



Enhanced TB Surveillance Efforts in British Columbia First Nation Children: A Framework for
Evaluation

Master of Public Health

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Lakehead University

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Master of Public Health

- Project -

Title of Project:

Enhanced TB Surveillance Efforts in British Columbia First Nation Children: A Framework for Evaluation

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Purpose of Project: to investigate evaluation of enhanced TB surveillance in British Columbia First Nation on-reserve children since the discontinuation of Bacille Calmette-Guèrin (BCG) vaccine in 2003 by 1) outlining a framework for evaluation of such programs, 2) possible implications for public health based on current evidence

8. Implementation of Evaluation	51
9. Cost of TB	52
10. Implications for Public Health Practice and Policy	53
10.1. Contact Investigation.....	54
10.2. Screening Guidelines.....	55
10.3. Resources.....	55
10.4. HIV and Substance Use.....	56
10.5. Social Determinants of Health.....	56
11. Summary	57
12. References	59

List of Tables

Table 1	Risk Factors for Progression to Tuberculosis Disease.....	12
Table 2	Provincial and Territorial Tuberculosis Incidence Rates per 100,000 Population.....	15
Table 3	Estimated Incidence of Adverse Events Associated with BCG Vaccine in First Nations Children, 1996-2000.....	27
Table 4	Criteria for Low Endemicity.....	30
Table 5	World Health Organization Indicators for Tuberculosis Programs.....	46
Table 6	Tuberculin Skin Test Results for First Nation Children.....	48
Table 7	Demographic Characteristics of Aboriginal Children in British Columbia, Tuberculosis Control, 1998-2005.....	49

List of Figures

Figure 1	Enhanced Surveillance Screening Evaluation Map.....	44
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List of Appendices

Appendix 1	BCG Policies and Practices in Other Select Countries.....	67
Appendix 2	Methodology for Literature Search.....	68
Appendix 3	International Standards of TB Care.....	69

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1. Introduction/Background

In 2003, British Columbia (BC) opted to discontinue routine Bacille Calmette-Guerin (BCG) vaccination for First Nation children and replace this with enhanced tuberculosis (TB) control activities as recommended by First Nations and Inuit Health, Health Canada (Public Health Agency of Canada, National Advisory Committee Statement on BCG, 2004). BCG is the most widely administered vaccine in the world and is used to prevent serious forms of TB in children, most notably TB meningitis and miliary TB (Fine, P., Carneiro, I., Milstien, J. & Clements, C.J., 1999). Evaluation of reports detailing serious adverse events caused by the BCG vaccine in some First Nation children raised concerns that the routine neonatal BCG immunization program may well be associated with unforeseeable and unacceptable health risks (Public Health Agency of Canada, 2004a). The decision to shift from mass vaccination of infants to selective vaccination of high risk groups is guided by criteria established by the International Union against Tuberculosis and Lung Disease (IUATLD) (World Health Organization, 2004). Of significant importance to meeting these criteria, there must be an efficient notification system in place to monitor, case find and treat active TB cases.

BC Center for Disease Control (BCCDC) is the centralized health authority for maintaining communicable disease registry and services for the province of British Columbia. All core TB services are delivered by BCCDC in partnership with First Nation & Inuit Health, Pacific Region. To monitor and improve TB control efforts with First Nation reserves, an enhanced surveillance and screening program was developed and implemented in June 2004.

Effective evaluation of the enhanced surveillance program will help facilitate future direction for TB control initiatives and priorities with First Nation communities and provide additional research for public health policy.

1.1 Pathophysiology of Tuberculosis

Mycobacterium tuberculosis (*Mtb*), the bacteria that cause TB, have seriously plagued mankind for centuries. The genetically related group known as Mycobacterium TB complex (or MTBC) has been established as the case definition of TB in Canada, and includes the species *M. bovis*, *M. africanum*, *M. caprae*, *M. microti* and *M. pinnipedii* (Canadian Tuberculosis Standards, 2007). *Mtb* is the etiologic agent of TB in humans; therefore humans are the only reservoir for this bacterium. *Mtb* is a nonmotile rod shaped bacterium that requires oxygen, hence why classic cases of active TB are found in the well-aerated upper lobes of the lung (Todar, 2009). The unique and sophisticated cell wall deserves special attention as it contains high concentrations of complex fatty acid that provide an extraordinary lipid barrier. The cell wall of this bacterium has been associated with impermeability to stains and dyes, resistance to many antibiotics, and acidic and alkaline compounds (World Health Organization, 2004). Of particular significance is its resistance to osmotic lysis and lethal oxidations which allow it to survive inside of macrophages (Todar, 2009). Transmission of *Mtb* occurs when droplet nuclei containing *Mtb* bacilli are expelled by coughing, sneezing, singing or other forceful expectoration. These droplets can remain suspended in the air for minutes to hours depending on ventilation factors. The number of bacilli in the droplets, the virulence of the bacterium, exposure of the bacilli to UV light, the degree of ventilation in a room, and your own immune system, all influence the risk of transmission (Knechel, 2009). Infection by *Mtb* and the clinical manifestations that may ensue also represent a complex interaction between host and organism (Schluger, 2005). Once the infectious droplets have been inhaled, the *Mtb* must gain entry to the alveoli of the lung. Macrophages, the cells that act to initiate an immune response and destroy pathogens are alerted to these foreign invading bacteria and will engulf the *Mtb* using various phagocytic receptors.

However, the parasitic nature of this relationship has just begun, for the *Mtb* have now found a niche inside the macrophage where they can survive and regenerate very slowly. Evidence has clearly shown that *Mtb* bacilli and host macrophages are essential to the pathogenesis of TB (Lee, Hartman, & Kornfeld, 2009). Within 2 to 6 weeks of this infection, macrophages recruit other accessory cells, most notably CD4 and CD8 T -cells to activate cell-mediated immunity (Saunders & Cooper, 2000). The recruitment of inflammatory cells surround and help contain infected macrophages to limit spread of the bacilli. The result is containment of the bacilli and dead macrophages into a caseum, where a granuloma is formed. The granuloma will keep the bacilli in check perhaps forever, reactivate later in life, or it will break down and discharge bacilli into the airways causing necrosis of the bronchi and cavitation (Raja, 2004). One hypothesis about the importance of granuloma formation is that it provides a protective wall of macrophages and lymphocytes to surround infected cells, therefore when these infected cells die, the surrounding macrophages are in place to phagocytose the escaping *Mtb* and prevent secondary spread of infection (Saunders & Cooper, 2000). This complex protective immune response keeps *Mtb* from further transmission and is called latent TB infection (LTBI). *Mtb* can exist for many years or over ones' life time encased in granulomas, and possess the genetic ability to survive in anaerobic environments in a state of dormancy (Canadian Tuberculosis Standards, 2007). Latent infection occurs in approximately 90% of all of those individuals who become infected with *Mtb* and they will never develop clinical illness or be infectious to others, unless reactivation of the latent infection should occur (Schluger, 2005). Empirically, LTBI is diagnosed through the use of the protein purified derivative (PPD) or tuberculin skin test (TST) that will induce a delayed hypersensitivity reaction from being previously infected with the *Mtb* (Cardona, 2006). It is estimated that only 10% of those with LTBI will ever go on to develop

active disease, this usually occurs in those who have underlying clinical risk factors such as HIV or other forms of immunosuppression (Schwartzman 2002).

1.2 Reactivation of Latent Tuberculosis Infection (LTBI)

LTBI truly represent one of the most challenging obstacles to overcome in order to gain control over TB. The inability of the immune response to totally eliminate *Mtb* atests to the remarkable evolution of this pathogen and its survival for thousands of years.

Control of *Mtb* within the granuloma depends entirely upon successful immune responses, where we know this structure to be comprised of various immune cells (Chakravarty, Zhu, Tsai et al., 2008). In approximately 5% to 10% of latent infections the immune response fails and the *Mtb* that were once held within the granuloma reactivate and develop into active TB disease (Flynn & Chan, 2001). Necrosis cause the granuloma to liquify and the protective walls lose structural integrity, allowing the necrotic material along with *Mtb* to drain out into bronchial pathways and nearby blood vessels, leaving behind a cavity (Knechel, 2009). This cavitary TB found in the pulmonary apex is the most frequent form of active TB found in adults, and evidence is widely accepted that these infections are the consequence of *Mtb* escaping from a lower base of the lung where *Mtb* favour the oxygen rich environment (Cardona, 2006). The *Mtb* are now able to infect new host cells and grow as extracellular pathogens in the various necrotic cavities that have been left behind (Lee et al., 2008); this is essentially reactivation of LTBI into active TB disease.

1.3 Risk Factors for Development of Active Tuberculosis Disease

The integral functions of a successful immune response are required to keep *Mtb* contained to the granuloma. However, there are many illnesses and medications that result in immunosuppression

which can cause reactivation of an untreated latent infection. Over the last decade more research has developed in the areas of HIV and tumor necrosis factor-alpha (TNF α).

1.3.1 Tuberculosis and HIV

There are numerous studies throughout the literature on the higher incidence of TB among those who are HIV infected. The progression of a recently acquired TB infection into active disease in those who are HIV positive is rapid (Raja, 2004). Those at highest risk for reactivation of LTBI are persons with HIV coinfection; the association of the two opportunistic infections has shown to result in more than a one hundred-fold increase in risk (Schwartzman, 2002). The co-infection with HIV is believed to bring about a reduction in CD4 T cells, which play a prominent role in the immune response to TB infection in granulomas (WHO, 2004). Conversely, TB infection also accelerates the progression of HIV disease to AIDS due to the macrophages that produce tumor necrosis factor-alpha (TNF α), a potent activator of HIV replication (see description of TNF α below) (Raja, 2004). On a global level, the impact of HIV on TB mortality rates has been substantial. TB is the most common cause of death in HIV infected individuals and will have an impact on TB control efforts in low-income and industrialized countries for years to come (Canadian Tuberculosis Standards, 2007). Current surveillance reports from the Public Health Agency of Canada (PHAC) indicate that HIV/AIDS is steadily rising in the Aboriginal population, particularly in women, representing an increase from 15.0% to 21.4% in the proportion of positive HIV test results; non-Aboriginal population has seen a decline from 75.7% to 58.4% (PHAC, 2007b).

1.3.2 Tuberculosis and TNF- α

TNF-a, a cytokine, is a key mediator in the inflammatory process of the immune system (Nash & Florin, 2005). TNF-a acts as a messenger to activate macrophages, which will in turn control *Mtb* replication and trigger an inflammatory response to form protective structures (granulomas) in the lung (Marino, Sud, Plessner, et al., 2007). This poses a dilemma for those persons with LTBI who also suffer from chronic inflammatory diseases, most notably rheumatoid arthritis, chronic hepatitis and sarcoidosis. The expression of TNF-a is the driving force behind inflammation and the consequential damage to cartilage, joints and bone seen in rheumatoid arthritis (Nash & Florin, 2005). Controlled trials for TNF-a inhibitors in rheumatoid arthritis have shown great success in reducing signs and symptoms, improving quality of life and preventing further damage in these patients (Nash & Florin, 2005). A suspicion for reactivation of TB in patients with rheumatoid arthritis who are being treated with TNF-a inhibitors such as infliximab should be maintained by health care workers. The general rule of thumb for physicians is the necessity to screen patients for TB and LTBI and treat these conditions appropriately before initiating infliximab, a TNF-a inhibitor (Long & Gardam, 2003). This is of particular concern in Aboriginal populations, as they experience a higher prevalence of arthritis and rheumatism when compared to non-Aboriginal Canadians (Shah, 2003). A Health Canada (2003) report on arthritis reported rheumatoid arthritis as the most prevalent chronic condition in Aboriginal communities, with 27% of Aboriginal people over the age of 15 suffering from chronic inflammatory arthritis compared to 16% in the non-Aboriginal population (Health Canada, 2003).

