UNIVERSITY OF CALGARY

Geomapping Influenza in the Calgary Health Region

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF COMMUNITY HEALTH SCIENCES

CALGARY, ALBERTA

JULY, 2008

Abstract

This study examined the use of Geographic Information Systems (GIS) to describe the spatiotemporal distribution of laboratory-confirmed influenza in the Calgary Health Region (CHR), over the 2006-2007 season. The influenza season peaked in December 2006, which had the largest number of influenza cases and outbreaks in one month. Most of the outbreaks over the season were in schools. Cases with the H3 influenza A subtype were significantly older than those with the H1 subtype. GIS proved to be very useful in providing a visual description of the spatiotemporal distribution of influenza cases and outbreaks over the season. The influenza cases identified were scattered all over the CHR, with the largest proportion being within the city of Calgary. Influenza outbreaks occurred in areas with both high and low rates of individual influenza cases. No correlation was observed between rates of influenza and the 2001 Socio-Economic Status variables.

Acknowledgements

I would like to extend sincere thanks and gratitude to a few individuals for all of their effort, and for so generously giving their time and knowledge to assist me in this program.

To my committee, Dr. Elizabeth. A. Henderson, Dr. Judy MacDonald, Dr. David Strong, Dr. Kevin Fonseca, and Ms. Afsheen Remtulla, for all of their guidance and advice throughout the study. I would like to especially thank Dr. Henderson for being such an incredible and attentive supervisor, without whom I would not have made it through this program. Special thanks also to Dr. Fonseca and Ms. Remtulla for helping to make the data collection process so effortless.

To all of the professors, teaching assistants, and administrative staff in the Department of Community Health Sciences, for all of their help and guidance through the program. Special thanks to Joseph Amuah for his invaluable assistance with statistical analysis.

To Tom Stowe for guiding me through the ProvLab databases, and to Leah Wuitschik, Sally Strople, and Maya Charlebois, for so graciously assisting me with the collection of missing data.

Very special thanks to Laurie Schretlen and Rizwan Shahid for guiding me through the mapping process, and for patiently answering my numerous questions on GIS.

Dedication

For Mom and Dad

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List of Abbreviations

Abbreviation	Definition
CHR	Calgary Health Region
CMA	Census Metropolitan Area
CTs	Census Tracts
GIS	Geographic Information Systems
H	Hemagglutinin
ILI	Influenza-Like-Illness
N	Neuraminidase
NE	North-East quadrant of the city of Calgary
NW	North-West quadrant of the city of Calgary
ProvLab	The Alberta Provincial Laboratory for Public Health
SE	South-East quadrant of the city of Calgary
SES	Socio-Economic Status
SW	South-West quadrant of the city of Calgary
TARRANT	The Alberta Recording and Research Network

CHAPTER 1: INTRODUCTION

Influenza is the greatest cause of annual morbidity and mortality worldwide (Monto, 2000). It is estimated that influenza affects about 500 million people every year (approximately 10% of the world's population) (Gerdil, 2003). Influenza continues to be a very important public health issue because of its wide scale impact all over the world. Surveillance of influenza is crucial to understanding the disease better and in planning and implementing prevention and control strategies. One method that could potentially be employed for this process is the use of Geographic Information Systems (GIS) for influenza surveillance. This study examined the feasibility of using GIS for influenza surveillance in the Calgary Health Region.

Purpose and Objectives

The purpose of this study was to examine the feasibility of mapping the geographic distribution of influenza as it appeared in the Calgary Health Region (CHR) using Geographic Information Systems (GIS). The primary objective was to employ GIS to describe the spatiotemporal patterning of laboratory-confirmed influenza in the CHR over the 2006-2007 respiratory season. Secondary objectives were the following:

1) To examine the age and sex distribution of individuals with influenza in the region over the season; and

2) To assess whether there was an association between Socio-Economic Status and influenza distribution.

CHAPTER 2: BACKGROUND

Introduction

Disease surveillance will be discussed in this chapter, including the important components and characteristics of a surveillance system. The main types of surveillance used for influenza will be presented. The characteristics of influenza will be discussed. This will include the virology of influenza, its transmission, and the clinical manifestations and complications that may occur as a result of influenza infection. The epidemiology of seasonal and pandemic influenza will also be discussed, as well as the use of vaccination and antiviral agents for prevention and management of the disease.

The characteristics and uses of Geographic Information Systems (GIS) software will be presented in this chapter. Examples will be given on the use of GIS in mapping environmental contaminants and biological agents. The mapping of non-infectious and infectious disease using GIS applications will be discussed, with particular emphasis on the use of GIS for influenza surveillance. Influenza surveillance in the Calgary Health Region will also be presented.

Surveillance

Disease surveillance is very important as it provides information on changes in disease incidence and affected groups, and for the planning of prevention, response, and control strategies (Flahault et al, 2006). Surveillance is the ongoing systematic collection, analysis, and interpretation of disease and health data, which is important to the planning, implementation, and evaluation of public health practice. An important part of the process is the timely dissemination of this data to those who need to know. Surveillance is important for the following: 1) it helps in guiding public health strategies and policies; 2) it assists in assessing the impact of an intervention, or progress towards a particular public health goal; 3) it enables the monitoring of the epidemiology of a condition to assist in the setting of priorities; and 4) it serves as an early warning system and helps to identify public health emergencies (World Health Organization, 2008). Surveillance is also important for the detection of cases, estimating the impact of a disease, and in stimulating research and the formulation of hypotheses (Buehler et al, 2004).

A surveillance system must have a number of components that make up the system. Firstly, it is important to determine the population that is under surveillance. The second component of a surveillance system is the case definition. The type of data that is collected, how it is collected, data sources, as well as the time period for the collection of data are also important. Other surveillance components are how and where the data is stored, and the maintenance of confidentiality and system security. Finally, the mechanisms for data analysis and dissemination must be determined (Centers for Disease Control and Prevention, 2001).

Surveillance systems vary widely according to a number of factors. These factors determine the type of system that is set up. One of these factors is the stakeholders for a system. Stakeholders may include the following: federal, provincial, and/or regional governments; research organizations; those who collect the data and carry out the analysis; those who support the technology that is used for surveillance; and those who provide the support for the development of the system and for its use. The other factors that determine the nature of a surveillance system are as follows: 1) the purpose of the system; 2) the population that is under surveillance; 3) the type of information that is collected for the system; 4) who uses the surveillance system; and 5) the action that is expected to be taken from the analysis of data and its interpretation (Health Surveillance Coordinating Committee, 2004).

The common characteristics of surveillance systems are of great importance as they help in assessing the usefulness of a system, and whether or not it is accomplishing its objectives. The acceptability of the system is determined by the willingness of stakeholders to participate in it. The structure of the system and how easy it is to operate are important. Another characteristic is the flexibility of the system to accommodate changes that may occur in the information needed, or the way that it is operated. The quality of the system data is important, and this is determined by the completeness of the data and its validity. Other system characteristics include the proportion of individuals that are reported to the system who actually have the health event being surveyed (positive predictive value), and the proportion of cases with the health event that the system is able to detect (sensitivity). Sensitivity also encompasses the ability of the system to detect outbreaks, and changes that may occur in the number of cases over time.

How representative the system is in reflecting the incidence of the health event in the population by person, place, and time is another major characteristic. The timeliness of the surveillance system is measured by the time between the occurrence of the health event and the report of the event to the health agency, the identification of trends and outbreaks by the health agency, and/or the implementation of control measures. Finally, how stable and reliable the system is, and how long it takes to disseminate information to those who make decisions are important characteristics of the system (Health Surveillance Coordinating Committee, 2004).

Influenza Surveillance

Influenza surveillance is carried out in many countries for several important reasons. One major reason is that influenza causes significant morbidity and mortality in large numbers of people every year. Secondly, epidemics of the disease occur every season. Influenza also causes the expenditure of vast amounts of resources. Finally, influenza is detectable, preventable, and control measures for influenza illness do exist.

There are four main types of surveillance used to monitor influenza and Influenza-Like-Illness (ILI), namely syndromic surveillance, sentinel surveillance, laboratory-based surveillance, and global surveillance.

Syndromic Surveillance

Syndromic surveillance is used as an early warning system for the detection of infectious diseases and for the rapid identification of disease clusters (Ritzwoller et al, 2005). This system uses the signs and symptoms of clinical diagnoses as early indicators of infectious disease transmission (Wijngaard et al, 2008). Syndromic surveillance allows for syndromes to be detected before the results of laboratory diagnoses are available, which may take days or even weeks (Miller et al, 2004). It also allows for the detection of syndromes for which there was no additional diagnosis available or requested (Wijngaard et al, 2008). In many cases, the diagnoses are non-specific and the case diagnosis is not confirmed. Various data sources are used for syndromic surveillance, such as ambulance dispatch data, emergency room complaints, and clinical diagnosis data. Private practice billing codes that are grouped into syndromes can also be used. Other potential data sources include nurse help-line telephone logs, and over-the counter and prescription medication sales (Miller et al, 2004). The expansion of this type of surveillance may enhance the ability of public health systems to identify outbreaks of infectious diseases and respond in a timely manner (Ritzwoller et al, 2005).

Clinical diagnosis of influenza based on symptoms is limited because the symptoms of influenza overlap with those of illnesses caused by other pathogens (Centers for Disease Control and Prevention, 2006). Syndromic surveillance has been used successfully in the past for diseases that are infrequent and have syndromes that are quite specific (Buehler et al, 2004). The usefulness of syndromic surveillance for influenza is increased when it is combined with other surveillance types such as sentinel and laboratory-based surveillance

Sentinel Surveillance

Sentinel surveillance is the collection and analysis of disease data by particular institutions and individuals who are selected for this purpose because of their medical speciality, ability to accurately diagnose and report on data, and their geographic location (Surveillance Working Group, 2008). Sentinel physicians are usually general practitioners within the community who report on ILI in their patients and provide specimens for diagnostic tests for influenza (Surveillance Working Group, 2008). Sentinel surveillance is very important as these physicians provide information on how ILI is circulating in the community and assist in the detection of epidemics. The specimens that sentinel physicians provide for laboratory diagnosis help in identifying the influenza strains that are circulating in the community. The usefulness of data provided by sentinel systems may be limited because this data may not represent disease incidence in the general population as sentinel physicians may only be located in specific areas. The level of reporting may differ among the sentinel physicians, leading to under-representation of some regions and therefore disease estimates that may be erroneous.

Laboratory-Based Surveillance

Laboratory-based surveillance of influenza is important in confirming influenza infection. This helps to reduce inappropriate treatment with antibiotics, and allows for the use of antiviral therapy if it is done in a timely manner. The results of diagnostic tests should however be interpreted in relation to epidemiologic and clinical information that is available (Centers for Disease Control and Prevention, 2006).

The types of specimens used for laboratory diagnosis of influenza are nasopharyngeal, throat, or nasal aspirates, swabs, or washes. These should be taken within the first four days of illness in order to be most useful (Centers for Disease Control and Prevention, 2007).

Rapid laboratory tests for influenza provide results within 30 minutes (Centers for Disease Control and Prevention, 2006). These are important in the rapid response to, and control of influenza outbreaks (Surveillance Working Group, 2008). These tests vary however in the types of influenza that they can detect, and whether or not they can distinguish between types of influenza. They also do not provide any information on influenza A subtypes. The sensitivity of rapid tests is lower than that for viral culture. As a result, there are more false negative results with rapid tests than with viral culture (Centers for Disease Control and Prevention, 2006). In potential outbreak situations, specimens are taken from multiple affected individuals to increase the likelihood of identifying an influenza outbreak because of the low sensitivity of rapid tests. This allows for appropriate control measures to be implemented as quickly as possible.

Standard viral culture tests for influenza provide results in 3-10 days (Centers for Disease Control and Prevention, 2007). A major advantage of laboratory-based surveillance is that viral culture specimens provide valuable information on the circulating influenza subtypes and strains. This information is important to guide decisions on influenza vaccines, prophylaxis, and treatment. This type of surveillance is also critical for monitoring the emergence of antiviral resistance and novel influenza strains that may pose a pandemic threat (Centers for Disease Control and Prevention, 2006).

A disadvantage of laboratory-based surveillance is that it is dependent upon other surveillance systems to provide the specimens that are tested for influenza. The amount of time that viral cultures take limits the response to influenza epidemics as the control of epidemics is largely dependent on a quick response. This time lag limits the use of antiviral therapy as influenza antivirals work best within the first 48 hours of symptom onset.

Global Surveillance

The World Health Organization (WHO) coordinates global influenza surveillance allowing for the detailed analysis of circulating virus strains in humans, birds, and pigs. This enables the identification of newly evolved variants of influenza A and B that may be able to cause disease in humans. This surveillance data is monitored regularly to keep track of what is happening globally. Twice a year, investigators at the WHO Collaborating Centers for Influenza Reference and Research in Atlanta, Tokyo, London, and Melbourne review the data to determine which variants are likely to cause human illness in the upcoming influenza season. This informs their recommendation for the formulation of the influenza vaccine for the Northern and Southern Hemispheres (in February and September respectively). Vaccine manufacturers have six months to produce the vaccine and deliver it to healthcare providers (Gerdil, 2003).

Influenza

Influenza causes the greatest amount of disability, restriction of activity, and lasts the longest of all upper respiratory illnesses (Monto, 2000). In Canada, between 4,000 and 8,000 people die from influenza and its complications every year (Public Health Agency of Canada, 2005). Globally, the number of deaths is estimated at about one million (Influenza Sub-Committee, 2007). Influenza also has a major impact on the world's economy. It is estimated that in the United States alone, seasonal influenza epidemics cost in excess of $14 billion USD per year (Monto, 2000).

