. Women's involvement with and

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[6] Silbergeld 1991.
[7] Akesson et al. 2002; Goyer 1997.
[8] Osman et al. 2000; Fischer et al. 2003; Li et al. 2000; Stevens 2003; Castoldi et al. 2003.
[9] Hinton et al. 2003; Mines and Communities 2003; Stephens and Ahern 2001.
[10] Cleghorn et al. 2001.
[11] Jiwani 1998; Bhanumathi 2002.
[12] Bhanumathi 2002; Byford 2002.
[13] Mines and Communities 2003; Bhanumathi 2002; Byford 2002; Downing 2002; Northern Secretariat 1999; Jiwani 1998.

participation in the mining industry – both voluntary and not – must be recognized. It is equally crucial that the impacts of the mining industry on women's health be studied.

Many of the health effects of mining on women are linked to the social determinants of health – particularly gender equality and socioeconomic status. Resolving the problems inherent to gender, mining, and health will require that women's status be raised in all social and economic sectors. Without this, as natural resources grow scarcer, women's health burden from mineral exploitation will only continue to grow.

Recommendations

Several recommendations are presented in the *Overburdened* review. These recommendations address some of the issues that affect women in the workplace and in the home; some are specific to artisanal mining, where women constitute a huge proportion of the work force; and others are specific to the issue of sexual exploitation. Some of the key recommendations include:

- Increasing women's access to gender-sensitive occupational training, safety measures, and technological assistance;
- Minimizing sexual harassment in the workplace by training workers on issues of gender sensitivity;
- Enhancing other opportunities for economic self-sufficiency, including skills development (e.g., managerial and accounting skills), establishment of credit lines and microlending programs, and support for the acquisition of mineral titles;
- Educating women regarding nutrition, health, and safety issues;
- Providing opportunities for women to work together, through the organisation of women's cooperatives for food acquisition and preparation, childcare, and labour organizing;
- Educating male mine employees about sexual health and HIV prevention, and providing accessible and free condoms;
- Empowering commercial sex trade workers;
- Implementing regular screening and treatment for sexually transmitted infections for both men and women;
- Providing community outreach and support for addictions, mental health services, and access to adequate health care and family violence prevention programs;
- Developing alternative sources of income generation to reduce reliance on mining operations; and
- Using community-based research principles and methods to enable communities to identify problems and solutions related to community health and safety surveillance.

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1.0 INTRODUCTION

Overburdened is a comprehensive literature review on women, mining, and health. Evidence regarding the impact of mining, mineral extraction, and processing on the health of women and their communities is presented. The purpose of the review is to provide information to help heal and protect women, their families, and their communities from the adverse health impacts of mineral extraction through:

- Enhancing the level of knowledge about the impact of mining on women's health; and
- Developing the capacity of women in mining communities to protect themselves and their families from the effects of mining.

In Canada and internationally, mines at all stages of development are known to affect the culture, health, economy, subsistence lifestyles, and environment of nearby communities. Often, women are the central members of the community and their families who address, contemplate, and cope with the social and environmental impacts of mineral resource development (Cleghorn et al. 2001). The focus of the *Overburdened* literature review is to provide an evidence-based gender analysis of the impact of mining on women's health.

1.1 Context: Gender, Mining and Health

The World Health Organisation (WHO) defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease and infirmity" (WHO 2003). Women may experience the effects of mining in a range of ways – from working in large-scale coal mines to small-scale gold panning operations; from washing the dusty laundry of their miner family members and/or providing services to male miners out of a dire need of cash; to living downstream from a mine and consuming the contaminated fish and drinking water.

The majority of women's health problems in mining regions are caused by unchecked pollution and high levels of toxicity, mine tailings, and mine disasters. The health and safety problems vary from one mineral to another, from the technology used, from the type of mining – open cast to underground –, to the size of operations. The lands, water bodies, air, and environment are polluted by the constant release of chemical wastes, by dust generated by blasting and excavation, and by the dumping of mine wastes and overburden in the surrounding lands and rivers.

To date, most information on the health impacts of mining-related contaminants has been compiled from occupational health and safety research and case studies primarily on men of working age (Vahter et al. 2002). For example, a recent report by Stephens and Ahern (2001) provides general health information across the mining sector, but has negligible information on women's health. In a survey of published epidemiological studies from 1971 to 1990, 46% contained data only on white men, 35% included white women, only 14% presented any gender analysis, and few included minorities (Zahm et al. 1994). The findings of this body of research previously have been referred to as "human health" without assessing different toxicological factors for women, children, the elderly, or individuals with specific sensitivities or diseases. Animal toxicology studies use male animals, and even tissue and cell cultures are taken from male animals.

Research has rarely discussed gender differences in health, for example, such as whether health effects are more or less likely to occur in women as compared to men, or how the symptoms may be different. Often, different statistics may be offered on men and women similarly exposed, but either no gender analysis is provided to describe the reasons for differences or the differences are explained as being caused by pregnancy. While pregnancy may be part of the explanation, biological factors and non-biological gender factors affect women differently than men regardless of having ever been pregnant. There may be health disorders unique to women, or enhanced susceptibility to hazards caused by female physiology, reproductive status, or life stage (Roberts and SiIbergeld 1995). Additionally, due to social factors such as women not being taken seriously, the severity of women's symptoms (e.g., chest pain or fainting) have often been minimized by medical attendants, and this has led to misdiagnosis of ailments (Greenberg and Dement 1994). Similarly, anaemia and hæmaturia (blood in urine) are frequently dismissed as resulting from menstruation instead of indicating clues for analyzing symptoms of disease (Greenberg and Dement 1994).

Women's health research has been given attention primarily in relation to reproductive health, such as the risk of impact to a foetus, or to a baby through breast milk. It is increasingly understood that *in utero* exposure to toxins can lead to negative health effects later in life.

Establishing causation in this area is very challenging. Determining the specific effect caused by a specific contaminant is difficult outside controlled laboratory experiments because environmental exposures can be in low concentrations, over an extended period of time, and only one of a variety of substances that impact health from a variety of sources. Chronic exposure can result in a long lag time or latency period before symptoms are felt or perceived, and often may be experienced as unspecific symptoms of general ill health. Women most often experience mining contamination in chronic exposure situations, so it can be difficult to pinpoint the cause of their ailments. Women may also be exposed to different contaminants in their different life roles, making it very difficult to untangle the various threads of exposure and effects.

It is equally difficult to medically prove the association between certain mine-induced illnesses and diseases, especially in the informal sector where workers shift between jobs – from agriculture, to construction work, to mining – all of which may expose them to hazardous substances and conditions. Due to the migratory nature of these individuals, they are impossible to study longitudinally over time. Mining companies often try to hide the true conditions of both working conditions and workers' health and instead attribute workers' illnesses to addictions like alcoholism and smoking. Silicosis, asbestosis, and other respiratory illnesses may be misdiagnosed as tuberculosis or other illnesses incurred by workers from non-occupational exposures, thus enabling the mining companies and government hospitals to deflect any direct correlation to the specific mine pollution and toxicity. Due to the general lack of scientific evidence, the mining industry has been able to turn a blind eye from its responsibilities towards the health of the communities and people the industry affects (Mines and Communities 2003).

1.2 Gender-related Determinants of Health

Biological gender factors that influence health can be thought of as the physical determinants of health. A woman's physiology changes with monthly menstruation, pregnancy, and menopause, and this in turn affects susceptibility to disease resulting from contamination. Physical characteristics of women such as body weight and size, fat content, lung capacity, muscle structure, and presence of female reproductive organs (breasts, uterus, and ovaries, etc.) may also influence susceptibility to contaminants (Roberts and Silbergeld 1995). Gender differences in toxin uptake (inhalation, skin, or intestinal absorption), distribution, metabolism, and excretion may affect the external exposure relationship to internal impact (Greenberg and Dement 1994).

Non-biological gender factors that influence health range widely and can be grouped under what are called "social determinants of health." Social determinants of health are those factors, such as socioeconomic status, housing, lifestyle (smoking, exercise, drug/alcohol use), diet, and stress, which can directly influence and affect a person's health. Societal factors such as culture, class structure, and occupational selection bias create different conditions for women, and this influences health differently by gender. Because a disproportionate number of women in the world are poor, without safe and stable housing or personal environment, and have enormous stresses in their lives, these determinants are often underlying and contributing factors affecting the health of women.

The concept of the social determinants of health has become intricately linked to the concept that health, as defined by the World Health Organisation, is a human right. In order to contextualize or see the big picture of the research summarized in this review, it is important to underscore that while mining is certainly the immediate cause of many problems, the broader issues are poverty, displacement, misogyny, and the disempowerment of women and girls around the world. The influence of mining has often exacerbated rather than diminished these problems.

2.0 METHODS

Health Canada defines a gender-based analysis as a method of evaluation and interpretation that takes into account social and economic differences between women and men (Health Canada 2002). The application of gender-based analysis is governed by four fundamental principles:

- Gender equality can be achieved only by recognizing the different impact of norms or measures on women and men according to their diverse life situations;
- Gender-based analysis is an integral part of the substantive analytical process and must be applied at each stage of this process;
- Gender-based analysis focuses not only on results but also on concepts, arguments, and language used in the work process; and
- Gender-based analysis must lead to remedies to inequality.

This literature review has adopted a gender-based analytical approach by deliberately and systematically searching the medical, toxicological, and community-based literature for information regarding the impact of mining on women's health. In doing so, it has attempted to take account of both direct and indirect impacts of mining – the exposure of women and children to mine disasters and mine pollution, as well as to the reduction in quality of life due to denial of access to food security, natural resources and livelihoods, and from sexual and other forms of exploitation.

Data, however, on the direct and indirect impacts of mining on women's health is scarce, and the lack of evidence is even more glaring for women living in low-income countries such as those in South Asia, Africa, or Latin America (Mines and Communities 2003). Information on women workers was almost non-existent, particularly on the issue of workplace sexual harassment.

This review has involved extensive searches of the epidemiological, toxicological, and community-based literature. Scientific journal and abstract databases searched were PubMed, MedLine, ToxNet, OVID, NRCC, and the Integrated Risk Information System (IRIS). Community-based literature was sought via the Internet, using the Google search engine. Various combinations of the following keywords were employed in both instances: gender, women, health, mining, specific minerals and metals (arsenic, selenium, cadmium, lead, mercury, diamonds, nickel, asbestos, chromium, etc.) pregnancy, breastfeeding, menopause, stress, violence, mineworker, sexual harassment, cancer, AIDS, subsistence, foetal alcohol syndrome, birth defects, birth-weight, developmental and behavioural effects, malaria, prostitution, family violence, addictions, vulnerability, children, and paediatrics.

In addition to broad Internet searches, the following specific websites and organisations were investigated:

Canadian: Health Canada, Environment Canada, Canadian Women's Health Network, Canadian AIDS Society, Alternatives Magazine, Indigenous Women, Cultural Survival, Women's Environment and Development Organization, Canadian Aboriginal Rights Action League, Fetal Alcohol Syndrome Society Yukon, FREDA, People's Health Assembly, Indigenous Environmental Network, CINBOISE, Aboriginal Centre for Development and Research Environments, Rachael's Environment and Health News.

International: World Health Organisation, United Nations AIDS Program, International Institute for Environment and Development, Project Underground, European Centre for Environment and Health, United States Environmental Protection Agency, U.S. National Institutes of Health, International Agency for Research on Cancer, IDRC, Mining Minerals and Sustainable Development (MMSD), World Bank, International Centre for Research on Women, Centre for Excellence in Women's Health.

There were a number of limitations to the research. Many of the community-based papers lack substantiating data or information (e.g., no statistics, no comparisons, etc.) making it difficult to judge the validity or interpretability of the information. However, much of the community-based information was based on personal testimonials, and as such was very powerful.

The scientific papers often did not come from "important" journals, or were published in journals no longer in print. Relevant papers/studies are often quite old and limited in their methods and analyses (the fields of epidemiology and biostatistics have evolved greatly over the past twenty years). Gender-based analyses were rarely done, and gender issues were seldom mentioned.

3.0 TOXICOLOGICAL REVIEW OF WOMEN'S HEALTH

The following section discusses the toxicology of individual women's health as it is affected by specific mining contaminants. The *Overburdened* literature review has focused on gender-specific health research and is not a comprehensive review of all health impacts related to mining and mineral development. Many sections in this report do not describe health impacts of a specific compound extensively if information specific to women is not available.

Health impacts and specific sensitivities will vary over a woman's life depending on her changing physiology. A general discussion of life stage changes in physiology is presented first to provide context for the discussion on the toxicity of specific metals during different life stages. Information at different life stages was not consistently available and most of the research focused on effects on reproductive health and children.

3.1 Life Stages

All stages of a woman's life bring unique physiological states that may both influence susceptibility to toxins as well as be directly and indirectly influenced by toxins. For example, timing of menstruation or menopause may be affected, and fertility, reproductive health, and lactation may be compromised. Bone and fat provide primary storage for toxins in the body. The liver and kidney also provide storage and help the body metabolize and remove toxins. Release of toxins from body storage is usually slow, minimizing the impact of release. Stored toxins can and do accumulate and cause health risks. For example, breast cancer is more common in women because there is more fat in women's breast tissue and thus a greater amount of fat-stored toxins. Physiological changes to these body storage functions may increase the amount of toxin released over a relatively short period of time. This may alter the resiliency of an individual to the toxin during certain physiological states. The following describes the physiological changes associated with different life stages in women and discusses the importance of these changes in relation to the level of harm caused by exposure to toxic substances.

3.1.1 Pregnancy

During pregnancy, a woman's entire body physiology shifts dramatically. For example, blood flow and cardiac output almost double, fat stores increase by over three kilograms, food intake and metabolism increase, energy requirements increase, hormone cycles change, mineral and nutrient absorption changes, and the immune system is altered (Metcalf et al. 1988).

