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**Socioeconomic and Environmental Causes for Respiratory Infection Death in  
Alaska Native Villages**

By Sarah McBeth

The following manuscript is submitted for partial fulfillment of the requirements of a  
Master of Public Health Degree at Wright State University.

Committee

Sara Paton, Ph.D.

Raymond Ten Eyck, M.D., M.P.H.

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## I. Abstract

**Objectives.** This ecological study evaluates the association between community characteristics and death rates from pneumonia/influenza, tuberculosis, and infectious diseases in 196 Alaska Native villages.

**Methods.** Ecological variables studied included percentage of Natives in the population, age distribution, latitude, average household size, socioeconomic status, percentage of homes with complete plumbing and/or kitchens, type of heating fuel used, community alcohol restrictions, level of healthcare access, and residence in specific regions of Alaska. These data come from the 2000 U.S. Census, the Alaska Alcohol Beverage Control Board, and the Alaska Native Tribal Health Consortium. A stepwise analysis of variance using the Proc GLM procedure in SAS® was performed for these variables and for the death rates with least significant difference used to separate the means.

**Results.** Significantly higher rates of pneumonia/influenza death were associated with high average household size and low household income. Higher rates of death from tuberculosis were associated with residence in specific regions of Alaska and with the type of heating fuel used. Death rates from infectious disease were associated with a high percentage of Natives in the population, high average household size, low percentages of the population below poverty, and a lack of healthcare within the village.

**Conclusions.** This study linked multiple community characteristics with the risk of death from several types of infectious diseases in Alaska Native villages. This and other ecological studies can be used to identify the risk factors associated with higher death rates from infection for defined populations such as the residents of Alaska Native villages. Understanding the

specific cause or causes of illness is essential in order to best direct efforts to eliminate disparity and to curtail disease and death.

## **II. Introduction**

Alaska Natives live in a harsh environment, in communities very different from those in the rest of the United States. For the residents of these communities, disparities exist in health outcomes, housing, utilities, income, and access to healthcare, among others. Respiratory infections disproportionately affect Alaska Natives leading to high rates of morbidity and mortality (Alaska Native Epidemiology Center, 2009). This ecological study will examine the characteristics of 196 Alaska Native villages including demographic, socioeconomic, and housing information to determine if there is a correlation between these factors and the rates of death from respiratory infection in the villages.

## **III. Review of Literature**

### **A. Population Description**

The term “Alaska Native” encompasses a wide variety of indigenous peoples who speak more than twenty different languages (See Map 1, Appendix A.), have diverse traditional food sources, and practice varied customs. The federal government recognizes more than 200 Alaskan tribes. Major cultures include the Athabascans in the inland East, the Eyak, Tlingit, Haida, and Tsimshian in the Southeast, the Alutiiq of the central Gulf Coast, the Unanga of the Aleutian chain, and the Eskimo, including the Inupiat and Yupik peoples, of the North.

Athabascans are the indigenous people of the Alaskan Interior. Rivers are major sources of food as well as the main method of transportation for those in this part of Alaska (Langdon, 2002). Among the Athabascans, obtaining subsistence food requires fishing in the summer and

fall, hunting caribou and moose in the fall, trapping water mammals in the spring, and harvesting native plants in the spring, summer, and fall. Historically, housing types have varied greatly among the Athabascans. Some communities built semi-subterranean homes while others built large, multi-family plank homes and still others lived in dome-shaped, caribou skin tents (Langdon, 2002).

The Unangas or Aleut people lived in the Aleutian Islands thousands of years before Europeans arrived in Alaska. The people of these remote, volcanic islands are subject to some of the harshest weather in the world. The Unangans have adapted to this environment to become excellent navigators and skillful harvesters of the bounty of the Aleutians (Bibbs, 2006-2007). Whaling is highly ritualized by the Unangans. Sea otter, seals, cod, and halibut are hunted, but traditionally, the most important food source is the Steller sea lion. Traditionally, hides were used to cover boats, sinews were used for line, flippers were made into shoe soles, the blubber was used for oil lamps, intestines were formed into waterproof coats, even the teeth were made into fishhooks (Langdon, 2002). Customarily homes of the Unangans, *barabaras*, were pits covered by a structure of wood or whalebone frames overlain with grass or sod. Pole ladders were used to enter through the ceiling of homes that were heated by oil lamps or a small hearth. Unangan society has always been matrilineal with women owning homes. Unangans tradition holds that there is a creator deity related to the sun. Animals are thought to have spirits, which greatly influences hunting success. Unangans believe in a reincarnation of souls that migrated between earth, a world above earth, and a world below (Langdon, 2002).



The Alutiiq or Sugpiaq people originate from the central Gulf of Alaska from Kodiak Island to the Copper River delta. They share ancestry with both the Unangan and Eskimo people. Traditional food sources for the Alutiiq include migratory whales, Steller sea lion, harbor seal, as well as birds and shellfish. Notches, cylindrical stones dating back 3,800 years show that the Alutiiq were some of the first people to develop and use weighted fishing nets to collect salmon and herring (Langdon, 2002). The Alutiiq often split their time between winter villages of partially subterranean barabaras and seasonal encampments near salmon streams. Larger communities often have a central community house, the kazhim. Traditionally, the heads of households form a council that meets in the kazhim and makes decisions for the community. Adult males sometimes meet to discuss relations with outside communities. Each spring, all adults in the community meet in the kazhim to discuss plans for seasonal camps and fall festivals.

The Yupiit people of Alaska's northwest are also known as Bering Sea Eskimos. Yup'ik, the language of the Yupiit, is the most widely spoken Alaska Native language with an estimated 10,000 speakers. Traditional Yupiit housing varied with the terrain and location. For Central Yupiit, homes consisted of partially dugout rectangular structures with a tunneled entryway for warmth (Langdon, 2002). Where wood was available, plank floors and walls were used. The female head of household, young male children, and unmarried daughters occupied these small homes. Men lived with groups of male relatives in larger structures known as the qasigih, or men's house. The qasigih served as living quarters, a workshop, and a gathering place for the community. Siberian Yupiit made their homes in yurt-like structures made of reindeer skins (Langdon, 2002). Families were patrilineal with the entire extended family living together.

Platforms were constructed throughout Yupiit villages for the storage of food and equipment. Along the Bering Sea and St. Lawrence Island, Yupiit hunted sea mammals, especially walrus and bowhead whales. Central Yupik took advantage of a variety of food sources including salmon, seals, caribou, moose, ground squirrels, eels, and migratory waterfowl.

Inupiaq occupy the Northwest coast of Alaska and are also known as Northern Eskimos. Their culture and language is continuous with the native people across northern Canada, all the way to Greenland (Langdon, 2002). Hunting of bowhead whale, seal, caribou, and fish is central to the Inupiaq people's livelihood and has been for centuries. The settlement patterns of the Inupiaq vary by location. While in large coastal communities residents can remain year round due to the presence of sea mammals for hunting, other communities move between seasonal camps following food sources such as caribou. The stereotypical igloo is used for shelter only in emergencies. Historically, homes of the Inupiaq were semi-subterranean and were generally entered first through a storage room, then through a tunnel below the level of the living quarters, thus preventing cold air from entering the living area. Houses were constructed with sod blocks, whalebone, and driftwood. They were generally dome-shaped with a gut-covered opening to let in light. Larger communities usually had a men's house or qargi where tools were made, equipment was repaired, and ceremonies were held. While at seasonal camps, different methods provided housing including teepee-like structures.

The Natives of Southeast Alaska include the Tlingit, Haida, and Tsimshian. Southeastern Alaska, or the Alaskan panhandle, is largely temperate rainforest. These societies are traditionally matrilineal with distinct moieties (Langdon, 2002). For the Tlingit there are two moieties: raven and eagle. Sources of food include abundant salmon runs, herring, halibut, and

other fish. Seals, deer, bird eggs, and clams are also hunted. Food has always been abundant in the rainforests of the Southeast allowing the natives to become skilled craftsmen and traders. Their traditional winter homes were usually large cedar plank houses occupied by twenty to thirty people in four to six families.

### **B. Alaska Native Healthcare**

At the time of their first contact with Europeans contact, Alaska Natives, like the American Indians, had an extreme susceptibility to the infectious diseases that had plagued Europe for centuries. Smallpox first reached the Natives of Alaska sometime between 1775 and 1780 with an estimated mortality of one in three Alaska Natives (Metcalf, 2005). While it was initially believed that this disease was brought to Alaska by contact with Spaniards in 1775, a more accepted theory suggests that smallpox reached Alaska by crossing North America's extensive Native American trade network (Fortune, 1989). The disease not only killed, but it also blinded and scarred many Alaska Natives, demoralizing or destroying entire communities.

Traditional Alaskan life meant spending winter in close quarters with gatherings in distant villages in the spring, thus promoting the spread of infection. With only traditional shamans to provide medical care and no familiarity with the European concept of quarantine, smallpox was only the first of many infectious diseases to take its toll on Alaska Natives (Fortune, 1989). The Spanish influenza of 1918 killed millions worldwide and did not spare Alaska Natives. Measles, typhoid fever, diphtheria, and scarlet fever terribly affected the largely immune naïve population. In the late 19<sup>th</sup> century, tuberculosis also plagued the Alaskan Native population. Fortune (1989) describes the impact of tuberculosis:

“Practically every Native family in some parts of the territory was touched by [tuberculosis] which usually manifested itself by a chronic, productive cough, wasting, and a low grade fever, sometimes associated with night sweats. Not infrequently a victim coughed up blood... The disease often affected whole families, living as they did in crowded, poorly ventilated houses.”

The first suggestions of modern medicine reached Alaska Natives in the form of Russian priests administering smallpox vaccination to natives in the early 1800’s (Fortuine, 1989). While vaccine supplies were limited and epidemics still plagued Alaskans, the ideas of modern hygiene, quarantine, and vaccination began to take hold. A small Russian hospital was built in Sitka and later became a U.S. military facility when the U.S. purchased Alaska in 1867. Other than the rare physician serving U.S. settlers or Christian mission clinics, Alaska was without medical care for much of the 19<sup>th</sup> century (Fortuine, 1989).