Virology of Influenza

There are three types of influenza viruses, A, B and C. Influenza viruses are classified into these types based on their matrix and nucleocapsid proteins, such that all type A viruses share common internal antigens that are different from those of all type B viruses, and those of type C viruses (Strohl et al, 2001). Only A and B viruses cause outbreaks (Nicholson et al, 2003). Influenza A viruses were first isolated from humans in 1933 in the United Kingdom, and in 1934 in the United States. Influenza B viruses were first isolated in 1940. Type C was isolated later. Influenza C causes mild respiratory illness and has only been found in humans (Monto, 2000). Influenza B has been found in humans and seals (Osterhaus et al, 2000).

Influenza A viruses show great antigenic diversity because they have genomes that are segmented. This means that the genetic material of the virus is divided up into separate parts that can change individually. This genetic make-up facilitates reassortment of the segments (Nicholson et al, 2003). When two different influenza viruses coinfect the same cell they can exchange genetic material leading to the creation of a new virus strain. The influenza A genome has eight separate genes which encode the production of one or more proteins. These proteins are important either in making up the virus itself, or in regulating its growth within cells (Monto, 2000).

Influenza A viruses are divided up into subtypes according to differences in their two surface glycoproteins, hemagglutinin and neuraminidase. Hemagglutinin facilitates the attachment and entry of the virus into host cells and is the main antigenic component that host antibodies respond to. It is also the most important component of current influenza vaccines because the body mounts a stronger immune response to hemagglutinin than it does to neuraminidase. Neuraminidase facilitates the release of progeny virions from infected cells and their spread within the respiratory tract. Neuraminidase is an important target for antiviral agents (Nicholson et al, 2003).

So far, there have been 16 hemagglutinin antigens (H1 to H16), and nine neuraminidase antigens (N1 to N9) identified. Viruses with all of these subtypes have been identified in wild birds, which are considered to be the natural reservoir for influenza A (Nicholson et al, 2003). Some of these subtypes have also been detected in pigs, domestic poultry, horses, whales, and seals (Nguyen-Van-Tam and Hampson, 2003). Only three of the hemagglutinin subtypes (H1, H2, and H3), and two of the

neuraminidase subtypes (N1 and N2) have been found to be stable within the human population since 1918 (Nicholson et al, 2003).

Unlike influenza A, influenza B is not classified according to subtypes. Influenza B is associated with morbidity and mortality in humans, but generally causes seasonal epidemics that are less severe than those caused by influenza A (Centers for Disease Control and Prevention, 2005). Influenza B does not cause pandemics, whereas influenza A does because of its ability to mutate or reassort into a novel virus strain to which most of the world's population has little or no immunity (Wareing and Tannock, 2002).

Antigenic Drift and Shift

Two types of variation occur in the surface glycoproteins of influenza viruses, antigenic drift and antigenic shift. In antigenic drift, new virus strains emerge due to point mutations in the surface glycoproteins. These strains are related to those circulating in prior epidemics. Antigenic drift allows the virus to evade host immune systems which leads to the influenza epidemics that occur seasonally, and is the reason why a new vaccine is needed each year (Nicholson et al, 2003).

Antigenic shift refers to major changes in the viral hemagglutinin, which may or may not be accompanied by major changes in neuraminidase. Antigenic shift leads to a strain of influenza which may be quite different from the strains that circulated in prior years. When antigenic shift occurs, the conditions exist for an influenza pandemic to take place (Monto, 2000).

Both influenza type A and B viruses undergo antigenic drift from year to year. Only type A has also shown antigenic shift (Strohl et al, 2001). Seasonal influenza epidemics can therefore be caused by either influenza A or B, but the influenza pandemics that have occurred so far in history have all been caused by influenza A

Influenza Transmission

Influenza infections are primarily spread by respiratory droplets laden with virus that are expelled through coughing and sneezing. Influenza is also transmitted through fomites which are inanimate objects that are contaminated with the virus. The vehicle of transmission is often contaminated hands that then have contact with mucous membranes (i.e. eyes, nose, or mouth). The virus has been shown to survive on surfaces such as steel and plastic for up to 48 hours (World Health Organization Writing Group, 2006). Influenza is occasionally transmitted to people from pigs and birds when they live in close proximity (Nicholson et al, 2003).

The incubation period for influenza ranges from one to four days with an average of two days (Monto, 2000). Most adults are infectious one day before symptoms begin and up to five days after (Centers for Disease Control and Prevention, 2008). Children shed higher titres of the virus for longer periods of time than adults. They are able to spread influenza for more than seven days, and the virus can be detected from them for several weeks after the onset of symptoms (Nicholson et al, 2003).

There has been some controversy over the transmission of influenza. One of the factors under discussion is how significant transmission is from infected individuals before the onset of symptoms, or from those who do not show symptoms at all. Experimental and observational studies have shown that infected individuals start to excrete low levels of the virus from their respiratory tracts before the onset of symptoms. Serological studies of immunity in the population have also shown that some individuals have antibodies to influenza infection and yet may not recall having symptoms. There are however, only a few reports of infections that have been spread by pre-symptomatic or asymptomatic persons, therefore the importance of this type of transmission remains unclear (Influenza Team, European Centre for Disease Prevention and Control, 2007).

There has also been controversy over the amount of transmission that takes place through fomites, from large droplets, and from aerosols. Human to human transmission through fomites has been rarely documented and is not well studied. Influenza transmission is most often attributed to the expulsion of respiratory particles through coughing and sneezing which produce large droplets (>=5µm). Large droplets do not stay in the air for very long distances such that the risk of transmission of the virus falls considerably beyond a metre from the infected individual (Influenza Team, European Centre for Disease Prevention and Control, 2007).

It is also uncertain whether or not there is transmission through smaller aerosolized particles (<5µm). If this were the case, influenza viruses would be able to travel over longer distances. Some micro-organisms such as varicella are transmitted through aerosols and one infected individual can infect many others, whereas influenza

transmission from an infected symptomatic individual is to an average of less than two people (Influenza Team, European Centre for Disease Prevention and Control, 2007).

Clinical Manifestations and Complications

Initial replication of the influenza virus occurs in the ciliated epithelial cells of the trachea and bronchi. The whole respiratory tract however, is involved in replication. A rapid onset of cough and fever (greater than 37.8˚C) are the most predictive symptoms of influenza. Fever may however not be present in the elderly (Nicholson et al, 2003). Other classic clinical symptoms include nasal congestion, a sore throat, myalgia, and malaise which can be debilitating for two days or more. Fever may last for as long as five days, but malaise and cough can last up to several weeks. Influenza can also cause a cold or other respiratory syndrome that does not show the classic symptoms (Monto, 2000). More than 20% of influenza infections are subclinical. Individuals not showing symptoms may however still be infectious (Walker et al, 2006).

How influenza affects an individual is dependent on a variety of factors. In healthy individuals, influenza is often a self-limiting disease. The characteristics of the virus itself are important because some strains are more pathogenic than others. The level of pre-existing immunity in an individual also has a role in severity of disease. Some individuals may be more immune to a virus strain than others if they have encountered it or a similar strain before. Immunosuppression renders an individual more likely to become ill when infected and to develop complications as their immune system is not able to perform its normal functions. The age of an individual and the presence of

comorbidities (which will be discussed in the next section) are also important (Nicholson et al, 2003).

Complications that commonly occur following influenza include myocarditis, pericarditis, pneumonia, bronchitis, and sinus and ear infections. Influenza can also destabilize or aggravate pre-existing conditions such as diabetes, asthma, chronic congestive heart failure, and chronic obstructive pulmonary disease. These complications can lead to death.

Children with chronic conditions, and adults 65 years of age and older are at higher risk for developing severe complications from influenza (Nguyen-Van-Tam and Hampson, 2003). Over the 2002-2003 influenza season in the Calgary Health Region (CHR), the largest group of patients (39%) admitted to the hospital for influenza and influenza-related complications was those aged 65 years and older. The highest mortality rate (25%) was also found in this age group (Henderson, 2004).

Epidemiology of Influenza

Epidemiology is the study of the frequency, distribution, and determinants of disease in populations (Mayhall, 2004). It is also defined simply as the study of the occurrence of disease (Rothman, 2002). The “frequency of disease” refers to the identification of a disease and the quantification of its occurrence. The “distribution of disease” encompasses three main aspects: where disease is occurring; when it is occurring; and in whom it is occurring. Hypotheses are formulated and tested in order to identify risk factors and therefore the possible “determinants of disease” (Lautenbach and Woeltje, 2004). The epidemiology of influenza is different for seasonal and pandemic

influenza. The occurrence of seasonal or pandemic influenza is determined in part by antigenic drift and shift in the virus (*Refer to page 12*).

Seasonal Influenza

Inter-pandemic or seasonal influenza is characterised by very low levels of influenza transmission over the summer months in the northern and southern temperate zones, followed by an upsurge in transmission over the winter months. Both the intensity and the duration of seasonal influenza vary from season to season. The influenza season usually lasts for three to six months. There is often more than one influenza strain circulating during the season (Nguyen-Van-Tam and Hampson, 2003).

In tropical and sub-tropical regions influenza usually occurs all year although some seasonal increases in transmission may be observed (Nguyen-Van-Tam and Hampson, 2003).

The normal influenza mortality curve resembles a U-shape. In children, mortality is highest in those under one year of age. Mortality is low in those 18-45 years of age then begins to increase with people 45-64 years of age, with a sharper increase for those 65 years of age and above. This increase relates to there being a larger proportion of people above 64 years of age with chronic and high-risk conditions (Monto, 2000).

Complications and death due to seasonal influenza usually occur in those with chronic illnesses, the very young, and the elderly. The hospitalization rates for children less than one year of age are similar to those for high-risk adults (Nguyen-Van-Tam and Hampson, 2003).

Pandemic Influenza

Influenza pandemics occur when a novel influenza virus emerges. Most of the world's population has little or no immunity to it (Nguyen-Van-Tam and Hampson, 2003). The emergence of a novel virus alone however, is not sufficient to cause a pandemic. The virus has to be able to replicate in humans and to spread efficiently from one person to the next (Nicholson et al, 2003)

Influenza pandemics are not constrained by season, occur in waves lasting 12-15 weeks, and may last for two or more years. They not only cause high mortality, but also high morbidity, social disruption, and economic loss (Cox et al, 2003). One characteristic of a pandemic is that it may not follow the usual trend of age-specific mortality that is seen in seasonal influenza epidemics, as evidenced by the 1918-1919 pandemic. In England and Wales during the first quarter of 1918, the seasonal age-specific mortality trend continued. In the last quarter however, during the second wave of the pandemic, the death rates among those less than 40 years of age rose dramatically, with the highest rates being among those between the ages of 25 and 29 (Nguyen-Van-Tam and Hampson, 2003).

Four of the five recorded influenza pandemics occurred in the 20th century. The H1N1 pandemic of 1918-1919 was the most devastating. It is estimated that during this pandemic, about 50% of the world's population became infected, with half of these people showing clinical symptoms (Nguyen-Van-Tam and Hampson, 2003). Mortality was estimated at about 40-50 million deaths (Nicholson et al, 2003).

Influenza viruses circulate throughout the year in southern China. There is evidence that the H2N2 pandemic of 1957, and the H3N2 pandemic of 1968 both originated in China. It is thought that this region provides the appropriate ecological niche for the emergence of novel and potentially pandemic viruses because of the close proximity of dense human populations, pigs, and wild and domesticated birds. This facilitates the genetic reassortment of viruses from different species (Nicholson et al, 2003).

It is not possible to predict when the next pandemic will occur or how severe it will be. Most experts feel however, that an influenza pandemic is inevitable (Monto, 2000).

Major interest has been shown in various strains of the viruses that cause avian influenza. Avian influenza viruses normally infect birds and sometimes pigs. These viruses are highly species-specific but have been able to cross the species barrier and infect humans on rare occasion (World Health Organization, 2008). It is believed that the strain which caused the major influenza pandemic of 1918 originated in birds (Monto, 2000).

Over the last few years, a highly pathogenic strain of avian influenza has spread over a large geographic area in Asia and Eastern Europe. This is a type A virus of the subtype H5N1 (World Health Organization, 2006). This virus was first identified in humans in Hong Kong in 1997 (Oyana et al, 2006). It has caused the greatest number of severe cases of illness and death in humans of the few avian influenza viruses that have crossed the species barrier to infect humans (World Health Organization, 2005). The virus had caused illness in approximately 379 people (laboratory-confirmed cases) by

April 8th, 2008, and led to the death of 239 people in Djibouti, Egypt, Turkey, Indonesia, Cambodia, China, Myanmar, Nigeria, Pakistan, Vietnam, Azerbaijan, Iraq, Lao People's Democratic Republic, and Thailand (World Health Organization, 2008).

Most of the human avian influenza cases identified with the H5N1 subtype were previously healthy young adults and children (World Health Organization, 2005). No sustained human-to-human transmission has yet been shown. Current evidence indicates that the principal source of H5N1 infection in humans is close contact with sick or dead birds (Reyes et al, 2008). It is feared that this strain of avian influenza may mutate or undergo genetic reassortment to become a strain that can be easily transmissible from one person to the next and lead to a pandemic (National Wildlife Health Center, 2006).