Since the maternal blood volume is higher during pregnancy, the body requires more calcium to avoid calcium stress. Hormonal shifts, changes in digestion and bone-stored calcium releases combine to increase calcium release to the blood (Silbergeld1991). Later in pregnancy, the foetus needs high quantities of calcium for bone development (Metcalf et al. 1988). Many metals (e.g., lead, cadmium, aluminum, and mercury) are stored and moved in the body in the same way as calcium. Changes to the rate of calcium metabolism can also release these metals into the blood stream.

Copper and zinc are required for foetal development, and if the maternal dietary supply is not enough, additional amounts can be drawn from liver and kidney stores (Suzuki 1990). The body also shifts its physiology significantly to supply sufficient energy and fat for the pregnant woman and developing foetus (Roberts and Silbergeld 1995).

Breastfeeding is similar physiologically to pregnancy, except that the maternal need for calcium and fat can be even greater during breastfeeding. Toxins that tend to be stored in fat will also tend to be transferred to a baby through breast milk.

3.1.2 Childhood

Childhood physiology is influenced by three growth phases. In children, growth rate is a good index of nutritional status, health, and psychological well-being. Changes in growth rate will change the child's requirements for all nutrients, calcium, fluids, and protein in particular. The first phase of foetal development and infancy up to one year is nutrition-dependent growth. This phase is characterized by both the most rapid growth rate and the most rapidly decreasing growth rate experienced during an individual's growing lifetime. The digestive tract is immature at birth, and milk (breast or formula) initially provides sufficient nutrients for growth and development. The second phase of growth in one- to two-year old children is influenced by growth hormone and is characterized by a long period where growth rate slows. The onset of puberty is the third phase and is regulated primarily by oestrogen (Allen 2002).

These physiological changes will influence a child's susceptibility to different toxins. For example, during periods of rapid growth, a child becomes more susceptible to the effects of toxins that are likely to be stored in bone (cadmium, lead, aluminum, etc.). Similarly, during brain development, the effects of neurotoxins such as mercury or lead may be more dramatic.

3.1.3 Puberty

From a biological perspective, puberty is the stage of physical maturation in which an individual becomes physiologically capable of sexual reproduction. The biological changes that occur during puberty include several neurosecretory factors and/or hormones, all of which modulate growth, the development of the sex glands, as well as endocrine and exocrine secretions (Dubuis 2002).

Secondary sex characteristics appear and/or begin to mature at an average age of 10.5 years in girls (ovaries, uterus, vagina, labia, and breasts, and growth of pubic hair. There is a short-lived pre-pubertal slowing in growth kinetics followed by the typical adolescent growth spurt, and acne is frequent between 11 and 14.5 years of age. First menstruation is usually around 12.5 to 13 years of age (Dubuis 2002).

The resultant increase in sex steroid production will ensure the appearance and maintenance of sexual characteristics and the capacity for reproduction. The entire endocrine system is altered during adolescence (Dubuis 2002).

3.1.4 Aging

Aging in women brings major changes in body constitution and physiological functions that influence the impact of toxic metals. During menopause, both oestrogen levels and the rates of the metabolism of vitamin D and calcium decrease (Baeckland et al. 1999). Postmenopausal hormonal shifts are related to increases in body fat, and decreases in body water and plasma volume. Metabolism and absorption of nutrients and toxins also change with hormonal shifts (Baeckland et al. 1999). During menopause, metabolism decreases and fat distribution shifts, increasing the risk of cardiovascular disease, diabetes, and hypertension. Increased fat provides more storage space and can increase the retention of toxins (Roberts and Silbergeld 1995). Changes in bone mass begin around age 35 in women. These changes occur after a lifelong exposure to and accumulation of a range of metals and other contaminants. High blood metal levels in elderly women may cause extra stress on aging tissues and influence premature aging (Grandjean1991). Age-related diseases may be more prevalent in women, but this may be related to the generally longer life-span of women (Roberts and Silbergeld 1995).

3.2 Cadmium

Cadmium is mined around the world, primarily for use in batteries. Cadmium is a toxic metal that accumulates in the liver and kidney and causes kidney damage, anaemia, osteoporosis, and osteomalacia. Cadmium is also present in tobacco smoke (Furman and Laleli 1999).

Iron prevents cadmium from being absorbed during digestion and thus is important in regulating the impact of cadmium on women's health. Women tend to have lower iron levels than men and become more susceptible to the impact of cadmium. This is especially the case during menstruation and throughout childbearing years because there can be significant iron loss in blood, and low iron absorption during menstruation (Akesson et al. 2002; Goyer 1997). Women's iron levels are influenced by genetic factors such as how often and how long their menstrual periods last, how much blood is menstruated, and metabolic factors such as how well an individual absorbs and retains iron (Bjorkman et al. 2000). Low iron levels increase gastrointestinal absorption of other metals and result in three times higher internal cadmium levels (blood, urine, kidneys) in women than in men (Baeklund et al. 1999; Vahtu et al. 2002). Low or deficient dietary protein may also lower iron levels and increase cadmium absorption (Ragan 1983). Women who have had abortions have been found to have higher cadmium levels (Durska 2001).

Once cadmium is taken up, it tends to be stored in the body for a long time (Baeklund et al. 1999). Cadmium is often stored in bone (Roberts and Silbergeld. 1995).

Itai-Itai disease (Ouch-ouch disease) is a painful condition known as a woman's disease. Itai-itai is caused by cadmium accumulation in bone resulting in bone damage, fractures, and pain (osteoporosis and osteomalacia). Itai-itai mostly affects women due to their higher body burden of cadmium and greater susceptibility of cadmium uptake. Japanese studies of exposure from eating rice contaminated by cadmium mining have shown that the body burden of cadmium accumulates over time (Tsuchiya 1969). Women who have had multiple pregnancies and low calcium levels may be more likely to suffer Itai-itai disease when exposed to cadmium (Tsuchiya 1969).

Women's higher internal cadmium levels may increase the risk of kidney damage from cadmium at lower exposure levels than would affect men, but little research has confirmed this (Nakadaira and Nishi 2003; Vahter et al. 2002; Oo et al. 2000). One out of three women in a cadmium-polluted area in Japan had kidney damage after 16 years of eating cadmium-contaminated rice (Aoshima 1987). Kidney damage from cadmium also decreases vitamin D, which in turn harms bone regeneration. This combined influence increases the harm cadmium already causes to bone structure.

In Japan, a mineral processing plant for cadmium, lead, and zinc had for years discharged wastewater into the water supply for a downstream farming community. The soil and agricultural products in the area were very high in cadmium, as were cadmium levels in resident women's tissues. This resulted in a syndrome that caused progressive degeneration that included rheumatic lower back pain, bone fractures, pain in bones (lumbago, pseudofractures, and osteomalacia). Cadmium toxicity also causes kidney damage. Women in the area were already deficient in calcium due to poor nutrition and multiple pregnancies (Emmerson 1970).

3.2.1 Pregnancy

Cadmium is somewhat prevented from affecting the foetus by the placental barrier (Iyengar and Rapp 2001; Osman et al. 2000). While it has been estimated that foetal blood cadmium levels will be one-third of the maternal blood cadmium levels (Durska 2001), newborn hair samples show foetuses do accumulate cadmium in the womb (Durska 2001). Only a small quantity of cadmium is transferred through breast milk (Hallen et al. 1995). As iron levels decrease during pregnancy, cadmium may increase in the mother but will not be substantially transferred to the foetus.

Previous studies have conflicted as to whether cadmium causes birth defects in humans. Some studies show cadmium increases chromosomal aberrations and DNA breaks that can lead to birth defects (Palus et al. 2003). Low levels of maternal cadmium increase the risk of developmental impairment in infants (Salpieto et al. 2002).

Premature births and low birth-weights have been associated with cadmium exposure in a smelter town (Fischer et al. 2003) and in mining districts in the Czech Republic (Epstein et al. 2000). Early delivery and low birth-weight may be related to cadmium exposure early in pregnancy (Nishijo et al. 2002). Essential metals such as magnesium, zinc, or selenium may protect against the impact of cadmium (Palus et al. 2003).

Cadmium is stored in the kidney and liver, where it is metabolised before combining with zinc or copper, which minimizes cadmium's toxicity. During pregnancy, zinc and copper are required for foetal development and are taken out of bodily stores leaving cadmium unattended by the protective mechanism of zinc and copper (Suzuki 1990). During pregnancy, iron stores decrease (Akesson et al. 2002; Goyer 1997) and cadmium stored in bone is released in conjunction with the calcium released for foetal development (Roberts and Silbergeld 1995). This increases maternal blood cadmium levels (Silbergeld 1991).

3.2.2 Childhood

No information on the impact of cadmium toxicity during childhood was found.

3.2.3 Adolescence

No information on the impact of cadmium toxicity during adolescence was found.

3.2.4 Aging

As a woman ages, her bones naturally become less dense as calcium is released from the bone. The rate of bone demineralisation in postmenopausal women is influenced by decreasing oestrogen and other hormones, reduced metabolism of vitamin D, calcium deficiency, and lower uptake of calcium (Vahter et al. 2002; Baeckland et al. 1999; Silbergeld et al. 1988). Cadmium can be released from bone in the same way as calcium, but at a different rate. Reduced oestrogen after menopause increases cadmium-related bone effects in women by increasing the natural loss of bone mass after menopause (Freeman 1996). Consequently, middle-aged women may be more likely to suffer Itai-itai disease than younger women when exposed to cadmium (Tsuchiya 1969).

After menopause there is less of a gender difference for total body cadmium levels (Baeklund et al. 1999).

3.3 Lead

Environmental exposure to lead comes from a variety of sources. Other than mining, lead is also found in gasoline, batteries, paint, ceramics, etc. Smoking also increases exposure to lead (Furman and Laleli 1999).

In the body, lead is moved in the same way as calcium or zinc, allowing it to cross the blood-brain barrier, be stored in bone, and enter nerve cells (Lidsky 2003; Bressler and Goldstein 1991). Unlike calcium and zinc, lead does not have a biological purpose and is toxic. Lead can harm reproduction, the central nervous system, cardiovascular functioning, as well as the blood.

Lead is stored in the bone for a duration spanning from years to decades (Rabinowitz et al. 1976). When bone is demineralised during weight loss (Han et al. 1999), pregnancy, or lactation, lead is mobilized from the bone to blood (Gulson et al. 1999). Uptake of lead into the blood may be increased by low body iron (as in cadmium discussion above), but research is conflicting (Goyer 1997). A diet containing sufficient calcium minimizes lead uptake and re-mobilisation from bone (Schneider et al. 2003; Stevens 2003; Weyermann and Brenner. 1998).

At levels well below recommended U.S. occupational exposure limit guidelines, blood lead has been found to increase blood pressure and hypertension in women (Nash et al. 2003). Women generally have lower blood lead levels than men due to lower occupational exposures (WHO 1995). However, women in the workplace are more likely to experience adverse lead effects than men due to women's more lead-sensitive haematopoietic system, which regulates blood development (Sittig 1985).

There is no known mechanism for removing lead once it is stored in the brain (Qian and Tiffany-Castiglioni 2003).

Broken Hill, Australia, is one of the world's largest lead-mining cities. Women living in Broken Hill had lower blood lead levels than men, since men tended to have higher lead exposure from working in the mine. Women's environmental exposure is thought to be from a combination of gasoline lead and contaminated food and water. Children had highly elevated blood lead levels and their exposure has been linked to mine dumps (Gulson et al. 1994, 1996).

The long-term effects of lead exposure on the health of women workers at Bunker Hill mining and smelting facility in Idaho, and in women residents in the surrounding communities, included higher bone and blood lead levels and greater reduction in bone density (Lee 1997). They were also more likely to have had hysterectomies or to have stopped menstruating earlier in life (Lee 1997).

Women may be more susceptible than their male counterparts to both the physiological and psychological consequences of lead poisoning in the workplace. The level of fatigue increases a woman's susceptibility to lead poisoning. It is suggested that the length of the workday for female workers should be limited since fewer work hours would limit exposure, reduce fatigue, and allow more complete elimination of lead from the body (Hamilton 1997).

3.3.1 Pregnancy

Lead is readily passed across the placental barrier to the foetus (Gardella 2001; Iyengar and Rapp 2001). It has been estimated that foetal blood lead levels will be only one-fifth lower than maternal blood lead levels (Durska 2001). Newborn hair samples show that the foetus accumulates lead while in the womb (Durska 2001).

Lead can be stored in the bone for decades after exposure. Stored lead tends to be mobilized from bone during pregnancy and lactation, increasing the risk of exposure to the foetus during *in utero* development and to a breastfeeding baby long after maternal exposure to lead (Li et al. 2000; Wang et al, 2000; Baeckland et al. 1999). During foetal brain development, neurite morphology (brain cells) will be damaged at lead levels 1000 times less than that which causes cell death (Schneider et al. 2003). The younger the child is at time of exposure, the greater the risk of harm (Stevens 2003). Since very low levels of lead in placental blood cause harm to cognitive development, very low levels of released lead could be dangerous (Bellinger 2000). Calcium deficiency during pregnancy and lactation can increase mobilisation of lead stored in the bone (Baeckland et al. 1999). This is particularly a concern during the sixth month of pregnancy when the foetal brain is developing quickly and the skeleton is also forming (Stevens 2003). A high calcium diet for the mother minimizes lead mobility from the bone (Lidsky and Schneider 2003; Weyermann and Brenner 1998) and can decrease maternal blood levels by up to 16% during breastfeeding (Stevens 2003).

Women lead mineworkers and partners of lead mineworkers have reported higher rates of miscarriage (Landrigan et al. 1995). Higher maternal blood lead increases pre-term delivery, although no association was found for low birth-weight or small-for-gestational-age infants (McMichael et al. 1986). Premature births and low birth-weights have also been associated with lead exposure in a Bulgarian smelter town (Fischer et al. 2003) and in the Czech mining districts (Epstein et al. 2000). Sub-toxic lead levels have increased membrane rupture and premature deliveries for women in lead-mining communities (Fahim et al. 1976). Lead exposure during pregnancy has harmed bone growth in foetuses and in later development of children (Schwartz et al. 1986). In mining areas in China, blood lead and breast milk lead levels in pregnant women were found to be very high (Wang et al. 2002).