Alaska Natives remained without medical facilities to care for Natives until 1892 when the territorial governor, Lyman E. Knapp, appealed to Washington for help,

“As a nation, we owe it to ourselves and to the natives of Alaska that we build, equip, and support hospitals in various parts of the Territory for the care of the sick and the chronically diseased. Humanity demands it, treaty obligations require it, and self-interest ought to prompt it” (Metcalf, 2005).

Despite the governor’s pleas, it was not until 1915 that \$25,000 was appropriated for a health service and hospital based in Juneau and physicians dedicated to caring for the Natives were stationed in Nome, Russian Mission, Seward, and Sitka (Metcalf, 2005). In 1931, tuberculosis remained rampant in Alaska and a sanatorium was added to Juneau’s hospital

(Metcalf, 2005). In 1946, tuberculosis diagnosis and treatment was provided to Alaska Natives as some former World War II ships and vehicles were transformed into mobile units, staffed by the U.S. Public Health Service, and sent to Native villages.

The Indian Health Service (IHS) was not officially established until 1954 when the responsibility of Indian health was transferred from the Bureau of Indian Affairs to what is now known as the Department of Health and Human Services (IHS Communications Office, 1989). Currently, throughout most of Alaska, native health consortiums contract with the Indian Health Service to provide care to the Alaska Native Population. The Alaska Native Tribal Health Consortium (ANTHC) is made up of 12 regional health consortiums that operate seven hospitals and hundreds of clinics throughout the state.

Few programs have impacted the health of Native Alaskans more than the Community Health Aide Program (CHAP). CHAP serves more than 45,000 people living in 171 Native villages, ninety percent of which are accessible only by aircraft (Caldera, 1991). In 1964, Dr. Walter Johnson began this program in which minimally trained villagers provided healthcare, midwifery, and triage services in their villages. The local village councils select the villagers who serve as health aides. The aides are usually women with, on average, 9 years of primary education (Haralson, 1990). They receive three months of training and are equipped with a kit of selected medications, vaccines, and equipment. The aides keep in daily contact by radio with physicians at hospitals and large clinics to determine the need for patients to be treated or transported. Alaska's network of health aides is world renowned as a model for providing healthcare to populations living in remote locations.

### **C. Current Population Status**

Alaska Natives are the largest minority in Alaska constituting 15.6% of the population (Bibbs, 2006-2007). A 2007 reported estimated there were 134,361 Alaska Natives (Alaska Native Epidemiology Center, 2009). Given current trends, the population is expected to grow to 165,000 by 2020 (Bibbs, 2006-2007). A very large proportion of the population is under age 20 (41%) but the number of Alaska Native elders is also increasing. Between 2000 and 2030 the number of Alaska Natives over age 65 is expected to triple (Alaska Native Epidemiology Center, 2009). The median age was 17 in 1960 and in the 2000 census the median age was 24. This is still young compared to the rest of America where the median age was 35 in 2000.

Population growth among Alaska Natives has been predominantly in urban areas with 40% of Alaska Natives living in cities. This has increased from about 20% in 1970 and about 30% in 1990 (Goldsmith, 2004). The population dynamics differ for Native Alaskans living in rural areas. Rural Alaska Native household sizes are larger and more likely to be headed by a married couple. In rural areas, birth rates are higher and Native Alaskans are less likely to be of mixed race (Goldsmith, 2004). Urban Alaska Natives are more likely to be working age adults while in remote rural areas the population consists of more children and elders. In 2000, the average household size was smaller by about two people for Native households than it was in 1960. However, in 2000, the average Alaska Native household size was 3.63 compared to 2.59 in non-Native households (Goldsmith, 2004).

Poverty is widespread among Alaska Natives. The 2000 census showed that household incomes were most commonly reported as being between \$10,000 and \$19,999 while Alaskan Whites most commonly reported incomes between \$50,000 and \$75,000. The proportion of

Alaska Native children living below the poverty level was over 22%, more than twice the level of Alaskan White children. Adult Alaskan Natives living below the poverty level exceeded 18%. Educational attainment among Alaska Natives is also less than that of their white counterparts. While only 7.5% of U.S. Whites did not complete high school, 28.2% of Alaska Natives did not (Alaska Native Epidemiology Center, 2009).

A lack of jobs is also an issue among Alaska Natives. In some regions such as the Yukon Delta the unemployment rate is as high as 19.4% (Alaska Native Epidemiology Center, 2009). Despite the presence of billion dollar petroleum, mining, and seafood industries in remote Alaska, Native Alaskans receive relatively few financial benefits or opportunities for employment. For example, in southwest Alaska, local residents received only ten percent of the enormous profits brought in by the salmon fisheries in their region. Still, this industry has been crucial for the Natives of southwest Alaska, employing thousands of residents. Certain employers including the enormous Red Dog zinc mine of Alaska's northwest and the CDQ program of federally managed fisheries have been crucial employers for Alaska Natives returning the financial benefits of a rich landscape to its native people (Goldsmith, 2004). Even so, for those living in remote rural areas of Alaska, the largest share of jobs come from the government and Native non-profit organizations that manage health care and other federally sponsored programs for Alaska Natives (Goldsmith, 2004).

#### **D. Current Health Status**

Health disparities are rampant in the Alaska Native population. This is especially true for rural Alaska Natives; their health status is related to poverty, rapid social change, harsh climate, and the isolation of the communities in which they live (Alaska Native Epidemiology Center,

2009). While the life expectancy of Alaska Natives has improved in recent years from 64.4 in 1980 to 69.5 in 1997, it still remains much below the national average of 76.5. For the time period between 2004 and 2007 the all-cause death rate for Alaska Natives was 1.4 times that of U.S. Whites and 1.5 times that of Alaskan whites (Alaska Native Epidemiology Center, 2009). The infant mortality rate of Alaska Natives, another important health indicator, is twice that of Alaskan Whites (Alaska Native Epidemiology Center, 2009).

A multitude of issues contribute to such dismal statistics in the Alaska Native population. The leading causes of death for Alaska Natives are listed in Table 1 (Alaska Native Epidemiology Center, 2009).

Death rates from unintentional injury, suicide, and homicide are much higher among Alaska Natives compared to U.S. Whites. The rates of death from unintentional injury remain high for Alaska Natives despite the fact that unintentional injury deaths decreased 47% between 1980 and 2007. Between 2003 and 2005 there were more than 4800 injury hospitalizations among Alaska Natives. The leading causes for these hospitalizations were falls (27.0%) followed by suicide attempts (18.9%), assaults (12.0%), motor vehicle accidents (5.6%), all-terrain vehicle accidents (4.4%), and snow machine accidents (4.3%) (Alaska Native Epidemiology Center, 2009).



**Table 1: Leading Causes of Death in Alaska Natives (AN), 2004-2007\***

Rank	Cause of Death	% AN Deaths	U.S. White rank	% U.S. White Deaths
1	Cancer	20.7%	2	23.1%
2	Heart Disease	14.2%	1	27.2%
3	Unintentional Injury	13.1%	5	4.7%
4	Suicide	6.8%	10	1.4%
5	Cerebrovascular Disease	4.4%	3	6.0%
6	COPD	4.3%	4	5.6%
7	Chronic Liver Disease	2.1%	13	1.1%
8	Pneumonia & Influenza	1.9%	8	2.6%
9	Diabetes Mellitus	1.5%	7	2.8%
10	Homicide	1.5%	18	0.4%

\*Table modified from Alaska Native Health Status Report, 2009.

A major contributor to high death rates from injury, suicide, homicide, and chronic liver disease is alcoholism (Goldsmith, 2004). Additionally, alcohol fuels high rates of domestic violence, child abuse, and Fetal Alcohol Spectrum Disorder among Alaska Natives. A 1995 survey of Alaska Natives showed that Natives recognize that alcohol use and abuse was a problem in their villages and was the primary source for criminal behavior in their communities (UAA Justice Center, 1995). As of 2001, sixty percent of Alaska Native villages had banned the sale of alcohol (Goldsmith, 2004). A 2006 study showed that in Alaska Native villages where

alcohol was prohibited, there were lower rates of serious injury from assault, motor vehicle accidents, and other causes (Wood & Gruenewald, 2006).

It is known that several respiratory diseases disproportionately affect Native American populations nationwide. The incidence and mortality rate from lung cancer is higher among American Indians / Alaska Natives as is the death rates from interstitial lung disease, COPD, and asthma. Infectious diseases including pneumonia and tuberculosis have been documented to have disproportionately occur and cause death in American Indians/Alaska Natives (NHLBI Working Group, 1995).

Respiratory disease, both chronic and acute, is a major cause of morbidity in Alaska Natives. Cancer is the leading cause of death in Alaska Natives and cancer of the lung and bronchus is the leading cause of cancer death in this population (Alaska Native Epidemiology Center, 2009). Respiratory disease is the second leading cause of hospitalization, second only to childbirth, and is the leading cause of outpatient visits in the Alaska Native Tribal Health System (Alaska Native Epidemiology Center, 2009).

The reasons for high rates of respiratory illness among Alaska Natives are multifold. Certainly smoking contributes to lung and bronchial cancer rates as well as the prevalence of chronic obstructive pulmonary disease (COPD). It is estimated that the rate of smoking among Alaska Natives is more than twice that of non-Natives (41% versus 20%) (Alaska Native Epidemiology Center, 2009). Smoking is also a problem among Alaska Native youth. A 2007 survey found that 32% of Alaska Native high school students had smoked within the past 30 days compared to 13% of non-Native students (Alaska Native Epidemiology Center, 2009).

Additionally, respiratory infections excessively affect Native Alaskans. Respiratory pathogens ranked among the top five reportable infectious diseases in Alaska Natives between 2007 and 2008 (Alaska Native Epidemiology Center, 2009). Invasive pneumococcus was the fourth most common with 135 cases and pulmonary tuberculosis was the fifth most common with 52 cases. Only chlamydia, gonorrhea, and hepatitis C were more commonly reported. Pneumonia and influenza are the grouped together as the eighth leading cause of death among Alaska Natives despite the mortality rate dropping from 66.0 deaths per 100,000 in 1980-1983 to 26.8 deaths per 100,000 in 2004-2007 (Alaska Native Epidemiology Center, 2009).