Prevention and Management

Vaccination

Vaccination is the most effective way to reduce the impact of influenza by reducing the likelihood of infection, and decreasing the severity of the disease in those who do become infected (Influenza Sub-Committee, 2007). Vaccines have been shown to significantly decrease complications and death due to influenza (Monto, 2000). Vaccines have also been shown to prevent laboratory-confirmed illness in about 70% of healthy individuals when there is a good match to the circulating influenza strains (National Advisory Committee on Immunization, 2006). Vaccination recommendations vary from country to country but most of them consist of the annual vaccination of the elderly and those with chronic conditions (Nicholson et al, 2003). Antibodies against influenza

develop in the body about two weeks after vaccination (Centers for Disease Control and Prevention, 2008).

The Canadian National Advisory Committee on Immunization (NACI) recommends that those at increased risk of complications due to influenza, and those that may be able to transmit influenza to these individuals, be vaccinated for influenza every year. Those at increased risk of complications due to influenza include adults and children with chronic conditions such as pulmonary or cardiac disorders, cancer, immunodeficiency or immunosuppression, diabetes mellitus, renal disease, anaemia, and hemoglobinopathy. Residents of continuing care facilities, individuals over the age of 64 years, pregnant women, and healthy children between the ages of six and 23 months, are also considered to be at high risk of influenza-related complications (National Advisory Committee on Immunization, 2007). Individuals who may be able to transmit influenza to high-risk persons include health care providers, emergency response workers, those in contact with residents of continuing care facilities, those providing care at home, regular visitors, pregnant women (to their newborns), and household contacts. The immunization of individuals providing essential community services is also recommended in order to minimize the disruption of services during annual influenza epidemics. The NACI does however, encourage influenza immunization for all individuals (National Advisory Committee on Immunization, 2006).

The first influenza vaccine was produced in the 1940s (Gerdil, 2003). Influenza vaccines are produced from viruses grown in fertile hens' eggs (Nicholson et al, 2003). As a result, they are not to be administered to individuals known to have allergic reactions to chicken or egg proteins (Committee on Infectious Diseases, 2008). Two

subtypes of influenza A (H3N2 and H1N1), and one strain of influenza B are currently included in the vaccines (Gerdil, 2003).

There are two types of influenza vaccine. The inactivated vaccine or “flu shot” contains killed virus particles and is given with a needle intramuscularly. There may be soreness at the injection site which may last up to two days (National Advisory Committee on Immunization, 2006). This vaccine cannot cause influenza as it does not contain live virus. It might, hypothetically, cause mild influenza-like symptoms as it induces the same cytokines that are associated with an influenza infection. The inactivated vaccine is approved for use in all people six months of age and above (Committee on Infectious Diseases, 2008).

The live attenuated vaccine contains live weakened virus and is administered in the form of a nasal spray. It is approved for use in healthy individuals who are 2-49 years of age and not pregnant (Centers for Disease Control and Prevention, 2008). This vaccine is not currently licensed for use in Canada. Live attenuated vaccines may potentially produce mild signs and symptoms of influenza infection (Committee on Infectious Diseases, 2008). They mimic a natural infection giving a broader immune response and therefore more durable protection than inactivated vaccines (Nicholson et al, 2003).

Antiviral Agents

Antiviral drugs have been shown to decrease the duration of influenza illness by about 1.5 days if taken within 48 hours of symptom onset, and to be 70-90% efficacious when used as prophylaxis (for influenza prevention). They may prove to be crucial in the early stages of a pandemic when vaccine supplies will be severely limited (Monto, 2003).

Two classes of antiviral drugs are currently used for influenza management. The first class consists of the M2 ion channel blockers called amantadine and rimantadine. The M2 ion channel is only found in influenza A and regulates the internal pH of the virus. This is crucial to viral replication (Nicholson et al, 2003). Changes occurring in the M2 protein are related to resistance to these two drugs (Monto, 2000).

Amantadine has three limitations: it has no effect on influenza B (which has no M2 protein); it has adverse side-effects such as insomnia, confusion, dizziness, hallucinations, and headaches; and resistance to it emerges quickly during treatment. Rimantadine has less severe side-effects but is not available in most parts of the world, and is not approved for use in Canada (Nicholson et al, 2003). Amantadine and rimantadine are inexpensive and are taken orally (Monto, 2003).

The second class of antivirals consists of the neuraminidase inhibitors including zanamivir and oseltamivir. They interrupt the replication cycle of the virus by preventing the release of influenza virions from infected cells, and by causing them to clump together (Monto, 2003). Zanamivir is administered through an inhaler and can be used for treatment of influenza A and B in people aged 12 years and above. Oseltamivir is administered orally and is used for treatment of influenza A and B in people aged one year and above (Nicholson et al, 2003). Both zanamivir and oseltamivir are also used for prophylaxis of influenza A and B. Zanamivir is used for prophylaxis in individuals over four years of age, and oseltamivir is used in individuals aged one year and above (Hayden and Pavia, (2006).

The efficacy of neuraminidase inhibitors is higher if they are administered within 48 hours of symptom onset. Resistance to these antivirals has been low so far. The use of neuraminidase inhibitors is limited however as their production is complex, time-consuming, and expensive (World Health Organization, 2008). Side effects include nausea, vomiting, abdominal pain, and headache (National Advisory Committee on Immunization, 2006).

Improving Strategies

Influenza continues to be an extremely important public health issue. As a result of its large-scale impact and the threat of an impending pandemic, it is imperative that prevention and control strategies continue to be improved. Improving these strategies is dependent on having complete and accurate information on the various circulating strains of the virus, how the disease is transmitted through a population, and how it affects communities. This in turn relies upon constantly improving the strategies that are used to gain this crucial information. Surveillance strategies have been developed within the CHR and expanded to gain as much knowledge as possible on the influenza virus, and how it affects the communities in the region. One potentially important strategy that could be used to gain additional knowledge on influenza, and which is yet to be studied in the CHR, is geomapping influenza as it occurs during the season as part of influenza surveillance.

Geographic Information Systems

Geographic Information Systems (GIS) are computer-based integrated systems of tools and methodologies that are used to analyze events that occur or things that exist on earth. They are designed to analyze data using geographical/spatial coordinates (GIS Development, 2006). They are used for the collection, storage, retrieval, analysis, and display of spatial and non-spatial information (Meade and Earickson, 2000). A GIS is able to combine statistical analysis of data with geographic analysis and visualization that can be obtained through the use of maps (GIS Development, 2006).

A GIS is also a process that creates a set of stacked map layers, where each layer contains a set of data that is unique but shares the same geography as the other layers on the map. Any number of layers can therefore be overlaid or combined in any way that will serve the purpose of the desired analysis (Queen and Blinn, 2006).

Data analyzed using GIS can be viewed on the computer or in hardcopy, as a map or in tabular format. The features shown using GIS can be presented in two-dimensional space in the form of points, lines, or polygons. This is called Vector Format GIS. The points have x,y coordinates that represent a place on the earth's surface, the lines join points together, and the polygons represent areas. These three types of features are used to represent objects on a map in the following manner: a point may be used to represent the location of a hospital or other type of health care facility; a line may represent a road or part of a transportation network; and a polygon may represent an area such as the CHR (Glass, 2004).

The rapid growth of the internet continues to influence the increasing interest in web-based GIS. This allows sharing of disease information over a variety of networks. The sharing of disease maps over the internet greatly assists in collaborative decision-making over health jurisdictions and authorities, and helps in responding to, controlling, or even preventing disease outbreaks. Comparisons of various variables at different times and on different geographic levels allows for the visualization of possible patterns in the movement of an infectious disease (Gao et al, 2008).

The Geography of Disease

The geography of disease, or medical geography, consists of the spatial analysis of pathological factors such as vectors, hosts, reservoirs, and causative agents, and their relationships to biological, physical, and cultural geographic environments (Cromley, 2003). Examples of medical geography will be discussed in the following sections.

Environmental Contaminants

GIS has been used in the study of environmental contaminants. Environmental contaminants are unnatural substances that may be placed into a natural system, or that are present in unnatural concentrations. These may include chemicals, the products of radioactivity, or even bacteria and viruses (United States Environmental Protection Agency and Environment Canada, 2005). One of the earliest ways in which GIS was used which had implications for the study of disease, was to map point sources where toxic chemicals were being released into the environment. One of the earliest supporters of the use of GIS in environmental health studies was the Agency for Toxic Substances and

Disease Registry in the United States. The agency adopted the use of GIS in 1990 and sponsored a workshop on GIS applications in risk analysis and public health in 1994. GIS is being used to implement recommendations on the management of groundwater contamination near wells, bringing together information on how these contaminants are distributed from a variety of sources. Non-point source pollution has also been analysed using GIS. The transportation of hazardous materials such as nuclear waste has been analysed using GIS applications that map out routes (Cromley, 2003).

GIS was used in a study in the late 1990s to map and evaluate arsenic concentrations in water that was drawn from 173 wells containing water from the Ogallala Aquifer in West-Central Texas. Arsenic compounds were applied to the cotton fields in that area as pesticides (a common practice in many agricultural areas in the United States). Arsenic was also present however, in naturally occurring rock formations in the area. The study showed that it was the application of the pesticides and not the rock formations that led to high concentrations of arsenic in the water. Higher concentrations of arsenic were observed at shallower water table depths, whereas groundwater samples near rock formations potentially bearing arsenic showed lower levels. Other agricultural chemicals were also detected at high concentrations in the water (Cromley, 2003).

Biological Agents

The monitoring of sources and geographical distribution of biological agents of disease using GIS has been shown to be more difficult than monitoring sources in the physical environment. Air and water quality monitoring systems have traditionally been more focussed on monitoring chemical and physical properties rather than on detecting

biological agents. The presence of biological agents is often detected only after there has been an outbreak of disease. Human case data is often relied upon to provide information on biological agents, especially if there is a short duration between exposure and the onset of disease (Cromley, 2003).

For example, the Centers for Disease Control and Prevention (CDC) in the United States has published a National Lyme Disease Risk Map which was developed using human case data (Cromley, 2003). GIS was used to combine information on human cases, the distribution and abundance of the vector (ticks), and infection prevalence in the host (mice and reptiles). Counties considered to be high risk were those where the populations of ticks were established, there was a high prevalence of infection in hosts, and the human cases reported were within the top tenth percentile from 1994 to 1997 (Centers for Disease Control and Prevention, 1999).

Mapping Diseases

The mapping of diseases has proven to be very useful in public health studies. One advantage of using disease maps is that they provide a visual means by which cause and effect relationships can be identified between humans and their environments. They also allow for health practitioners and the public to visually communicate about the distribution of disease (Gao et al, 2008). The mapping of diseases helps in the identification of disease clusters, in the monitoring of epidemics, and in providing baseline patterns of disease and identifying changes in these patterns over time. The identification of clusters may help in the generation of hypotheses on the physical, environmental, and biological risk factors that may increase the chances of a disease

occurring in a particular area (Elliott et al, 2000). GIS makes it easier to link spatially referenced physical and social phenomena to health, well-being, and disease patterns in the population (Krieger, 2003).

The CDC has projected that the use of GIS to map diseases will have a tremendous effect on public health in the future (Bush, 2004). GIS was originally developed by Departments of Defence in the Cold War for military purposes. It is now being used for applications that are quite different from those that were originally intended (World Health Organization, 2007). GIS software has been used extensively in various fields such as forestry, archaeology, engineering, criminal justice, and transportation. It has also been used in public health for the investigation of outbreaks (Bush, 2004).

An example of GIS use is in the monitoring of malaria control in various regions in Africa. GIS has been used in malaria control to identify areas that meet specific criteria, such as areas that are within 100 metres of a water source, areas that are low lying, or those with specific vegetation that encourages the breeding of mosquitoes. This has enabled the creation of buffers around areas with specific attributes (Cromley, 2003).

GIS tools are being used more and more in different regions of the world to assist with planning and implementing various public health strategies such as in risk assessment, disease surveillance, and the prevention and control of diseases (Bush, 2004). The use of GIS in public health is expanding rapidly due to the realization that: 1) most health data has a spatial component; 2) the use of maps can be very informative to public health; and 3) associating health data with other types of data such as environmental or census data can be of great value (Public Health Agency of Canada, 2007).

GIS is being used in public health for a variety of purposes including the following: 1) mapping populations at risk of disease; 2) determining the geographic distribution of disease and the spread of disease over time; 3) showing the spatial patterns of disease outbreaks; 4) planning and targeting interventions and monitoring these interventions over time; 5) assessing the allocation of resources; and 6) assessing the availability of, and access to health care (World Health Organization, 2007).

Non-infectious Diseases and Geographic Information Systems

GIS has been used in a variety of ways to help in the study of non-infectious diseases. It has been used to map the spatial distribution of possible hazards, exposures, and health outcomes, and to assess and implement possible interventions (Cromley, 2003).

For example, GIS was used in San Diego to study the association between residence near highly travelled roads and asthma in children. The locations of the residences of children 14 years of age and younger who were diagnosed with asthma in 1993 were compared to those of a random control group of children with nonrespiratory diagnoses. The number of medical visits the children with asthma had was also evaluated in relation to traffic levels. Traffic data was used to calculate the traffic counts at the highest traffic street, the nearest street, and all the streets within a 550 foot buffer around the residence. The analysis of the distribution of the cases and controls did not show any odds ratios that were significant. Analysis on children with asthma however, showed that those living near streets with high traffic flow were more likely to have two or more medical visits for asthma over the year than those living near low traffic flow. It was

suggested therefore that exposure to the exhausts of motor vehicles may aggravate the symptoms of asthma in children (Cromley, 2003).