Other risk factors for the development of active TB in those who have LTBI are presented in Table 1 below. This table shows that in addition to HIV and TNF-a, organ transplant immunosuppressant therapy, silicosis and chronic renal failure also increase the risk for TB.

Table 1. Risk Factors for Progression to Tuberculosis Disease

Risk Factor Status	Estimated Risk of TB Relative to Persons with No Known Risk Factors
<p>HIGH RISK</p> <ul style="list-style-type: none"> • Acquired immunodeficiency syndrome (AIDS) • Human immunodeficiency virus (HIV) • Immunosuppressant therapy for organ transplantation • Silicosis • Chronic Renal Failure – hemodialysis • Carcinoma of the head and neck • Recent TB infection (< 2 years) • Abnormal chest x-ray, fibronodular disease <p>INCREASED RISK</p> <ul style="list-style-type: none"> • Treatment with glucocorticoids • Tumor necrosis factor (TNF-alpha inhibitors) • Diabetes mellitus (all types) • Underweight (<90% ideal body weight; for most persons this is a body mass index <20) • Young age when infected (0-4 years) • Smoker (1 pack/day) • Abnormal chest x-ray; granuloma 	<p>110 - 170</p> <p>50 - 110</p> <p>20 - 74</p> <p>30</p> <p>10 – 25</p> <p>16</p> <p>15</p> <p>6 – 19</p> <p>4.9</p> <p>1.5 – 4</p> <p>2.0 – 3.6</p> <p>2 – 3</p> <p>2.2 – 5.0</p> <p>2 – 3</p> <p>2</p>
<p>LOW RISK Infected person, no known risk factors, normal chest x-ray (low risk reactor)</p>	<p>1</p>

Source: Courtesy of the 6th Edition Canadian Tuberculosis Standards, 2007 (page 65)

1.4 Active Tuberculosis Disease

Approximately 10% of individuals infected with *Mtb* will develop active TB disease at some point over the course of their lifetime, usually within 2-5 years after infection (Lillebaek, 2005). Most TB disease occurs in the lungs where *Mtb* replicate and cause damage to the lung, this disease is known as pulmonary TB and is considered infectious (Francis J Curry National TB Center, 2007). In approximately 15% of TB cases, the disease can spread to distant parts of the body and settle in organs, bone or other tissue. TB that develops in these areas is not considered infectious (Francis J Curry National TB Center, 2007).

The general symptoms of pulmonary TB disease include coughing for more than 2 weeks, fever, night sweats, fatigue, unexplained weight loss and sometimes hemoptysis (blood in sputum) (Canadian Tuberculosis Standards, 2007). The diagnosis of TB disease is confirmed in laboratory from a minimum of three culture samples, and a single positive culture for *Mtb* is generally adequate to define active disease (Canadian Tuberculosis Standards, 2007). Chest radiography is used to evaluate an individual who presents with pulmonary TB symptoms, and can not be used alone in diagnosis of TB disease (Canadian Tuberculosis Standards, 2007).

1.4.1 Treatment of Tuberculosis

Treatment for active TB disease is divided into two phases: (1) daily medications (initial phase), and (2) twice-weekly medication (continuation phase) (Canadian Tuberculosis Standards, 2007). Treatment with anti-tuberculous medications usually ranges between 6 to 9 months or until a minimum of 80% of the prescribed doses have been taken (Canadian Tuberculosis Standards, 2007). Anti-tuberculous medications are prescribed for bactericidal activity, sterilizing activity and prevention of drug resistance (Hershfield, 1999). The standard first line anti-tuberculous medications used are Isoniazid (INH), Rifampin (RMP), Pyrazinamide (PZA) and Ethambutol (EMB) (Canadian Tuberculosis Standards, 2007).

Treatment for LTBI consists of treatment for 9 months with one drug, INH, which is taken in conjunction with vitamin B6 due to INH interference with pyridoxine metabolism, which produces peripheral neuropathy (Canadian Tuberculosis Standards, 2007).

The preferred method for adherence of anti-tuberculous medications is with directly observed therapy (DOT). In a systematic review of DOT, (Cox, Morrow & Deutschmann, 2008) this strategy for TB control was recommended by the WHO in 1995 and has continued as an

important measure to complete treatment and cure patients with TB, while reducing the risk of drug resistance. To deliver DOT, a health care provider must watch the patient ingest the medication twice weekly for short term therapy.

1.4.2 Epidemiology of Tuberculosis

The World Health Organization (WHO) estimates that one third of the world is infected with mycobacterium TB; in 2006 there were 9.2 million new cases reported and 1.7 million deaths from TB (WHO, 2008). The emergence of multi-drug resistant (MDR) and extensively drug resistant (XDR) strains of TB is a genuine global threat that requires urgent attention and response.

The national rate for TB in Canada continues to decline, and as of 2007 it was reported to be 4.7 per 100,000 (PHAC, 2007a). This is a reflection of decreasing TB cases in the general Canadian-born non-Aboriginal population, as true incidence rates based on Canadian born Aboriginal populations remain consistently higher and have not decreased over the last decade (PHAC, 2007a). The vast majority of TB cases in Canada remain with Aboriginal peoples and foreign-born citizens. In particular, Aboriginal people account for 20% of all cases reported in Canada; in Saskatchewan, the Northwest Territories, Nunavut and Yukon, they account for over 88% of TB cases, and for Manitoba the case rate is 66% (PHAC, 2007a). These provinces represent the highest current rates found in First Nation populations. Table 2 provides current rates of TB among Aboriginal and non-Aboriginal populations.

Table 2: Provincial and Territorial Tuberculosis Incidence Rates per 100,000 Population

Province/Territory: 2007	Canadian Born Aboriginal	Canadian Born Non-Aboriginal	Tuberculosis Cases and Overall Incidence Rates per 100,000
Alberta	15	13	3.2
BC	41	32	6.4
Manitoba	68	7	8.6
New Brunswick	0	2	0.7
Newfoundland	1	5	1.4
Nova Scotia	0	4	0.7
Ontario	13	49	5.1
Prince Edward Island	0	0	0
Quebec	22	55	3
Saskatchewan	99	3	10.6
Northwest Territories/Nunavut/Yukon	48	0	45.6

Source: Tuberculosis in Canada: 2007 Report, Public Health Agency of Canada, page 15.

The most interesting revelation has been the prediction for reactivation of TB done in a study by Clark & Vynnycky (2004) where analysis done between 1972 and 2000 showed 73% of TB cases in the 35 – 44 year age group were due to reactivation (Clark & Vynnycky, 2004). This could signify a variety of confounding factors, such as underlying chronic illness or poor treatment compliance. Non-compliance to TB medication regimens is one of the many challenges for TB control, where many studies find non-compliance to be associated with recurrence of TB (Picon, Bassanesi, Caramori, Ferreira, Jarczewski & de Borba Vieira, 2007). According to the most current 2007 TB Report for Canada, the Aboriginal population has a large percentage of younger TB cases (0 – 14 years) compared to Canadian born non-Aboriginals whereby those affected tend to be 65 years of age and older (PHAC, 2007a). This is of significance due to the age category, where it may be assumed some cases were most likely vaccinated with BCG and therefore should have had some protection against developing active

TB. A study by Cook et al., (2005) also confirmed that TB cases amongst Aboriginals tend to be younger, and they are more likely to be associated with a clustering of active TB cases.

Clustering suggests recent or ongoing transmission within the community, as opposed to reactivation of old TB, and has been estimated to be 50% to 60% of TB cases. The study also concluded that BCG vaccination status had limited value in preventing clustering of TB cases and that more appropriate strategies to reduce transmission are required (Cook, et al., 2005).

1.5 History of Tuberculosis and Aboriginal People

The terms used for “Aboriginal” people in Canada consist of three distinct groups: First Nations (North American Indians), Metis and Inuit and are recognized in the Constitution Act of Canada 1982 (Canadian Tuberculosis Standards, 2007).

The decimation of Indigenous populations due to infectious diseases with the arrival of European contact is well documented throughout the literature. The exposure of Canadian Aboriginal people to TB some 300 years ago contributed to extraordinary high mortality rates, as many as 9,000 deaths per 100,000 people until the end of the 19th century (Blackwood, Al-Azem, Elliot, Hershfield & Kabani, 2003). Approaching the twentieth century, First Nation reserves on the Canadian prairies had lost between 40% and 50% of their populations to disease, with average child mortality rates surpassing birth rates and mortality rates documented at 60 per 1000 population for the Qu’Appelle First Nations in Saskatchewan (Lux, 1998). These high mortality rates are thought to reflect Aboriginal people’s lack of ancestral exposure to TB and consequent lack of antibodies for TB (Grzybowski & Allen, 1999).

There are very few trials to examine TB and Aboriginal people from a historic perspective; however the study on the Qu’Appelle reserve in Saskatchewan examined how these Aboriginal

children became the subjects of a BCG vaccine trial in 1933; something that was extraordinary given the intolerant racial disparity that existed during that time (Lux, 1998). In 1921 the Saskatchewan Anti-tuberculosis Commission performed the first survey of school children for the province. Results found that 54% of the 1,184 non-Aboriginal children had a positive TST, whereas the sample of 192 Aboriginal children had a 92.5% positive TST rate (Lux, 1998). It was reported that the medical conditions of children admitted into the “Indian Industrial” schools or former “residential schools” was rarely questioned by school staff, while most children had TB. There was no attempt to isolate or ventilate classrooms or dormitories and transmission of TB was inevitable. In 1907 a school report noted that 69% of all ex -pupils were deceased subsequently upon discharge from the school. In all cases the cause of death was reported as TB (Lux, 1998). In spite of the deficiency of reliable TB data for the pre-chemotherapy era for Aboriginal people, Clark & Vynnycky (2004) were able to obtain an annual risk of infection (ARI) by using maximum likelihood methods, and is one of the few studies that attempt to estimate long-term trends in ARI. TB meningitis mortality rates and ARI trends from Statistics Canada since 1926 for First Nation children aged 0 -4 years were used to estimate the risk of primary, endogenous reactivation, and exogenous re-infection rates. Results concluded that the ARI during the pre-chemotherapy era likely ranged between 6% in 1926 and 21% in 1944 (Clark & Vynnycky, 2004).

The first Canadian TB sanatorium opened in 1897, with only preventative methods of isolating infected patients and providing rest, nutrition and fresh air for rehabilitation. These hospitals were primarily for non-Aboriginal patients, and it was not until the end of 1953 that Aboriginal people were offered treatment and improved TB care (Grzybowski & Allen, 1999). The sanatoria experience and history of TB has influenced perceptions of TB treatment today, mostly from

those who experienced lengthy separations from family and community, loneliness and fear (Gibson, Cave & Doering, 2002).