Given the historically high rates of respiratory disease, in recent years, efforts have been made to improve the immunization status for Native Alaskans of all ages. Alaska is a universal vaccine coverage state, allowing all children to receive vaccination. Also, through efforts of state and tribal health departments and through the awareness of healthcare providers statewide, high levels of vaccination have been achieved among Alaska Natives (Wood & Santibanez, 2003). In 2008, 48.4% of Alaska Natives over age 65 received influenza immunizations that year and 90.8% had received pneumococcal vaccination at some point. Among those ages 19-35 months, 82.9% were up to date on their immunizations, which met the Healthy People 2010 goal (Alaska Native Epidemiology Center, 2009).

### **E. Village Descriptions**

In 1971, after decades of conflict and discrimination in Alaska, the U.S. Congress passed the Alaska Native Claims Settlement Act, which settled Native Alaskan land and financial claims and also established 13 regional corporations to distribute the settlement to Alaska Natives. Native village corporations are subsidiaries of the regional corporations and about 200 Native

village corporations exist. The villages vary widely in their locations, demographic characteristics, and economic viability. Villages usually have between a few dozen and a few hundred residents. They may be located on islands in the Alaskan panhandle or the Aleutians. Some border the Bering Sea or the Arctic Ocean. Many are located along inland rivers. Alaska has very few roads relative to the lower 48 states and often the villages are accessible only by boat or seaplane.

The remote geography and harsh climate of Alaska Native villages present challenges that are not often faced in the rest of the developed world. Transportation to and from villages is difficult and expensive. The cost of living is very high. In rural areas, food costs run 50% more than in Anchorage and electricity rates can be four times as high (Goldsmith, 2004). Residents, by tradition and out of necessity, rely a great deal on subsistence activities such as hunting, fishing, trapping, and berry picking to provide food and necessities. As one elder from the village of Kake, Alaska described, “The cost of living is high, but if you are into hunting, every time the tide goes out, the table is set” (Kake Class of 1998, 1998). About 90% of rural households participate in subsistence hunting and fishing with annual harvests as high as 664 pounds per person in parts of remote rural Alaska (Goldsmith, 2004).

In rural Alaska, homes are generally small with manufactured housing commonly used. Prior to the Alaska Native Claims Settlement Act, a 1968 report called *Alaska Natives and the Land* documented that nearly 7,100 of 7,500 homes in Native Villages needed replaced. Also, due to population growth, an additional 350 homes would be needed each year. Since the report’s publication, vast improvements have been made. More than 13,000 homes have been built in rural Alaska (Goldsmith, 2004). As of 2000, only 18% of homes were built before 1970.

Heating homes in the arctic regions of Alaska presents a challenge to these impoverished communities. Heat is most often provided by fuel oil, though some in some communities, natural gas, electricity, or wood stoves are used.

In 1974, fewer than 10% of homes in rural Alaskan villages had running water and flush toilets (Goldsmith, 2004). At that time around 100 small villages hauled their water directly from lakes or rivers and removed human waste in honey buckets. Since the 1970's, More than \$1 billion was invested in sanitation improvements in about 90 rural Alaskan communities between 1980 and 2003. As of 2003, 77% of rural Alaskan homes had complete sanitation systems via piping, flush/haul, or individual wells and septic tanks though 32 rural communities still completely lacked piped water and sewer systems (Goldsmith, 2004). As of 2009, the percent of housing units with water and sewer still varied a great deal depending on the region. Some regions had 98% of homes with water and sewer (i.e. Southeast Alaska Regional Health Consortium and Kodiak Area Native Association) while in other regions (i.e. Yukon-Kuskokwim Health Corporation) only 58% of homes had these utilities (Alaska Native Epidemiology Center, 2009).

Providing remote villages with in-home water is a serious technical challenge. Four factors make this task especially difficult: 1) the harsh climate, 2) the lack of external road systems resulting in a high cost for parts and consumables, 3) poor economic conditions resulting in a limited ability to pay for sanitation services, and 4) reduced revenue base and limited labor pools in these small communities (Ritter, 2007). Due to arctic and subarctic conditions, water would have to be provided by insulated, above ground water mains with continuously circulating heated water. This greatly increases the cost of achieving in-home

water in remote villages. Additionally, the seasonal availability of water requires many villages to store an entire year's worth of water during an eight to twelve week period during the summer (Environmental Protection Agency Office of Water, 1999). This also greatly increases the cost and difficulty of achieving in-home water in remote Alaskan villages.

Solid waste disposal also poses a problem in Alaska Native villages, as there are no managed landfills in areas with so few residents. In 95% of Alaska Native villages, solid waste is disposed of at open dumpsites (Gilbreath & Kass, 2006). These open dumpsites can cause water and soil contamination, disease transmission, and fire danger, and injury to site salvagers (Gilbreath & Kass, 2006). The hazardousness of dumpsite has been a growing concern in villages and regional health corporations monitor and rank dumpsite hazardousness.

## **F. Selected Respiratory Infections & Their Known Risk Factors**

### **1. Pneumonia**

Pneumonia occurs in over six million people annually and is one of the top ten causes of death in the United States (Graham, Nelson, & Steinhoff, 2007). Pneumonia is an infection of the lung tissue by any of numerous pathogens including bacteria, viruses, and fungi. Symptoms of pneumonia generally include a productive cough, shortness of breath, chest pain, and fever. Factors that are known to put one at risk for acute respiratory tract infections like pneumonia include old age and malnutrition. Environmental factors also play an important role. Outdoor air pollution containing respirable particles, sulfur dioxide, nitrogen dioxide, or ozone has been linked to higher rates of pneumonia (Graham, Nelson, & Steinhoff, 2007). Similarly, indoor air pollution from passive cigarette smoke and wood stoves cause an increased risk. Cold weather

has not been found to contribute to an increased risk for acute respiratory infection, however, the increased crowding and the higher levels of air pollution that occur during winter months have been linked to these infections (Graham, Nelson, & Steinhoff, 2007).

The bacterium *Streptococcus pneumoniae* is responsible for between 60 and 75% of community-acquired pneumonias. This bacterium also infects the bloodstream, and causes meningitis and ear infections. Pneumococcal pneumonia occurs more frequently in infants, the elderly, those who abuse alcohol, and those of lower socioeconomic status (American Public Health Association, 2000). The Yukon-Kuskokwim Delta (YK Delta) region of southwest Alaska historically has had a rate of pneumonia/bronchitis among infants that was more than three times that of the general U.S. population. A 1980-1986 study by Davidson et al. (1989) found that the rates of invasive pneumococcal disease were six to 34 times higher than in other parts of the U.S. and were the highest documented rates of invasive pneumococcal disease of any population in the world. The authors postulated causes for this including concurrent influenza, co-morbid chronic illnesses, and maternal and household smoking (Davidson et al., 1989). A subsequent study found that introduction of the seven-valent pneumococcal conjugate vaccine to the YK Delta resulted in a decline in invasive pneumococcal disease and the elimination of vaccine serotypes of *S. pneumoniae* followed by an increase in invasive pneumococcal disease caused by non-vaccine serotypes (Wenger et al., 2010). In the same study it was found that high rates of invasive pneumococcal disease in the YK

Delta are associated with a lack of in-home water, controlling for household crowding and per capita income (Wenger et al., 2010).

Similarly, Singleton et al. (2007) found inordinately high rates of respiratory syncytial virus (RSV) among Alaska Native infants in the Yukon-Kuskokwim delta region of Alaska. This virus, which causes bronchiolitis and pneumonia, caused hospitalizations in the YK Delta at a rate more than five times that of the general U.S. population. A multivariate analysis showed that risk factors for RSV among infants in the YK Delta were the presence of an underlying medical condition, not being breastfed, having four or more children under age 12 in the household and having a household crowding index of two or more persons per room.

## **2. Influenza**

Influenza is an acute viral respiratory tract infection that is characterized by fever, headache, muscle aches, sore throat, cough, and cold symptoms (Steinhoff, 2007). The public health importance of influenza derives from the rapidity with which epidemics evolve and with the seriousness of its complications, specifically viral and bacterial pneumonia. In the U.S., around 36,000 people die from infection with influenza or its complications each year (Centers for Disease Control and Prevention, 2008). The annual increase in mortality during winter months is largely attributed to influenza (Steinhoff, 2007). The main risk factor for infection with influenza is exposure to aerosolized respiratory secretions containing the virus (American Public Health Association, 2000). School-aged children are at the highest risk for influenza though the elderly, infants, and those with underlying chronic illness have the highest risk for



complications from the disease. Having a school-aged family member increases the risk for infection. Annual epidemics occur between November and March in the Northern Hemisphere and in May through September in the Southern Hemisphere. In the tropics the virus can usually be isolated at any time of the year, but epidemics are influenced by weather patterns such as monsoons. The occurrence of epidemics during monsoon season in tropical climates suggests that indoor crowding plays a critical role in the spread of influenza (Steinhoff, 2007).

### **3. Tuberculosis**

According to the World Health Organization (2004), tuberculosis kills more than 900,000 each year. It is most commonly an infection of the lungs, but the organism *Mycobacterium tuberculosis* can infect any tissue. Historically tuberculosis rates have been extremely high among Alaska Natives, but rates have drastically improved in recent years (Metcalf, 2005). Known risk factors for acquiring tuberculosis include living in an endemic area, crowding, and malnutrition. Poverty is also a risk factor because it serves as a surrogate for crowding. While infection with *M. tuberculosis* is a function of exposure, development of the disease has many associated risk factors including time since infection, age, sex, genetics, stress, malnutrition, and the presence of a co-morbidity like HIV/AIDS (Coberly & Chaisson, 2007).