The impact of paternal lead exposure on reproductive health has not been studied, though male lead toxicity may impact foetal development as has been shown with other neurotoxic substances such as alcohol, morphine, and cocaine (Colie 1993; Needleman et al. 1990).

Erythropoieitin (EPO) is a hormone crucial to having sufficient oxygen in the blood because it produces haemoglobin that prevents anaemia. Pregnant women with moderately elevated blood lead levels have low EPO and tend to be anaemic (Graziano et al. 1991).

3.3.2 Childhood

Children are much more susceptible to lead toxicity because more lead is absorbed than in adults, and lead can enter tissues that are more vulnerable during growth and development (Cory-Schlecta and Schaumberg 2000). Children may show symptoms of anorexia, vomiting, anaemia, and lethargy, and they may develop extreme seizures and coma (Lidsky and Schneider 2003). Often these symptoms are not attributed to lead poisoning, as they are general symptoms of illness. The effects on brain development are consistently harmful at low-level exposure (Landrigan et al. 1995).

Most studies on the impact of lead exposure in children have looked at IQ tests as an indication of cognitive ability. Children under three years of age are at the greatest risk of IQ losses since this is the age when basic cognitive abilities develop (Schwartz 1994). A Mexican study of six- to nine-year olds showed children with higher lead exposures have a lower ability to concentrate (Calderon 2001). Recent studies have looked at antisocial behaviour and delinquency as indicators of the impact of lead exposure in children (Needleman et al. 2002; Denno 1990). Hyperactivity, learning disabilities, attention-deficit disorders, and aggression in children have been linked to very low lead exposures (Stevens 2003; Bayer 2001). Prenatal exposure to lead has been reported as contributing to later anti-social behaviour of children (Dietrich et al. 2001).

An Ecuadorian study found that while children living in a lead-contaminated area had higher blood lead levels, there was no effect on their hearing ability (Counter et al. 1997; Counter et al. 1998) Other studies have shown that hearing loss can occur at very low lead exposures in children (Stevens 2003).

A study in a Bulgarian smelter town showed children with higher blood lead tended to be smaller. The study linked lead contamination of the children to their diet of homegrown food (Fischer et al. 2003). Children of lead miners were found to have blood lead levels that increased with the severity and duration of parental exposure at work, as well as with an increase in in-house dust lead levels (Paoliello et al. 2002; Baker et al. 1977). Poverty and poor maternal nutrition increase the impact of lead to low birth-weight and increased blood lead levels in children (Krieger et al. 2003; Dubay et al. 2001).

A Brazilian study assessed the exposure to lead and cadmium of 295 children aged seven to fourteen years living near lead refineries. It found that children living close to the refinery were over 10 times more likely to have high blood lead levels, and that the average blood lead level obtained in children living close to the lead refinery was four times higher than in children in other areas (Paoliello et al. 2002). Boys were twice as likely as girls to have high blood lead levels (Paoliello et al. 2002). In Australia, children of lead-zinc-copper mineworkers had lower blood lead levels than non-occupationally exposed families (e.g., whose exposure might come from sources such as lead paint) (Chiaradia et al. 1997).

Children living in a lead mining town who had lead exposure had hyperactivated EPO (erythropoieitin) production, meaning that more EPO than normal needed to be produced in order for the children to not become anaemic (Factor-Litvak et al. 1998).

3.3.3 Adolescence

Prenatal and childhood lead exposure has been linked to alteration in growth and endocrine function in adolescent girls (Kaplowitz et al. 2001). Higher blood lead has been associated with decreased adolescent height and delayed puberty (Selevan et al. 2003).

Lead exposure early in life is associated with a seven times greater chance that an adolescent will quit high school and a six times greater chance of reading disabilities (Needleman et al. 1990). There is a link between early-life lead exposure and the chance of adolescent pregnancy (Nevin 2000). Violent crimes, such as assault, rape, murder, and robbery have been associated with early-life exposure to lead (Nevin 2000).

3.3.4 Aging

Postmenopausal women have been found to be particularly sensitive to very low blood lead levels that increase their blood pressure and hypertension (Nash et al. 2003). In elderly women, past exposure to neurotoxicants such as lead can decrease reserve capacity of the brain and harm neuropsychological function (Baeckland et al. 1999).

After menopause, bones naturally release calcium (through demineralisation), bone density decreases, and lead is released from the bone, increasing blood lead levels (Nash et al. 2003; Silbergeld et al. 1988). Osteoporosis is very common in elderly women, whereby extreme bone density loss results in the bones becoming weakened, brittle, and vulnerable to fractures (Silbergeld et al. 1988). Blood lead levels are high in postmenopausal women and even higher in osteoporotic postmenopausal women because the lead is released from bone to blood in the same way as calcium (Silbergeld et al. 1988).

Blood lead levels in postmenopausal women peak at the median age for menopause and then decrease as bone demineralisation slows (Silbergeld et al. 1988). Postmenopausal women with prior pregnancies had lower blood lead levels (Silbergeld et al. 1988). The rate of bone demineralisation in postmenopausal women is influenced by naturally decreasing estrogen and other hormones, reduced metabolism of vitamin D, calcium deficiency, and lower uptake of calcium (Vahter et al. 2002; Baeckland et al. 1999; Silbergeld et al. 1988). Lead released from bone will also have a more harmful impact in elderly women because the protective influence of vitamin D and calcium are diminished. The impact of the rapid increase of blood lead in postmenopausal women has not been studied.

3.4 Mercury

Mercury exposure due to gold mining is most common because mercury is used to extract the gold from the ore. In cases of small-scale miners, mercury is then burned off as a vapour where it can be inhaled by the worker. Mercury is also commonly present geologically with gold deposits and can be released when the gold is mined.

Mercury toxicity and its health impacts depend on the chemical form mercury takes. When inhaled, mercury is harmful to the kidney and the central nervous system (nephrotoxic and neurotoxic). Methylmercury, the biological form of mercury most commonly ingested through fish or seafood containing mercury, is also harmful to the central nervous system (Guimares et al. 1999). A study of kidney concentrations of mercury in the Swedish population shows women have three times greater levels than men (Barregard et al. 1999.) Gender-specific sensitivities to mercury have not been analysed (Yahtu et al. 2002.)

Selenium, vitamin E, and zinc are thought to decrease the toxicity of methylmercury, while magnesium and thiamine deficiency may increase susceptibility to methylmercury toxicity (NRCC 1979).

In the Lake Victoria gold fields of Tanzania, methylmercury levels were measured in inhabitants of the gold mine and the nearby community. Hair and urine samples showed higher levels of methylmercury for the women in the non-gold mining community because their food source was contaminated fish. Wives of the gold miners had much lower levels than women engaged in mercury amalgamation (Ikingura and Akagi 1996).

Eating fish contaminated with mercury had similar effects in the Amazon Basin and in northern Quebec. Women and infants in fish-eating populations of the Amazon living downstream of mercury-releasing gold mines were found to have high mercury levels in hair samples. As the amount of fish consumed increased, so did the mercury levels (Boischio and Cerniche 1998; Lebel et al. 1996). Similar results were found in Cree women and children of northern Quebec (McKeown-Eyssen et al. 1983). Among two gold-mining-affected communities in Brazil, mercury hair samples of women showed that women with diets containing a high proportion of carnivorous fish had eight times higher methylmercury levels than those women who ate herbivorous fish (Eve et al. 1996). This shows that mercury will accumulate up the food chain. In the Amazon, high fruit diets decreased mercury levels in people eating fish contaminated with mercury. This may be due to increased vitamin C or other nutrients that affect absorption, metabolism, or excretion of mercury (Passos et al. 2003).

3.4.1 Pregnancy

Mercury and methylmercury both pass readily from maternal blood through the placenta to the foetus and may result in twice the amount in the baby's blood (Vahter et al. 2002). Breastfeeding also exposes babies to these compounds. Foetuses and developing children are vulnerable to mercury toxicity at levels that have no impact on the mother, and effects may be seen immediately or arise later in life (NRCC 1979). Prenatal exposure to methylmercury is the most sensitive time for exposure and harms later child development for psychomotor and cognitive skills (Castoldi et al. 2003).

Low birth-weight and premature births in the Czech Republic have been linked to maternal mercury exposure in mining districts (Epstein et al. 2000). Minamata, Japan, was the first recorded large-scale mercury poisoning when the bay was contaminated by effluent from a manufacturing plant in the 1950s. At the time of the greatest mercury exposure to Minimata residents, more female than male babies survived (Sakamoto et al. 2001). Deafness, blindness, seizures, and cerebral palsy have found in severe cases of foetal Minamata disease (Castoldi et al. 2003).

3.4.2 Childhood

Children who assist their parents in small-scale gold mines, or who live near by, are often exposed to mercury vapours and methylmercury, and have been found to have impaired neurodevelopment (Counter 2003).

A German study examined the internal burden of mercury among children and found that the most significant factor affecting urinary mercury levels was the number of dental amalgam fillings (Trepka et al. 1997).

3.4.3 Adolescence

No information on the impact of mercury toxicity during adolescence was found.

3.4.4 Aging

No information on the impact of mercury toxicity among aging women was found.

3.5 Copper

Copper is mined worldwide for use in wiring, pipes, and a range of other manufactured products. Copper is an essential element that is generally not very toxic to humans but can cause skin irritation, stomach ulcers, and kidney damage.

Copper toxicity can cause irregular menstruation (Loudianos and Gitlin 1998).

Women living in a copper mining community in Montana had higher levels of skin and lung cancer. The impact of the copper may have been enhanced by the presence of arsenic in the air emissions (Newman et al. 1975).

3.5.1 Pregnancy

Breastfeeding can decrease both the exposure and impact of copper to the infant (Zietz et al. 2003). Stillbirths were over twice as common among the offspring of men who worked in a copper smelter compared with the offspring of office workers (Beckman and Nordstrom 1982), but the sample used in this study was small.

3.5.2 Childhood

Wilson's disease tends to be a disease of children, adolescents, and young adults (El-Youssef 2003). Wilson's disease is a metabolic disorder that causes accumulation of copper in the liver, central nervous system, and kidneys. Elevated copper levels in drinking water have been linked to an increased occurrence of Wilson's disease (Walker-Smith and Blomfield 1973). This has been linked to brain and liver damage, and the development of neurological or psychological symptoms that could include changes in behaviour at school or abnormal physical movement (Lewis and Howdle 2003). Zinc has been used to counteract the metabolism of accumulating copper (El-Youssef 2003).

Indian childhood cirrhosis is an advanced and fatal scarring of the liver caused by copper accumulation in the liver of one- to three-year old children. It has been linked to elevated levels of copper in drinking water (Muller-Hocker et al. 1988). Exposure to copper during early infancy puts a child at greater risk of experiencing the toxic effects of copper contamination, such as immune system problems (Muller-Hocker et al. 1988). Children metabolize copper differently than adults, and the child's metabolism makes him/her more susceptible to damage from the copper exposure. Furthermore, copper exposure in childhood can affect the development of the change to adult metabolism, thus increasing the duration and severity of the harmful effects of the copper (Muller-Hocker et al. 1988).

3.5.3 Adolescence

Adolescents and young adults are susceptible to copper-related symptoms of Wilson's disease as described in the above section on children and copper exposure (El-Youssef 2003).

3.5.4 Aging

No information on the impact of copper toxicity among aging women was found.

3.6 Other Metals and Minerals

The following section discusses a range of metals for which very little gender-specific information is available. Arsenic, selenium, aluminum, antimony, and nickel are reviewed. Other mining-associated contaminants such as cyanide, ammonia, chromium, manganese, diamonds, asbestos and zinc were investigated but no gender-specific analysis was found.

3.6.1 Arsenic

Arsenic is geologically associated with many different mineral deposits and is liberated in the mining and processing of these ores to extract specific minerals. Arsenic has mostly been used as pesticides and as wood preservative.

Arsenic exposure can contribute to skin and internal organ cancer or lesions. Chronic exposure can contribute to a range of diseases including diabetes, cardiovascular disease, nerve damage, chronic lung problems, and hearing impairment (Centeno et al. 1996). Arsenic can become methylated in the body and this allows easier removal of arsenic through urination; however, the methylated forms are also more toxic. There are gender differences in the way the body metabolizes arsenic that may be related to the frequency of pregnancy (Vahter et al. 2002).

In a Montana copper mining community, arsenic was present in smelter emissions and was thought to increase the incidence of skin and lung cancer in women (Newman et al. 1975). A study of 122 households (404 individuals) in a copper mining/smelting town in Arizona examined house dust as the source of elevated levels of inorganic urinary arsenic concentrations in community members. Results showed that seafood consumption during the previous three days and smoking contributed significantly to inorganic urinary arsenic, but that arsenic in house dust was not significantly associated with inorganic urinary arsenic measurements (Hysonga et al. 2003).

A German study examined the internal burden of arsenic among 950 five- to fourteen-year old eastern German children living in a region of intense smelting and copper mining and found the mean urinary arsenic concentrations were high (Trepka et al. 1996).

Another study found the risk of leukemia and lymphomas may increase among pregnant women exposed to arsenic (Epstein et al. 2000). Arsenic exposure during pregnancy may increase the incidence of problems during pregnancy such as pre-eclampsia, birth defects, miscarriages, and stillbirths (Centeno et al. 1996). Arsenic has been found to readily cross the placental barrier from maternal to fetal blood. However, only small amounts pass through breast milk (Concha et al. 1998; Mossop 1989). Arsenic may also decrease the birth-weight of newborns (Centeno et al. 1996). Low birth-weight and premature births in the Czech Republic have been linked to maternal arsenic exposure in mining districts (Epstein et al. 2000).