With the advent of anti-tuberculosis antibiotics to treat active TB by 1948, mortality rates of TB in the general population of Canada declined dramatically throughout the 1950's, 60's and 70's (Health Canada, 1999). The mortality rate for Aboriginal populations also decreased during this timeline, yet Aboriginal populations on-reserve were still ten times more likely to have TB than non-Aboriginal Canadians (Health Canada, 1999). TB control activities on reserves sparsely existed before the 1980s, and were inconsistent from community to community as health services were not uniformly provided until 1982 (Smeja & Brassard, 2000). With higher rates of LTBI currently found in Aboriginal communities, these pools of TB infection have the potential to increase TB disease substantially, keeping the perpetual cycle of TB ongoing. If TB control efforts and resources are relaxed within these high risk communities, TB will continue to pose a public health risk for the future (Fitzgerald, Wang & Elwood, 2000).

1.6 Bacille Calmette-Guerin (BCG) Vaccine

As a component of the 1992 Tuberculosis Elimination Strategy for Aboriginal Peoples of Canada, the use of the Bacille Calmette-Guerin (BCG) vaccine was recommended as a strategy in communities that have a rate of new infections higher than 1%, or with a high incidence of active TB disease (Health Canada 1999). The goal to reduce the incidence of TB disease to 1 per 100,000 by the year 2010 is clearly not going to occur (Health Canada 1999). Questions remain as to the role of BCG in Canada and in the future for TB control. This section describes the history and current knowledge of the BCG vaccine.

BCG, a live attenuated vaccine that comes from the *Mycobacterium bovis* was initially developed at the Pasteur Institute in Paris in 1921 by Albert Calmette and Camille Guérin (Pereira, Dantas, Ximenes & Barreto, 2007). Current BCG vaccine strains are all descendants of the original *M.bovis* isolate and are used throughout the world (Canadian Tuberculosis Standards, 2007). BCG is currently the only TB vaccine available that provides protection for children against TB meningitis and disseminated TB, potentially fatal forms of TB. Thousands of lives have been saved over the past decades through BCG vaccination, particularly in most countries with a high burden of TB (WHO, 2004). There are approximately 172 high prevalence countries where BCG is routinely received, and over 3 billion doses are administered annually (Cook & Elwood, 2004).

A single intradermal injection of the recommended dosage of BCG vaccine is administered over the deltoid region of the arm. The indication of BCG vaccination is the development of erythema followed by minimal ulceration that produces a noticeable scar (Canadian Immunization Guide 2006). Unlike other vaccines that may provide ultimate protection, BCG does not prevent TB infection, but it is most effective at providing protection from *dissemination* of TB throughout the body. As a result, it is valuable for children at high risk of disseminated disease (Cook & Elwood, 2004).

In a meta-analysis of the most current important studies to date on the efficacy of BCG and pulmonary TB, Barreto and colleagues (2006) found that there is common consensus on the first dose protection that BCG offers children against serious forms of TB meningitis and miliary TB. However there is controversy on whether BCG has any protective efficacy against the prevention of TB disease, and the duration of protective coverage it provides (Barreto, Pereira & Ferreira, 2006). In a meta-analysis of the literature, Brewer (2000) reviewed trials conducted over a period

of 46 years, analyzing data from 14 prospective trials and 12 case controlled studies. This meta-analysis revealed that vaccination with BCG significantly reduced the risk of TB by an average of 50%, which supports the use of BCG in those children at risk. Yet there remains uncertainty and inconsistencies in the literature as to how long the benefit of BCG lasts (Brewer, 2000). The WHO position statement on the duration of BCG protection was that the vaccine gradually declines with time and is likely to be lost after 10-20 years (WHO, 2004).

A study conducted on long term efficacy of BCG vaccine in American Indians and Alaska Natives (Aronson, Santosham, Comstock, et al., 2004) used retrospective records reviews and supplemental interviews with some original participants of a placebo-controlled trial of BCG more than 50 years ago. The overall incidence of TB was calculated to be 66 and 138 cases per 100,000 for the BCG vaccine group and placebo group, respectively. Vaccine efficacy of 52% protective coverage from TB meningitis and miliary TB was reported, which compares favorably with many other trials (Brewer, 2000). In the study conducted by Aronson and colleagues (2004), the *duration* of BCG was studied, and was found to have protective benefit lasting between 50 and 60 years after one single dose. This represents the longest follow-up trial to date, where most other controlled trials have reported 15 to 20 years at the most (Aronson, et al., 2004). This finding also supports the use of BCG in high risk children, or those who are continually exposed to active TB.

Barreto and colleagues (2005) recently conducted a randomized follow-up trial of children in two cities in Brazil, and chose one city closer to the equator due to the evidence that BCG efficacy tends to be lower in populations where environmental mycobacterium exposure is greater. This study also reported substantial protection (39%; 95% CI 9-58) of neonatal BCG against serious forms of childhood TB some 15-20 years after vaccination (Barreto, M.L.,

Cunha, S., Pereira, S., et al., 2005). The Canada Communicable Disease Report (2004) concluded that BCG efficacy is estimated at approximately 50% for prevention of TB disease, 64% for meningitis and up to 80% for disseminated disease in infants.

However, with such a variation between studies, the duration of BCG protection will most likely be debated for years to come. It is obvious that BCG plays a minimal role in preventing the transmission of TB as a public health measure, and as such its routine use has been questioned.

1.6.1 Factors Related to the Decision to Discontinue BCG in British Columbia First Nation Children

The decision to discontinue routine BCG vaccination in First Nation populations was made with deliberation based on the evidence of serious implications for continued BCG use and the need for a safer and more effective alternative to BCG vaccination (Clark & Cameron, 2006). While research has shown that the BCG vaccine protects vulnerable populations from serious forms of TB, the discontinuation of routine BCG use in First Nation children was prompted by adverse event notifications and complications of the vaccine, which resulted in higher rates of disseminated BCG disease than what was expected - many of which were fatal (PHAC, 2004a). Rates of pediatric TB disease have declined rapidly in the last ten years, and interventions such as early detection and treatment may be more appropriate now (Dawar, Clark, Deeks, Walop & Ahmadipour, 2003). In this section, discontinuation of BCG vaccination is discussed primarily in relation to low incidence rates of TB and adverse effects caused by the vaccine.

1.6.1.1 Low Incidence Rates

In Canada, the use of BCG is currently limited to on-reserve First Nation and Inuit children as part of a TB elimination strategy to reduce the disproportionately high TB rates in this

population, and is not a routinely recommended vaccine for the general Canadian population (Canadian Tuberculosis Standards, 2007). Canada, like many other developed nations chose to evaluate the efficacy of BCG in light of the declining incidence of TB and changing epidemiology.

As of 2003, the BCG vaccine has been discontinued from all BC First Nation neonatal vaccination schedules though other provinces, with the exception of the Atlantic Provinces (i.e., New Brunswick, Newfoundland, Labrador, Nova Scotia, Prince Edward Island) and Quebec who continue to offer it (PHAC, 2007d). In the Atlantic Provinces, the decision to discontinue the BCG vaccine was related to very low TB incidence rates (i.e., range from 0 to 4 cases over the past 10 years) which included First Nation communities in New Brunswick and Nova Scotia; Quebec had discontinued routine use of BCG in the mid-late 1970s for school students, and has discontinued BCG in all First Nation communities as of 2005 (PHAC, 2007d).

The province of Alberta is also moving to systematically withdraw the use of BCG; careful review of the evidence to support the BCG policy change with minimal impact to First Nation communities have been underway. BCG has been discontinued in 41 of 44 First Nation communities as of 2007 (PHAC, 2007d). A study by Long and colleagues (2004) examined the occurrence of pediatric TB in Alberta First Nations over a period of 10 years from 1991-2000; within two separate micro-epidemics that were reported, there was scant evidence that BCG reduced the severity of disease. Disease rates in the BCG vaccinated close pediatric contacts were 7/20 (35.0%) and unvaccinated pediatric contacts were 13/39 (33.3%) respectively. The results from the pediatric cases concluded that disseminated disease was found in 0/11 BCG-vaccinated pediatric cases, and 1/20 BCG-unvaccinated cases, and all cases completed satisfactory course of treatment. The recommendation to use enhanced surveillance for detection

of infection and disease in children by serial tuberculin skin testing as an alternate to BCG was therefore proposed. It is evident in Long's work that maintaining BCG coverage does not influence burden of disease among children, even though it does reduce individual childhood morbidity. Consequently, enhanced surveillance and screening in children would also serve as a marker for on-going transmission in the community (Long et al., 2004). Targeted TB screening of children in high risk populations has also provided evidence of decreasing the burden of TB further. A recent study by Brassard and associates evaluated a school based TB screening program in Montreal for immigrant children aged 4 – 18 years. Investigation also included household associates and other family members with previous TB information. The study results found 542 (21%) schoolchildren with a positive TST, and 342 were started on therapy. There were 555 associates skin tested, of which 211 (38%) were found to be TST positive. Of these, 131 had chart reviews for previous TB information, and 108 (82%) were started on treatment. Multivariate analysis also verified that screened schoolchildren who had at least 2 family members also brought in for screening was positively associated with adherence to treatment, which further reduced risk of transmission. A cost-benefit analysis also estimated that 36.1 cases of active TB were prevented by the school-screening and resulted in substantial health care savings (Brassard, Steensma, Cadieux & Lands, 2006).

Evidence from case study analysis of various associative investigations by Moonan, Quitugua, Cox, Do, and Wiess (2002) revealed that children very seldom transmit TB bacilli to others due to the rarity of having cavitory lung disease and ability to produce a forceful cough to expel and aerosolize the droplet nuclei required for transmission. When a child is found to have a positive TB skin test (TST), this indicates recent infection that usually comes from an adolescent or adult

family member. Investigation and prompt treatment for those infected will prevent further unnecessary transmission.

However, there will remain circumstances where the benefits of BCG vaccination to prevent serious forms of TB in children still outweigh any risks. For example, a retrospective population study conducted in Greenland by Soborg, Soborg, Pouelsen, Pallisgaard, Thbyo, and Bauers (2001) found that use of mass BCG vaccination in Greenland, which had one of the highest incidences of TB in the world (2300 per 100,000 in 1955), greatly reduced TB rates to an acceptable level (i.e., 25 per 100,000 by 1985). BCG vaccination at birth had always been provided in this country until 1990 when it was discontinued. After discontinuation, the greatest increase of TB cases were noted among children aged 0 – 7 yrs; two cases of fatal TB meningitis occurred during this time and prompted reimplemention of BCG in 1996. Between 1990 and 1997 an increase in TB rates had doubled and reached 172 per 100,000 by 1997, (Soborg et al., 2001). This study found groups of children born between 1990 and 1996 who did not receive BCG vaccine had the greatest increase in incidence from 12 per 100,000 to 171 per 100,000, showing that recent transmissions were occurring. Much of the increases were partly due to micro-epidemics located in small isolated Native settlements where multi-faceted challenges of medical staff shortages, weak case finding and treatment, over-crowded housing, and greater susceptibility due to lack of vaccination increased risk (Soborg et al., 2001). It was noted that Greenland had no reporting system for monitoring TB treatment results or quality control measures in place at the time of this study. Review of the International Union against TB and Lung Disease (IUATLD) criteria for shifting mass BCG campaigns to more selective programs specifies that a surveillance system must be in place; lack of any kind of surveillance in Greenland may very well have added to the consequential transmission of TB.