GIS applications have not only been used to link hazards, exposures, and outcomes, but have also been used in some cases for intervention. A study was conducted in Jefferson County, Kentucky in which the blood lead concentrations in a cohort of children were mapped. The children in the study were those born in 1995 and screened in 1996 and 1997, and those that were less than seven years old and had been screened between 1994 and 1998. The data showed that only 79 homes had housed 35% of the 524 children with lead poisoning. The results of this study led to these housing units being made a high priority for lead hazard remediation. The data also showed that only half of the children who lived in zones that were designated for universal screening had actually been screened (Cromley, 2003).

Infectious Diseases and Geographic Information Systems

Dr John Snow is sometimes identified as being the first individual in public health to use GIS. He plotted a map of the deaths that occurred during an outbreak of cholera in London in 1854. The deaths were plotted in relation to the location of the communal water pump on Broad Street, and the pump mapped in relation to a variety of features such as factories, residences and workhouses (Glass, 2004). Dr Snow believed that the water coming from the pump was contaminated with untreated sewage that was dumped into the Thames River and into open pits near town wells. He suspected that those who lived and worked near the pump were more likely to use it, and therefore also more likely

to contract cholera. He used the map to convince his colleagues that cholera was caused by drinking contaminated water (Tuthill, 2003).

Although the use of GIS software tools is becoming more widespread, a wide gap still exists in the knowledge of the spatiotemporal distributions of infectious diseases in the human population (Oyana et al, 2006).

Influenza and Geographic Information Systems

A variety of GIS applications have been used to map the distribution of influenza and ILI in Asia, Europe, and Australia. Some of these studies have been country-wide and others have been over a provincial area. Examples of these studies are presented in the following section.

Sakai et al (2004) conducted a study in Japan which used GIS software to look at the spatiotemporal trends of ILI throughout that country from 1992 to 1999. ILI was defined on the basis of respiratory symptoms such as rhinitis, nonproductive cough and a sore throat, a sudden fever of over 38˚C, and myalgia. The investigators used information obtained from the Infectious Disease Surveillance Center at the National Institute of Infectious Diseases in Tokyo. This information had been generated through a surveillance system that included 663 health centres and sentinel paediatric and general physicians throughout the country. GIS software was used to map when ILI peaked in each of 46 prefectures during the annual influenza seasons over this time period. Peaks of disease were determined by calculating the number of reported ILI cases per sentinel per week. This study was able to show that the initial epidemic areas were the same in six of the seven influenza seasons studied. The investigators were also able to illustrate that the

influenza epidemics spread in concentric circles from the western-central part of Japan to the east in all of the seasons studied (Sakai et al, 2004).

Gierl and Schmidt (2005) used a similar geomedical information system in Mecklenburg-Western Pomeranian, Germany, to map influenza cases using area ZIP-codes. This was part of a geomedical early warning system for epidemics and possibly pandemics. The computer-based Telecommunication on Medical Events (TeCoMed) was used to assess the spatial and temporal spread of epidemics of communicable diseases. The investigators used a GIS application called ArcView to create maps to visualize the spatiotemporal spread of influenza. Data collection in this study was based on the use of sick certificates from a health insurance company in Mecklenburg-Western Pomeranian to detect cases of illness. This limited the sampling pool to only those members of the population who were employed and had their health insurance covered by this particular company. This group of people represented only about 27% of the total population in that state (Gierl and Schmidt, 2005). This method of data collection excluded a large number of possible cases within the communities in that area and may therefore have given results that did not truly represent the disease transmission within the state.

Carrat and Valleron (1992) used a different type of mapping called Kriging analysis. This is a statistical method used in the earth sciences to model spatial correlations and spatial trends (Torok et al, 1997). Kriging analysis was used in a study to map six successive weeks of an ILI epidemic that occurred in France in the winter of 1989-1990. The data used for mapping was obtained from 500 sentinel general practitioners practicing throughout the country. A case that was considered to be positive for ILI presented with myalgia, respiratory symptoms, and a sudden fever over 39˚C. The

mean weekly numbers of cases per practitioner were used to produce contour maps of the ILI epidemic. Successive curves on the maps were separated by four cases. The geographic coordinates of the departmental administrative centre (prefecture) were used to identify the locations of the cases such that all the cases within a prefecture were identified by one central location (Carrat and Valleron, 1992). Using just the geographic coordinates of the prefecture gave a non-specific representation of where the case most likely acquired the illness. The study did show the utility of mapping however, as the maps produced illustrated the temporal pathway of the epidemic as it moved progressively from north-western to southern France (Carrat and Valleron, 1992).

Carrat et al (1998) also conducted a study in France to assess if the continuous collection of ILI morbidity data from a sentinel network that was based on medical practices could be used to monitor epidemics of ILI. The investigators also looked at vaccine effectiveness. The collection of data was computerized. A subject was considered to be a case if they had a sudden fever of 39˚C or above, and respiratory symptoms or myalgias. A weekly national incidence rate for ILI that exceeded the seasonal threshold for two successive weeks was considered to be an epidemic. The incidence rates were calculated using the 1982 and 1990 census data for France. The results of the study showed that an ILI epidemic occurred between November 1995 and January 1996. The attack rate was highest in children of school age and decreased as the age rose. In order to map the outbreak, the investigators set the geographic location of each case to the geographic coordinates of their practitioner's practice (Carrat et al, 1998). Using the geographic coordinates of the practitioner's practice did not give a good representation of where the case was likely to have contracted the illness. The location of a practitioner's

practice is not necessarily the same as the area in which a patient lives. Another major weakness of this study was that there was no well-defined system for the collection of specimens and virological testing for influenza for those considered to be cases. The case definition for influenza depended primarily on the symptoms observed by the practitioner and whether or not they thought that those presenting with ILI actually had influenza (Carrat et al, 1998). This places the estimates of disease burden that were reported in the study into question as the symptoms that were observed may have been caused by other respiratory pathogens and may not necessarily be attributable to influenza.

Influenza surveillance in Victoria, Australia is conducted as a combination of surveillance of ILI through a metropolitan medical locum service, sentinel general practice surveillance for ILI with laboratory confirmation of selected cases, and surveillance of laboratory-confirmed influenza. The objective of this surveillance is to identify the onset, duration, and relative magnitude of the annual influenza seasons. Turner et al (2005) looked at influenza surveillance in Victoria in 2004. General practitioners sent in weekly reports on the number of patients that presented with ILI, and their clinical impression on the likelihood that the patient actually had influenza. They were asked to send in a minimum of five respiratory specimens (nose and throat swabs) during the influenza season. Of the 267 specimens tested for influenza over the season, only 13.9% tested positive for influenza A, and 4.1% for influenza B. Almost a third of the specimens (30%) tested positive for other respiratory viruses (Turner et al, 2005). The use of only five specimens per sentinel practitioner for confirmation of influenza over the entire season did not give a very accurate representation of what was actually going on with the disease. The small percentage of specimens that actually tested positive for

influenza shows that just a clinical impression may not be enough for an influenza diagnosis as other respiratory illnesses have symptoms similar to those caused by influenza.

A major benefit of mapping disease transmission is that knowledge of how a disease is most likely to be transmitted through an area helps in the making of decisions on the allocation of resources for prevention and control. Longini et al (2004) conducted a study on how best to use antiviral agents for control of influenza in the event of a pandemic. The study illustrated the importance of careful allocation of resources. The investigators used a discrete-time software model to simulate the transmission of influenza by infected individuals to close and casual contacts through the population. They then assessed the effectiveness of various intervention strategies. The study results suggest that resources should be targeted to the areas where influenza is likely to be circulating instead of uniformly throughout a region. This method was thought to be more effective in the control of the disease as it specifically targets the areas of transmission of the illness, and also because there will not be enough antiviral agents to give to everyone during a pandemic (Longini et al, 2004). Geomapping the transmission of illness will help in the rapid identification of the areas where the disease is being propagated.

Barrett et al (2005) conducted a similar study to assess the effectiveness of intervention strategies in a simulated pandemic of smallpox in Portland, Maine. The investigators used an epidemiology simulation model called EpiSims which has previously been used to study how social networks participate in the spread of diseases. The results of this study showed that rapid detection and implementation of interventions is crucial for pandemic control (Barrett et al, 2005).

Very few studies have employed GIS to map the transmission of infectious diseases in the CHR. One such study was conducted in 2003. GIS was used to assess the spatial patterning of chlamydia and gonorrhea in the CHR, and to identify areas with high disease prevalence. Cases of chlamydia and gonorrhea that had been reported to the Sexually Transmitted Diseases (STDs) Clinic, the Family Planning Clinic, and community physicians, were used for the study. A STDs surveillance database obtained from Alberta Health and Wellness was used to access data on all cases of reportable STDs within Calgary. The information obtained from this study was used to assist in the allocation of resources, and program delivery for the prevention and control of these diseases (Bush, 2004). GIS has not previously been used to map the distribution of influenza in the CHR.

Influenza in the Calgary Health Region

Vaccination

The annual influenza vaccination program in the CHR seeks to vaccinate those at high risk of complications due to influenza, and those who may transmit influenza to these high-risk individuals. The program includes the following: 1) registered nurses vaccinate eligible patients during their stay in acute care settings; 2) residents and staff at care centres are vaccinated by regional or facility staff; 3) clients confined to their homes are vaccinated by Home Care Community Coordinators; 4) employees in the CHR are vaccinated by Occupational Health and Safety nursing staff; and 5) public health nurses and physicians administer the largest number of doses of vaccine to the general public.

The coverage rates over the 2006-2007 influenza season were 62% in those 65 years of age and older, 95.3% in residents of continuing care facilities, 82.2% in the staff of continuing care facilities, 80% in eligible home care clients, 69% in home care staff, and 43.1% in employees of the region (Influenza Sub-Committee, 2007).

Surveillance

ILI and confirmed influenza are monitored throughout the year in the CHR. Regular summary reports of influenza activity in the CHR are prepared by the Influenza Program Coordinator for the region, and are distributed to various stakeholders (Influenza Sub-Committee, 2006). The surveillance system for influenza in the CHR consists of information from acute care, urgent care, and continuing care facilities, outbreak reports, school absenteeism reports, weekly reports from The Alberta Recording and Research Network (TARRANT) sentinel physicians, and virological results from the Alberta Provincial Laboratory for Public Health (ProvLab) (TARRANT, 2006).

Syndromic Surveillance

Syndromic surveillance in the CHR includes the daily review of emergency room logs and inpatient admissions by Infection Prevention and Control departments at acute care centres. This is done in order to identify patients with ILI, patients admitted to Intensive Care Units with severe respiratory symptoms, and to monitor influenza activity (Surveillance Working Group, 2008).

Other aspects of syndromic surveillance in the CHR include the monitoring of influenza outbreaks in schools, continuing care centres, and lodges, and the identification of ILI syndromes through Health Link. Health Link is a health information and telephone advice program in which registered nurses provide information and advice on symptoms and other health concerns (Calgary Health Region, 2008). The number of telephone calls received from patients with ILI or confirmed influenza is reported to the health region every month (Surveillance Working Group, 2008).

Sentinel Surveillance

TARRANT is the Alberta Viral Watch program of sentinel physicians in the community who report regularly on ILI in their patients, and take samples for viral culture. The number of TARRANT sentinel physicians in the CHR grew to 22 during the 2006-2007 season (Influenza Sub-Committee, 2007).

Sentinel physicians provide clinical data on the number of patients seen with ILI each week. These data are used to generate weekly ILI rates for the CHR and for all of Alberta. They also submit nasopharyngeal swabs from two patients with acute respiratory syndromes per week for laboratory diagnosis. The TARRANT sentinel surveillance program plays an important role in providing information on how influenza is spreading within the communities in Alberta, and on the occurrence of epidemics. Alberta is usually one of the first provinces in Canada to report an upsurge in ILI at the beginning of the influenza season, and the first specimens that are tested in the laboratory for influenza usually come from TARRANT (Dickinson, 2006).

One weakness of the TARRANT surveillance system is the low level of reporting from sentinel physicians. Over the 2006-2007 season, only 56% of the sentinels actually submitted data on ILI in their patients, and the level of reporting over one week went as low as 27%. The TARRANT sentinel physicians only make up approximately 3.5% of the primary care physicians in the health regions in Alberta. As sentinel physicians are not spread equally over the province, there is more reporting from some parts of Alberta than others. The data that is collected is therefore not representative of all the communities in Alberta (TARRANT, 2007).

Laboratory-Based Surveillance

Samples to be tested for influenza in the CHR are submitted to the ProvLab by sentinel physicians, as well as from emergency departments, physicians in the community, acute care centres, continuing care sites, and school nurses during outbreaks of ILI (Influenza Sub-Committee, 2007). Rapid tests on influenza specimens are important for the control of outbreaks in institutions such as acute care and continuing care centres (Surveillance Working Group, 2008). Viral cultures provide information on circulating influenza subtypes and strains. A graph of the number of positive influenza isolates per week is posted on the region's website (Influenza Sub-Committee, 2007).

Influenza surveillance is a major part of Alberta's plan for a possible influenza pandemic. GIS has not yet been used for influenza surveillance in the CHR. It may help to provide valuable information on disease clusters, the distribution of subtypes and outbreaks, and may help in establishing the patterns of influenza transmission in the region over time.