### **4. Haemophilus influenzae type b**

*Haemophilus influenzae* type b (Hib) infection provides an interesting example of environmental factors contributing to the development of infectious disease. This bacterium may asymptotically colonize the oropharynx or it may become invasive,

causing severe bacterial infections, especially in infants. Prior to Hib vaccination, it was the leading cause of bacterial meningitis in children less than five years old (Centers for Disease Control and Prevention [CDC], 2008). Known risk factors for invasive Hib disease include household crowding, large household size, childcare attendance, the presence of school-aged siblings, and the existence of a co-morbid chronic disease. Invasive Hib disease also occurs in higher numbers among those with low socio-economic status, those with low parental education, and those of ethnic groups including African Americans, Hispanics, and Native Americans, though these risk factors may be surrogates for crowding or limited healthcare access (CDC, 2008).

Before Hib vaccination, Alaska Native children suffered from invasive Hib disease at a rate more than six times that of the general U.S. population. Universal infant vaccination for Hib began in 1991, reducing the Hib rate among Alaska Natives by 94% (Singleton, et al., 2006). In the 2000-2001 National Immunization Survey, vaccination coverage among Alaska Native children aged 19 to 35 months exceeded the national health objective for 2010 (Wood, Santibanez, Barker, & Singleton, 2003). However, in 2004, even in the wake of such a successful vaccination campaign, the rate of invasive Hib among rural Alaska Native children remained five times higher than that of other U.S. children. Similarly, high rates of invasive Hib have been noted in other indigenous populations including the Navajo of the Southwest, aboriginal Australians, and the indigenous people of Canada's Nunavut and northern Quebec (Singleton et al., 2006). Singleton et al. (2006) suggest that factors outside of vaccination like household

crowding, poverty, unemployment, or a lack of indoor plumbing may play a role in the persistently high rates of invasive Hib disease among Native Alaskans.

## **G. Villages Characteristics Possibly Contributing to Respiratory Infection and**

### **Infectious Disease Death Rates**

#### **1. Latitude**

It has long been postulated that the extreme northern latitudes of Alaska contribute to the high rates of respiratory infections among Alaskan Natives (Fortuine, 1989). As previously stated, cold weather has not been found to contribute to an increased risk for acute respiratory infection, however, the crowding and the higher levels of air pollution that occur during winter months have been linked to these infections (Graham, Nelson, & Steinhoff, 2007). Also, the seasonality of pathogens such as RSV, which has a prolonged season at northern latitudes (Singleton, Bruden, & Bulkow, 2007), could contribute to an increased infection rate. Therefore, it is possible that at northern latitudes where winters are longer, there will be higher rates of death from infections.

#### **2. Percent Native population**

When first making contact with Europeans, the aboriginal people of North America were extremely susceptible to the infectious pathogens brought by the newcomers. Asturias et al. (2000) note that this increased susceptibility to infection persists today. Some theorize that the period of time during which the aboriginal people migrated to North America across the Bering land bridge, cold temperatures and the fragmentation of society into isolated groups served to eliminate many pathogens.

Having spent hundreds of generations in the absence of these pathogens may have led to genetic differences in the immune systems of American Indians / Alaska Natives (Asturias et al., 2000). Because of these differences in genetics and therefore immunity, it is possible that villages with larger Native populations will have higher rates of death from respiratory and other infectious diseases.

### **3. Percent of population under age 4 / Percent of population over age 62**

Age is a well-accepted risk factor for many types of respiratory disease with the very young and the elderly being disproportionately affected. Not only are infants and the elderly more susceptible to infection, they are more likely to suffer serious complications to these illnesses. This is true for influenza, especially when those of either age extreme have co-morbid conditions (Steinhoff, 2007). Underlying co-morbid illnesses are certainly more common in the elderly and prematurity can also increase the susceptibility of infants to illness. Given that the population dynamics are such that children and elderly disproportionately inhabit Alaska Native villages while working age adults are more often found in Alaskan cities (Goldsmith, 2004), it is possible that a large percentage of the population being under age 4 or over age 62 could correlate with higher rates of death from infection.

### **4. Median household income / Percent below poverty / Unemployment rate**

A 1987 study of residents in Alameda County, California found that those living in federally designated poverty areas had a mortality risk of 1.71 times those living in all other areas (Haan et al., 1987). It is not simply a lack of income that causes this phenomenon, but the multitude of factors that are inextricably linked with poverty such

as household crowding, malnutrition, and limited access to healthcare. It is possible that poverty and the related factors of income and unemployment will correlate with respiratory and other infectious disease death rates.

### **5. Average household size**

As previously stated, household crowding is a known risk factor for pneumonia, influenza, and tuberculosis. Household crowding exists in Alaska Native villages. In 2000 the average Alaska Native household size was 3.63 compared to 2.59 in non-Native households (Goldsmith, 2004). In the YK delta region of Alaska, Singleton et al. (2007) found a direct correlation between household crowding and rates of infant hospitalization with RSV. It is certainly possible that there will be a correlation between average household size and infectious disease death rates in Alaska Native villages.

### **6. Percentage of homes lacking complete plumbing / kitchens**

One of the most studied aspects of remote, rural Alaska villages is the low rate of homes with in-home water. As of 2000, one-third of rural Alaskans were without running water in their homes (Hennessy et al., 2008). Multiple studies have shown this is a risk factor for disease. Hennessey et al. (2008) demonstrated that regions with a low proportion of water service had higher rates of hospitalization for pneumonia, influenza, and RSV. Also, it was found that there were more outpatient visits and hospitalizations for skin infections such as those caused by *Staphylococcus aureus* (Hennessy et al., 2008). Gessner (2008) found through linear regression analysis that the proportion of homes lacking water service in Alaska communities predicted the amount of both inpatient and outpatient visits for pediatric lower respiratory tract infections. This was

true even when controlling for household crowding, unemployment, adult education, smoking, wood stove use, and poverty. Given these studies that show a link between the lack of water service in some Alaskan communities and several types of infection, it is reasonable to predict that water service may also affect the rates of death from respiratory and other infectious diseases.

### **7. Percentage of homes using wood or coal heat**

The indoor air pollution caused by the burning of unprocessed solid fuels such as wood, coal, animal dung, and crop waste has a known link to respiratory illness. Dherani et al. (2008) conducted a systematic review and meta-analysis of 24 articles revealing that the risk of pneumonia in young children exposed to unprocessed solid fuels is increased by a factor of 1.8 (Dherani, Pope, Mascarenhas, Smith, Weber, & Bruce, 2008). Logically, the burning of solid fuels such as wood, which is a common method for heating homes in many Alaska Native villages, may be related to respiratory infection deaths.

### **8. Alcohol prohibition**

Heavy alcohol use is a risk factor for incidence and for re-infection with tuberculosis (Rehm, Samokhvalov, Neuman, Room, Parry et al., 2009). Alcohol abuse is also a known risk factor for pneumococcal pneumonia (American Public Health Association, 2000). Additionally, it predisposes inebriated persons to aspiration of gastric contents, which can cause a severe form of pneumonia due to stomach acid and gastrointestinal bacteria reaching the lungs. Alcoholism may also predispose one to respiratory infections through accompanying malnutrition and through decreased

immunity secondary to chronic, alcohol-related diseases such as cirrhosis (Lange & Hillis, 2007). Alaska law allows villages to prohibit alcohol sales, importation, and/or possession by local option election. For Alaska Native villages that have banned alcohol, it is possible that rates of death from respiratory infection and infectious disease overall are lower than in wet villages.

### **9. Healthcare access**

Given the remote setting of most Alaska Native villages, access to healthcare is a possible contributing factor to death from respiratory infection or other infectious diseases. This is especially true considering that infections often cause a rapid onset of severe illness. Since the 1930's, when Alaska still was a U.S. territory, attempts have been made to better the dismal health status of Alaska Natives through improved access to healthcare (Caldera, 1991). Development of the Community Health Aide Program is an example of such an attempt. It may be true that villages lacking health aides or higher forms of healthcare such as a hospital or a physician have an increased rate of death from respiratory or other infections.

### **10. Census region / Native regional corporations**

Alaska is the largest state in the nation and regional variation exists within the state. The climate, geographical features, and ways of life differ significantly depending on one's location within the state. Likewise, it is probable that variations in disease prevalence exist depending on the regions examined. Census regions provide a logical unit of analysis for the study of regional variation. Similarly, the 12 regional Native corporations established by the Alaska Native Claims Settlement Act provide well-

established regions in which to group Alaska Native villages. Maps of the census regions and regional corporations are seen in Appendix A.

## **H. Pertinent Seminal Papers**

### **1. Neighborhoods and health**

In recent years, a great deal of research has been devoted to the relationship between neighborhoods and health. It is not surprising that air pollution, a high crime rate, or access to a grocery with fresh produce might have effects on the health of those living in a community. The influence of a person's neighborhood on his or her health is strong. A landmark study of neighborhoods in Alameda County, California by Haan et al. (1987) found that those living in federally designated poverty areas had a mortality risk of 1.71 (95% CI: 1.20 to 2.44) compared to those living in all other areas. A follow-up study of Alameda County residents by Yen and Kaplan (1999) found that "low quality social environments" were associated with an increased risk of death, even when adjustments were made for age, sex, individual income, education, race/ethnicity, smoking status, body mass index, alcohol consumption, and perceived health status. Yen and Kaplan (1999) conclude that, "neighborhood characteristics such as income level of the population, percent employed in white-collar occupations, presence of stores, and the types of housing available contribute to a person's risk of death in addition to individual risk factors."

While the influence of a neighborhood's effect on the population's health may be statistically demonstrable, Link and Phelan (1995) note "social conditions ... are mere proxies for true causes lying closer to disease in the causal chain." In the context of



infectious disease, many risk factors are well known. Access to clean drinking water, the presence of functioning sewer systems, household crowding, air quality, nutrition, and the presence of underlying illness affect one's exposure and susceptibility to infection. Those living in Alaska Native villages have risk factors that may contribute to higher rates of infectious disease and infectious disease death.

## **2. Alaska Native village characteristics & health**

Several studies have examined Alaska Native village characteristics and their influence on the health of village residents. Gilbreath and Kass (2006) conducted a retrospective cohort study in which villages were grouped by the hazard ranking of their open dumpsites and that ranking was compared to birth outcomes among women in the village. The study found that communities with intermediate or highly hazardous dumpsites had higher rates of low birth weight infants and higher rates of intrauterine growth restriction. No specific contaminant or direct pathway of exposure was identified though the authors note, "reproductive outcomes can be sensitive indicators of environmental insults as the reproductive system often fails before other systems" (Gilbreath & Kass, 2006).