In other industrialized countries of low-incidence, immigration of populations from high TB endemic areas is increasing and changing the epidemiology of TB. Efforts in TB control programs are now primarily restricted to a few high-risk groups (Nguyen, Proulx, Westley, Thiebert, Dery & Behr, 2003). A recent study by Romanus (2006) investigated the surveillance of BCG vaccination in Sweden between 1989 and 2005, and found reason to continue selective BCG vaccination policies, even though Sweden has one of the lowest incidences of TB in the world (6.4 per 100,000 in 2005). General neonatal BCG vaccination was discontinued in 1975 due to frequency of BCG induced osteomyelitis (29 cases per 100,000) and changed to selective vaccination of those at risk. From 1979 to 1991 there were four cases of serious disseminated BCG infection; three were caused by severe combined immunodeficiency (SCID). In 1993 the recommendation to postpone BCG vaccination until 6 months or older was implemented. There have been no cases of disseminated BCG infection reported since 1991. The BCG coverage for children defined as a risk group (those children born to foreign-born parents) was estimated to be 88% for children born from 1998 to 2002. It was expected that the 1975 policy change would have affected the Swedish born children under five years of age who and were no longer vaccinated. However, even though there was a temporary increase in the annual incidence of TB in children, the rate had remained low varying between 0 and 1.9 per 100,000 during 1975 to 2004. Romanus' (2006) study supports the policy that restricting BCG vaccination to those children at risk (being born to foreign-born parents) has reduced the incidence of TB in those children, and the majority of Swedish born unvaccinated children still retain minimal risk of infection. Foreign-born age specific TB incidence rates are shown to be highest in the age group of 18-44 years, which constitutes 58 per 100,000 populations. This may pose some futuristic challenges for TB control in Sweden. With such high incidence rates in child-bearing age

groups, the increased risk of exposure for children in these families will need to be monitored. In the Swedish-born population, the incidence was shown to be 2.0 per 100,000 (Romanus, 2006). In contrast, the current proportion of foreign-born TB patients has increased by more than 70% from 34% in 1989 (Romanus, 2006). As of 2005 the estimated incidence of foreign-born TB has increased to 38 per 100,000, and immigration from African born populations has revealed an incidence of more than 200 per 100,000 (Romanus, 2006). Compared with the age specific Swedish group rate of 0.6 per 100,000, it is obvious that the majority of TB cases for Sweden are among the foreign-born.

These findings should serve as a reminder that even though Canada has a low incidence rate of TB compared to other countries, the rate is a reflection of the rate among the Canadian born non-Aboriginal population (PHAC, 2007a). Aboriginal communities must continue to be a priority for vigilant case finding and treating sources of infection as they continue to be at high risk (Fitzgerald, Wang & Elwood, 2000).

1.6.1.2 Adverse Effects

The Public Health Agency of Canada issued a statement in 2004 that revealed serious adverse events associated with the BCG vaccine had occurred among First Nation children (PHAC, 2004a). A review of the Immunization Monitoring Program-Active (IMPACT) identified 21 BCG vaccine related adverse events between 1993 and 2002. 15 of these cases were deemed serious (person died or was hospitalized for 3 or more days) and 14 cases were associated with the BCG vaccination. Five First Nation children died from disseminated BCG disease (PHAC, 2004a). Disseminated BCG disease is extremely rare, occurring in 1 per 3.4 million infants who have been vaccinated with BCG; however it is associated with a high mortality rate especially in

those with underlying immune deficiency diseases (Huang, Shyur, Weng, Chi, Tzen & Huang, 2005). Contraindications are clearly outlined *not* to vaccinate people who may have congenital immunodeficiency, symptomatic HIV infection, altered immune status or secondary immune function due to treatment with various immuno-suppressing medications (Canadian Tuberculosis Standards, 2007). In the case of these First Nation children, all had immunodeficiency and concurrent infections that were not identified prior to being given the BCG vaccination which resulted in a greater number of First Nation children with disseminated disease than anticipated from reported rates in other studies (Deeks et al., 2005). The Canadian Communicable Disease Report (PHAC, 2004a) suggests that immunodeficiency states may be more common within the First Nation population than previously known. Although there is prenatal screening for HIV available that would minimize contraindicated vaccination with BCG, there is still risk present for those suffering from congenital conditions such as severe combined immunodeficiency (SCIDS) that may not be detected until dissemination has already occurred (Cook & Elwood, 2004). Therefore the risk of disseminated BCG infection must be considered when assessing the risks and benefits of routine BCG immunization in these children.

The review by PHAC (2004a) calculated an extremely high estimated incidence of adverse events occurring in First Nation children when compared to global estimates (see Table 3 for comparisons of First Nation children and global estimates for disseminated disease).

Table 3. Estimated incidence of adverse events associated with BCG vaccine in First Nations children, 1996-2000*

Adverse event (AE)	Adenitis	Osteitis	Dissemination
Absolute number of AE	11	1	3
Canadian First Nations on-reserve AE/million does BCG (95% CI)	752 (375,1346)	68 (1.7, 381)	205 (42,600)

Global estimates of AE/million doses BCG	387	1.7 – 72.9	0.19-1.56
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*based on 14,622 doses administered when compared to global estimates.
Source: Public Health Agency of Canada (2004), page 6.

1.6.1.3 Other Rationale

In this section, other rationale used to discontinue the BCG vaccine are briefly presented. In particular, issues related to coverage, long-term effectiveness, and interpretation of tuberculin skin tests are discussed.

Coverage was among the issues that influenced the decision to discontinue routine BCG vaccination of First Nation children in British Columbia., Among First Nation communities that were eligible for the vaccine, only 25% were found to be actually administering the vaccine (Cook & Elwood, 2004). An analysis to review the uptake of BCG in First Nation communities was conducted by Dawar and associates (2003), where results suggested extensive variance in coverage between communities and within provinces. This study concluded that BCG coverage has been in decline since the late 1990s, and that uptake varied from 35% to as high as 98.5% across the country (Dawar et al., 2003). Additional studies on BCG vaccination among First Nations in Saskatchewan also reported low uptake of vaccination coverage (50%), signifying many infants have not received BCG vaccination as indicated by Health Canada recommendations (Reid, Ward, Marciniuk, Hudson, Smith & Hoeppe, 2007).

The long term effectiveness of the BCG vaccine also contributed to the decision to discontinue. The role of BCG in preventing serious forms of TB meningitis and disseminated TB in children is well established; however this defense wanes over time, to what extent is not clear as there remains controversy over the exact protective duration of BCG. BCG does not offer protection from adult acquired primary infection, nor does it protect from reactivation of latent pulmonary infection later in life, although it has been found to limit the spread of bacteria after infection

(Menzies, Tannenbaum, & FitzGerald, 1999; WHO, 2004). BCG is not likely to have any significant impact on transmission of TB within a population and thus limits its usefulness in TB control programs. In high and low incidence countries, TB elimination efforts focus primarily on case finding and prompt treatment of patients with active disease to prevent transmission, but more emphasis needs to occur equally to treat those with LTBI (Lillebaek, 2005).

One last factor that informed the decision to discontinue BCG vaccination programs is interpretation of tuberculin skin test (TST) in a person who has had a BCG vaccination. The standard use of the TST is monumental in identifying those with TB infection; however, BCG vaccine is known to interfere with accurate TST results, depending on when the individual received the BCG vaccination (Canadian Tuberculosis Standards, 2007). Therefore, many countries have discontinued BCG vaccine in order to preserve the diagnostic significance of the purified protein derivative (PPD) as an indicator of previous mycobacterium TB infection (Barreto et al., 2006). Further, it is generally accepted that people who have been vaccinated with BCG in the first year of life and are given a TST at age 10 years or older will have an accurate reaction regardless of BCG vaccination status, when it is administered after 12 months of age, it can be considered the likely cause of a positive TST (especially among non-Aboriginals and immigrants from a low risk areas) (Canadian Tuberculosis Standards, 2007).

1.6.2 Criteria for Discontinuing the BCG vaccine

In low-burden countries, the choice to limit BCG vaccination has been recognized by the World Health Organization (WHO, 2004). The International Union Against Tuberculosis and Lung Disease (IUATLD) have developed criteria defining low endemicity for those countries choosing

to amend immunization schedules from universal to selective BCG vaccination (WHO, 2004) (see Table 4 for criteria).

Table 4 Criteria for Low Endemicity

- | | |
|--------------------------|--|
| <input type="checkbox"/> | An average annual notification rate of smear-positive pulmonary TB cases below 5 per 100,000; or |
| <input type="checkbox"/> | An average notification rate of TB meningitis in children aged five years and below 1 per 10 million population during the previous five years; or |
| <input type="checkbox"/> | An average annual risk of TB infection below 0.1%. |

Source: World Health Organization, Epidemiological Record 2004, page 38.

Guidance for the decision by any country to discontinue a routine BCG vaccination program is based on recommendations from IUATLD (WHO, 2004). Discontinuation of BCG should be considered when (1) an effective notification system is in place; and (2) either the average annual notification rate of smear-positive pulmonary TB is <5 per 100,000 or the annual notification rate of TB meningitis in children <5 years of age is <1 per 10 million population over the previous 5 years or the average annual risk of TB is 0.1% or less (PHAC, 2004a).

Most countries with a low incidence of TB have chosen to discontinue universal BCG programs and implement selective programs to target those with higher risk factors for TB. Appendix 1 provides additional information on BCG profiles from various countries (i.e., Finland, Germany, Greenland, Spain, Sweden, UK, and USA) (World Atlas of BCG Policies and Practices, 2009).

1.6.3 Replacing BCG Vaccination with Enhanced Screening Surveillance

Although Canada has met the IUATLD criteria as a low-burden population for TB and can therefore safely discontinue routine BCG vaccination programs, it is recognized that TB continues to be problematic in some First Nation communities where microepidemics or clustering occurs (Dawar et al., 2003). Therefore, the replacement of BCG with enhanced

surveillance is crucial to monitoring trends in this population, and should consist of intensified case finding, treatment of active disease, screening and treatment for LTBI, and supervised directly observed therapy (DOT) for those taking medication (Canadian Tuberculosis Standards, 2007). To evaluate the effectiveness of enhanced surveillance, the BCCDC has a protocol to provide surveillance to monitor children and communities during the transition from vaccination to enhanced screening (Cook & Elwood, 2004). The number of active TB cases has defined the criteria for screening in First Nation communities as follows:

- “1. Annual community TB screening for all on-reserve band school children in grades 1 & 6, employees of health centers, band schools, daycare and pre-school, and those at higher risk with HIV/Aids, kidney dialysis, cancer, lymphoma, leukemia, organ transplants, low body weight, diabetes, and those on immune-suppressing medications.
2. Those communities with 1 or more cases of infectious TB disease in the past five years will have a community wide screening every 2 years for the entire community, including all grades for on-reserve band schools. Children born after June, 2000 will receive annual TB screening at 10 months, 2, 3, 4 & 5 years of age” (First Nation and Inuit Health TB and Immunization, 2009). Periodic evaluation of surveillance systems will enable BCCDC to decipher which communities have and do not have active cases, the extent to which screening is occurring, and if not, what is impeding screening efforts in a community.

1.7 Defining Enhanced Surveillance

Enhanced surveillance refers to the systematic collection of data, consolidation and evaluation of this data, and prompt dissemination of these trends, specifically to those who implement programs and policy (Canadian Tuberculosis Standards, 2007). In particular, the objectives of

TB surveillance programs are to: (1) guide health interventions; (2) estimate trends; (3) identify high risk groups; (4) monitor changes in the pattern of disease transmission; (5) evaluate prevention efforts and strategies; and (6) conduct related research (Canadian Tuberculosis Standards, 2007).