Secondary Data Analysis

Secondary data analysis was used for this study. Secondary data analysis is the use of data for a study that has already been collected for a different purpose (Bryman, 2001). This study employed data which was derived from influenza specimens collected within the CHR from a number of sources such as: the TARRANT sentinel surveillance system; physicians' offices; hospitals and walk-in clinics; and those collected under the direction of the Infectious Disease Outbreak Specialist as part of an outbreak. Influenza specimens are sent to the Calgary site of the ProvLab for influenza surveillance in the CHR.

Summary

Influenza affects many people all over the world every year. The threat of an influenza pandemic further increases the importance of influenza surveillance. GIS has already been shown to be very useful in various areas of public health such as in monitoring environmental contaminants and biological agents, mapping hazards, exposures, and outcomes for non-infectious diseases, and monitoring malaria control in Africa. GIS has been used in the CHR to study the distribution of STDs, and in making decisions on resource allocation for the prevention and control of these diseases. It has also been used for influenza surveillance in a number of countries such as Japan, Germany, France, and Australia, and for pandemic simulation studies in the United States. GIS is yet to be used for influenza surveillance in the CHR. GIS could prove to be a very powerful and useful surveillance tool for influenza in the region.

CHAPTER 3: METHODOLOGY

Introduction

The study design and definitions will be presented in this chapter. The inclusion and exclusion criteria used to determine the final study sample will also be presented. The sources of individual influenza case data, influenza outbreak data, influenza vaccination data, and Census Canada data will be discussed. The data collection procedure will also be discussed, as well as strategies used to deal with missing data, and the data cleaning process.

The data mapping process, and the procedure used to link individual case data to Census Canada data will be presented. Both were carried out using the ArcMap (version 9.2) package of Geographic Information Systems software. The data analyses carried out for the study will also be described.

Study Design

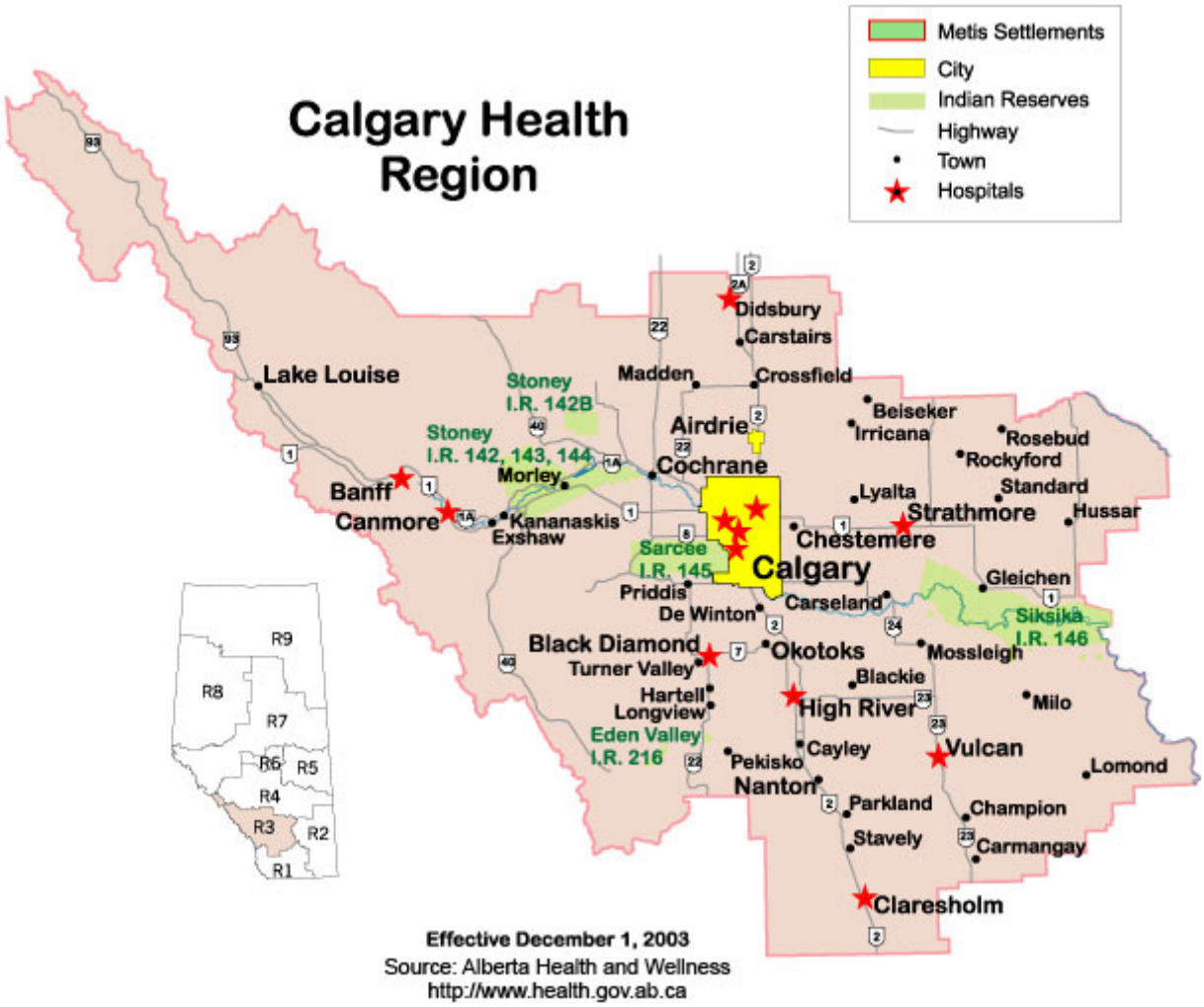
This was a descriptive, population-based study in which influenza was described relative to person (age and sex), place, and time. It was non-experimental (observational) as it focused on describing the distribution of disease and no intervention was incorporated into the study (Creswell, 2003). The study was conducted prospectively using data collected on cases of illness over the 2006-2007 influenza season.

Study Definitions

Alberta Provincial Laboratory for Public Health (ProvLab): The ProvLab supports the delivery of public health programs by providing real-time laboratory surveillance, population-based screening, outbreak investigation, and internationally recognized education and research programs. The programs supported by the ProvLab include Environmental Health and Food Safety, Communicable Disease Surveillance, Prevention, and Control, Outbreak Investigation and Emergency Response for Communicable Diseases, Integrated Data Management, and Policy Development and Evaluation. The ProvLab has two sites in Alberta, in Calgary and Edmonton (Alberta Provincial Laboratory for Public Health, 2007).

Calgary Health Region (CHR): The health region for the city of Calgary as well as the rural areas around the city (a total area of about 39,000 sq. km) (Calgary Health Region, 2005). A map of the Calgary Health Region is shown in **Figure 3.1.**

Figure 3.1 Map of the Calgary Health Region



(Retrieved May 26, 2008 from

http://www.calgaryhealthregion.ca/corporate/about_us/pdf/map.jpg)

Case: An individual residing within the CHR who had a swab that tested positive for influenza A or B at the ProvLab between October 1st 2006 and April 30th 2007.

Census Metropolitan Area (CMA): A census geographic area consisting of a major urban core with a population of 50,000 or more, surrounded by one or more municipalities. The whole CMA must have a population of at least 100,000 (2006 Statistics Canada Census Dictionary). Aggregated census characteristics of the Calgary CMA were used in this study.

Census Tract (CT): A census geographic area with a population of about 2,500 to 8,000 people. Census tracts are found in large urban centres with an urban core population that must be 50,000 people or more (2006 Statistics Canada Census Dictionary). Aggregated census characteristics of the CTs in the Calgary CMA were used in this study.

Dominant Educational Attainment (the education level variable): The highest grade or year of elementary or secondary education completed, or the highest year of college or university education completed (2001 Statistics Canada Census Dictionary). The aggregated dominant educational levels completed for each CT in the Calgary CMA were used for the analysis of Socio-Economic Status (SES) in this study.

Geographic Information Systems (GIS): Specialized software for input, storage, maintenance, retrieval, analysis, synthesis, and output of geographic-based information (Bush, 2004). ArcGIS version 9 (Environmental Systems Research Inc, Redlands, USA, 2007) was the GIS software package used for this study.

Influenza Outbreak: The definitions of an influenza outbreak from the Public Health Agency of Canada (2007) for the 2006-2007 season were as follows: a) greater than 10% absenteeism on any day most likely caused by Influenza-Like-Illness (ILI) in schools and at work sites; and b) two or more cases of ILI within a week in residential institutions, with at least one of them being laboratory-confirmed influenza. The outbreaks reported within the CHR over the 2006-2007 season were examined in this study.

Influenza-Like-Illness (ILI): An acute onset of respiratory symptoms accompanied by cough, fever (may not be prominent in those under five or older than 64 years), and any of the following: myalgia; sore throat; arthralgia; and prostration, which could be due to infection with the influenza virus. Gastrointestinal illness may also be present in children under five years old (Public Health Agency of Canada, 2007).

Median Household Income (the income level variable): An income value that divides the incomes of a specified group of households into two halves. One half have household income values that are below the median and the other half have household income values that are above the median (2001 Statistics Canada Census Dictionary). The aggregated Median Household Income values for each CT in the Calgary CMA were used for the analysis of SES in this study.

Socio-Economic Status (SES): Education level, employment status, and income level variables that are used to describe the social and economic status of a population in a CT (Bush, 2004).

Unemployment Rate (the employment status variable): The number of unemployed individuals, expressed as a percentage of the total labour force the week before the census. The unemployed were those individuals who were without paid work or self employment work and had one of the following characteristics: had actively looked for paid work in the four weeks prior to the census; were on temporary lay-off and expected to return to their jobs; or were definitely starting a new job within the next four weeks. The labour force refers to the population above the age of 15 years that are either employed or unemployed (2001 Statistics Canada Census Dictionary). The aggregated Unemployment Rate values for each CT in the Calgary CMA were used for the analysis of SES in this study.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: individuals who had influenza that was laboratory-confirmed at the Calgary site of the Alberta Provincial Laboratory for Public Health (ProvLab) between October 1st 2006 and April 30th 2007. These confirmed influenza cases had to have a valid postal code (or address from which a postal code could be determined), and had to reside within the Calgary Health Region (CHR).

Exclusion criteria were as follows: cases of respiratory illnesses that were not influenza; influenza cases with no postal code available or with a postal code that was not valid; and influenza cases that did not reside within the CHR.

Data Sources

Individual Influenza Case Data

Data was collected for the 2006-2007 influenza season. In North America, influenza usually affects people between November and April of every year but the season may start as early as the beginning of October (Government of Alberta, 2005).

Cases that had laboratory confirmation of influenza from the ProvLab were used in this study. Data on individual influenza cases in the CHR was collected from the Medical Virologist responsible for the Influenza Program at the Calgary site of the ProvLab. The ProvLab is the most comprehensive source of surveillance data on influenza in the region. Throat and nasopharyngeal specimens obtained from those who have a respiratory illness that may be influenza are sent to the ProvLab for testing. These specimens come from a number of sources such as sentinel physicians who are a part of the TARRANT program, other physicians in the community, emergency and inpatient departments from acute care hospitals (the Peter Lougheed Centre, the Alberta Children's Hospital, the Foothills Medical Centre, and the Rockyview General Hospital), as well as outbreak investigations in continuing care centres and schools (Downing and Fonseca, 2005).

Specimens submitted to the ProvLab must be accompanied by a requisition form *(See* ***Appendix A*** *for a sample of the virology requisition form submitted with the influenza specimens).* These forms are scanned into a database at the ProvLab. The forms may contain the following information: the address, postal code, and phone number of the physician and/or centre where the specimen was collected; the Personal Health

Number (PHN), name, address, postal code, sex, and date of birth of the patient; the date on which the specimen was collected; and the date of onset of illness.

Influenza Outbreak Data

Data on influenza outbreaks that occurred over the 2006-2007 season was obtained from the Influenza Coordinator for the CHR. The data consisted of aggregate tables of the respiratory outbreaks that occurred in 2006 and 2007 within the CHR. The tables included data on the report date, the outbreak number, the site of the outbreak, the type of facility where the outbreak occurred, the date of onset of the outbreak, the type of laboratory isolates that were obtained, and the date the outbreak was considered to be over.

Influenza Vaccination Data

Vaccination data on the influenza cases was obtained from the Influenza Coordinator for the CHR. This data is available in the “Phantim” database which is a regional public health information system (Calgary Health Region Community Physician Integration, 2007). Data on influenza vaccinations is entered in this database for children who are nine years of age and younger, a requirement of Alberta Health and Wellness. The database contains data on all of the vaccinations that have been received in this age group, including the most recent influenza vaccination.

Census of Canada Data

Census of Canada data was obtained from the Geographic Information Systems (GIS) Librarian at the University of Calgary Academic Data Centre. Data was obtained for both the 2001 Census and the 2006 Census. The data collected was for the Calgary Census Metropolitan Area (CMA), at the Census Tract (CT) level. The variables of interest were as follows: the total population of the Calgary CMA at the time of the census; the number of males and females in each age group; and Socio-Economic Status (SES) variables. **Table 3.1** shows the variables that were used to estimate SES. Data on SES was only available for the 2001 Census. This data had not yet been released by Statistics Canada for the 2006 Census at the time of data analysis.