As previously mentioned, several studies examined the lack of in-home water in rural Alaska and its relationship to infection incidence. Hennessy et al. (2008) found that Alaskan regions with lower rates of in-home water and wastewater service had higher rates of hospitalization for pneumonia and influenza (RR= 2.5), skin and soft tissue infections (RR=1.9), and respiratory syncytial virus (RR=3.4 among those less than 5 years). Similarly, Gessner (2008) found an increase in lower respiratory tract infections

among Alaskan children who came from villages with low rates of in-home water having controlled for household crowding, unemployment, adult education, smoking in the home, use of a woodstove, and poverty. Wegener et al. (2010) studied the unusually high rates of invasive pneumococcal disease in the YK delta of Alaska and concluded that a lack of water service was a statistically significant risk factor and remained so when stratified by income, household size, and use of wood for heating fuel.

The questions surrounding infectious disease risk in the Alaska Native population are not outdated. A study by La Ruche et al. (2009) found that H1N1 was occurring in indigenous populations (including American Indians / Alaska Natives) disproportionately with indigenous people dying at a rate three to six times that of non-indigenous peoples. Here the authors postulate why indigenous people are so affected,

“These observations may be associated with documented risk factors for severe disease and death associated with pandemic H1N1 influenza infection (especially the generally higher prevalence of diabetes, obesity, asthma, chronic obstructive pulmonary disease and pregnancy in indigenous populations). More speculative factors include those associated with the risk of infection (e.g. family size, crowding and poverty), differences in access to health services and, perhaps, genetic factors” (La Ruche, Tarantola, Barboza, Vaillant, Gueguen, & Gastellu-Etchegorry, 2009).

Establishing the existence of health disparities in vulnerable populations is only a first step. Understanding the specific cause or causes of illness is essential in order to best direct efforts to eliminate disparity and disease.

#### **IV. Statement of Purpose / Research Questions**

The purpose of this ecological study is to determine if there is a correlation between infectious disease death rates, particularly respiratory infections, and certain demographic and physical characteristics of 196 Alaska Native villages. For the time period between 1990 and 2007, the death rates for pneumonia/influenza, tuberculosis, and all-cause infectious disease deaths will be compared to village characteristics. The village characteristics examined include latitude, the percentage of the population that is all or part American Indian / Alaska Native, the percentage of population over age 62, the percentage of population under age 4, the median household income, the unemployment rate, the average household size, the percentage of homes that lack complete plumbing, the percentage of homes that lack complete kitchens, the percentage of homes using wood heat, the degree to which alcohol prohibition exists in the village, and the level of health care access available in the village.

#### **V. Methods**

##### **A. Subjects**

This is an ecological study of Alaska Native villages. The unit of analysis is the village. A list of 221 Alaska Native village statistical areas was obtained from the U.S. Census Bureau (<http://www.census.gov/geo/www/ezstate/aianapov.html>). Fourteen villages were not included in the study because the 2000 village population was zero. Eleven villages were not

included because there was no housing data available in the Alaska Community database.

Alaska Native villages included in this study numbered 196.

## B. Measurement

The independent and dependent variables of this study are listed in Table 2.

**Table 2: Study Variables**

Independent Variables	Description
Percent Native population	This is 2000 U.S. Census data showing the percentage of people in each village who considered themselves all or part Alaska Native / Indian.
Percentage of the population under age 4	This is 2000 U.S. Census data showing the percentage of the population under age four in each village.
Percentage of the population over age 62	This is 2000 U.S. Census data showing the percentage of the population over age 62 in each village.
Latitude	This is the latitude of each village as listed in the Alaska Community Database.
Average household size	This is 2000 U.S. Census data showing the average household size for each village.
Median household Income	This is 2000 U.S. Census data showing the median household income for each village.
Percent unemployed	This is 2000 U.S. Census data showing the percentage of persons unemployed in each village.
Percent below poverty	This is 2000 U.S. Census data showing the percentage of persons living below the poverty level in each village.
Percent of households lacking complete plumbing	This is 2000 U.S. Census data showing the percentage of households who lack a sink, bath/shower, and/or a flush toilet.
Percent of households lacking a complete kitchen	This is 2000 U.S. Census data showing the percentage of households who lack a stove, a refrigerator, and/or running water.
Percent of households using fuel oil for heat	This is 2000 U.S. Census data showing the percentage of households using fuel oil as their primary heat source.
Percent of households using electricity for heat	This is 2000 U.S. Census data showing the percentage of households using electricity as their primary heat source.
Percent of households using wood for heat	This is 2000 U.S. Census data showing the percentage of households using wood as their primary heat source.

Percent of households using bottled or piped gas for heat	This is 2000 U.S. Census data showing the percentage of households using bottled or piped natural gas as their primary heat source.
Percent of households using another source for heat	This is 2000 U.S. Census data showing the percentage of households using something other than fuel oil, electricity, wood, or natural gas as their primary heat source.
Alcohol prohibition status	Alaskan villages have the option to vote in a ban on the sale, importation, and/or possession of alcoholic beverages in their communities. The levels of alcohol prohibition in each community as of January 1, 2000 are a variable in this study and come from the Alaska Alcohol Beverage Control Board.
Level of Healthcare	Villages may have a hospital, a physician staffed clinic, a physician assistant or nurse practitioner staffed clinic, a clinic staffed by a public health nurse, a clinic staffed by a community health aide, or no clinic. This information was obtained from the Alaska Native Tribal Health Consortium and the Alaska Community Health Aide Program.
Census Region	This is 2000 U.S. Census data. Alaska Native villages in this study fall into 23 census regions. See Map 2 in Appendix A.
Native Regional Corporation	In Alaska, Native Regional Corporations were developed following the passage of the Alaska Native Claims Settlement Act in 1971. Twelve regional corporations exist in Alaska. See Map 3 in Appendix A.

Dependent Variables	Description
Pneumonia & influenza death rate	The number of deaths from pneumonia and/or influenza sorted by decedent's village of residence for the time period 1990-2007 was used to calculate the number of pneumonia deaths per 100,000 people per year for each village.
Tuberculosis death rate	The number of deaths from tuberculosis sorted by decedent's village of residence for the time period 1990-2007 was used to calculate the number of tuberculosis deaths per 100,000 people per year for each village.
Infectious disease death rate	The number of deaths from infectious diseases (causes of death in Chapter 1 of ICD-10) sorted by decedent's village of residence for the time period 1990-2007 was used to calculate the number of infectious disease deaths per 100,000 people per year for each village. (The first chapter of the ICD-10 includes septicemia, intestinal infections, hepatitis, tuberculosis, sexually transmitted infections, fungal and parasitic infections, among others. Therefore, this category includes two unusually frequent causes of illness among Alaska Natives: invasive pneumococcal disease and invasive <i>Haemophilus influenzae</i> .)

### **C. Data Collection and Analyses**

The source for most of the independent variables was 2000 U.S. census data available through the Alaska Community Database ([http://www.commerce.state.ak.us/dca/commdb/CF\\_BLOCK.htm](http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm)). Alcohol prohibition data came from the State of Alaska Alcoholic Beverage Control Board (<http://www.dps.state.ak.us/ABC/restrictions.aspx>). The level of healthcare access for each village was obtained from the Alaska Native Tribal Health Consortium (<http://www.anthc.org/ref/maps/>) in combination with the Alaska Community Health Aide Program website (<http://www.akchap.org/Listclinicsall.cfm>). Dependent variables came from death certificate data obtained by request from the Alaska Bureau of Vital Statistics and used to calculate death rates.

Descriptive statistics including, mean, standard deviation, minimum and maximum values, were calculated using Microsoft Excel®. A stepwise analysis of variance using the Proc GLM procedure in SAS® was performed using the variables in Table 2. Least significant difference was used to separate the means of categorical data. A  $P < 0.05$  was considered significant. Additionally, the solution for the regression was performed to determine if the covariates were positively or negative correlated with the outcomes.

### **D. IRB Exemption**

An IRB exemption for this study (SC #3915) was obtained from the Wright State University Office of Research and Sponsored Programs.

## VI. Results

### A. Descriptive Statistics

**Table 3: Descriptive data for the 196 Alaska Native villages studied**

Village Descriptor (2000 Census Data)	Minimum	Maximum	Mean	Standard Deviation
2000 Population	2.0	5471.0	397.0	657.0
Percent all or part Native Alaskan	0.0	100.0	78.8	24.9
Latitude (degrees)	52.2	71.3	61.7	3.8
Average household size	1.6	5.4	3.3	0.8
Percent age >62 years	0.0	100.0	8.5	7.4
Percent age <4 years	0.0	29.6	8.3	3.6
Median household income (dollars)	6,875.0	92,297.0	34,496.7	14,440.3
Percent unemployed	0.0	70.8	7.7	7.0
Percent below poverty level	0.0	64.5	21.4	13.4
Percent homes lacking complete plumbing	0.0	100.0	42.7	36.1
Percent homes lacking complete kitchens	0.0	100.0	38.5	35.4
Percent homes using fuel oil for heat	0.0	100.0	78.3	4.2
Percent homes using electricity for heat	0.0	25.6	1.8	25.3
Percent homes using wood for heat	0.0	100.0	16.5	23.2
Percent homes using piped or bottled natural gas for heat	0.0	89.4	2.7	11.5

**Table 4: Descriptive data – Death rates\* of the 196 Alaska Native villages studied**

Vital Statistics Data (1990-2007)	Minimum	Maximum	Mean	Standard Deviation
Number of pneumonia & influenza death	0.00	9.00	0.99	1.57
Pneumonia & influenza death rate	0.00	163.40	16.15	25.89
Number of tuberculosis deaths	0.00	3.00	0.12	0.38
Tuberculosis death rate	0.00	33.17	1.63	5.48
Number of infectious disease deaths	0.00	6.00	0.68	1.15
Infectious disease death rate	0.00	490.20	11.70	38.43

\*Death rate = deaths/100,000 persons/year

### B. Stepwise ANOVA Results

**Table 5: ANOVA results – Significant\* continuous variables**

Dependent Variable	Independent Variable	Mean	Standard Deviation	P value
Pneumonia & influenza death rate	Average household size	3.3	0.8	0.002
	Median income (dollars)	34,497.0	14,440.3	0.005
Tuberculosis death rate	Native region	See Table 6.		0.015
	Percent using oil heat	78.3	4.2	0.048
	Percent using electric heat	1.8	25.3	0.028
	Percent using gas heat	2.7	11.5	0.047
Infectious disease death rate	Percent Native population	78.8	24.8	0.013
	Average household size	3.3	0.8	0.029
	Percent below poverty	21.4	13.4	0.038
	Level of healthcare access	See Table 7.		<0.001

\* Only statistically significant variables are included (P<0.05).