Collection of TB surveillance data is a critical function of public health; without valid surveillance data there is a risk to misinterpret true epidemiology of TB, compromise program planning, evaluation and research, provide misguided interventions and inappropriate allocation of resources for TB prevention (Sprinson, Lawton, Porco, Flood & Westenhause, 2006).

Providing enhanced screening activities to those considered at high-risk for TB in endemic communities alongside case detection and improved compliance with treatment of LTBI will have considerable impact on transmission (Health Canada, 1999).

1.7.1 Setting the Stage for Enhanced Surveillance in British Columbia

The National Tuberculosis Elimination Strategy for Aboriginal Peoples of Canada was introduced in 1992 (PHAC, 2004a). However, elimination is currently not seen as a realistic goal; consequently, it was recommended in 2005 that the goal be changed to a target incidence rate of 3.6 per 100,000 by 2015; to achieve this goal, an annual reduction of 3.3% will be required between 2007 and 2015 (PHAC, 2007a).

The control of TB and consequential reduction in incidence rates can be achieved with delivery of the basic objectives outlined in the Health Canada TB Program, which include: 1) detect and diagnose TB infections among those exposed to infectious cases and prevent the transmission of disease to other community members, 2) provide treatment to those with active and latent TB, 3) support health care workers and communities with prevention education and awareness to understand TB (Health Canada, 2007).

TB services for British Columbia First Nation communities are administered through the centralized BC Center for Disease Control (BCCDC). A unique collaboration and protocol exists between First Nation & Inuit Health and BCCDC that increases support, treatment, and surveillance of LTBI and active TB cases in all First Nation communities. Health Canada does not have public health legislation that applies to federal on-reserve communities, therefore they must work with provincial health governments and First Nation communities to regulate public health activities (Health Canada, 2007).

Currently, the BC Center for Disease Control uses the Public Health Information System (iPHIS) to capture TB data for BC First Nation clientele. Information pertaining to TB status, BCG history, gender, date of birth, TB #, treatment plan, medication, completion of treatment, radiology results, laboratory results, contacts and TST screening activity is captured in this system (PHAC, 2007c).

For the purpose of evaluation, TB surveillance data is essential for tracking and monitoring changes in communities. The Center for Disease Control National Prevention Information Network (CDC NPIN) endorses TB surveillance to enhance efforts to prevent TB, improve allocation of resources to treat, and evaluate impacts of public health interventions (CDC TB Evaluation Handbook, 2006).

1.7.2 Challenges of Tuberculosis Control

There are numerous impediments that lay outside the domain of enhanced surveillance and public health that continue to challenge the control of TB in Aboriginal communities. New initiatives to address TB in Aboriginal communities with acknowledgement of the underlying social and economic determinants of health are urgently needed (Cook & Elwood, 2008).

Education and awareness about TB is crucial for the success of prevention and treatment efforts in any high risk group, and has often been a challenge for public health (Brassard, Anderson, Menzies, Schwartzman & Macdonald, 2008). Studies exploring Aboriginal knowledge, awareness and experience with TB have been few, and those that were undertaken have found similar themes indicating lack of TB knowledge. A recent study by Brassard and associates (2008) had conducted a tuberculin screening for urban Aboriginal people in Montreal and subsequently structured interviews to explore participants' knowledge and perceptions of TB. A sample size of 164 Aboriginal participants were recruited, and approximately one-third reported knowing very little about TB, including transmission, signs and symptoms, risk factors and cause. While the majority of participants felt that TB was not openly discussed in community or at home, half of the respondents were not worried about contracting TB. This study concluded that there was a general lack of knowledge and many misconceptions about TB within this sample (Brassard et al., 2008).

Considering that many of these respondents could potentially be at risk for active TB, this lack of knowledge may also contribute to on-going transmission. Many people who are started on treatment have sometimes misunderstood TB information by a provider or the terminology of drug resistance, and this has led to complications in management of the disease (Hoepfner & Marciniuk, 2000). Health education is an important component of TB control, and helps to ensure that people are able to recognize the signs and symptoms of TB and take measures to counteract the disease in a timely manner before infecting others (Gibson et al., 2001). In a study by Gibson, Cave, and Doering (2001) the sociocultural factors affecting TB treatment and prevention in Aboriginal populations in Alberta were explored. Their findings revealed a lack of understanding about TB in the Aboriginal communities. They also found a relationship between

knowledge and perceptions of TB, where those who did not know much about TB had a more negative perception (Gibson, et al., 2001). This study reinforced the importance of providing education that is acceptable, respectful and meaningful in one's culture.

Housing conditions, lack of housing and overcrowding in many First Nation communities have been identified as a common problem for TB control (Clark, Riben & Nowgesic, 2002). A report issued by PHAC (2007e) confirms that housing conditions serve as risk factors for TB infection and disease. Overcrowded houses combined with poor air ventilation have been implicated in the transmission and outcome of TB; in particular, an increase of 0.1 persons per room increased the risk of two or more cases of TB in a community by 40%. This is important as the current average number of persons per room for First Nation people is 0.6, which is 20% greater than in the general Canadian population (PHAC, 2007e).

Basic public health services in many small remote First Nation communities are increasingly vulnerable to environmental changes, climate change and limited natural and economic resource bases (Furgal & Seguin, 2006). A study of TB screening programs in a First Nation community in James Bay by Smeja & Brassard (2000) found that the high turnover of nursing and medical staff can negatively impact TB control in various ways. New practitioners may not be familiar with TB or its' epidemiology in Aboriginal communities, and this lack of awareness can lead to delays in diagnosis and potential outbreaks. A greater number of reactivations of TB is to be expected in the near future due to changes in diet and lifestyle that have resulted in massive increases of diabetes; one of the known risk factors for progression to active TB (Smeja & Brassard, 2000).

TB control programs in some high prevalence First Nation communities also have challenges with the movement of people from reserves to local communities and visa versa, which is a

major risk to default on treatment (Fitzgerald et al., 2000). The movement from rural to inner cities by Aboriginal people is concerning as studies have found that Aboriginal people form some of the poorest residents of Canada's inner cities (Fitzgerald et al., 2000). The more northern remote communities also have social networks through which TB transmission occurs that extend beyond the reaches of a local public health unit; individuals regularly travel out from one village to the next (Nguyen et al., 2003).

More recently, other contributing causes to TB transmission have been uncovered by Cook & Elwood (2008) in a study on the burden of TB in Aboriginal communities in BC. Specifically, they found that a large outbreak of TB was related to delays in diagnosis and seeking treatment, as well as to substance abuse (Cook & Elwood, 2008).

1.7.3 Evaluation of Enhanced Surveillance Screening in First Nation Populations

A review of the literature in Pub Med and the Cochrane Library was undertaken to find evidence and literature pertaining to discontinuation of BCG and evaluation of enhanced surveillance screening specific to First Nation communities; no evaluations were identified other than studies supporting the discontinuation of BCG in First Nation communities (see Appendix 2 for a list of keywords used in the search).

However, there is a plethora of literature on evaluation methods, surveillance systems, effective TB programs and screening in high-risk and hard-to-reach populations. With this information, a framework for evaluation specific to this population and based on the best available evidence can be accomplished.

The long term ambition of any TB control programs is evident: to improve control measures and eventually eliminate TB by using a diverse range of objectives to meet this goal (CDC TB

Program Evaluation Handbook, 2006). The priority for TB control is early detection of those with TB disease, followed by prompt treatment. Prevention of TB is also accomplished by early identification of those with LTBI and the provision of chemoprophylaxis to reduce the risk of future transmission (Yuan, Richardson, & Kendall, 1995).

Evaluations of TB programs are essential to program management, providing a framework for performance indicators, generation of knowledge, resource allocation, and assessment of outcomes (Bartholomew, Parcel, Kok, & Gottlieb, 2001). Successful evaluations are a work in progress, monitoring implementation and outcome factors as they are being conducted. The quintessential components of a TB program evaluation framework include: (1) stakeholder engagement; (2) description of the purpose and elements of the screening program; (3) detailed information on the evaluation design; (4) data collection; (5) data analysis and interpretation; and (6) dissemination (CDC TB Program Evaluation Handbook, 2006).

1.8 Goal of this paper

The purpose of this paper is to provide an evaluation framework for the enhanced TB surveillance screening of First Nation children in British Columbia that is culturally relevant to First Nation populations. To do so will entail a broad framework of components that are based on current evidence available in TB control programs and Aboriginal/First Nation health. The primary components of the framework will consist of 1) stakeholders, 2) program description, 3) evaluation design, 4) data analysis and interpretation, 5) dissemination of results.

2. Stakeholder Engagement

There are a wide variety of stakeholders with a vested interest in TB programs who will be potentially affected by the evaluation (CDC TB Program Evaluation Handbook, 2006). FNIH, BCCDC and First Nation communities work in partnership to deliver and receive TB services; therefore they are identified as primary stakeholders in the evaluation process. During the evaluation for discontinuation of BCG vaccine programs for First Nations, stakeholders advised FNIH to both be very careful and methodical when planning for discontinuation of BCG in communities that were at particular risk, and to ensure that TB program elements and resources were in place prior to the decision to discontinue (PHAC, 2004a). Participation by persons involved in program operations, persons served or affected by the program and consumers of the evaluation findings for funding are all priority stakeholders who contribute diverse perspectives (CDC TB Program Evaluation Handbook, 2006).

Of utmost importance is the engagement and collaboration with Aboriginal people for whom this service is intended. Current activities to address TB in Indigenous populations include collaboration on a strategic framework that promotes Indigenous specific approaches and methodologies for the control and eradication of TB (A Global Indigenous Peoples' Initiative to Stop TB, 2009). The control of TB requires a specialized centralized program with TB expertise; however it must include a relationship and partnership with Aboriginal communities that account for socioeconomic conditions and cultural characteristics unique to those communities (Hoepfner & Marciniuk, 2000). In order to achieve TB control and elimination goals, there will need to be a greater degree of community partnership delivered in a culturally sensitive manner that has not been practiced in the past (Fitzgerald et al., 2000). One strategy of the Indigenous People's Initiative to Stop TB is to incorporate Indigenous cultural values, traditions and life ways in TB control and advocacy activities by: 1) ensuring policy and action are informed by

cultural Indigenous people, 2) encouraging TB programs to become aware of and respect the significance of language, culture, traditions and beliefs, 3) ensure that respect, empowerment, capacity building, education and training are fundamental to Indigenous community engagement modalities (A Global Indigenous Peoples' Initiative to Stop TB, 2009).

While there are a large number of stakeholders, not all need to be available throughout the entire evaluation process. Depending on their roles, some may want to be involved at different times in the process. For example, program managers, supervisors, community health representatives, nurses and other staff may want to be more involved in defining evaluation questions and using the results for program modification, whereas others may help collect data or advocate for the program itself (CDC TB Program Evaluation Handbook, 2006).

Stakeholders at the community level play an important role in helping to reduce TB transmission, case finding and treating clients with TB. In Hoepfner & Marciniuk's article on TB and Aboriginal Canadians it was established that Aboriginal community lay-workers were more effective in increasing compliance with TB treatment than non-Aboriginal health care workers, which highlights the value of compatibility, sensitivity and familiarity of cultural differences (Hoepfner & Marciniuk, 2000). There is enormous potential at the community level to engage and create action plans with local health care providers to reduce TB.