Table 3.1: Socio-Economic Status Variables of Interest from the 2001 Census of Canada

Census Tract Variable	What it was used to assess
Dominant Educational Attainment (for the total population 15 years of age and older excluding institutional residents) **A derivative of the "Highest Level of Schooling" variable coded at three levels:** 1 = Grades 9 to 13; 2 = Other Non-University Education; 3 = University	Education Level
The **Median Household Income** of an area.	Income level
Unemployment Rate (expressed as a percentage) **Numerator:** the unemployed **Denominator:** the labour force (excluding institutional residents)	Employment Status

(2001 Statistics Canada Census Dictionary)

Data Collection and Management

Study Sample

All cases of laboratory-confirmed influenza detected between October 1st 2006 and April 30th 2007 that had a valid postal code within the CHR were included in this study. The sampling method used is called "census sampling," whereby all of the individuals in a population or group are included in the sample (Gay, 1999). All of the reported cases that had a specimen positive for influenza were used in this study. The size of the sample was therefore dependent upon the number of influenza cases that were confirmed over the season. In previous seasons, there have been approximately 300 cases detected (Remtulla et al, 2004).

Data Collection

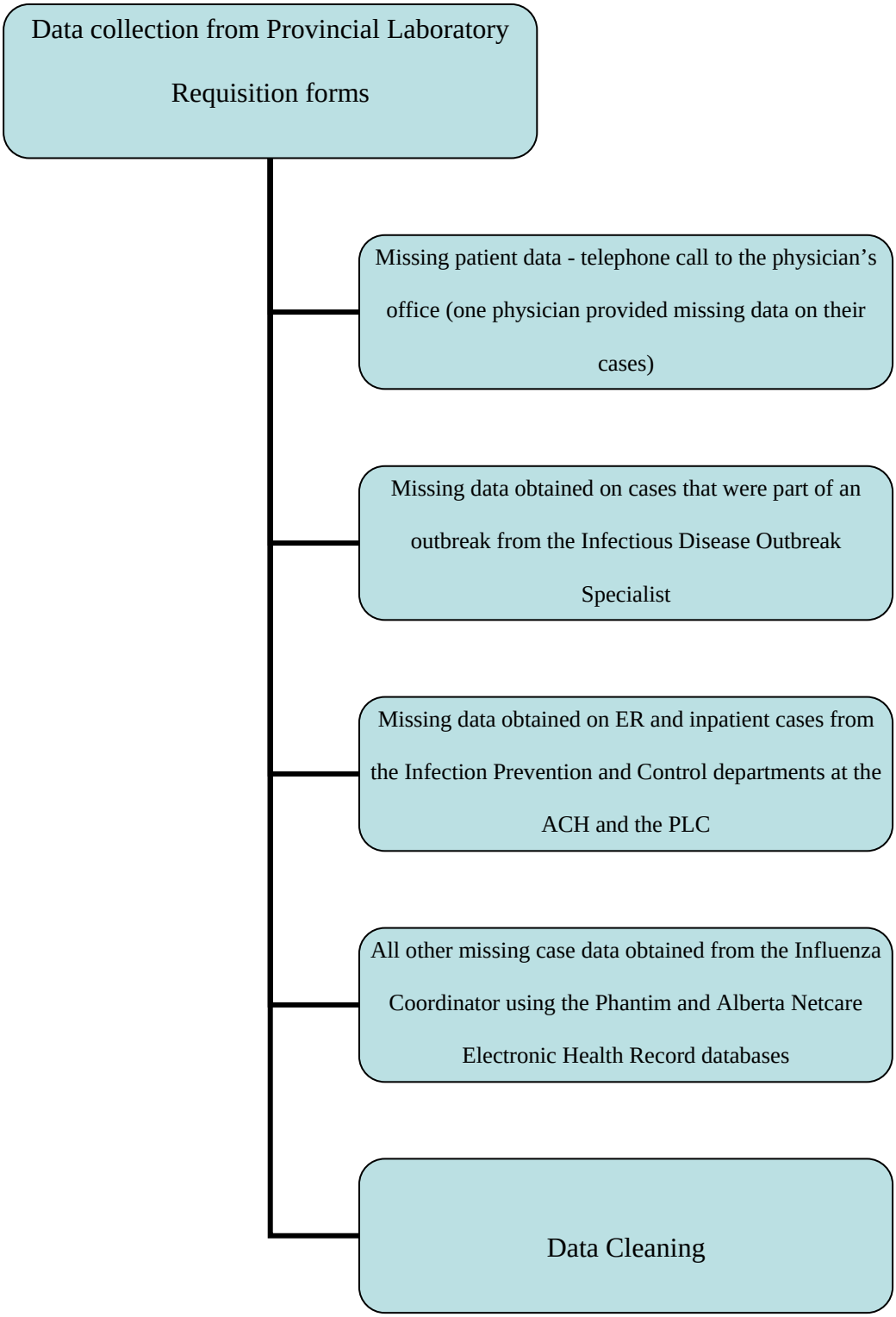
Data on the individual influenza cases in the CHR over the season was collected from the ProvLab. Data was collected on cases that tested positive for influenza between October 1st 2006 and April 30th 2007. Influenza A and B reports for the CHR were obtained from the ProvLab weekly. The reports included the following data: a record of the start and end dates of the week that was being reported on; the designated laboratory number for each individual influenza specimen; the source of the specimen (throat or nasopharyngeal swab); the name of the case, their sex, date of birth, and age; the type of influenza the case had; the date the specimen was received at the ProvLab; the outbreak number (if the case was part of an outbreak); the report date, and the city or town that the specimen was received from. The designated laboratory number for each influenza

specimen was used to retrieve the original specimen requisition form that had been submitted to the ProvLab with the specimen *(Refer to **Appendix A**).* The requisition forms are scanned into a secure database at the ProvLab as they come in. Data was collected on the variables of interest from the specimen requisition forms and the weekly influenza A and B reports.

Missing Data

Physicians' offices were contacted for missing data on the cases *(Refer to **Appendix B** for the questions and the data collection form used in the telephone calls to the physicians' offices).* One of the offices agreed to provide the missing data on their cases. Missing data on cases that were part of an outbreak was obtained from the Infectious Disease Outbreak Specialist at CHR Health Protection. Missing data on cases that were in an acute care setting at the time they got influenza was obtained from the Infection Prevention and Control departments at the Peter Lougheed Centre (PLC) and the Alberta Children's Hospital (ACH). Data on the rest of the cases that had missing data was obtained from the Influenza Coordinator for the CHR. The "Phantim" and "Alberta Netcare Electronic Health Record" databases were used to search for these. The procedure for the collection of missing data is shown in **Figure 3.2.**

Figure 3.2: Procedure for the Collection of Missing Data



Data Cleaning

Data on all of the influenza cases, vaccination data on the influenza cases that were nine years of age and younger, and aggregate data on the influenza outbreaks that took place over the season, were entered into and maintained in Microsoft Excel (Microsoft Inc, Seattle, USA) workbooks. The postal code for each case and for each of the sites where an outbreak took place (such as schools and continuing care centres) was verified using the Canada Post Postal Code Look-Up webpage: (http://www.canadapost.ca/tools/pcl/bin/advanced-e.asp). This was done to ensure that the postal code that was reported for each case corresponded with their address. The webpage was also used to look for postal codes for cases where only the address had been reported, and to look for the address when only the postal code had been reported (to ensure that the case did in fact reside in the CHR).

The cases were each assigned a unique number, and nominal data was removed from the database (name, date of birth, address, PHN). Physician data (name, address, and phone number) was also removed. The data on each case was then checked again using the original specimen requisition form to ensure that it had been entered correctly into the database. The Excel workbooks were then saved as Comma Delimited files that could be imported into the STATA (Statacorp USA, 2007) statistics program for data analysis.

Data Mapping

Geographic Information Systems

Geographic Information Systems (GIS) software was used to map the influenza cases and outbreaks identified over the 2006-2007 season in the CHR. GIS analysis employs the use of spatial data, such as postal codes, to allow for the visualization, tracking, and analysis of a phenomenon under study in an area (Meade and Earickson, 2000). The variables of interest for mapping were as follows: the postal codes of the individual influenza cases; the postal codes of the sites where influenza outbreaks occurred; the influenza rates for each CT; and the Median Household Income for each CT. These variables were used to create maps that illustrated the spatial distribution of confirmed influenza in the CHR over the season.

GIS was used in this study for the process of data querying. This approach attempts to investigate past and current infectious disease patterns, and is likely to be the most common use of GIS in public health. Data querying usually involves taking survey or administrative data collected on a particular topic, and using GIS to categorize or aggregate this data. This usually involves determining the numbers and geographic distribution of the cases with the disease in the area being studied, and how these relate to any particular features that may be of interest in that area. Another function of querying is to link data from a number of sources that may not be available from any one source (Glass, 2004). The ability to integrate various forms of data greatly enhances disease surveillance. GIS can bring together disease data and other forms of data such as environmental and demographic data (Gao et al, 2008).

In this study, data was extracted from the Statistics Canada Census databases for the CHR. These data were linked to the data collected on influenza outbreaks and cases in the CHR. The relational database formats which are a part of GIS software enabled the overlaying of features of interest in the study. The process of overlaying features is a common use of GIS (Glass, 2004).

The primary spatial mapping variable was the postal codes of individuals who tested positive for influenza, and the postal codes of the sites of influenza outbreaks. GIS data can be viewed as either x,y coordinate point data (the postal code data), or polygon data (the larger area of the CT) (Bush, 2004). Separate data files (for the case data, the outbreak data, and for Census Canada data) formed separate layers on the maps. These were stacked, one on top of the other, and viewed together. The maps helped to illustrate where in the region influenza had been detected, how the distribution of illness changed as the influenza season progressed, and the rates of influenza in different areas. The maps allowed for the visualization of the spatial distribution of confirmed influenza at any time during the season. The date when the positive influenza specimen was received at the ProvLab was used to designate which week of the season the case belonged to as this was the only specimen-related date that was available for all of the cases.

Mapping

ArcMap version 9.2 (2007) which is an application of ArcGIS version 9 (Environmental Systems Research Inc, Redlands, USA) was used for mapping. The Excel workbooks that contained the data on individual influenza cases and on influenza outbreaks were saved as dBase (database management system) files. These were imported into the ArcMap program for mapping.

The shapefiles for mapping were obtained from the GIS Librarian at the University of Calgary Academic Data Centre. A shapefile is a data storage format that is used to store the attributes, shape, and location of geographic features (GIS Dictionary, 2008). The shapefiles used were specific to Alberta and the CHR. The shapefiles included the Postal Code Conversion File (PCCF) which is used to generate x,y coordinates that approximate the locations of postal codes (L Schretlen, personal communication). A PCCF is a table containing postal codes and their latitude and longitude coordinates which give their locations (R. Shahid, personal communication). The Alberta shapefiles had all of the postal codes for Alberta. These were linked to the postal codes in the study sample. The postal codes that linked up (were present in both the Alberta shapefiles and in the study sample) were then exported to create a new set of data that would appear on the maps. The influenza case and outbreak data were mapped as point data.

The Median Household Income data was mapped as polygon data. Each polygon represented the Median Household Income of that CT. The influenza case data, the influenza outbreak data, and the Median Household Income data, all appeared as separate layers on the maps (*Refer to **Appendix C** for detailed information on the mapping process).*

A separate map was created for each month of the influenza season for the city of Calgary. Each map included representations of the cases that had influenza within that month, the outbreaks that occurred during that month, and the Median Household Income of the CTs. The Median Household Income was divided up into quintiles. A quintile is one-fifth or 20% of a given amount (R Shahid, personal communication). The quintiles were divided up so that the lowest quintile (the first 20%) represented the CTs with the lowest fifth of Median Household Incomes in the Calgary CMA, and the top 20% represented the CTs with the highest fifth of incomes in the CMA. Maps of all of the influenza cases and outbreaks in the CHR over the season were also created, as well as those of the influenza rates in the Calgary CMA over the season using the 2001 and the 2006 Census Canada data.

Correlation Analysis Data

The Census Canada data for correlation analysis was obtained from the GIS Librarian at the University of Calgary Academic Data Centre. This included data from both the 2001 and the 2006 Census of Canada. The census data was linked to the study sample data using GIS software *(Refer to **Appendix C** for detailed information on the linking of Census Canada data to sample data).* This enabled the creation of an Excel

workbook in which the postal code for each case was linked to the census attributes of the CT in which it fell (age, sex, and SES attributes). This Excel file was saved as a Comma Delimited File which was then imported into the STATA statistical software for correlation analysis.

Data Analysis

All of the data analyses were carried out using STATA (Statistics/Data Analysis) software version 9.1 (Statacorp, USA, 2007). The null hypothesis for all of the statistical tests done was that the difference between the mean values being compared for a variable was not statistically significant. The p-value (also known as alpha) was two-sided and set at 0.05. This means that there was a 5% chance of concluding that there was a statistically significant difference between the two mean values being compared when in fact the difference was not significant. Alpha (α), also known as a Type I error, is explained by the following statement:-

α = Type I error = Probability (rejecting the null hypothesis when the null hypothesis is true) (Norman and Streiner, 2000).

Sex

The proportions of male and female cases were compared using the one sample test for proportions to see if there was a significant difference between the proportions of males who got influenza and females who got influenza in the study sample over the season. A comparison of the mean ages of the male and female influenza cases was also done using the Student's t-test, to investigate whether or not there was a significant difference between them.

A power calculation was carried out to see if the Student's t-test had enough power to detect a statistical difference between the mean ages of the male and female influenza cases. If the power is too low, it is unlikely that a statistical difference would be found between the values being compared, even if a difference exists. Power is the chance of finding that there is a significant difference when there actually is one. Power is generally set at 80% for health research and is explained by the following statement:-

Power (1-β) = Probability (rejecting the null hypothesis when the alternative is true) (Norman and Streiner, 2000).