Running the solutions to the ANOVA found that average household size was directly correlated with the pneumonia/influenza death rate while median income was inversely correlated. Use of oil, electric, and gas heat were inversely correlated with the tuberculosis death rate. Having a high percentage of Natives in the population as well as a high average household size were directly correlated with the infectious disease death rate while poverty was inversely correlated.

### C. Post Hoc Analysis

**Table 6: Native region / tuberculosis death rate**

	Native regional corporation	Number of villages	Mean tuberculosis death rate	Standard deviation
1	Ahtna	9	0.0	0.0
2	Aleut	10	3.9	10.5
3	Arctic Slope	8	0.0	0.0
4	Bering Straits	15	5.4*	10.2
5	Bristol Bay	29	0.7	2.6
6	Calista	46	3.7**	7.4
7	Chugach	5	0.0	0.0
8	Cook Inlet	6	0.0	0.0
9	Doyon	39	0.0	0.0
10	Koniag	5	0.0	0.0
11	NANA	11	0.0	0.0
12	Sealaska	12	0.9	3.0

\*The mean for region 4 differs significantly from all other regions except region 6.

\*\* The mean for region 6 differs significantly from regions 1, 2, 5, 7, 9, 10, 11, and 12.

**Table 7: Level of healthcare access / infectious disease death rate**

	Level of healthcare available	Number of villages	Mean infectious disease death rate	Standard deviation
1	Hospital	4	7.0	3.1
2	Physician assistant / nurse practitioner staffed clinic	27	11.1	13.9
3	Community health aide staffed clinic	153	9.7	18.7
4	No clinic	11	45.1*	147.6

\* Mean is significantly different from other levels of healthcare access ( $P < .05$ ).

## VII. Discussion

### A. Descriptive Data

The population in this study lives in 196 widely scattered Alaska Native villages (See Map 4, Appendix A.). Among the villages studied, the percent of those claiming American Indian / Alaska Native (AIAN) heritage (78.80%) greatly exceeds the percentage of AIAN in the general U.S. population (0.9%). Poverty appears to disproportionately affect the study population with more than 21% of persons living below poverty, a median household income of \$34,497, and an unemployment rate of 7.71%. Meanwhile, the same 2000 U.S. Census data showed that in the overall U.S. population about 12% of individuals lived below poverty, median household income was \$41,994, and the unemployment rate was 3.7% (U.S. Census Bureau, 2000). The study population had an average household size of 3.34 while the average household size in the overall U.S. population was 2.59 (U.S. Census Bureau, 2000). Many homes in the Alaska Native villages studied lack complete plumbing and complete kitchens (42.7% and 38.5%, respectively)

while in the U.S. a home lacking plumbing or a complete kitchen is rare (0.6% and 0.7%, respectively) (U.S. Census Bureau, 2000).

The average death rates for the diseases studied in these Alaska Native villages differ from those in the general U.S. population. In this study, the average death rate from pneumonia and influenza was 16.2 though in some villages it was well over 100. For the general U.S. population, the 2000 death rate from pneumonia and influenza was 23.2 (Centers for Disease Control and Prevention, 2009). The average tuberculosis death rate in this study was 1.63, much higher than the 2000 U.S. death rate for tuberculosis, which was 0.3 (Centers for Disease Control and Prevention, 2009). For all infectious diseases in Chapter 1 of the ICD-10, the death rate in this study was 11.7; it was 21.0 in the general U.S. population in the year 2000 (Centers for Disease Control and Prevention, 2009). The large amount of variability in the death rates found in this study is likely due in part to the small populations of many of the villages.

### **B. Pneumonia and Influenza**

A significant finding in this study was that of the pneumonia/influenza death rate's association with average household size. Household crowding is a well-established risk factor for the acquisition of acute lower respiratory tract infection (Graham, Nelson, & Steinhoff, 2007). Therefore, it is not surprising that average household size was significantly associated with the pneumonia and influenza death rate. Crowding has also been shown to be a risk factor for RSV bronchiolitis among specific populations of Alaska Natives (Singleton et al., 2006).

An established risk factor for pneumococcal pneumonia is low socioeconomic status (American Public Health Association, 2000). In this study, median income was inversely correlated with the rate of death from pneumonia and influenza. Clearly, it is not simply a lack

of income that causes increased rates of death from pneumonia and flu, but possibly factors linked with poverty such as household crowding, malnutrition, limited educational attainment, or limited access to healthcare.

Previous studies have shown other risk factors for pneumonia or influenza that were not statistically significant in this study. For example, old age (Graham, Nelson, & Steinhoff, 2007) and indoor air pollution secondary to burning solid fuels such as wood (Dherani, Pope, Mascarenhas, Smith, Weber, & Bruce, 2008) are known risk factors for pneumonia. Studies specific to Alaska by Hennessy et al. (2008) and Gessner (2008) found that the hospitalization rates for lower respiratory infections were higher in communities with low rates of in-home water service. It is possible that these established risk factors were not significantly associated variables in this study because, while they may increase the risk for disease acquisition or hospitalization, the increased risk they pose is not so strong as to change the death rates in the villages.

While the argument could be made that the provision of in-home water should be a major priority in addressing the health disparities of Alaska Native villages, the results of this study suggest that other housing characteristics may also play a significant role. Given the enormous cost of developing community water systems in isolated arctic and sub-arctic villages, it may be more advantageous to direct resources toward addressing household crowding in these communities. Further study needs to be done to evaluate the underlying social practices and economic and environmental conditions that lead to a high average household size. With a better understanding of these conditions, resources can be efficiently directed to address a major cause of respiratory infection and pneumonia/influenza death.

### C. Tuberculosis

One risk factor for tuberculosis was found to be residence in certain regions of Alaska, specifically the Native regions of Bering Straits and Calista. (See Map 5, Appendix A) An established risk factor for tuberculosis is residence in an endemic area. Alaska has a long history of high tuberculosis rates, with Alaska Natives being disproportionately affected. A 2008 report found that while Alaska Natives account for only 18% of the Alaskan population, this population had 65% of the tuberculosis cases (Epidemiology Section, Alaska Department of Public Health, 2008).

The findings of high death rates of tuberculosis in the regions of Bering Straits and Calista are similar to current and historic trends in the incidence of tuberculosis in Alaska. In the 2008 report *Tuberculosis in Alaska*, the highest incidence rates of tuberculosis were seen in the Southwest (43.5 cases per 100,000 people, which is nearly six times greater than the statewide incidence rate) with the majority of the cases in the Yukon Kuskokwim (YK) Delta (Epidemiology Section, Alaska Department of Public Health, 2008). In this study, the YK Delta falls mostly within Calista Corporation, which had the second highest rate of tuberculosis death. The same 2008 report showed the Northern region of Alaska to have the second highest incidence (25.4 cases per 100,000 people) of tuberculosis with the Norton Sound area being the main source cases (Epidemiology Section, Alaska Department of Public Health, 2008). In this study, the Bering Straits Region, which includes Norton Sound, was found to have the highest tuberculosis death rate for all Native regional corporations. Public health efforts underway in Alaska are already addressing the regional variation in tuberculosis incidence and death with efforts

specific to the Norton Sound Health Corporation and the YK Delta region (Epidemiology Section, Alaska Department of Public Health, 2008).

Tuberculosis death rates were found to be significantly associated with the use of oil, electric, wood, and gas as heating fuel. In Alaska, heating homes is a necessity. This study found the most commonly used fuel was fuel oil with about 78% of homes using it. In some villages, wood was the predominant fuel though it accounted for only 16% of the fuel used in homes overall. Similarly, natural gas was the predominant fuel in a few villages, but accounted for just 3% of the fuel used overall. Around 2% of homes used electric heat. This study found that use of oil, electric, and gas heat were negatively correlated with the tuberculosis death rates, suggesting that use of these forms of heat may be protective. The use of wood as a heating fuel was not statistically significant in its association with tuberculosis death rates. Previous studies have shown that burning solid fuels such as wood inside the home increase the risk for the development of pneumonia (Dherani, Pope, Mascarenhas, Smith, Weber, & Bruce, 2008). It is possible that this may also be true for tuberculosis given that it is most commonly an infection of the lungs.

#### **D. Infectious Diseases**

In this study, the infectious disease death rate was based on death certificate data where the cause of death was in Chapter 1 of the International Classification of Diseases (ICD-10). A number of diseases fall into the first chapter of this classification system including septicemia, intestinal infections, hepatitis, tuberculosis, zoonotic diseases, sexually transmitted infections, fungal and parasitic infections, among others (World Health Organization, 2010). This would include two diseases that are known to occur at high rates in some regions of

Alaska: invasive pneumococcal disease and invasive *Haemophilus influenzae*. (Pneumonia and influenza are not included in Chapter 1 of the ICD-10 because they are classified in the respiratory disease chapter.) Given the wide range of diseases that are listed in Chapter 1 of the ICD-10, it is surprising how many factors in this study were found to correlate with the infectious disease death rate.