3. Description of the Program

A vital piece of planning an evaluation includes knowing exactly what was done when carrying out the project and why it was done; without this information, it is impossible to select appropriate and valid measures or to show causal relationship between project activities and outcomes (W.K. Kellogg Foundation, 1998). Further, within the description of the program, the

scope of the evaluation should reflect the system's current standard of care and public health practice, as well as how the program is organized in order to fully understand internal and external factors affecting program outcomes (CDC TB Program Evaluation Handbook, 2006). The principles of care for persons who have or are suspected of having TB are based on the International Standards for Tuberculosis Care 2006 (ISTC), and are currently endorsed by the Public Health Agency of Canada, the Canadian Thoracic Society and the Canadian Tuberculosis Committee (Canadian Tuberculosis Standards, 2007). The BCCDC TB Services for Aboriginal Communities (TBSAC) program provides TB services based on these standards of *what* should be done to provide quality TB care (Appendix 3 provides a summary of recommendations from the International Standards for Tuberculosis Care, 2006). All provinces and territories of Canada are legally required to report TB cases to public health authorities, who in return will provide select non-nominal data to the Canadian TB Reporting System (CTBRS) for annual TB reports (Canadian Tuberculosis Standards, 2007).

The task of creating a clear description of the TB program goals and objectives has already in part been accomplished with national and global indicators, as most TB programs have been in place for decades (CDC TB Program Evaluation Handbook, 2006). The description of the TB program should include the following components: 1) explanation of the community's need for the TB program, 2) depiction of the target audience for TB program services, 3) the context in which the program operates, 4) objectives of the program, 5) program's stage of development, 6) program resources/inputs, 7) all program activities, and 8) results or outcomes of the program (CDC TB Program Evaluation Handbook, 2006).

It should be noted that no matter how well thought out the program or utilization plan may be, if interaction with the target population is not happening, or does not happen according to the

parameters required to ensure success, the anticipated result or outcome will not occur (Bartholomew et al., 2001). Important outcomes or indicators of the proposed evaluation framework for enhanced TB surveillance in First Nation children include evidence of routine screening for TB and appropriate follow-up and treatment for those affected in order to prevent transmission of TB within the community.

4. Evaluation Design

Evaluations should be carefully designed in order to strengthen project activities and address important evaluation questions (W.K. Kellogg Foundation, 1998), though these may change over the course of the program. To account for possible changes in evaluation needs, the evaluation framework must be flexible. Flexibility of the evaluation design can be achieved by: 1) designing an evaluation that “fits” the needs of the target audience and stakeholders, 2) gathering only the data relevant to the specific questions, 3) revising the evaluation questions, plans, and data collection as project conditions change, 4) being sensitive to the cultural issues and history of communities, 5) knowing what resources are available for evaluation, 6) understanding existing capacity for staff to assist, and 7) being aware of the limitations of existing technologies and allowing for time interruptions (W.K. Kellogg Foundation, 1998).

Combining process and outcome evaluations can be a valuable way to assess efficiency of the program, as well as whether or not it achieved the desired effect (CDC TB Program Evaluation Handbook, 2006). While process evaluation measures the extent to which the intervention was delivered as intended, outcome evaluation seeks to assess the short term changes in perceptions, attitudes or other factors that have led to a change in behaviour or health status (Glanz, Rimer & Viswanath, 2008). With respect to the evaluation of the effect of the enhanced TB surveillance

screening of First Nation children, the change in rates of TB (the health problem) should be examined, as should the factors that contributed to the change observed (Bartholomew et al., 2001). For the purpose of enhanced TB surveillance screening, the evaluation method should include both a process and outcome focus.

According to evaluation research by W.K. Kellogg Foundation (1998) evaluation designs should always integrate both qualitative and quantitative data collection methods whenever possible in order to capture the richness and complexity of a program (W.K. Kellogg Foundation, 1998). For this reason, it is essential that the enhanced TB screening program incorporate both quantitative and qualitative data.

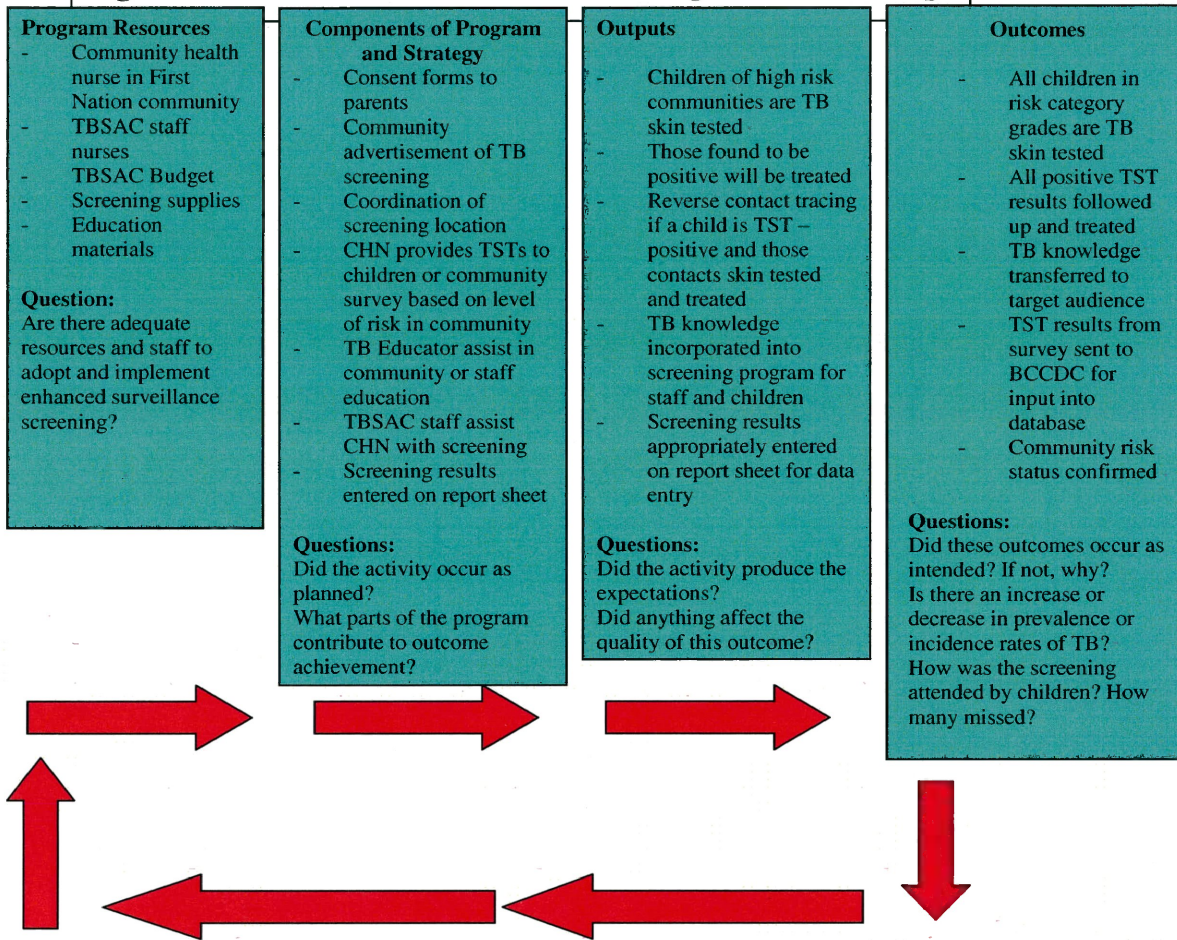
The WHO also highlights the importance of strengthening routine recording and reporting systems, as well as the importance of surveillance of all cases to improve estimates of burden and trends in a given population (WHO, 2008). For the purpose of enhanced surveillance in First Nation populations, data concerning TB surveys or screening is collected by community health nurses working within the community. Reporting TB cases to the local TB program is an essential public health function, and in most cases is legally mandated (International Standards for Tuberculosis Care, 2006). All reporting systems should be designed and capable of receiving and integrating data from several sources such as laboratories, hospital and individual practitioners (International Standards for Tuberculosis Care, 2006). Hence, the routine data collection processes between First Nation communities and the TB program should be standardized and concise.

In terms of assessing the impact of TB control efforts in First Nation populations, surveys and in-depth analysis of routine surveillance data should be used to both measure impact and establish a baseline in the community (WHO, 2008). One method to monitoring population based TB

control efforts can be done by calculating the incidence, which represents the number of new cases of TB that occur each year (WHO, 2008). As was mentioned earlier, the long term goal is to reduce the incidence of TB to 3.6 per 100,000 populations by the year 2015, and in doing so an indicator has been established to reach an annual reduction of 3.3% between 2007 and 2015. How this will occur depends on what the program objectives are to reach this milestone, which may include, for example, a specific number of community education sessions, people receiving LTBI treatment, or people completing treatment.

Logic models and intervention mapping are useful in public health for development of health promotion and prevention programs, and they provide planners with a framework for effective decision making at each step of the planning, implementation, and evaluation process (Bartholomew et al., 2001). The focus of the evaluation design can best be understood through the use of logic models, as they make it easier to identify the pertinent questions to be addressed (CDC TB Program Evaluation Handbook, 2006). The logic model for the enhanced TB surveillance screening program is illustrated below (Figure 1).

Figure 1: Enhanced Surveillance Screening Evaluation Map



Source: CDC TB Evaluation Handbook, 2006; Intervention Mapping, Bartholomew et al., 2001

Throughout the process, it is important to return to the evaluation questions regularly; evaluation teams often lose focus and end up concentrating too much on the information and methods to collect information. Therefore the more closely you design your evaluation to the priority questions, the more effective the team will be in finding the answers (W.K. Kellogg Foundation, 1998).

5. Data Collection

Decisions on which questions to address and what information is required to answer those questions should be identified early in the planning process to minimize the risk of collecting irrelevant data, and to ensure that needed data is available (W.K. Kellogg Foundation, 1998).

There will be numerous methods to choose from for data collection. Of importance to any evaluation is the extent of the validity and reliability of the data sources and instruments, which can increase or decrease credibility of the evaluation (CDC TB Program Evaluation Handbook, 2006). Most TB programs routinely collect massive amounts of data that will provide the required information for most outcome indicators (CDC TB Program Evaluation Handbook, 2006). Evaluating the timeliness of public health surveillance systems helps to determine availability of data for the health related event, intervals from the onset of symptoms or date of exposure to reporting the event and treatment, immediate control and prevention interventions, and overall program planning (CDC Updated Guidelines for Evaluating Public Health Surveillance Systems, 2001).

Data collection methods will vary according to the design and evaluation questions; for outcome evaluations, the use of surveillance and monitoring data is essential, whereas quantitative and qualitative data are used in process evaluation (Glanz et al., 2008). The Indigenous Stop TB

Strategy was implemented in 2008 to increase both awareness and surveillance of the burden of TB globally in an Indigenous context; this strategy represents an extension of the existing Stop TB Strategy that enhances National TB programs in various countries (A Global Indigenous People’s Initiative to Stop TB, 2009). An important component of the Stop TB Strategy is a toolkit that provides guidance and a minimum set of indicators related to the quality of performance at service delivery levels (WHO, 2008). Select impact/outcome indicators for the enhanced TB screening program that can be used within the proposed program evaluation framework are outlined in Table 5. Note that the focus is on quantitative measures.