A study of children aged six to nine years living within one and a half kilometres of a smelter complex in Mexico was conducted to evaluate the effects of lead and arsenic exposure on their neuropsychological development. The researchers found that verbal IQ decreased with increasing exposure to arsenic, and the children with higher arsenic exposures had poorer performances on tests involving long-term memory and linguistic abstraction (Calderon 2001).

3.6.2 Selenium

Selenium is geologically associated with many different mineral deposits and is liberated in the mining and processing of these ores to extract specific minerals. Selenium exposure can contribute to cancer, nerve and liver damage, dental problems, compromised immune systems, and reproductive and hormonal effects (Vinceti et al. 2001).

Selenium may affect female hormone secretion (Basini et al. 2000) and cause irregular menses or at high exposure levels, stop menstruation altogether (Vinceti et al. 2001; Nagai 1959). Exposure to selenium increases breast cancer risk in postmenopausal women (van Noord et al. 1993).

Selenium exposure has been found to increase the chance of miscarriage and to contribute to birth defects (Aschengrau et al. 1993; Tsongas and Ferguson 1977). Other studies do not indicate conclusive data about the effects of selenium on reproductive health (Vinceti et al. 2001).

3.6.3 Aluminum

Similar to cadmium and lead, aluminum can be stored in bone and released in conjunction with calcium during pregnancy (Roberts and Silbergeld 1995). Aluminum uptake and accumulation in women is enhanced by low iron levels (Greenberg and Dement 1994).

3.6.4 Antimony

Antimony is commonly associated geologically with gold deposits. Antimony can cause skin irritation, nausea, vomiting, insomnia, and an inability to smell properly. Women exposed to antimony dusts had increased incidence of miscarriages and premature births, and their children's growth was inhibited (IARC 1989).

3.6.5 Nickel

Nickel exposure results in allergy and hand eczema (itching, swelling, scales, and cracks) in women more than men, but this occurrence seems to be due to sensitisation caused by prolonged exposure in a variety of work places more commonly occupied by women, such as jewellery-making and factory work (Vahter et al. 2002).

3.6.6 Coal

The environmental impact of coal mining on the reproductive health of populations living in small towns of southern Brazil was studied. Portuguese researchers studied the frequency of birth defects in newborns by using hospital records. Of the 10, 391 babies' records evaluated during a 10-year period (1985-95), they found no increased frequency in the eight major birth defects studied, compared to the Latin American Registry of Congenital Malformation. This study is limited, however, by the lack of information about, and probable underreporting of, birth defects to the registry (Leite and Schuler-Faccini 2001).

Researchers from India examined birth outcomes among women living on the northern boundary of the Jharia coalfield. They found a high prevalence of miscarriages (16%), but otherwise birth outcomes were considered normal (Chakravarty 1994).

A historical Japanese study looking at the impact of coal mining on fertility in the 1920s found that coal-mining regions had lower birth rates than surrounding rural districts. This lower birth rate was caused by lower marital fertility (i.e. fewer babies per couple), rather than by excessively high mortality rates (Mosk 1981). Among the reasons for the lower martial fertility could be the effect of contaminants from the coal mine on the reproductive health of women and/or men in these communities.

An analysis of the reproductive health of 131 coal miners' wives in India (with a total of 300 pregnancies) found that there were 55 (18%) stillbirths with nearly 90% of women experienced bleeding problems following the birth. Thirty-seven per cent had post-partum haemorrhage (bleeding) continuously for 11-20 days, and 33% of women haemorrhaged for up to 30 days (Padhi and Choudhury 2003).

3.6.7 Boron

An assessment of fertility in boron-exposed populations in Turkey found no differences in fertility (number of offspring) whether or not families lived in villages with high boron levels in the drinking water, or whether or not one or both parents were employed in borate mining or processing (Sayli et al. 1998).

3.6.8 Uranium and Radiation

The role of environmental radiation in the development of birth defects, stillbirths, and other negative outcomes in pregnancy was evaluated for 13,329 Navajo children born in the Shiprock, New Mexico, hospital between 1964 and 1981. The only statistically significant association found between uranium operations and unfavourable birth outcomes was identified as the mother living near tailings or mine dumps (Shields et al. 1992). Another study examined environmental samples for the presence of uranium and found much higher uranium concentrations in the surface soil in areas close to mining or milling sites. The authors conclude that local residents have been exposed to low levels of radioactive contamination from the mining/milling activities on a daily basis for many years, and the health risk among the exposed residents is similar to that among nuclear workers (Au et al. 1998).

4.0 WOMEN MINEWORKERS

There are many different kinds of mining jobs held by women workers. Small-scale or "artisanal" miners are often independent or family-run operations such as placer mining or relatively shallow hardrock mines from which ore is easily accessed. Often these involve highly unregulated and hazardous working conditions. Companies own and run large-scale mines as these require much more expensive and specialized equipment to mine deep into the earth, and to process the minerals. The next section will describe the different types of hazards faced by women workers in small- and large-scale mines.

4.1 Small-scale Miners

"A hot dry wind envelops a statuesque woman as she kneels over wind-sifted trays of tin-bearing pulverized ore in Uis, Namibia. In Bolivia, a nine-year old girl scrambles down a steep pit wall yet again to refill her bucket of metal-rich sand. And yet another woman stokes the fire in her wood-burning stove in the Philippines, releasing the mercury from doré in a poorly ventilated kitchen; the thick black soot coating kitchen wall contains more than 15% mercury. Up to her knees in muddy water, a woman pans for gold to supplement the meagre family income in [Mali]" (Hinton et al. 2003).

It is estimated that there are currently around 13 million artisanal miners in 55 countries, supporting roughly 80 to 100 million dependents. Approximately 30% of the artisanal miners in the world are women, 40-50% in Africa, and up to 100% in some regions (Hinton et al. 2003).

Hazardous, labour-intensive, highly disorganized, and often illegal, artisanal mining is an important economic issue in low-income or developing countries (Hinton et al. 2003), and is a critical issue for women. Women tend to work without safety measures if there is limited safety gear available, are more willing due to economic pressures to work without safety measures in place, and are highly vulnerable to serious health hazards and sexual exploitation (Bhanumathi 2002).

The health issues involved in artisanal mining directly result from its informal and often illegal nature. Poverty prevents adequate equipment from being bought, the mines themselves put none into place, and chemical, noise, and dust exposures can be extreme. Lack of training in mining methods and health protection increase the hazards of small-scale mining (Hinton et al. 2003). As of 2001, there were more than 30 asbestos mines in India, producing 2800 tonnes of asbestos per month, and employing approximately 100, 000 workers, both female and male. Although women once formed 30-40% of the workforce in the mining sector, they now constitute less than 12%, and represent only 5% of the coal-mining workforce (Bhanumathi 2002). While men work in the mines, women work in the processing units, leaving them very vulnerable to asbestos exposure and the ensuing health risks from this exposure (Ramanathan and Subramanian 2001). Another report from India suggests similarly that women are employed by the mining industry in secondary activities, such as cutting, sorting, quarrying, and loading and unloading. Constant contact with dust and pollution, along with additional exposure to contaminated water, air, and soil, causes severe health hazards to the women mineworkers. Even during pregnancy, women have to work in hazardous conditions amidst noise and air pollution that have adverse effects on them and their offspring (Mines and Communities 2003).

4.1.1 Injury

Loss of eyesight in India is common. Women are not given any protective gear in any of the mine-sites whether stone crushing, quarrying, or while manually loading and transporting mineral ores like coal. In some places they are injected with iron and mineral supplements in order to increase their work output and to build up resistance for the hard labour. Chronic injuries among women working in these mines include the development of muscular and back pains, wearing out of joints, arthritis, inflammation of the spinal vertebrae, numbness, fatigue and lack of stamina, breathlessness, constant coughs, irritation of the eyes, and a general physical incapacity (Mines and Communities 2003).

In spite of underreporting due to the illegality of artisanal mining, it is believed that non-fatal accidents in artisanal mining are six to seven times more frequent than in formal, large-scale operations (Hinton et al. 2003).

4.1.2 Lung Disease

A study that tracked 526 women who had worked in two lead and zinc mines in Sardinia, Italy, for 37 years showed a strong association between women with the highest exposures to silica and nonmalignant respiratory diseases. Several women died of lung cancer but this was not related to the level or duration of exposure. Smoking was rare among these women (Cocco et al. 1994).

Advanced stages of silicosis have been documented among women and children as young as 14 in Ghana (Hinton et al. 2003). Women whose work was amalgam decomposition in pocket mines of Luzon Island in the Philippines frequently had elevated levels of mercury accumulation in their hair and experienced symptoms including kidney pain, respiratory problems, and dizziness (Murao et al. 2002). In Zambia, women illegally involved in the crushing of marble are at high risk of developing lung disease (pneumoconiosis)(Dreschler 2001). Women may also work reworking tailings for several hours a day. This exposes them to multiple pollutants and puts them at risk for a variety of negative health effects (Hinton et al. 2003).

4.1.3 Rock Salt Workers

A study of the mortality of rock salt workers employed in Italy between 1965 and 1989 was conducted. Of the 487 people in the cohort, 120 were women. By the end of the study period, 92 women were alive (77%), compared to 295 men (80%). The cause of death was known in all but two cases. The primary cause of death in these women were diseases of the circulatory system (e.g., heart attack, stroke) at 40%, and the second most common cause of death was cancer at 29%. There were two cases of ovarian cancer compared to the 0.42 of a case that would be expected based on the regional average. Increased mortality from lung and pleural tumours was found among both women and men, but predominantly in men (Tarchi et al. 1994).

Another study of 2120 rock salt workers, including 21% women, in Rajasthan found that major diseases and disorders among the workers were dermatological (skin-related), respiratory, musculoskeletal, gastro-intestinal, and opthalmological (eye-related), and these effects were found equally in both sexes (Haldiya et al. 1995).

4.1.4 Cancer

Many Aborigines, including women, in the community of Pilbara, Western Australia, work in the transportation of asbestos from the Wittenoom crocidolite operation (Stephens and Ahern 2001; Armstrong et al. 1988). When a female Aborigine was found to have malignant mesothelioma after known environmental exposure, all known cases of the disease in Aborigines in Western Australia were reviewed. All known cases of malignant mesothelioma occurred in Pilbara residents. Based on recent estimates of the size of the Aboriginal population in Pilbara, the incidence of this disease in this population is one of the highest population-based rates recorded (Musk et al. 1995).

4.1.5 Children

Most women working in mines have to leave their children at home, often unattended, for the entire working day. If they are able to take their children with them to the mine-site, they expose them to high levels of dust and noise pollution. In addition, children are at high risk of falling into the mine pits while playing and are susceptible to accidents from mine blasting (Bhanumathi 2002). A South African report indicates that nursing mothers carry their sleeping babies on their backs when rocks are blasted, and pound gold-bearing rocks without any protective clothing, exposing both mothers and infants to silicosis-inducing dust, noise pollution, and flying rock fragments (Agyapong 2003).

4.1.6 Workplace Harassment

No literature was found on workplace harassment in small-scale mines.

4.2 Mineworkers in Large-Scale Mines

There are methodological problems in studying female mineworkers in large-scale mines because there are few women workers compared to men. Epidemiological research has usually not examined women and minorities separately, and gender differences in bioassays for carcinogenicity and toxicokinetics have also been ignored (Pottern and Zahm 1994). Some studies that mentioned women were found, but no gender analysis was provided and numbers were generally averaged with no distinction made between men and women (Koskinen et al. 1997; McKenna et al. 1996; Ahlmark and Gerhardsson. 1981; Pemberton 1968; Meurman et al. 1994; Meng 1991). This section on health and safety for woman mineworkers therefore presents very little gender-specific information.

4.2.1 Worker Mobility

In comparing mobility rates (referring to a worker's movement between jobs/mines) of workers in diesel as compared to non-diesel mines, there was no difference based on type of mine. Women, however, were found to move twice as often as men in both kinds of mines. In general, it was found that women, white men, higher educated, and unmarried workers were more likely to move to a new mine. Mobility rates were not related to health status, mining experience or type of mine, but they were related to many social factors (Ames and Trent 1984).

4.2.2 Injury and Fatality

Worldwide, mining remains the most dangerous occupation with respect to health and safety of workers (Skovron 1992; Stout-Wiegand 1988; NIOSH 1989).

A Bureau of Statistics occupational injuries survey of U.S. labour from 1977 to 1983 showed that women working in the mining industry represented the area with the largest increase of female employment of traditionally male-dominated work. Fortunately, it also had the lowest proportional increase of injury (Stout-Wiegand 1986).

The U.S. National Traumatic Occupational Fatalities surveillance system shows mining as the highest risk industry category for female occupational deaths between 1980 and 1989. Women aged 25 to 29 had the most deaths as workers, as compared to women in the general population whose most common age of death was over 65 years (Jenkins 1994). Women worker fatalities in the age category 65 years and older (U.S. statistics 1980-1991) were related to osteoporosis, deteriorated vision, and balance leading to accidental death by fatal falls (Kisner and Pratt 1997).

An analysis of the 1978-1980 accident history of female coal miners collected by the Mine Safety and Health Administration in the U.S. found that fewer women were injured to the point that they lost time from work compared to men (4% vs. 7%). Women lost an average of 1.1 days each as compared to 2.4 days for men, and 0.01% of the female workforce was fatally inured as compared to 0.05% of men. Most injuries to both genders involved back sprains, and the majority of the remaining injuries were sprains and fractures to joints and bones (Watson and White 1984). Two issues are not clear from this study. First, it is unclear whether workers lost wages when off work due to injury. It is possible that a woman may be more likely to work with an injury if she is the sole breadwinner of the family. Secondly, it is not clear whether women were assigned relatively less dangerous tasks than the men. Either of these factors could explain the results.

An Australian study of 204 mineral sand mineworkers found that 60% of women suffered low back pain (vs. 77% of men), including 57% of women who experienced low back pain at least two to three times per month, and 12% of women who experienced low back pain daily. Only

6% of women (19% of men) had ever taken time off work due to low back pain (Hemsley et al. 1998).