Spearman's Rank Correlation analysis was used to see if there was an association between sex distribution and the rates of influenza in different areas.

Age

The mean ages of the influenza A cases were compared to see if there was a significant difference between the mean age of those with the H1 influenza A subtype and those with the H3 subtype. This analysis was done using the Student's t-test. Spearman's Rank Correlation analysis was used to investigate whether or not there was an association between age distribution and the rates of influenza in different areas.

Socio-Economic Status

Spearman's Rank Correlation analysis was used to investigate whether or not there was an association between rates of influenza and each one of the SES variables of interest, namely Median Household Income, Unemployment Rate, and Dominant Educational Attainment. Spearman's Rank Correlation analysis was used because the influenza rate and Unemployment Rate variables were not continuous, and Dominant Educational Attainment was ranked.

Correlation analysis attempts to quantify the degree to which two variables are related and in which direction. The r_s value (rho) ranges from -1 to +1 with $r_s = 0$ indicating no relationship. The closer the value is to -1 or +1, the stronger the relationship between the two variables (Norman and Streiner, 2000).

Ethical Considerations

The research proposal and protocol were submitted to the University of Calgary Conjoint Health Research Ethics Board (CHREB) for approval before the study began. Confidential personal information was protected as follows:

- Each case had a unique identifier number that was placed in the database for anonymity.
- All nominal data was removed from the data files.
- Only the information that was needed to answer the research questions was obtained for each case.

Additional ethical principles are discussed below:

- There were no drugs administered in the study, and no direct contact with study participants/cases.
- As secondary data was used for the study, study participant consent forms were not needed. Consent from the Alberta Provincial Laboratory for Public Health was obtained for access to the surveillance data as they are the custodians of this data.
- The computer used to store the study data had internet firewalls to minimize the chance of it being accessed by electronic intruders. It also had virus protection software that was updated and run regularly.
- The findings of the study are presented in aggregate form.

CHAPTER 4: RESULTS OF NON-SPATIAL ANALYSIS

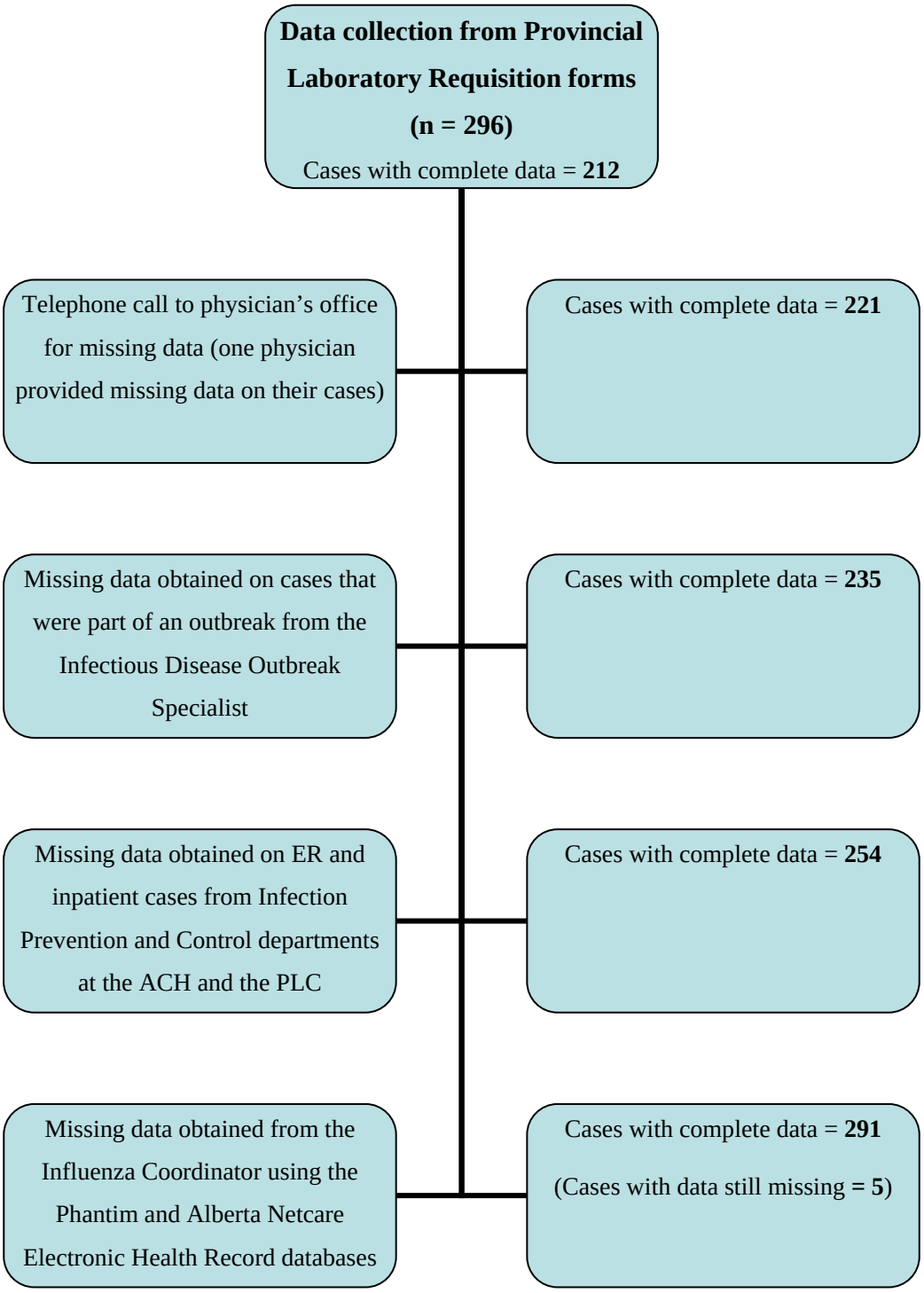
Introduction

The results of the non-spatial data analysis for the study will be presented in this chapter. A description will be given on how the final sample size was arrived at, using the inclusion and exclusion criteria for the study. The temporal distribution of confirmed influenza cases and outbreaks in the Calgary Health Region (CHR) over the season will be presented. The distribution of the influenza cases by age and sex will be shown. The influenza types and subtypes that were detected in the CHR over the season will be described. Comparative data analysis on sex and age, as well as on the influenza A subtypes will be presented.

Missing Data

A total of 296 cases were identified as having tested positive for influenza in the Calgary Health Region (CHR) over the 2006-2007 influenza season. There were 84 cases in the dataset that were missing sex, age (date of birth), and/or both address and postal code. The steps taken to collect this missing data are illustrated in **Figure 4.1.** Only five of the cases were still missing data on key variables after all of these steps had been taken.

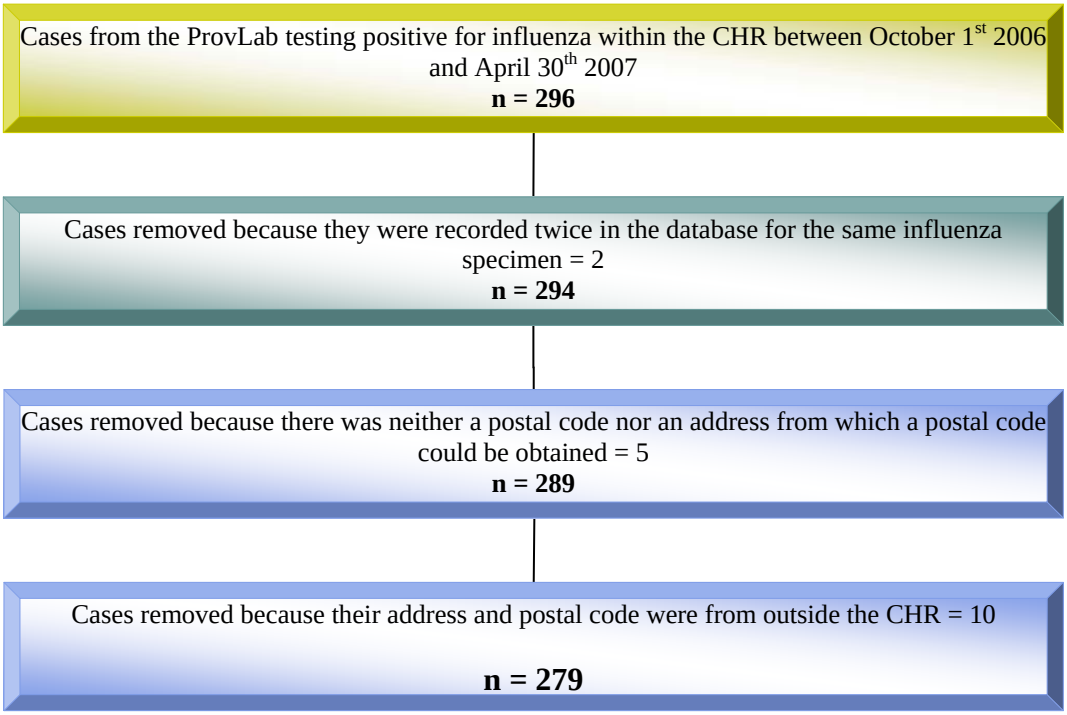
Figure 4.1: Procedure for the Collection of Missing Data with Total Cases Completed at Each Stage



Sample Size

The Sample Size flowchart is illustrated in **Figure 4.2**. The final sample size of 279 was obtained by following the rules set in the Inclusion and Exclusion Criteria *(Page 47)* and the Data Cleaning Process *(Page 55).* There were 296 cases obtained from the Calgary site of the Alberta Provincial Laboratory for Public Health (ProvLab) that tested positive for influenza within the CHR between October 1st 2006 and April 30th 2007. Two cases were removed because they had been recorded twice in the database for the same influenza specimen. A total of 15 cases were removed from the database because they did not meet the inclusion criteria. Five cases were removed because neither a postal code nor an address from which a postal code could be obtained was available. There were10 cases removed because their addresses and postal codes were from outside the CHR. Eight of those cases had their influenza specimens sent in from the Banff Mineral Springs Laboratory. Their influenza specimens were sent to the ProvLab from within the CHR but there is no way of knowing if the cases were inside the CHR when they were infected. One of these cases was from British Columbia, one from Sussex, England, five were from Ontario, and one was from Edmonton. The other two cases were (and had their specimens sent in) from outside the CHR (Medicine Hat and Three Hills, Alberta).

Figure 4.2: Flowchart for the Calculation of the Final Sample Size



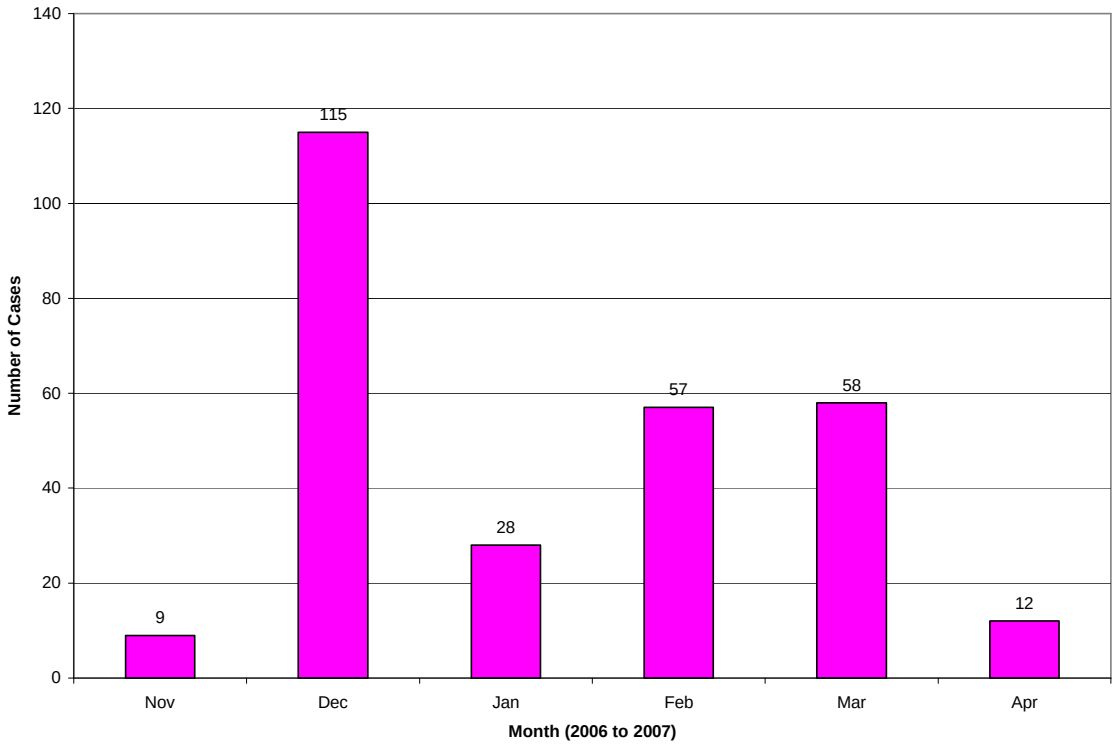
Temporal Distribution of Confirmed Influenza

Distribution of Influenza Cases

The distribution of the influenza cases by month is illustrated in **Figure 4.3**. There were no confirmed cases of influenza in the CHR in October of 2006. Nine cases were confirmed in November. There was a large increase in the number of confirmed cases in December with a total of 115. The number of cases went down to 28 in January 2007, and then approximately doubled in February to 57. It stayed almost the same with 58 in March, and then went down again to 12 in April.