Similar to pneumonia and influenza death rates, infectious disease death rates were found to be associated with high average household size. This is logical given that many infectious diseases are transmitted through person-to-person contact. Also, household crowding is known to be prevalent in Alaska Native villages. Percent poverty was inversely correlated with the death rate from all-causes infectious disease, suggesting that poverty is protective. This is in contrast to the correlation between median household income and the pneumonia-influenza death rate. It is difficult to explain poverty's negative association with infectious disease death given the many challenges that poverty presents for a population in the context of health such as the availability of transportation, health care access, nutrition, household crowding, etc. Level of healthcare access was found to be a risk factor for infectious disease death in this study. In particular, those villages that had no clinic were most at risk for high death rates. In a state with few roads, transportation is often limited to plane or boat travel. This can make healthcare access difficult, especially in an emergent situation such as a worsening infection. In communities that lack even a basic clinic staffed by community health aides, residents usually do not often have access to routine health visits that could prevent a health emergency from occurring. These results may also be a testament to the effectiveness of Alaska's community health aide (CHA) program. In the 153 villages that had CHA's, infectious

disease deaths rates were significantly lower than in the villages with no clinic. This suggests that access to even a basic clinic staffed by these minimally trained providers plays an important role in preventing death from infectious disease.

Rates of infectious disease death were associated with high percentages of Natives in the village population. Nativity is a known risk factor for many diseases. For example, previous studies have shown that pneumonia incidence and mortality is higher among American Indians as is tuberculosis incidence, prevalence, and mortality (NHLBI Working Group, 1995). Such correlations may stem from socioeconomic conditions that occur in many groups of AIAN, though some theorize that those of AIAN heritage may have a lessened immune response for some pathogens that did occur regularly among their ancestors (Asturias, Brenneman, Petersen, Hashem, & Santosham, 2000).

#### **E. Strengths and Limitations**

Ecological studies such as this can provide valuable insight into the causes of disease and death by assessing health outcomes at a community, rather than an individual, level. Advantages to ecological studies include low cost, the use of existing data, and the ability to study large populations quickly. However, at least two major disadvantages exist when using this methodology.

First, there is ecological fallacy. This is the bias that may occur because an association between variables on an aggregate level does not necessarily represent what happens on an individual level. Ecological data are distinct from individual characteristics. For example, having a low income affects an individual differently than living in a poor community. Therefore, it is important to interpret the results of ecological studies cautiously, realizing that what may be



true for the group is not necessarily true at an individual level, especially in the context of disease causation.

A second disadvantage to ecological studies is imprecision in the types of data available for use. Because such large populations are under study, the accuracy of available data can greatly affect the ability to draw accurate conclusions from the study results. In this study, use of U.S. Census data may have over simplified the complex and dynamic characteristics of the villages studied. However, in an attempt to control for this, the decennial census used occurred roughly in the middle of the 17 year study period (1990-2007). Similarly, the use of death certificate data can be problematic. While the use of death certificate data has the advantage of completeness as a death in the U.S. is unlikely to go unrecorded, cause of death may often be unclear or recorded differently by different physicians. For example, if an individual dies of pneumonia secondary to influenza infection, one physician may record pneumonia as the cause of death, while another may record influenza.

An additional limitation to this study is the small population of many Alaska Native villages. While 196 villages were studied, the population of individual villages varied greatly and was often quite small. This resulted in a large amount of variability in the death rates because one or two deaths in small village affects the death rate for that village much more than it would for a city with large population. The use of 17 seventeen years worth of data and the large number of villages studied may help to compensate for the erraticism of the death rates.

## **F. Conclusions**

Using ecological data and a general linear model, this study linked multiple community characteristics with the risk of death from several infectious diseases in Alaska Native villages.

Pneumonia/influenza death rates were positively correlated with average household size and negatively correlated with median household income. Tuberculosis death rates were associated with residence in specific regions of Alaska, already known as endemic for tuberculosis. Tuberculosis death was negatively associated with the use of fuel oil, natural gas, and electric heat, suggesting that these forms of heat may be protective. Overall infectious disease death rates were associated with villages lacking a medical clinic and were directly correlated with the presence of a high percentage of Natives in the population and a high average household size. Having a large percent of the population below poverty was negatively associated with infectious disease death. While the health outcomes of Alaska Natives have greatly improved in the last 50 years, disparities remain. When directing resources to best address the remaining health disparities, this and other ecological studies can be used to identify “at risk” populations.

## VIII. References

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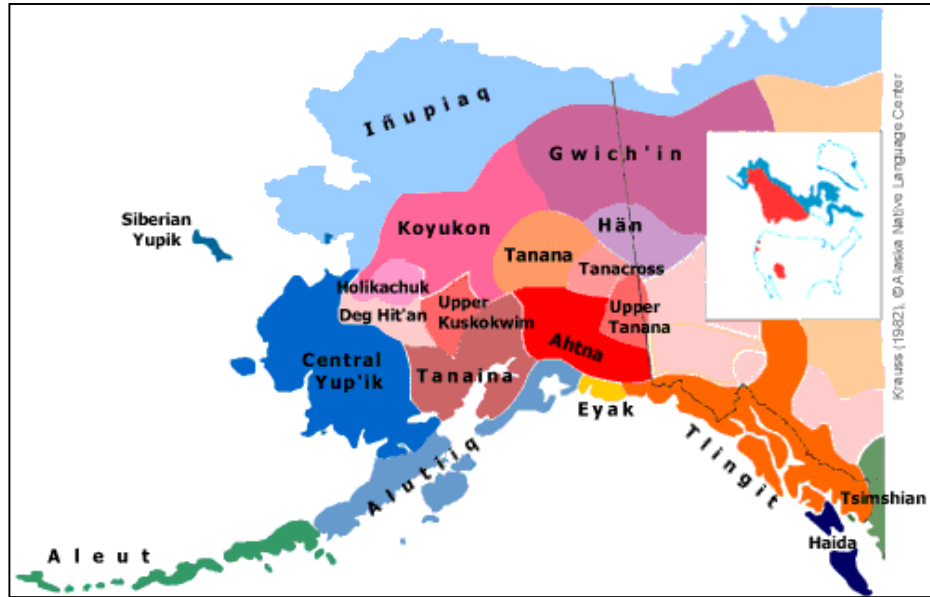
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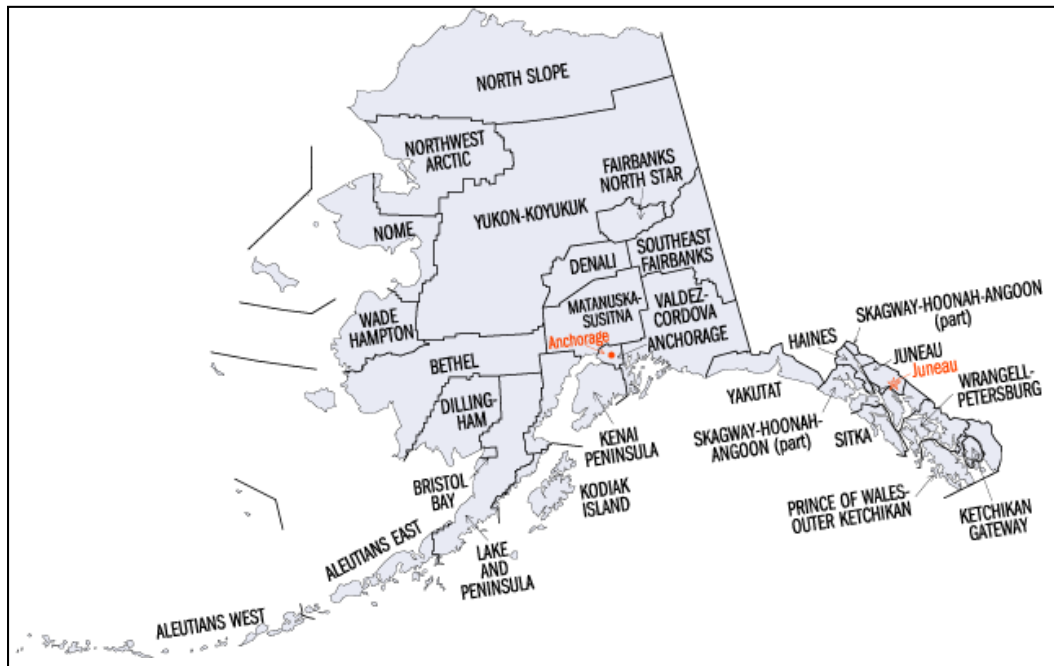
## IX. Appendices