4.2.3 Physical Stress

Women are generally smaller with less physical strength than most men. Often mine equipment is designed to fit men causing various physical stresses for women using the same equipment. Physical stress levels in mining have not been reduced by any significant degree by mechanisation and automation. Ergonomic job redesign involving improved working methods and equipment is needed (Landau 1996). Different maximum weights and correct procedure of lifting for women of different ages as compared to men is recommended, as well as hydraulic and mechanical equipment for heavier lifting (Potter 1986).

Posture analysis in the Finnish steel and mining industry shows women with poor working postures had more sick leave due to musculoskeletal disorders, especially lower back pain and neck and shoulder disorders. Improving posture and equipment placement decreased strain, increased productivity, and improved health (Heinsalmi 1986).

In the Soviet Union, analysis of occupational exposure to vibration and noise showed women formed the majority of patients suffering effects of vibration (Suvorov et al. 1992).

Female worker compliance with safety programs requiring the use of personal protective devices for dust on mining work sites was affected by discomfort and encumbrance caused by weight, resistance to normal body function and movement, interference with job performance, added stress, need for maintenance, and cosmetic factors. Mining dust effects are due to chronic exposure, and with delayed effects of the hazard, workers are less likely to comply with safety programs than in industries where the exposures are acute with immediate hazard to the eyes (Cohen 1982).

4.2.4 Shift Work

A 1979 survey of Japanese workers researched the effects of shift work on social and biological functioning of the workers. Though 70% of the individuals in the study were mineworkers and women were mentioned, no gender analysis was provided. In general, shift work affects physiological disorders, work performance, safety, health risks, sleep patterns, family and social life, and professional relationships (Kogi 1981).

4.2.5 Pregnancy

Noise and whole body vibrations experienced by pregnant workers may lead to Robinson's syndrome, which can cause structural malformations of the developing foetus, such as pressure on the brain due to increased fluid in the skull (hydrocephalus)(Handke and Rostan 1986). A survey investigating pregnant mineworkers doing heavy work showed one-third stopped work by month three, one-third by month six, and the last third between months seven and nine. Little information is available on the effects of vibration, noise, and health hazards for pregnant mineworkers (Tabor 1983).

A large 1980 U.S. study called the National Natality and Fetal Mortality Survey analysed data from a large sample of married women, looking at the impact of both maternal and paternal occupation on the risk of a variety of birth outcomes. The researchers found no association with either the mother or father working in the mining industry on the risk of stillbirths, pre-term delivery, or size for gestational age of the babies (Savitz et al. 1989). There were not, however, many people who reported working in the mining industry in the population, especially women, and this affects the power of the study with respect to the impacts of mining.

Women working in a lead- or copper-smelting environment have been found to have low birth-weight babies (Nordstrom et al. 1978; Nordstrom et al. 1979).

4.2.6 Workplace Harassment

No literature was found on workplace harassment in large-scale mines.

5.0 WOMEN IN MINING-AFFECTED COMMUNITIES

Mining is an industry of extraction and exploitation that intensively uses resources, both human and environmental, at the expense of communities. In addition to causing pollution of resources, mining uses large quantities of water and destroys land masses that might have been otherwise used for purposes such as agriculture or housing. The health of women in mining-affected communities is influenced by the compounded effects of a wide range of physical and social factors. This section will examine community exposure through air, water, and soil and look at the effects of exposure on health (both cancer and non-cancer outcomes), stress, accidents, displacement, migration, malaria, AIDS, sexually transmitted diseases, violence, addictions, and health care. It is difficult to put distinct boundaries around the discussion of these health issues. For example, poverty increases with loss of land for agriculture or forest harvest and in turn increases stress, malnutrition, and exhaustion, and may contribute to limiting options for work (and as such increase the chance of poor working conditions or working in prostitution). These may all contribute to a general state of ill health and increase the physical impact of contamination.

5.1 Community Exposure: Non-Cancer Outcomes

Communities can be exposed to mining contaminants through soil, water, or air sources, and often through all three. Soil contamination can cause plant food sources to be affected, and toxic dust may increase toxic levels in the home and community. Water can become contaminated by mine effluent discharges, run-off, or blowing dust and smelter emissions that settle out in water sources. This can affect the health of fish and wildlife, and the irrigation and drinking water near mine-sites. Air emissions affect not only air quality, but also settle out in soil and water in some instances for much greater distances than blowing dust. The following sections discuss specific examples of community exposure to mine contaminants through soil, water, and air sources.

5.1.1 Exposure through Soil

Cherokee County, Kansas, has a heavy metal-mining (lead-zinc) waste site with numerous tailings. In and around the city of Galena, lead and zinc mining, milling, and smelting operations took place from the late 19th century until the early 1970s. About 3.9 square kilometres of land in and around Galena are covered with mine wastes. A study looked at health problems related to lead and cadmium in drinking water, mine wastes, and surface soils, using health information from 1980-85, and compared these to two non-exposed towns. Female residents of Galena over 45 years of age had high rates of heart disease; women aged 45 to 64 had high rates of anaemia; and those over 65 years of age had elevated rates of chronic kidney disease. Women living in Galena had higher incidence of death due to hypertensive disease (elevated blood pressure), ischemic heart disease, and stroke. The contaminants from the Galena mine contributed to several chronic diseases in residents of this community (Neuberger et al. 1990).

Women living in an area with heavily contaminated soil from previous lead mining had blood lead concentrations that were 50% higher than for women living in a non-contaminated area. This was due to the contamination of homegrown produce (Stephens and Ahern 2001; Gallacher et al. 1984).

The relationship of mining waste to blood lead concentrations of rural children is controversial (Malcoe et al. 2002). A study that examined 245 children aged one to six years, both Native American and Caucasian, found that blood lead concentrations increased as a result of soil lead concentrations, mouthing behaviours, caregiver's education, and residence in former mining towns. The lead in soil and dust derived largely from mining waste posed a health hazard to both Native American and Caucasian children (there were no ethnic differences). Poor children were especially vulnerable to lead exposures, and residential standards should consider socio-economic conditions as well as lead sources (Malcoe et al. 2002).

A 1996 study of 58 children in the lead mining town of Broken Hill found that while 60% of children had slightly elevated blood lead levels, in fact the sources of their lead exposure were from paint or petrol or both (Gulson et al. 1996). Another study of 125 children in Missouri evaluated the contribution of soil lead to blood lead levels and found that in homes in the lead mining area, there were high soil and dust lead levels and higher blood lead levels (Murgueytio et al. 1998). The primary source of dust lead was soil lead (Murgueytio et al. 1998).

5.1.2 Exposure through Water

Communities surrounding mine-sites often have no alternative to the contaminated drinking water. The source of the contamination is from polluted mine effluents and emissions that seep into the ground water and soil. Women in particular are more susceptible to water pollution due to the role they play in the family. This involves contact with water sources for performing household chores like collecting water, washing clothes and dishes, and bathing children (Mines and Communities 2003). In India, tube wells contaminated by arsenic increase women's work-load and level of exhaustion because they have to find clean water from sources farther away and carry water longer distances (Caldwell et al. 2002).

A study from Thailand examined the impact of arsenic in well water in a tin- mining area in the south of the country. Slag heaps containing arsenic were located close to a mountain stream that ran into the village, and which was the probable source for widespread contamination of ground water, including the shallow village wells. Keratoderma and/or hyperpigmentation (skin conditions typical of arsenic poisoning) were found in nine per cent of adults. There were several cases of children who had typical signs of chronic arsenic poisoning. The most severe cases occurred in individuals using the well with the highest amount of arsenic (Foy et al. 1992).

In East Parej and North Karanpura coalfields of Jharkhand state in India, research called the Environmental and Health Impact Assessment found that concentrations of metals like fluoride, manganese, nickel, and sulphate in the drinking water were high. The life-span of people living in the coal mine communities has been drastically reduced as a result of these toxins in the water and soils. The average life-span of women was found to be 45 years, and in most of the villages only one or two women had reached the age of 60. The number of deaths in a five-year period in the area was also found to be high. The majority of the children were reported to be lethargic as a result of inhalation of toxic dust and consumption of contaminated water (Mines and Communities 2003).

The chromite mines in Orissa, India, have caused severe health problems due to the contamination of rivers. A study commissioned by the Regional Research Laboratory (RRL) revealed that mine seepage water released into the Domsala River in the Sukhinda valley has severely affected the lives of communities as this river is the main water source for many people in the area. The hexavalent chromium present in the water caused marked irritation of the respiratory tract, nasal septum ulcers, irritant dermatitis rhinitis, bronchospasm, and pneumonia. Children with sores all over the body are reported to be a common sight. The study further revealed that chromium has entered the food chain and has been found in edible plants (especially mango and rice), meat, and fish (Mines and Communities 2003).

In Germany, the effect of lead in tap water was not associated with blood lead levels in children living in a contaminated community. Factors associated with blood lead levels were gender, the city of residence, lead in house dust, regular contact with dogs, and the dirtiness of the child after playing outdoors (Meyer et al. 1998).

The depletion of ground water due to over-consumption for mining purposes causes serious changes in the water table, which affects the irrigation and drinking water facilities of the communities. In many places, companies set up water treatment plants that do not function properly if at all, and the situation deteriorates to such an extent that the ground water can no longer be used for human consumption. Often, villages "voluntarily" relocate or migrate. Villagers have no alternative but to drink the water from the wells provided by the mines. People often complain the water tastes foul, is coloured, and is dirty.

Areas of large-scale mining face acute scarcity of water mainly in summer and winter seasons. Dug wells generally dry up during these two seasons. The natural drainage system is obstructed and diverted due to dumping of overburden and the expansion of open-cast mines. At times, companies truck in drinking water to the local communities as the mine draws up all the ground water. This dependence on the companies leads to tense situations in which the communities have to constantly fight with the management for regular and adequate supply of water. Women and children spend a large part of their time and energy waiting in queues for water, and women also tend to reduce their water consumption due to rationing of water supplies. Women's hygiene is thus compromised as bathing, washing of clothes, and water consumption is reduced. This is one of the most common situations in the coal mines in India, as reported in a study conducted in East Parej coal washeries. The study revealed that due to water contamination, the villagers bathe only every five to ten days. Clothes are unclean and washed infrequently. Children are the most affected by living in unhygienic conditions and filth (Caldwell et al. 2002).

The lack of supply and poor quality of water in the slums and shanty towns of the mine-sites also leads to social ill-health as tensions build among the women who daily search for water that is in short and uncertain supply (Mines and Communities 2003). Mining has dried up natural water sources within communities in the Cordillera (Philippines) as well, and this places additional physical burdens on women who are responsible for fetching water (Cariño 2002).

5.1.3 Exposure through Air

A Canadian study investigated the community health effects of a copper smelter in Rouyn-Noranda, Quebec. Between 1965 and 1974, Rouyn-Noranda women experienced higher death rates than the rest of the province. The higher death rates were due to endocrine, metabolic, and chronic respiratory diseases, but not due to other causes of death including infective and parasitic diseases or malignant neoplasms (cancer)(Cordier et al. 1983). Similarly, living near a copper smelter in the United States was found to increase the risk of death due to acute non-malignant respiratory disease, but not the risk from either chronic respiratory diseases or cancer of the respiratory tract (Mattson and Guidotti 1980).

In India, a preliminary survey of 14 villages around an abandoned chrysotile asbestos mine found a high probable link between the asbestos exposure and several adverse health effects such as low back pain, difficulty breathing, coughing up blood, and blindness (Dutta et al. 2003). Many women live in proximity to the uranium mines in Jaduguda, India, where radiation levels are above permissible limits, and where there is a direct correlation between the reproductive and health problems of women and the radiation from uranium. There were many miscarriages, births of physically and mentally deformed children, and deaths from terminal illnesses such as leukaemia and thalasemia. Despite international lobbying and publicity on this issue, the local government continues to choose to ignore the situation. On the contrary, Adivasi women are expected to take national pride in sacrificing their health for the larger "national security" concerns of India (Mines and Communities 2003).

A study in central Mexico of 73 people including 52 women living within a manganese mining district showed excessively high blood concentrations of manganese and air concentrations that were two to three times higher than those in other urban centres. Lead and manganese levels were highly correlated, and the higher the manganese level, the lower the haemoglobin level (low haemoglobin leads to anaemia). Blood manganese levels were associated with a 12 times increased risk of deficient cognitive performance (Santos-Burgoa et al. 2001).

In North Sulawesi, Indonesia, near a submarine tailings disposal site, traces of arsenic were found in blood and nails of women. In addition, there were many people in the community suffering from skin conditions (Simatauw 2002).

5.2 Community Exposure: Cancer Outcomes

A study of lung cancer in an abandoned lead-zinc mining and smelting area in three contiguous counties in the United States (Cherokee County, Kansas; Jasper County, Missouri; Ottawa County, Oklahoma) found high rates of lung cancer among women living in the area. While the lung cancer rates among women were not statistically proven, they were higher than rates for women in St. Louis City (a comparable area nearby). Cancer in the smelter community women was increasing 60% faster than that of the state of Missouri as a whole, and 47% faster than in the rest of the U.S. In Cherokee County, the rate of increase in the mortality rate was 425%, three times faster than the rest of the state of Kansas. For both Jasper and Cherokee counties, the rate of increase in the female deaths was greater than for similar size counties. Ottawa County also had high rates of lung cancer in women. Overall for the smelter region, rates of lung cancer among women were 28% higher than the rest of the U.S. (Neuberger and Hollowell 1982).

In Sweden, children had double the risk of having cancer during childhood if their mother lived near a smelter while pregnant (Stephens and Ahern 2001; Wulff et al. 1996).

A Canadian study looked at the impact of coal mining and steel mills on the health of Cape Bretoners. Women in Cape Breton have a reduced life expectancy compared to other Canadian women, by as much as five years. Cancer is the cause of the majority of the deaths among Cape Breton women (Veugelers and Guernsey 1999).