Table 5. World Health Organization Indicators for Tuberculosis Programs

	Indicator	Target	Measurement
Impact	1. TB Incidence Rate: Estimated number of TB cases (all forms) occurring per year, per 100,000 populations.	Having halted the incidence of TB by 2015 and begun to reverse rate	The notification rate can be a close proxy of TB incidence where the coverage and quality of the routine surveillance system is high; the trend in TB incidence can be measured by assessment of trend in case notifications if there have not been significant change in case finding efforts and/or recording and reporting practices.
	2. TB Prevalence Rate: Estimated number of TB cases (all forms) per 100,000 populations at a given point in time.	By 2015 half of the prevalence relative to 1990 rates	Measured by population-based disease prevalence survey where applicable
	3. TB Mortality Rate: Estimated number of deaths due to TB (all forms) per year, per 100,000 populations.	Halving of mortality rates by 2015, relative to 1990 rates.	Measured by high quality and coverage vital registration system or population based mortality survey.
Outcome	1. Case Detection Rate: New smear positive TB patients detected and reported to the national health authority, among the new smear positive TB patients estimated to occur countrywide each year (number and percentage)	At least 70% aiming at 100% detection	Measured by routine recording and reporting system.

	2. Treatment Success Rate: New smear positive TB patients cured plus completed treatment among the new smear positive TB patients registered during a specified period (number and percentage).	At least 85% successfully treated	Measured by routine recording and reporting system.
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Source: WHO Monitoring and Evaluation Toolkit: HIV, TB and Malaria, Draft 2008, page 17.

Qualitative data is information that can be used to describe how the program is functioning and deals with the context of the program or people’s experiences and the meaning they attach to that experience (W.K. Kellogg Foundation, 1998). This type of information may be obtained through interviews with stakeholders, focus groups, observation, or case studies (CDC TB Program Evaluation Handbook, 2006). Qualitative data can be collected by posing questions to better understand the impact of TB in First Nation communities. The use of open-ended question data tools to focus on distinct perspectives in order to understand and contrast is important (W.K. Kellogg Foundation, 2007). For example; how has the impact of TB affected your community? Explain how TB has impacted on your family or children? What does TB prevention mean to you? What are some of the positive or negative experiences you have encountered with the TB program? Identifying various perspectives will help uncover new information and understandings to shape the next phase of the program, which may be significantly enhanced by new opportunities (W.K. Kellogg Foundation, 2007).

6. Data Analysis and Interpretation

Analysis of data involves looking at what the data represents and what it insinuates when compared with benchmarks or standards (CDC TB Program Evaluation Handbook, 2006). If the program data fails to produce the desired outcome, then process evaluation data can be helpful in determining why the program failed, and what program modifications may be needed

(Bartholomew et al., 2001). One of the performance indicators that have been set out for the BCCDC TBSAC program has been to reduce the TB incidence to 3.6 per 100,000 people by 2015 in all Aboriginal communities, in accordance with the long term national goal (Canadian Tuberculosis Standards, 2007). The incidence of TB is the number of new cases of TB that occur each year and can be measured by six methods: 1) directly from TB notification data; 2) directly from prospective cohort studies; 3) indirect estimation based on surveys of annual risk of infection (ARI); 4) indirect estimation from studies of the prevalence of TB in the population; 5) indirectly from vital registration data including TB mortality data; 6) indirect estimation from assessment of the complete TB notification data (WHO, 2008).

All cases of TB are captured on the public health information system kept by BCCDC as previously mentioned. Quantitative data analysis will require interpretation of the results by a statistician and software program designed to capture aggregate data (WHO, 2008). When using inferential statistics, the first step is to create subgroups within the population and examine your sample to ensure you have an appropriate size, in addition to critical variables of gender or age (National Library of Medicine, 2006). For example, the evaluation of surveillance screening activity of First Nation children will need to include age, gender, time period for TB screening and TST results. Statistical tests such as chi square and t-test can be used to test the significance of relationships between variables (National Library of Medicine, 2006). Table 6 is an example of TST results by time period for First Nation children (n=1677) during BCG and after discontinuation of BCG using frequency and percent.

Table 6. Tuberculin Skin Test Results for First Nation Children

TST Result	BCG D/C	BCG ON	TOTAL	Statistical
Negative	458	1149	1607	Frequency
	27.34	68.6	95.94	Percent
	28.5	71.5		Row Pct

	98.28	95.04		Col Pct
Positive	8	60	68	Frequency
	0.48	3.58	4.06	Percent
	11.76	88.24		Row Pct
	1.72	4.96		Col Pct

Source: BCCDC TB Control Program, Epidemiology Report, 2009.

An analysis summary of this table can best be explained by asking the following question: How many First Nation children tested positive with a TST during the time periods specified? The generalization we can conclude is that 1.72% of children who have not had a BCG had a positive TST, while 4.96% of First Nation children who had received BCG had a positive test result. We may also draw a conclusion that some of these children who had a BCG vaccination tested positive on the TST because of BCG vaccination interference with the TST; therefore these results may indicate false positives. Table 7 is an example of a statistical table of results generated using a Statistical Analysis System 9.1.3. (SAS) for First Nation children during BCG and after discontinuation of BCG.

Table 7. Demographic Characteristics of Aboriginal Children in British Columbia, TB Control 1998 – 2005 (n=1677)

Demographics	Period at BCG	Post BCG	Total
Gender:			
Female	635	235	870
Male	574	232	806
Age Group (yrs):			
0 – 4 yrs			
10+	327	445	772
	18	0	18
TST Results:			
Negative	1149	458	1607
Positive	60	8	68
TB Cases:			
Yes	6	3	9
No	1204	464	1668

Source: BC Center for Disease Control, Epidemiology Report, 2009.

This table represents all First Nation children (n=1677) categorized by gender, age, TST results and TB cases spanning a seven year period. Analysis yields that more children were screened prior to discontinuation of BCG in 2003; however the post BCG results may appear low since screening is on an annual basis, hence only 2 screenings were done during that time. The 0-4 year age groups screened are relatively consistent and will vary depending on birth rates. The higher number of positive TST results in the BCG vaccinated population is expected due to some interference of the BCG vaccine. There were fewer active TB cases even after discontinuation of BCG, which would support the evidence that BCG does not prevent TB infection. A total of 9 TB cases were detected in children for this period, and all have received treatment.

7. Dissemination of Results

All participants and stakeholders involved in the evaluation process should receive a written formal report that summarizes conclusions and recommendations from the evaluation, including action steps to improve the program (CDC TB Program Evaluation Handbook, 2006). Not only will dissemination of evaluation results help improve programs, but they also contribute to the development of new knowledge for others to utilize. The creation of new theory refines existing theories and contributes to further evidence based practice for interventions (Glanz et al., 2008). It is generally agreed upon in public health practice that any impact will occur when effective interventions are disseminated widely and as often as possible (Glanz et al. 2008). All too often, many evaluation reports make the mistake of simply documenting project activities and expenditures and convey little about lessons learned and significant outcomes (W.K. Kellogg Foundation, 1998). Effective evaluations support action and should inform decisions, clarify options, identify strengths and weaknesses of a program, and provide recommendations for

improvements; therefore during each planning and implementation step stakeholders and evaluators need to be engaged about how results will be used to make decisions (W.K. Kellogg Foundation, 1998).

Dissemination of evaluation results to First Nation communities affected by TB is essential, but commitment to sustainability of TB control efforts and transfer of public health knowledge to the grass roots level is fundamental for communities to take control and ownership over TB. The Canadian Institute of Health Research (CIHR) in collaboration with its' Aboriginal Health division has helped move population and public health knowledge into action for some of these communities through research initiatives aimed at successful knowledge translation (CIHR, 2006). Previously, public health care utilization data had only the attention of researchers and academia, but the shift is now towards empowering and partnering with First Nation communities to build research capacity and establish successful research opportunities to build an evidence base for policy claims (Elias & O'Neil, 2006; CIHR, 2006). In terms of TB control at the community level, there may also be the opportunity to uncover other important prevention factors outside of the traditional case detection and treatment protocol that currently exists for TB control strategies.

8. Implementation of Evaluation

The implementation of evaluation will depend on the phase of the project, the purpose of the evaluation and particular questions you are attempting to address (W.K. Kellogg Foundation, 1998). In this case, the enhanced surveillance screening of First Nation children in BC is a program that has been operating for several years already. When evaluating an established program, the evaluation may be designed as a continuous monitoring, feedback, and

improvement loop that will provide staff with ongoing feedback for modification or reform (W.K. Kellogg Foundation, 1998). A population based screening framework was developed in Australia in 2008, and may be useful for implementation and management of TB screening programs elsewhere (Australian Population Based Screening Framework, 2008). The screening framework's key principles for monitoring and evaluation include: 1) developing a formal approach for on-going monitoring and evaluation; 2) identify appropriate measurable indicators; 3) develop indicators that enable comparison over years and between international programs; 4) develop nationally consistent methods for reporting and collecting data under indicators; 5) identify reporting milestones; 6) align evaluation with quality management plan; and 7) identify timeframes that necessitate program review (Australian Population Based Screening Framework, 2008).

9. The Cost of TB

The actual expenditures of TB care in Canada prior to an analysis done in 2006 by Menzies and colleagues were virtually unknown due to the complexity of various federal, provincial, territorial, county and municipal governments involved in diverse aspects of TB care. Total government expenditures for TB in 2004 was calculated to be \$47,290 per active TB case, equivalent to \$74 million, while actual expenditures attributed to patient care with active TB totaled \$19,906 per case, or a total of \$31 million. Those patients being treated for latent TB infection cost \$845 per patient on therapy, for a total LTBI expenditure of \$10.1 million. Contact tracing expenditures were \$8.3 million or an average of \$300 per contact screened and research was designated \$4.5 million. These calculations do not include expenditures for the Aboriginal TB program that is funded by FNIH; the federal government budget for on-reserve TB care in

each province. TB in Canada, particularly active TB cases cost considerably more than prevention and treatment of latent TB infection, however, Canada's expenditure is comparable to other high-income countries. Almost half of these expenditures for active TB cases are made for hospitalizations, laboratory costs and public health staffing. Provinces and territories have been spending close to double (\$52.5 million) of what the federal government contributed (\$16.3 million) for TB related care (Menzies, Oxlade & Lewis, 2006). In these uncertain economic times, the enhancement of uptake for screening and treatment of LTBI would be prudent. The federal government contribution of \$16.3 million is used for overseas and in-Canada screening for active TB among immigrants and refugees, TB control in federal correctional institutions, PHAC TB Prevention and Control Program, National Reference Centre for Mycobacteriology, and Aboriginal TB care (Menzies et al., 2006). Supplement of TB funding and partnerships from provincial TB programs are crucial to the existence of Aboriginal TB programs. An example; in 2007 there were 307 cases of active TB in the Aboriginal population for Canada (PHAC, 2007a), and if we use the formula from Menzies et al., 2006 cost analysis, the total cost of TB care is \$14.5 million, not including resources required for LTBI treatment or screening activities. This expenditure alone would take up the majority of the federal government contribution. Active TB cases are preventable, and the repercussions for public health and Canada in general will continue to be costly if quality TB treatment and prevention, surveillance and advocacy for social change are not delivered to those who need it most.

10. Implications for Public Health Practice and Policy

Evaluation of enhanced surveillance screening of First Nation children in the province of BC will undoubtedly reveal findings that will directly or indirectly impact on current TB control

practices. The majority of evidence indicates that screening children in high risk TB areas is an important indicator of public health achievement in disrupting and preventing the transmission of TB. However, to do so requires the necessary resources and expertise of TB control providers. For example, Lobato and associates (2000) have reported that important missed opportunities to prevent TB in children in the US are largely due to public health case mismanagement. The importance of contact investigation, screening guidelines, resources, HIV and substance use, social determinants of health.