### A. Maps

1. Alaska Native Languages (<http://www.ankn.uaf.edu/npe/images/ANLmap.gif>)

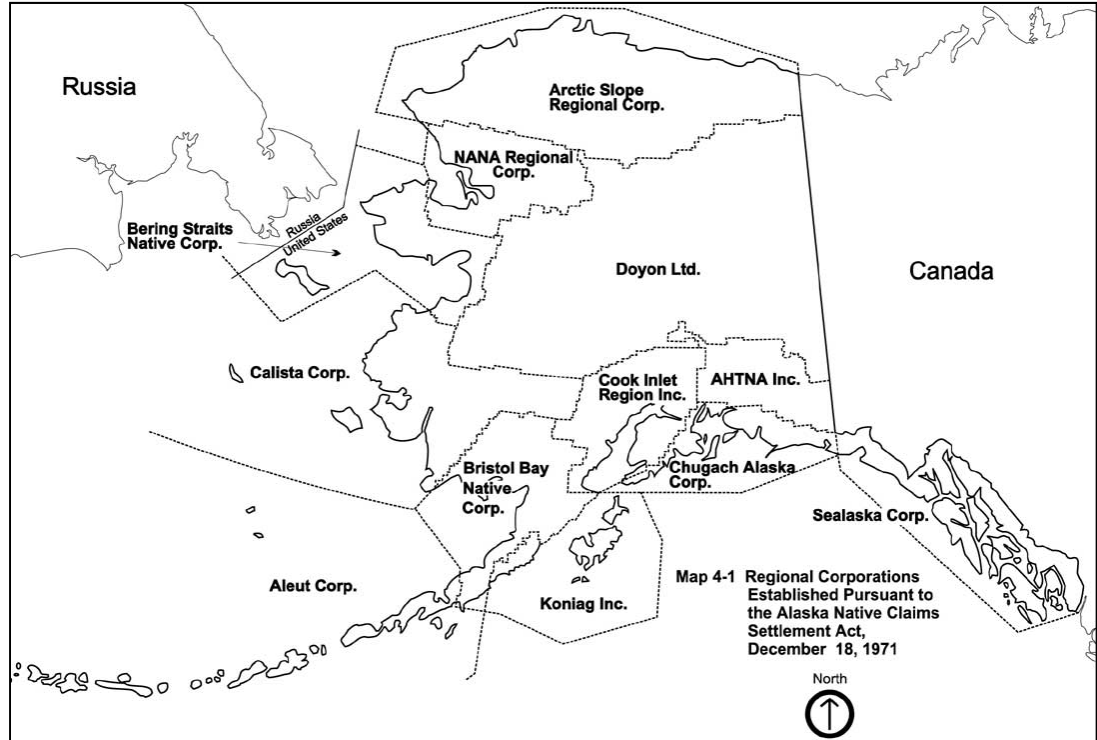


2. Alaska Census Areas (<http://www.fedstats.gov/qf/maps/stout02.gif>)



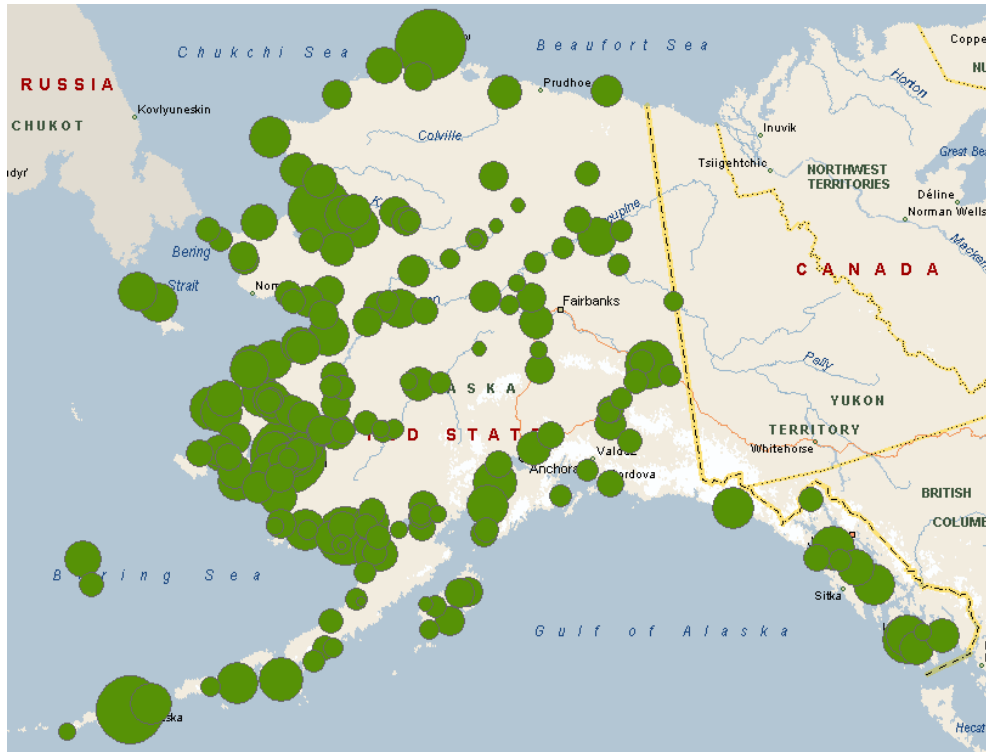
### 3. Alaska Native Regional Corporations

(<http://www.ankn.uaf.edu/Curriculum/Articles/MikeGaffney/ CPP/images/ANCSA.jpg>)

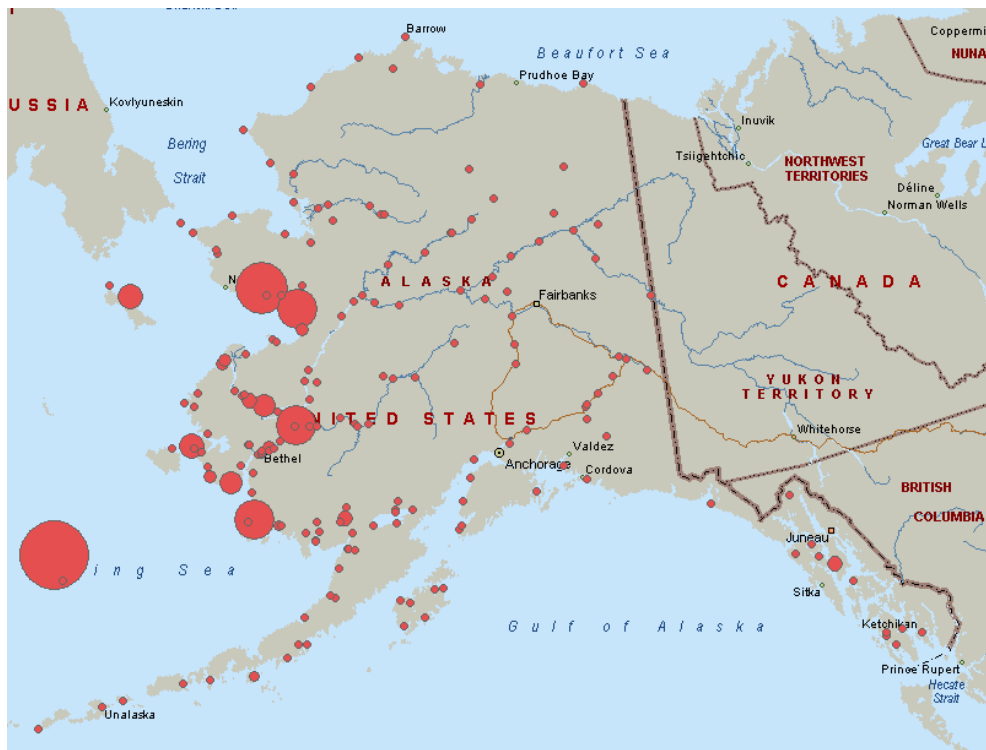




4. Alaska Native Villages Studied (Dots are proportional to village size.)



5. Alaska Native Villages Tuberculosis Deaths (Dots are proportional to village tuberculosis death rate.)




**B. IRB Documentation**

Office of Research and Sponsored Programs  
201J University Hall  
3640 Col. Glenn Hwy.  
Dayton, OH 45435-0001  
(937) 775-2425  
(937) 775-3781 (FAX)  
e-mail: rsp@wright.edu

**DATE:** June 10, 2009

**TO:** Sarah McBeth, P.I., MD/MPH Candidate  
Community Health  
Sara Paton, Ph.D., Asst. Prof.  
Community Health

**FROM:** B. Laurel Elder, Chair  
WSU Institutional Review Board 

**SUBJECT:** SC# 3915  
*'A Correlation Analysis of Community Characteristics and Respiratory Infection Death Rates in Alaska Native Villages'*

At the recommendation of the IRB Chair, your study referenced above has been recommended for exemption. Please note that any change in the protocol must be approved by the IRB; otherwise approval is terminated.

This action will be referred to the Full Institutional Review Board for ratification at their next scheduled meeting.

**NOTE: This approval will automatically terminate one (1) year after the above date unless you submit a "continuing review" request (see [http://www.wright.edu/rsp/IRB/CR\\_sc.doc](http://www.wright.edu/rsp/IRB/CR_sc.doc)) to RSP.**

If you have any questions or require additional information, please call Robyn Wilks, IRB Coordinator at 775-4462.

Thank you!

Enclosure

## RESEARCH INVOLVING HUMAN SUBJECTS

SC# 3215

ACTION OF THE WRIGHT STATE UNIVERSITY  
EXPEDITED REVIEW

Assurance Number: FWA00002427

Title: 'A Correlation Analysis of Community Characteristics and Respiratory Infection Death Rates in Alaska Native Villages'

Principal Investigator: Sarah McBeth, P.L., MD/MPH Candidate  
Community Health  
Sara Paton, Ph.D., Asst. Prof.  
Community Health

The Institutional Review Board Chair has approved an exemption with regard to the use of human subjects on this proposed project.

REMINDER: Federal regulations require prompt reporting to the IRB of any changes in research activity [changes in approved research during the approval period may not be initiated without IRB review (submission of an amendment), except where necessary to eliminate apparent immediate hazards to subjects] and prompt reporting of any serious or on-going problems, including unanticipated adverse reactions to biologicals, drugs, radioisotope labeled drugs or medical devices.



Signed

Chair, WSU-IRB

Approval Date: June 10, 2009

IRB Mtg. Date: July 20, 2009

### C. Public Health Competencies

- Analytical / Assessment Skills
  - Defines a problem
  - Selects and defines variables relevant to defined public health problems
  - Applies ethical principles to the collection, maintenance, use, and dissemination of data and information
  - Makes relevant inferences from quantitative and qualitative data
  - Applies data collection processes, information technology applications, and computer systems storage/retrieval strategies
  - Recognizes how the data illuminates ethical, political, scientific, economic, and overall public health issues
- Policy Development/Program Planning Skills
  - Collects, summarizes, and interprets information relevant to an issue
- Cultural Competency Skills
  - Identifies the role of cultural, social, and behavioral factors in determining the delivery of public health services
  - Understands the dynamic forces contributing to cultural diversity
- Basic Public Health Sciences Skills
  - Defines, assesses, and understands the health status of populations, determinants of health and illness, factors contributing to health promotion and disease prevention, and factors influencing the use of health services
  - Understands the historical development, structure, and interaction of public health and health care systems
  - Applies the basic public health sciences including behavioral and social sciences, biostatistics, epidemiology, environmental public health, and prevention of chronic and infectious diseases and injuries
  - Identifies and retrieves current relevant scientific evidence
  - Identifies the limitations of research and the importance of observations and interrelationships
  - Develops a lifelong commitment to rigorous critical thinking
- Leadership and Systems Thinking Skills
  - Identifies internal and external issues that may impact delivery of essential public health services (i.e. strategic planning)