A study of stomach cancer in a coal-mining region of Pennsylvania found that while coal mining did not increase stomach cancer in men, being a wife of a coal miner did increase risk of stomach cancer. The death rates of stomach cancer in the region for women and men were 33% higher than the U.S. rate. The authors suggest that since none of the women worked in the mines, being the wife of a coal miner may be associated with other unidentified factors (e.g., smoking), or that women are directly exposed to coal dust or coal by-products in the home. Why coal mining was not a risk factor for men, however, was not clear (perhaps men used protective gear while working) (Weinberg et al. 1985).

A significant amount of attention has been paid to the risk of malignant mesothelioma. Malignant mesothelioma is a rare tumour known to be associated with prior exposure to asbestos. A South African study identified 1347 cases between 1976 and 1984, 27% of which were in women. Eighty-five per cent of women, a similar proportion to the rate for men, had contact with asbestos, but mostly through different types of exposure (e.g., transport, etc.). "Coloured" women (the antiquated term under the Apartheid regime denoting people of mixed race or South Asian descent) had the third highest incidence of malignant mesothelioma (13.9 per million population per year), following white males (32.9 per million per year) and coloured males (24.8 per million per year) (Zwi et al. 1989). A 1995 update of this study that looked only at white people found mortality rates from mesothelioma for women were 172 per million person-years. The rate of lung cancer in women was 151 per million person-years. Considering these white women had never worked in the mines, the authors concluded that these rates were indicative of environmental exposure (Kielkowski et al. 2000). An Australian study found elevated rates of mesothelioma in a crocidolite-mining town, but no breakdown by gender was provided (Rogers and Nevill 1995).

In contrast, death rates in two groups of women in asbestos-mining areas in Quebec showed that there were between 0 and 6.5 excess deaths from lung cancer among the women with non-occupational exposure to asbestos. This was a much smaller number than had been predicted. Seven deaths from pleural cancer were observed (Camus et al. 1998).

The Northeastern Ontario Regional Cancer Centre serves as a catchment area for over 650,000 people. One of the region's major industries is, and has historically been, mining. This study examined cancer incidence and mortality trends in the area during two decades: from 1971 to 1980, and from 1981 to 1990. Among women, excess cancers were observed for tracheal, bronchus, and lung cancer cases, as well as both excess cervical cancer cases and deaths (Lightfoot et al. 1996). However, it should be noted that there is a high prevalence of cigarette smoking in this region, and this was not accounted for in the analysis.

A Texas study, requested by county residents due to an apparent high occurrence of cancer, found from the Texas Cancer Registry, hospital records, and death certificates that cancer rates were the same as the rest of the state. There were, however, high rates of leukaemia and multiple myeloma. While not directly attributable to the mining activities in the community, there is need for stricter regulation regarding the disposal of combustion wastes from mining and fossil fuels (Strom et al. 1994).

A British study of mortality from stomach cancer conducted over the period 1958 to 1975 in several mining and non-mining towns in Nottinghamshire showed there was not an increased risk of stomach cancer in the mining communities among either women or men (Davies 1980).

5.3 Stress

Stress related to mining affects women and their health in several ways. Women working in or around mining are subject to difficult physical conditions. They are often either separated from their children or looking after them while working. Women may have to contend with the harassment of their supervisors. These stresses arise in addition to other daily life stresses such as poverty. Women who are the spouses of miners often have to deal with the stress of living in small, isolated communities, with the worry of contamination of themselves and their families. Several studies address the impact of mining on stress and stress-related issues.

A South African study found that among 1,239 women living in four isolated diamond-mining towns, between 23% and 31% were considered "clinically disturbed." The number of women who were considered depressed ranged from 22% to 38%. Among these women, 23% to 31% drank alcohol at least once a day, a much higher percentage than that found in the general population (Michalowsky et al. 1989). Similarly, the prevalence of depression and anxiety in two mining villages in southern Italy was high, with 20% of women and 11% of men being clinically depressed. Women were also much more likely to experience anxiety. Among those with depression, 44% of women used benzodiazepines (highly addictive psychotropic medications) (Carta et al. 1991).

In Zimbabwe the extent that the level of rural economic development was associated with variations in women's blood pressure in the community was examined. Those in the traditional economy on communal lands had the lowest blood pressure. Those in wage economy in areas of large-scale commercial agriculture had elevated blood pressure. Those in wage economy in mining areas had the highest blood pressure. Women in the mining community carried double the risk of elevated blood pressure, and three times the risk of moderate to more severe blood pressure. The women in the mining community had the highest incomes, and even had disposable income (they were all spouses and relatives of miners). Ironically, the financially "better-off" women had the highest blood pressure (Hunter et al. 2000).

In rural mining communities of northern British Columbia, isolation (both physical and emotional), the uncertainty of employment in the fluctuating resource-based economy, the harsh climate, and the limited access to resources were described as stresses to women's health. Mental illness was found to be more prevalent in these communities than in urban areas (Northern Secretariat 1999).

5.4 Accidents

Another important but understudied manifestation of stress is the prevalence of accidents. In a remote Norwegian coal mining community, the prevalence of non-occupational accidents was 24 out of a population of 976, or 2% over the 20-year period of the study. This included 6 out of 200 women (3%) and 16 of 776 men (2%). Analyzing the data by deaths per 1000 population, 1.5 per thousand women died of non-occupational accidental deaths and 1.03 per thousand men. When compared with the non-occupational accidental death rates on the Norwegian mainland, the researchers found that for every one female death on the mainland, 17.9 women died in the mining community and for every one male death on the mainland, 2.86 men died. Alcohol was a factor triggering the fatal event in 6 of the 24 deaths (25%). The alcohol consumption in the Norwegian mining community amounted to 16 litres (pure alcohol) per person, per year (Risholt 1992).

Communities living around mine-sites are vulnerable to mining accidents. Mining companies use explosives for blasting that result in houses cracking and collapsing on women and children. As well, when companies do not warn them of explosions while they are working in the fields or walking in their villages, explosions catch them by surprise causing serious injury or death. Mine pits, which are left following the closure of a mine, are dangerous because women, children, and livestock fall in and drown (Mines and Communities 2003).

5.5 Displacement and Migration

It is estimated that mining displaced 2.55 million people in India between 1950 and 1990. India is generally considered to be among the leaders in the world for displacing people to accommodate development projects (Downing 2002). Displacement leads to the "Resettlement Effect," which is defined as the "loss of physical and non-physical assets, including homes, communities, productive land, income-earning assets and sources, subsistence, resources, cultural sites, social structures, networks and ties, cultural identity, and mutual help mechanisms" (Downing 2002). In other words, displacement leads to poverty, landlessness, joblessness, homelessness, and a myriad of health effects such as diarrhoea, dysentery, and epidemics of infectious diseases. The health impacts fall disproportionately on children, infants, expecting mothers, and the elderly. Several areas related to the effects of displacement and migration due to mining and these impacts on women are highlighted in this review; in particular, nutritional issues in India, sexual exploitation in Africa and India, and malaria. These descriptions should be viewed as available case studies.

5.6 Malnutrition

A comparative study of pre-mining and post-mining communities in India shows a clear shift in livelihoods and way of life particularly for women in the affected communities. Displacement from land and loss of access to forests has a direct impact on the health and nutrition of women and children. In traditional land- and forest-based forms of livelihood, communities had access to a wide variety of agricultural and forest produce. The diversity of crops grown by these communities is a means of ensuring balanced nutrition that is supplemented by the variety of forest species like tubers, roots, leaves, fruits, and nuts collected by the women and children. Since access to food is not dependent on cash flow as it is in the non-agriculture- and non-forest- based economies like mining (in which money is needed to purchase even basic food items) women have better access to food security in traditional systems (Bhanumathi 2002; Communities 2003).

Families in northern Canada who have subsistence lifestyles rely heavily on wild meats and plants for proper nutrition. The contamination of this food source can limit the availability of food, and fear that the food is contaminated can cause a shift to buying processed foods from stores. This is expensive for a family and often results in a poor quality diet that increases heart disease, blood pressure, and diabetes. For northern First Nation people, loss of traditional food sources is more than a dietary problem; it harms the health of a spiritual connection to the land (Cleghorn et al. 2001).

Among forest-dwelling communities, women's main source of cash is the forest wealth (e.g., fruit, herbs, roots, etc.), which they collect and sell in the village markets. After selling the produce, the women purchase food and other household items from the market and are in a position to save in seasons when the forest produce is collected in abundance. It is from this income that they meet their medical expenses, purchase clothes for themselves and their children, and invest in agricultural inputs. Thus, the loss of traditional rights over land and forests has contributed to the deterioration of women's health status. The only access to health care for women is often the forest, rich in medicinal plants, which becomes inaccessible through deforestation and development and leaves the women without this important natural source of medicine. Further, the mining activities have introduced a number of previously unheard of diseases, many of which are not treatable with their traditional health remedies (Bhanumathi 2002; Mines and Communities 2003).

The issues regarding the impact of the shift from traditional economies and food sources on malnutrition have also been documented in Papua New Guinea and Indonesia (Byford 2002; Simatauw 2002).

5.7 Malaria

Many mines in low-income countries employ large numbers of migrant labourers. Large numbers of people live together in concentrated conditions, often in close contact with the forest environment and in shelters that provide little or no protection from the elements (Sawyer 1993). These are the ideal conditions under which malaria and bacterial infections can thrive. It has been documented that since the 1970s, when gold mining began in earnest in Amazonia, there has been an enormous resurgence of malaria, and that the malaria cases are concentrated around the "garimpos" or gold mining operations. People with different genetic backgrounds migrate into places where their immune systems are unaccustomed and as such are more susceptible to diseases new to them. Wild animals, which would otherwise provide an alternative food source for the mosquitoes, have been hunted or harmed by deforestation and are thus reduced in numbers. The combination of these factors has contributed to the upsurge in malaria. The circular migration of people back to their homes means that the malaria is spread more broadly. Self-reported malaria rates suggest that rates are higher among girls aged 7 to 15 years and boys aged 16 to 21 years[14] (Sawyer 1993). A similar situation exists in Zambia (Sharp et al. 2002) and in inhabited areas involved in the gold mining industry (Sawyer 1993).

5.8 Sexual Exploitation: Violence, HIV/AIDS and Other Sexually Transmitted Infections

South Africa, along with most other sub-Saharan African countries, is in the midst of a devastating HIV/AIDS epidemic. In 1990, the prevalence of HIV infection among women attending antenatal clinics was less than 1%. By the end of 1999, national HIV prevalence in pregnant women had reached 23%, with provincial prevalence ranging from a low of 7% in the Western Cape to a high of 33% in KwaZulu Natal (Anonymous 1999). A study published in 2001 found that the prevalence of HIV in women and men aged 14 to 24 was 34.4% and 9.4%, respectively. Among 24-year old women, the prevalence of HIV was 66.7%. Fifty-three per cent of

[14] The difference between the genders in childhood is probably due to gender bias, whereby the mosquito net is more likely to be provided to the boy than the girl. The difference between them in adolescence may be attributable to adolescent boys traveling or being outdoors more.

women and 17% of men also had herpes simplex virus, and having herpes was a strong predictor of also having HIV (Auvert et al. 2001). The situation in mining communities is even worse. Women who reported having had sex with a mineworker were three times more likely to be infected with HIV (Auvert et al. 2001). A 1999 survey revealed that 25% of miners and 69% of sex workers around the mine were HIV positive (Campbell 2000).

The primary transmission route for HIV throughout sub-Saharan Africa including South Africa is unprotected heterosexual sexual intercourse. The average probability of HIV transmission in the developed world is 0.1 to 0.3 per coital act. It is believed that this rate may be higher in the developing world, due in part perhaps to the high prevalence of co-infection with herpes and other factors (Auvert et al. 2001).

The mining industry, and particularly the migrant labour system upon which it depends, has been a primary factor in the evolution of this devastating epidemic throughout sub-Saharan Africa, and particularly in South Africa (Steen et al. 2000). It is estimated that in South Africa, the mining industry generates approximately 50% of all export earnings, and 20% of the gross domestic product. In 1999, there were approximately 350,000 (primarily male) workers employed in the mining industry, who supported between 2.5 and 3 million dependents (Meekers 2000). Very few miners are allowed to bring their families to the mining areas, and the overwhelming majority of the workers are housed in single-sex hostels (Jochelson et al. 1991; Campbell 2000). Mining communities are therefore magnets for the commercial sex trade, because large numbers of men reside there, have an income, are usually without their families, and usually have limited opportunities for activities during their leisure time. Further, working conditions are dangerous, and some men compensate for the fear of these conditions by having sex with large numbers of women in order to feel secure in their masculinity (Campbell 2000). Women are often employed to do domestic work (e.g., cooking, cleaning) by the mines and workers' residences or are drawn there specifically to generate income through the selling of sex (Jochelson et al. 1991; Meekers 2000; Clift et al. 2003). The travelling of men and women between the mines and their families has created a geographic network of HIV/AIDS throughout the country (Jochelson et al. 1991). Factors that lead to the disruption of communities or the separation of couples are known to enhance the spread of sexually transmitted infections, including HIV (Steen et al. 2000). Men who work as transporters (e.g., bus drivers) between the mining communities and other parts of the country are also believed to be an important conduit for HIV transmission (USAID 2000).

The women who provide sexual services have been described as falling into one of three groups in terms of why they turned to the sex trade (Jochelson et al. 1991). The first group, accounting for approximately 20% of women, is comprised of those who have either been abandoned by their husbands (who left them to live with other women), had left their husbands following physical abuse or inadequate financial support, or had been orphaned as children (Campbell 2000). The second group, about 30% of women, had been abandoned by their lovers when they became pregnant. These women are often from rural areas and are under 18 years of age. In the third group are those women who were wives of migrant mineworkers, entered South Africa illegally, and then found themselves with no other source of financial support. The decision to provide sexual services is usually an economic one. Many women in South Africa talk about prostitution as "spanning donkeys" because they are harnessing men's desires as a means of survival. Underlying these issues is that belief held by many women that it is the migrant labour system related to the mining industry that enables them to make any money at all (Jochelson et al. 1991).