10.1 Contact Investigation

It is well established that positive TST results in children represent TB transmission from an adult source case, and that contact investigation of the source case is the only means to identify, treat and prevent further TB cases. A study by Lobato, Mohle-Boetani, and Royce (2000) examined data records for 165 children with active TB and found that only 37% of children had a source case identified, and 7% had no record of any contact investigation. There were also numerous children who were not properly evaluated – they received no TB evaluation at all, there were delays in reporting source cases, no chest radiograph were performed, and treatment was not started in a timely manner (Lobato et al., 2000). The authors further concluded that at least 11% of these cases may have been preventable. Based on these findings it appears that either resources are not adequate to carry out contact investigations, or communication, education and timely interventions within the TB program are deficient. Regardless, findings point to missed opportunities for TB prevention.

10.2 Screening Guidelines

Heymann and colleagues (2000) have provided evidence of need for public health policy to both improve and maintain stringent TB screening guidelines for First Nations. They found that TB control programs have been less successful among children than in adults, which points to the need for multiple interventions aimed at improving screening of children *and* adults in high-risk First Nation communities.

10.3 Resources

Determination of what resources are needed to appropriately and adequately manage TB interventions at differing Aboriginal community levels and locations is an important consideration for public health practitioners and decision-makers. Ideally, the enhanced TB surveillance and screening of First Nation children would occur in an established community that has a school willing to participate and where there is adequate public health staffing; however it is not always a realistic one given both the changing epidemiology of TB and limited resources in some communities. In addition, there is a large proportion of the First Nations population that resides in urban areas and account for an increasing number of TB cases in those regions. In fact, in some urban areas of Canada, the incidence of TB among urban Aboriginal people is equal to or higher than the incidence among those living on-reserve (Canadian Tuberculosis Standards, 2007). Just over half (53%) of registered First Nation individuals live on one of Canada's 2,796 reserves, and the remainder live off-reserve (Canadian Tuberculosis Standards, 2007). For this reason, it is important that enhanced TB surveillance programs targeting First Nations children also happen in urban areas, off-reserve.

10.4 HIV and Substance Use

Public health practices and policies will also need to be mindful of increasing rates of HIV, substance abuse and injection drug use – all of which have a direct impact on TB control measures. A recent study by Callaghan and colleagues (2007) provided a retrospective medical chart review of inpatient detoxification records that illustrated the mobility patterns of Aboriginal injection drug users (IDU) between on and off reserve communities. The reciprocal movement between these settings is contributing substantially to the transmission of HIV and other infectious diseases. During the period 1998-2003, there were 59.4% of HIV positive cases attributed to IDU in the Aboriginal population. It is often assumed that IDU is largely confined to urban centers; however, it affects all settings. It is well known that HIV and TB co-infection is the greatest contributor to mortality (Callaghan, Tavares, & Taylor, 2007). In 2000, a Health Canada report concluded that substance abuse was a risk factor in 47.6% of all TB cases for BC and Alberta on-reserve populations (Health Canada, Tuberculosis in First Nation Communities 1990-2000). As a result, public health practice will need to address the challenge of substance abuse behavior and work in partnership with communities to reduce this associated risk for TB.

10.5 Social Determinants of Health

Substantial resources are required to align current TB practices and socioeconomic strategies if TB is ever to be eliminated in the Aboriginal community. Progress towards economic sustainability and improvements in the social determinants of health in most Aboriginal communities has been dismal and shameful in Canada. Data from the 2005 Statistics Canada report reveals that in urban centers such as Toronto, 27% of Aboriginal people lived under the low-income cut-off compared to 18% for non-Aboriginal populations. Further, though

Aboriginal people made up approximately 2.7% of Canada's population in 2001, it consisted of about 2.5% of the labour force (Statistics Canada, 2007). These reports indicate that poverty in Aboriginal populations and communities remains a pressing issue that negates TB control efforts. Schluger (2005) reiterates this reality by stating that “the antituberculosis movement cannot be understood if seen only in its medical perspective, for the historical and social backgrounds looms large in the picture” (Schluger, 2005, p.245). This remains the principle challenge for public health TB control programs.

11. Summary

TB continues to be one of the most challenging infectious diseases, and has yet to be eradicated. In Canada, TB affects a significantly higher number of First Nations people, and so efforts to prevent, manage, and treat TB must be culturally appropriate to ensure buy-in from First Nations communities. The changing epidemiology of TB has implications for public health planning and prevention initiatives as chronic illness, HIV, and daunting socioeconomic trends continue to plague First Nations communities.

TB Control programs build upon a specialized body of knowledge that has been evolving for many years, and while technology has paved the way for enhanced surveillance activities that capture the ever changing patterns of disease within populations, it cannot solve the problem itself, or the numerous social underpinnings that contribute to it.

The evaluation of enhanced screening and surveillance of First Nation communities, particularly children, is an important component of TB Control programs. The research and evidence that support the process of enhanced TB surveillance has been a developmental work in progress from the early days of TB control. The TB control strategies used today are predominately based

on the rich experiences of others, trials and errors, and most prominently, the outcomes of prior evaluations. The evaluation framework suggested here is meant to guide and support TB program development. Evaluation of the enhanced surveillance screening efforts of TB control will undoubtedly yield more questions than answers, and more challenges than solutions, but it remains a noble pursuit as it strives to improve the health of First Nations communities. The health and well-being of Aboriginal people is fundamental for the health and wealth of Canada as a whole, and any investment into the health of this subset of the population will yield return for all Canadians.

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Appendix 1

BCG Policies and Practices in Select Countries

Sweden

TB prevalence is currently 5 per 100,000 population and historically recommended BCG for everyone. BCG was first introduced in the 1940s. Current practice is to vaccinate only select high risk groups such as children at increased risk for exposure to TB and immigrants born in high incidence areas.

United States

TB prevalence is 3 per 100,000 population and has never recommended BCG for everyone in this country. BCG was only given to high risk groups such as health care workers.

Germany

TB prevalence is 5 per 100,000 population and used to recommend BCG vaccination for everyone, but currently does not. Vaccination was introduced in 1961 and given at birth. It was discontinued in 1998 as a routine, and is now given only to high risk children.

Spain

TB prevalence is 24 per 100,000 population. This country used to recommend BCG vaccination for everyone, but currently only gives to high risk groups.

United Kingdom

TB prevalence is 12 per 100,000 population. This country used to recommend BCG vaccination for everyone, but currently does not. BCG was introduced in 1953 and discontinued in 2005. BCG was previously given to adolescents, now only infants at risk for TB and health care workers get BCG vaccination.

Canada

TB prevalence is 4 per 100,000 population. BCG was never recommended for everyone in this country, and was given to only high risk groups including children, health care workers and First Nations.

Source: World Atlas of BCG Policies and Practices (2009) <http://www.bcgatlas.org/>

Appendix 2

Methodology for Literature Search

A search for literature was undertaken using the PubMed MeSH database, Cochrane Library and Google search for appropriate articles relating to Tuberculosis, BCG vaccination, Aboriginal populations and evaluation methods. The search focused on current literature between 1998-2008.

MeSH terms used:

BCG vaccine AND Aboriginal children (0) hits for Aboriginal or First Nations
BCG vaccine (15157)
BCG vaccine AND Children (3167)
BCG vaccine AND Population Groups (129)
BCG vaccine AND Population Surveillance Programs AND Tuberculosis (89)
Tuberculosis vaccines AND Outcome Process Assessment (3003)
Tuberculosis AND Health Care Evaluation Mechanisms (23566)
Tuberculosis AND Health Care Evaluation Mechanisms AND Mass Screening (2475)

Google terms used:

Tuberculosis AND Canada
Tuberculosis AND Aboriginals
Tuberculosis AND First Nations

Cochrane Library terms used:

Tuberculosis (5933)
BCG Vaccine (27436)

Appendix 3

International Standards of Tuberculosis Care

Standards of practice for the care of those afflicted by TB are consistent with World Health Organization (WHO) recommendations, and are intended to support and guide health care practitioners in diagnosis, treatment and public health policy (International Standards for TB Care, 2006).

Standards for Diagnosis

1. A productive cough lasting two-three weeks or more should be evaluated for TB
2. All patients suspected of having pulmonary TB should have at least two, and preferably three sputum specimens obtained. When possible, at least one specimen in the early morning should be obtained.
3. All patients suspected of having extrapulmonary TB should have appropriate specimens obtained from suspected sites for microscopy.
4. All persons with chest radiographic findings suggestive of TB should have sputum specimens submitted for microbiology examination.
5. Diagnosis of sputum smear-negative TB should be based on these criteria: at least three negative sputum smears; chest x-ray findings consistent with TB; and lack of response to a trial of broad spectrum antimicrobial agents. In persons with known HIV infection, the diagnostic evaluation should be expedited.
6. The diagnosis of intrathoracic TB in symptomatic children with negative sputum smears should be based on the finding of chest x-ray abnormalities consistent with TB, and either a history of exposure to an infectious case or evidence of TB infection.

Standards for Treatment

1. Any practitioner treating a patient with TB is responsible to prescribe an appropriate regimen and capable of assessing adherence of the patient to the regimen. Including addressing poor adherence when it occurs.
2. All patients who have not been previously treated should receive an internationally accepted first-line treatment regimen using drugs of known bioavailability. Initial phase of two months isoniazid, rifampin, pyrazinamide, and ethambutol. Continuation phase for four months of isoniazid and rifampin. Alternative continuation can consist of isoniazid and ethambutol for six months when adherence cannot be assessed. Doses of antituberculosis drugs should conform to international recommendations based on combinations and directly observed therapy (DOT).
3. A patient centered approach to administration of drug treatment based on patient's needs and mutual respect should be developed. Supervision and support should be gender-sensitive, age specific and

should draw on supportive interventions and services, including education and counseling. This may include DOT.

4. All patients should be monitored for response to therapy by follow-up with sputum microscopy at the time of completion of initial phase and completion of treatment. Patients who have positive smears during the fifth month of treatment should be considered as treatment failures and have therapy modified.
5. Written records of all medications, bacteriology results and adverse reactions should be maintained for all patients.
6. High prevalence areas of HIV infection and where TB and HIV infection are likely to co-exist should HIV test and counsel patients.
7. All patients with TB and HIV co-infection should be evaluated to determine if antiretroviral therapy is indicated during the course of treatment for TB. Consultation with a physician who is expert in this area is recommended before initiation of treatment.
8. An assessment for drug-resistance, based on history of prior treatment, exposure to a drug-resistant organism, and the community prevalence of drug resistance should be obtained for all patients.
9. Patients with drug-resistant (MDR) TB should be treated with specialized regimens containing second-line antituberculous drugs. A minimum of four drugs to which the organism is susceptible should be used, and treatment given for at least 18 months.

Standards for Public Health Responsibilities

1. All providers of care for patients with TB should ensure those children under 5 years and those with HIV infection who have been in close contact with an infectious case are screened, evaluated and managed.
2. All providers must report new and re-treatment TB cases and treatment outcomes to local public health authorities.

Source: Tuberculosis Coalition for Technical Assistance. *International Standards for Tuberculosis Care: Diagnosis, Treatment and Public Health*. The Hague: Tuberculosis Coalition for Technical Assistance, 2006.