"If there were no hostels we would die of hunger. We live because of the hostel system" (Jochelson et al. 1991).

Tanzania is another country with a long history of small-scale gold mining. Throughout the country, artisanal miners live in scattered, mobile, low-income communities. In 1993, the prevalence of HIV was already higher in artisanal mining settlements than in other rural communities. Twenty-three per cent of women and 15% of men aged 15 to 54 were HIV infected, compared to 3% of women and 2% of men in other rural villages, and also compared to 9% of women and 5% of men in large roadside settlements in the same region. The same pattern seen in South Africa with herpes is repeated in Tanzania but with syphilis (Mosha et al. 1993). By 2001, a survey of female food and recreational facility workers in a mining community found that 42% were HIV positive, compared to 6% of male mineworkers, and 16% and 18% of other community men and women respectively. Being HIV positive was strongly associated with alcohol consumption, having or having had syphilis, and being single. Among the female food and recreational facility workers, 25% had active syphilis. Overall, 50% of these women and 50% of the community men reported never using condoms (Clift et al. 2003). Factors associated with the food and recreational facility women being HIV positive were being single, working as a barmaid, having high alcohol consumption (≥15 drinks per week), having or having had syphilis, and having received payment for sex in the previous 12 months. The authors suggest that the prevalence among the mining men in this study is low because the men who have contracted HIV no longer work in the mine and so were not counted in the study.

Although the majority of literature related to the mining industry and HIV pertains to sub-Saharan Africa and particularly South Africa, a similar situation can exist wherever there is a large pool of migrant labour. The parallel effects of mining have been documented in Guinea (USAID 2000) and in Timika, in the Papua Province of Indonesia (Silitonga et al. 2002). These authors indicate that because there are so many mining companies operating in Indonesia, existing or burgeoning HIV epidemics may occur or be occurring, albeit without documentation (Silitonga et al. 2002).

India is another area of the world where the mining industry and sexual exploitation of women are inextricably linked but in a different manner from southern Africa. In some mining communities, the preference is towards employing mostly unmarried women and girls, the rationale being that they are healthier, stronger, and have less family burden. They are also easy prey for the contractors, mining officials, and other mineworkers who do not bring their families to the mine. For fear of further harassment and loss of employment, the women rarely report sexual exploitation. Serious health problems such as AIDS and other communicable diseases, which are uncommon among the tribal communities, are becoming rampant in mining towns both among women mine labourers and among other women in the communities who contract the diseases from the men (Mines and Communities 2003).

Women living in the mining regions of India are highly susceptible to sexual assaults when going to the forest, while walking to their fields, or just while living in their homes. Atrocities against women, committed mostly by migrant mineworkers, contractors, mine owners, and higher-level management staff, are common in mining towns. Many of the grass-roots groups and communities in the mining regions have identified this as a cause for serious concern. For instance, in a remote tribal area of Vizag district where Indian Rayons and Industries was laying a road for a calcite mining project, women complained of sexual assaults and gang rapes by the company employees and along the Border Roads. In some cases, when social action groups expose the misdeeds, the local authorities hastily pay meagre compensation and hush up the issue. Along with the problems already mentioned, the mining regions have widespread problems of unwed mothers, deserted women, and concubines of the contractors (Mines and Communities 2003).

Sexual violence is also common in other mining regions of the world. There is evidence to suggest that in the gold mining areas of the Amazon, there is sometimes forced prostitution. Women and young girls are reportedly enticed from their towns by the promise of jobs in mining encampments, only to be sold into servitude in brothels. The authors suggest that this problem is widespread throughout Amazonia (Hinton et al. 2003). In Guyana, the rape of Amerindian girls has been reported (Hinton et al. 2003).

Women living with HIV in rural mining communities in northern British Columbia describe the lack of anonymity or privacy in a small town and as such the social environment can be emotionally devastating. Similarly, women who are street-involved or substance-users are highly visible and this brings stigmatisation, stereotyping, and both physical and systemic abuse (Northern Secretariat 1999).

5.9 Addictions and Family Violence

Exposure to direct mining-related contaminants is not the only the health risk posed to women in mining communities. Cigarette smoking is very common in mining households and communities, and the health risk posed by first- and second-hand smoke is well documented. Alcohol is commonly abused in many mining households and communities (Michalowsky et al. 1989; Risholt 1992; Byford 2002; Kopusar 2002; Simatauw 2002). Physical violence against women often accompanies inappropriate alcohol use, and many women are reported to suffer as a result (Byford 2002; Downing 2002; Simatauw 2002). In rural mining communities of northern British Columbia, the transient population of mineworkers contributes to increased violence against women in the home and community and to a high rate of single parent homes (83% of which are headed by women) (Northern Secretariat 1999).

The "frontier culture" of mining communities in northern Canada has drawn personalities in search of "quick money, adventure, anonymity or other dubious goals which become unrealized" (Women's Research Centre 1979). "The wife of such a person may be the first overt casualty in this immature or unrealistic adventure" (Women's Research Centre 1979). Violence in the home in single- industry towns has been described as resulting from a "rural patriarchy" that contributes to the isolation and devaluation of women (Jiwani 1998). Immigrant workers are often hired in mines, and the women in these families may feel additional isolation due to language barriers (Cleghorn et al. 2001). Tolerance of domestic violence against women tends to be higher both in these communities and by the legal system as well (Cleghorn et al. 2001; Northern Secretariat 1999). Mining is an industry of exploitation that brings with it an ethic of exploitation harmful to women and families in mining communities (Cleghorn et al. 2001).

The Yukon, a mining region with high transience in the work force, has the highest per capita incidence of alcohol and drug consumption in Canada, as well as high incidence of Foetal Alcohol Syndrome (Cleghorn et al. 2001). Mining communities in northern BC cite similar statistics (Northern Secretariat 1999; Jiwani 1998). Children with FAS will experience behavioural, social, and emotional problems as a result of being hyperactive, impulsive, and having a short attention span, poor judgment, lack of consideration of consequence of one's actions, and very low IQ (Eustace et al. 2003). The chance of miscarriage is doubled if a pregnant woman consumes alcohol (Masis and May 1991).

5.10 Health Care in Mining Communities

Another important way of evaluating the health of a population is to study health care utilisation. There are few studies on this issue in the context of mining communities, and none specific to women. In a mining village in Greenland there was a higher rate for mineworkers and their families seeking medical contact as compared to the rest of Greenland. There was no gender analysis provided, but more of the Inuit workers were women and the Inuit had a disproportionately high rate of seeking medical contact (11% of the Inuit had 37% of the medical appointments) (Gottlieb 1990). A study from the United States examined the impact of the termination of health benefits for Pittston mineworkers on the workers and their families and found that the termination of these benefits had devastating effects, both physically and emotionally (Demers et al. 1990).

Health care utilisation is inseparable from income and medical insurance around the world. In the chromite mines of Orissa, India, the regular women workers, who are very few in number, were paid a meagre amount per month for health benefits. Compensation for pregnant women was only marginally better and only if the women were directly employed by the company. The contractors pay at their discretion (Mines and Communities 2003).

Most of the community-based papers from South Asia reviewed emphasized the impact of deforestation on women's ability to practice traditional medicine – the destruction of plants necessary to make medicines has meant that women must purchase medicines to treat their illnesses, resulting in an increased demand for cash (Byford 2002; Cariño 2002; Kopusar 2002; Simatauw 2002).

Rural, remote and northern regions in Canada have difficulty attracting and retaining qualified and experienced health care providers. Pregnant women often have to travel to other communities to deliver their baby, which brings emotional and financial burdens. The same is true of specialist services (Northern Secretariat 1999).

6.0 CASE STUDIES

Case Study 1: Combined Influence of Mining Contamination and Agricultural Irrigation in the Aral Sea Region

The Aral Sea case study shows the combined influence of multiple stresses to the environment and shifting environmental conditions that have resulted in population-level harm to women's health in the area.

In the Aral Sea region, irrigation of cotton fields has drained half the Aral Sea bed, leaving over three million hectares of contaminated sediments exposed. This soil is now wind-blown all over the region, with devastating consequences: drinking water quality has been affected, fish have been contaminated, and the quantity, quality, and kinds of fish have been decreased by the changed water quality (less water to dilute ongoing pollution). The Aral Sea contamination is the result of mining contamination combined with agricultural pesticides.

The population of 1.5 million in Karakalpak is most affected due to wind direction; half of this population is comprised of Karakalpak people who have a unique native language and culture and live almost entirely in this polluted region. General bad health in the area, particularly among women and children due to long-term chronic exposure, along with worsening ecological health of the area, has been disastrous. Over the past 15 years, there have been increasing rates of maternal and infant morbidity and mortality, anaemia, kidney diseases (one out of three pregnant woman), liver diseases, hypothyroid problems (three times the rate of Europe), allergies, cancer, tuberculosis, birth defects (five times higher than Europe), and miscarriages and complications during pregnancy and while giving birth (e.g., one out of seven experience bleeding during pregnancy as compared to 1 out of 100 in Russia). Most of the women are anaemic (including teenagers, pregnant women (who have the highest rate in the world) and non-pregnant women), most newborns have early neonatal anaemia, and in the last 10 years anaemia among children has tripled. These statistics are significantly higher than in other central Asian countries with similar traditions and food sources.

For several decades, the cause of anaemia has been thought to be due to the high number of births and poor diet among women. Programs were focused on birth control and healthy diets with supplements of iron and vitamins. Anaemia continued in this region but has now been found not to be related to social level, age, or poverty but rather due to the contaminated food and water (Ataniyazova 2001).

This study shows the extreme health conditions that can result in a small population exposed to contaminants from a variety of sources (food, dust, water).

Case Study 2: Gold Mining in the Amazon Basin

Gold mining in the Amazon basin is very common, and it affects women in a multiple of ways. It is a representative example of the many ways the mining industry worldwide makes women vulnerable.

Since the late 1970s, mercury has been widely used for gold extraction throughout the entire Amazon basin (Cordier et al. 1998). The mining process involves the extraction of gold from the soil or river sediment through amalgamation with mercury. The amalgam is then heated, giving off mercury vapours while leaving the ore. It has been estimated that 1.32 kilograms of mercury is used in the gold mines for each kilogram of extracted gold, and many consider this an underestimate. From this, approximately 55-60% is lost to the atmosphere, and 40-45% enters the aquatic environment where the mercury settles into the food chain, including the fish that are a major food source for people living there (Branches et al. 1993; Lebel et al. 1996; Counter et al. 1998). It is estimated that there are one million gold miners in the region, whose activity releases over 130 tonnes of mercury per year into the Amazon environment (Lebel et al. 1996). There is increasing concern about the potential neurotoxic effects of exposure to methylmercury (metallic mercury is transformed into methylmercury by the activity of bacteria present in soil and sediment) for the six million people living in the Amazon, even in regions situated very far away from the gold mines (Harada et al. 2001). Although there is some knowledge on methylmercury intoxication from the exposures in Minamata Bay, Japan, in the 1950s, from Iraq in the 1970s, and from the effects on the Cree in northern Quebec of mercury-contaminated fish due to the hydroelectric dams, much less is known about the health impacts that may occur with long-term, low-level exposures to methylmercury (Lebel et al. 1996).

The inhalation of vapours from the burning of the amalgam is a major source of mercury intoxication among gold miners. Methylmercury, the result of mercury being released into the environment, affects people by getting into the food chain. Women are exposed to mercury and methylmercury through a number of mechanisms, and thus are at high risk of health complications due to mercury intoxication. Women work in the mines as cooks or managers, where they are exposed mainly to indoor elemental mercury during the burning of amalgam. Women also work in gold dealers shops, where a great amount of amalgam is burned daily. Fish consumption is an important source of dietary protein and represents an important pathway of exposure (Hacon et al. 2000).

A study of pregnant women in Brazil found that mercury hair concentrations ranged from 0.05 to 8.2 micrograms per gram, with 13% showing concentrations of over 2 micrograms per gram (Hacon et al. 2000). The World Health Organisation (WHO) safety limit for mercury concentrations is 10 micrograms per gram (Frery et al. 2001). Hair concentrations were higher among pregnant women if they had worked in gold mining areas, had consumed alcohol, if their husbands had worked as gold miners, if they ate fish, and if they had malaria before or during their pregnancy (Hacon et al. 2000). A study of 132 fisherman and their families found similar results in terms of high concentrations of mercury in head hair, but additionally found various symptoms of mercury contamination (e.g., tremors, balance problems, sensory disturbances) (Harada et al. 2001). A study of 55 Amazonian patients, including 12 women, suggested that symptoms of mercury poisoning were present, including poor coordination, disequilibrium, and tremors (Branches et al. 1993).

A study from French Guyana that examined over 500 individuals attending health clinics throughout the country, found elevated levels of mercury in hair samples, and in 12% of samples the mercury levels exceeded 10 micrograms per gram. In some Amerindian communities, up to 79% of children had hair mercury levels exceeding 10 micrograms per gram. The factor that contributed the most to elevated levels was the consumption of freshwater fish and livers from game. No other factors, including age, dental amalgams, use of skin-lightening cosmetics, and residence near a gold-mining community, contributed significantly to mercury levels (Cordier et al. 1998). A more in-depth study of Native Amerindians in French Guyana showed that 57% had levels above the WHO safety limit. Overall, 14.5% of the fish collected exceeded the 0.5 milligram per kilogram safety limit (Frery et al. 2001). A 1996 study found that women's manual dexterity decreased with increasing mercury levels in their hair, and there was a trend towards women having reduced grip (Lebel et al. 1996).

In Ecuador, research has showed that 45% of in habitants in the study area experienced headaches and/or memory loss, and several experienced severe neurological impairment and middle ear pathology. There was a relationship between mercury levels and hearing loss in children (Counter et al. 1998).

This case study suggests that whether women work in the industry or not, it directly and indirectly affects their health and well-being.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Literature specific to women's health was sparse in general and almost non-existent in Canada. Often toxicological and epidemiological studies would mention data on women but not provide any gender analysis or discussion on why women were affected differently than men. There are a number of common themes that emerge from the community-based literature, in particular, alcoholism and both physical and sexual violence against women. Few scientific papers reviewed for this project acknowledged alcohol as an issue, and none of them mentioned violence. Similarly, no literature was found on sexual harassment in the workplace for mineworkers; in fact, very little information on women as workers was available.

A variety of recommendations to improve the status of women's health in mining-affected communities have been compiled. These recommendations do not attempt to mitigate all negative impacts of mining, but summarize some suggestions for minimizing the effects of mining on women, families, and communities.

The physical health of women in mining-affected communities can be improved by changing the diet to reduce the harm caused by metal exposure:

- vitamin C helps iron absorption;
- essential nutrients iron, magnesium, zinc, and selenium prevent cadmium absorption;
- where food fish is contaminated with mercury, people with high fruit diets had lower mercury levels;
- calcium, zinc, and vitamin D are important for maintaining healthy bones and preventing release of bone-stored lead, cadmium, aluminum, and mercury during pregnancy, lactation, and aging;
- iron, calcium, zinc, and copper in the maternal diet is important for foetal development;
- chelation helps to remove lead, mercury, cadmium, heavy metals and aluminum (does not work as well for other metals);
- selenium, vitamin E, and zinc are thought to decrease the toxicity of methylmercury, while magnesium and thiamine deficiency may increase susceptibility to methylmercury toxicity;
- fat and calcium are important while breastfeeding; and
- calcium supplements are more likely to enhance rather than inhibit the carcinogenic process, whereas zinc and magnesium tend to inhibit cancer causing agents.

There were a number of recommendations for mitigating women worker and community health risks resulting from the mining industry found in the literature. It is recommended that there be:

- gender-sensitive technology assistance initiatives, including training and protective measures;[15]
- workplace training on issues of gender sensitivity and sexual harassment;
- enhancement of other skills, including managerial and accounting skills;
- financial support through the establishment of credit lines and microlending programs;
- support for the acquisition of mineral titles;
- consideration of women in the development of regulations and policies;
- awareness of health and safety issues, with consideration of children who may accompany their mothers or who themselves may take part in artisanal mining activities;

[15] The first 9 recommendations were raised by Jennifer Hinton in her discussion on the enhancement of women's participation in the artisanal mining industry (Hinton et al. 2003)

- education for women about safe and unsafe species of fish for consumption;
- organisation of women's cooperatives for food acquisition and preparation, childcare, and labour organizing;
- the challenging of social norms, cultural beliefs, and attitudes that prevent benefit to women, or put women at risk in any way;
- development of alternative sources of income generation, such as agriculture, in order to reduce reliance on mining operations;[16]
- the use of community-based research principles and methods to enable communities to identify problems and solutions related to community health and safety surveillance;[17]
- the development and implementation of peer-based health promotion and disease prevention programs;[18]
- the enhancement of opportunities for women's participation in community and social organisations or programs (including church groups, residents associations, youth groups, etc.);[19] and
- the providing of community outreach and support for addictions, mental health services, and access to adequate health care and family violence prevention programs.

The following are recommendations specific to issues related to HIV/AIDS, commercial sex work, and sexual exploitation.

- HIV prevention and sexual health education programs and activities would be best directed at the miners, rather than at sex workers. For example, there is evidence that women are aware of the danger of HIV/AIDS and that they would prefer to use condoms in every sexual encounter. However, clients often refuse to use them, and so the principle that "the customer is always right" dominates the situation;[20]
- Interventions aimed at empowering commercial sex workers would also be beneficial, including the legalisation of commercial sex work;
- Programs related to alcohol dependency could help women reduce the harms associated with their work;[21]
- Another important intervention found to have a favourable impact is the implementation of regular screening and treatment for sexually transmitted infections among both men and women.[22]

In conclusion, this literature review has shown that women are affected by the mining industry from work to home; at all stages of their lifecycles; by all types of mining; and in ways that include the physical, emotional, sexual, and spiritual. Women's involvement with and participation in the mining industry – both voluntary and not – must be recognized. It is equally crucial that the impacts of the mining industry on women's health be studied. For most research it would only take some simple statistical analyses to understand the differences in health status, if any, between men and women.

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[16] USAID 2000
[17] Pena et al. 1994
[18] Williams et al. 2003
[19] Campbell et al. 2002
[20] Campbell et al. 2002
[21] Campbell et al. 2002
[22] Steen et al. 2000

Many of the health effects of mining on women are linked to the social determinants of health – especially gender equality and socioeconomic status. Resolving the problems inherent to gender, mining, and health will require that women's status be raised in all sectors, including the social and economic sectors. Without this, as natural resources grow scarcer, women's health burden from mineral exploitation will only continue to grow.

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9.0 RELATED RESOURCES

The following is a list of resources related to the women's health topics presented in this literature review:

Barlow, M. and E. May. *Frederick Street: Living and Dying on Canada's Love Canal*. HarperCollins Publishers, 2000.

Brundage, D. and M. Lahey (eds.). *The Toxic Legacy of the Phosphate Fertilizer Industry. Acting on Words: An Integrated Reader, Rhetoric, and Handbook*. Toronto: Pearson, 2003.

Doyal, L. *What Makes Women Sick: Gender and the Political Economy of Health.* Houndmills, England: Macmillan, 1995.

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Vyner H. *Invisible Trauma: The Psychological Effects of Invisible Environmental Contamination*. Lexington, Massachusetts: Lexington Books, 1988.

APPENDIX A: GLOSSARY

AIDS (Acquired Immunodeficiency Syndrome): A disease caused by infection of the human immunodeficiency virus (HIV).

anaemia**:** Too few red blood cells in the bloodstream, resulting in insufficient oxygen to tissues and organs.

anorexia**:** Lack or loss of appetite resulting in an inability to eat.

arthritis**:** An inflammatory condition that affects joints. Can be infective, autoimmune, or traumatic in origin.

attention-deficit disorder**:** An inability to control behaviour due to difficulty in processing neural stimuli.

bioassay**:** The determination of the amount of a particular constituent of a mixture or of the biological or pharmacological potency of a drug, for the activity or potency of a substance that involves testing its activity on living material.

biomagnification: The increase in concentration of a compound in organisms through the food chain resulting in higher body burden of carnivores.

bronchospasm: An abnormal contraction of the smooth muscles of the bronchi, resulting in coughing.

calcinosis**:** A condition characterized by the deposition of calcium in nodular foci in the body tissues.

carcinogen**:** A cancer-causing substance**.**

cardiovascular system**:** The heart and the blood vessels by which blood is pumped and circulated through the body.

central nervous system: Pertaining to the brain, cranial nerves, and spinal cord. It does not include muscles or peripheral nerves.

cerebral palsy: A persisting qualitative motor disorder appearing before the age of three years, caused by nonprogressive damage to the brain.

coma: A deep, prolonged unconsciousness from which the patient cannot be aroused. This is usually as the result of a head injury, neurological disease, sudden swelling of the brain, intoxication, or metabolic derangement.

dermatological: Skin-related.

eczema: Condition causing itching, swelling, scales, and cracks in skin.

endocrine: Pertaining to internal secretions; hormonal.

epidemiology: The study of the distribution and determinants of health-related states and events in populations, and the control of health problems. The study of epidemic disease.

ergonomics: A branch of ecology concerned with human factors in the design and operations of machines and the physical environment.

erythropoietin: A hormone, released in the kidney, that promotes the oxygen carrying capacity of the blood.

exocrine: Physiology, secreting outwardly, via a duct. Anatomy denoting such a gland or its secretion.

gastro-intestinal: Pertaining to the digestive system.

haemorrhage: Bleeding.

haematopoietic system: Those organs and tissues (including bone marrow and the spleen) involved in the formation and functioning of blood elements.

haematuria: Blood in the urine.

HIV (human immunodeficiency virus): The virus that causes AIDS.

hormone: A naturally occurring substance secreted by specialised cells that affects the metabolism or behaviour of other cells possessing functional receptors for the hormone. Hormones may be hydrophilic, like insulin, in which case the receptors are on the cell surface, or lipophilic, like the steroids, where the receptor can be intracellular.

hyperactive: General restlessness or excessive movement such as those characterizing children with attention-deficit disorder or hyperkinesis.

hypercalciuria: The excretion of abnormally large amounts of calcium in the urine, seen in cases of hyperparathyroidism.

hypertension: Persistently high arterial blood pressure. Hypertension may have no known cause (essential or idiopathic hypertension) or be associated with other primary diseases (secondary hypertension). This condition is considered a risk factor for the development of heart disease, peripheral vascular disease, stroke, and kidney disease.

Indian childhood cirrhosis: An advanced and fatal scarring of the liver caused by copper accumulation in the liver of one- to three-year old children.

IQ test: The intelligence quotient test. A numerical scale that attempts to measure the intelligence of an individual, usually based on the results of a written test.

Itai-itai disease: A form of cadmium poisoning described in Japanese people, characterized by renal tubular dysfunction, osteomalacia, pseudofractures, and anaemia, caused by ingestion of contaminated shellfish or other sources containing cadmium.

lethargy: Low energy, abnormal drowsiness.

leukemia: An acute or chronic disease of unknown cause in humans that involves the blood forming organs, is characterized by an abnormal increase in the number of leucocytes in the tissues of the body with or without a corresponding increase of those in the circulating blood. Classified according of the type of leucocyte most prominently involved.

lumbago: Lower back pain.

lymphoma: Malignant tumour of lymphoblasts derived from B lymphocytes. Most commonly affects children in tropical Africa: both Epstein Barr virus and immunosuppression due to malarial infection are involved.

malignant mesothelioma: A mesothelioma is a tumour of the lining of the lung and chest cavity, known as the pleura. Benign mesotheliomas do occur but are much rarer than the malignant type. Malignant mesothelioma affects men more commonly and about 80% of cases have a history for prior exposure to asbestos. Symptoms include chest pain, shortness of breath, cough, and weight loss.

Minamata disease: A neurological disorder caused by methylmercury intoxication, first described in the inhabitants of Minamata Bay, Japan, resulting from their eating fish contaminated with mercury industrial waste. Characterized by peripheral sensory loss, tremors, dysarthria, ataxia, and both hearing and visual loss.

musculoskeletal: Bone- and muscle-related.

neonatal: Pertaining to the first four weeks after birth.

nephrology, nephropathy: Concerning the kidney – its development, anatomy, physiology, and disorders/diseases.

neurite: A process growing out of a neuron. As it is hard to distinguish a dendrite from an axon in culture, the term neurite is used for both.

neuropsychology: A branch of psychology that investigates the correlation between experience or behaviour and the basic neurophysiological processes. The term neuropsychology stresses the dominant role of the nervous system. It is a more narrowly defined field than physiological psychology or psychophysiology.

neurotoxicity: Toxicity to nervous tissue (both brain and peripheral nerves).

osteomalacia: A condition marked by softening of the bones (due to impaired mineralization, with excess accumulation of osteoid), with pain, tenderness, muscular weakness, anorexia and loss of weight, resulting from deficiency of vitamin D and calcium.

osteoporosis: A reduction in the amount of bone mass, leading to fractures after minimal trauma.

placenta: An organ characteristic of true mammals during pregnancy, joining mother and off-spring, providing endocrine secretion and selective exchange of soluble, but not particulate, blood-borne substances through an apposition of uterine and trophoblastic vascularised parts. Normally maternal blood and foetal blood do not mix, exchange of nutrients occurs at the placenta.

pleural tumours: Cancerous growths in the serous membranes covering the lungs (visceral pleura) and lining the inner aspect of the pleural cavity (parietal pleura).

pneumonia: Infection of the lungs.

pneumoconiosis: Fibrosis and scarring of the lungs secondary to the repeated inhalation of dust associated with some occupation. Examples include silica, asbestos, and coal dust exposure.

pre-eclampsia: An abnormal condition of pregnancy in which hypertension develops after 24 weeks.

psychomotor: Pertaining to motor effects of cerebral or psychic activity. Movement produced by action of the mind or will.

respiratory: Lung- and breath-related.

rhinitis: Inflammation of the mucous membranes of the nose.

seizure: A sudden attack or convulsion due to involuntary electrical activity in the brain. It is due to an uncontrolled burst of electrical activity in the brain that can result in a wide variety of clinical manifestations such as: muscle twitches, staring, tongue biting, urination, loss of consciousness, and total body shaking. Examples include: focal seizure, absence seizure, partial seizure, psychomotor seizure, petit-mal seizure, and grand-mal seizures.

silicosis: Inflammation of the lung caused by foreign bodies (inhaled particles of silica). Leads to fibrosis but unlike asbestosis does not predispose to neoplasia.

synergism: The combined effect of two compounds is more than the sum effect of each acting individually.

toxicology: The scientific study of the chemistry, effects, and treatment of poisonous substances.

toxin: A poison, frequently used to refer specifically to a protein produced by some higher plants, certain animals, and pathogenic bacteria, which is highly toxic for other living organisms. Such substances are differentiated from the simple chemical poisons and the vegetable alkaloids by their high molecular weight and antigenicity.

Wilson's disease: An inherited (autosomal recessive) disorder in which there are excessive quantities of copper in the tissues, particularly the liver and central nervous system. Wilson's disease causes the body to absorb and retain copper. The copper deposits in the liver, brain, kidneys and eyes. Complications include dementia and liver failure. Symptoms include jaundice, vomiting, tremors, weakness, and slow stiff movements. Blood tests show serum ceruloplasmin is low. Medications are given to remove the excess copper from the body. Even with life-long treatment, disabling (and life-threatening) side effects are common.