Figure 4.3: Number of Confirmed Influenza Cases by Month (2006-2007) in the Calgary Health Region

(n = 279)



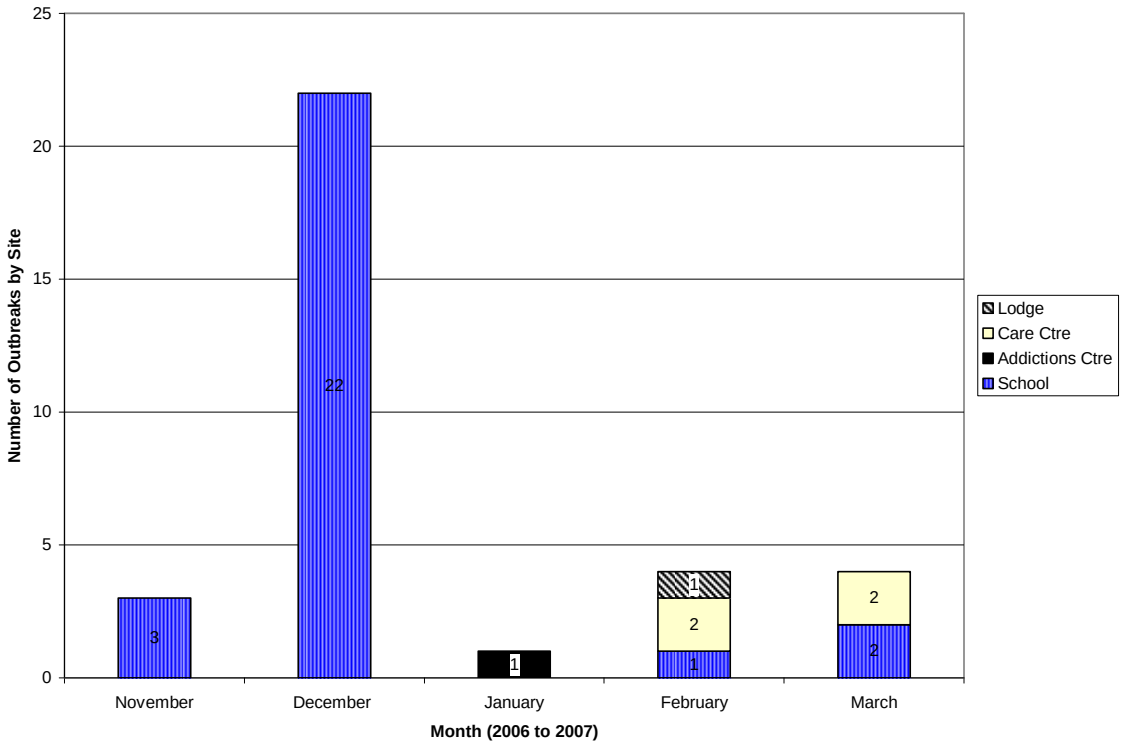
Distribution of Influenza Outbreaks

The number of influenza outbreaks by month and type of facility is illustrated in **Figure 4.4.** There were three influenza outbreaks reported in the CHR in November of 2006. There was a large increase in the number of outbreaks to 22 in December, which corresponded with the increase in individual influenza cases that were confirmed over this month. The majority (65.2%) of the influenza cases confirmed in the CHR in December 2006 were part of an outbreak. All of the outbreaks that occurred in November

and December of 2006 were in schools. Only one outbreak occurred in the CHR in January of 2007 at a mental health and addictions centre. There were four outbreaks in February, one at a school, one at a lodge, and two in continuing care centres. Four outbreaks occurred in March. Two of them were in schools and two in continuing care centres. No influenza outbreaks were reported in the CHR in April 2007.

Figure 4.4: Number of Reported Influenza Outbreaks by Month (2006-2007) and Type of Facility in the Calgary Health Region

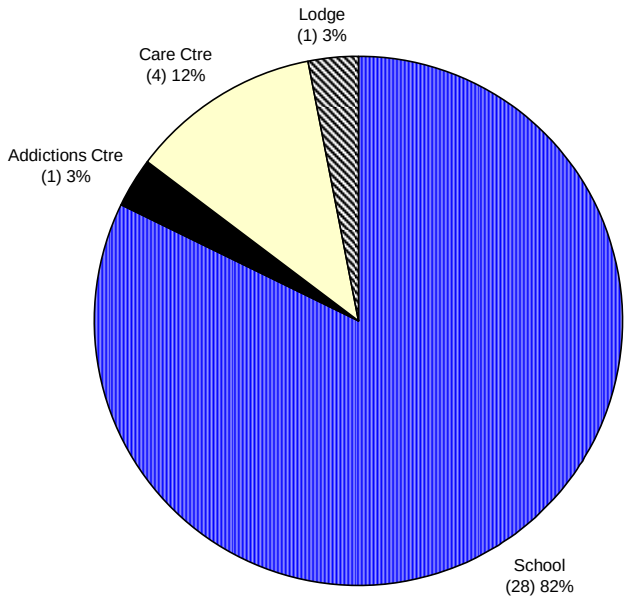
(n = 34)



The distribution of influenza outbreaks by type of facility is illustrated in **Figure 4.5.** About 82% of the influenza outbreaks that occurred in the CHR over the 2006-2007 season were in schools. Approximately 12% of the outbreaks occurred in continuing care centres. Outbreaks in lodges and addictions centres each made up about 3% of the total number of outbreaks over the season.

Figure 4.5: Distribution of Reported Influenza Outbreaks by Type of Facility in the Calgary Health Region over the 2006-2007 Season

(n = 34)



Characteristics of Influenza Cases

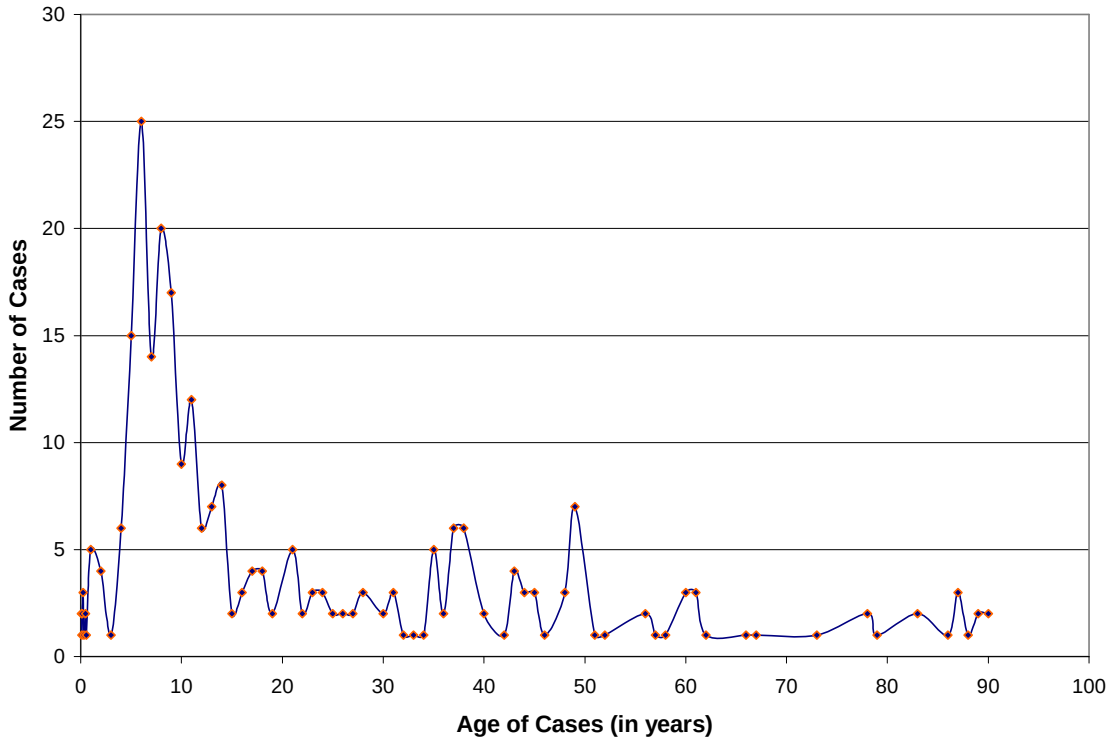
Age

The number of influenza cases by age is illustrated in **Figure 4.6**. A U-shaped graph would have been expected for this distribution as influenza is more likely to affect the very young and the elderly. This was not the case for the 2006-2007 influenza season. The graph is positively skewed, showing that a large number of the cases were very young. The highest peak in the graph (25 cases) is that of cases that were six years old. The highest peak for the seniors (those 65 years of age and older), was only three cases that were 87 years old at the time of influenza illness. Only 6.1% (17) of the cases in the study were above 64 years old *(See **Appendix D** for figures of the number of influenza cases by age for each month of the season).*

The age distribution of all the influenza cases and of the cases confirmed per month is shown in **Table 4.1**. The minimum age of all of the influenza cases was 0.08 years and the maximum age was 90 years. The median age of the cases was 11 years, the mean age was 22.1 years, and the standard deviation was 22.1 years.

Figure 4.6: Number of Confirmed Influenza Cases by Age in the Calgary Health Region over the 2006-2007 Season

(n = 279)



In November 2006, the age range of the influenza cases was 4-13 years, with a median age of seven years. The age range increased as the influenza season progressed with the largest range being in March 2007, when the cases confirmed were from 0.08-90 years of age. The median age of the cases also increased as the influenza season progressed, with the lowest median age being seven years in November 2006, and the highest being 40.5 years in April 2007. There was a slight dip from February to March with the median age being 26 years in February and 23.5 years in March.

Table 4.1: Age Distribution (in years) of Confirmed Influenza Cases by Month (2006-2007) in the Calgary Health Region

Month	n (%)	Minimum	Maximum	Median	Mean (SD)
All Cases	279 (100)	0.08	90	11	22.1 (22.1)
November	9 (3.2)	4	13	7	7.6 (2.6)
December	115 (41.2)	0.5	49	8	10.8 (10.2)
January	28 (10.1)	0.08	60	23.5	25.5 (18.2)
February	57 (20.4)	0.25	88	26	33.7 (25.5)
March	58 (20.8)	0.08	90	23.5	30.9 (27.8)
April	12 (4.3)	4	60	40.5	35.8 (17.2)

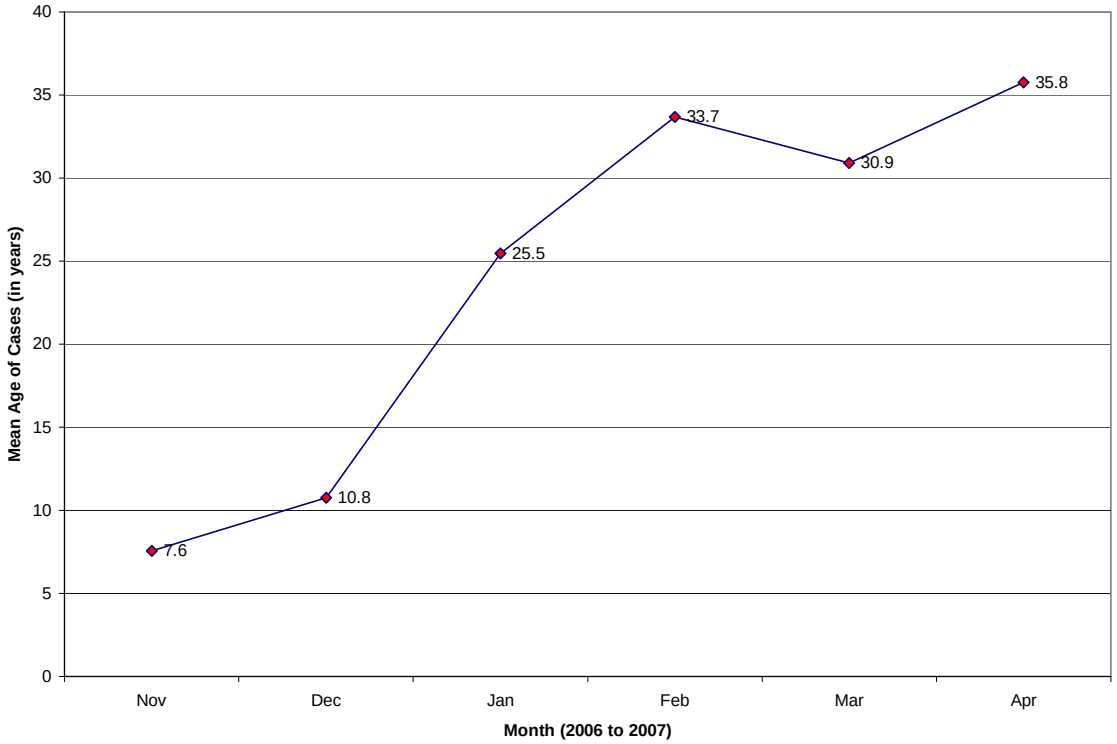
n = Number

% = Percentage of total

SD = Standard Deviation

The mean age of the influenza cases by month is illustrated in **Figure 4.7.** There was an increase in the mean age of the influenza cases as the season progressed. The mean age of the cases was at its lowest in November 2006 at about 7.6 years. It rose as the season progressed to approximately 33.7 years in February 2007. There was a slight fall in mean age to about 30.9 years in March, and then it rose again to approximately 35.8 years in April which was the highest mean age of the season.

Figure 4.7: Mean Age of Confirmed Influenza Cases by Month (2006-2007) in the Calgary Health Region

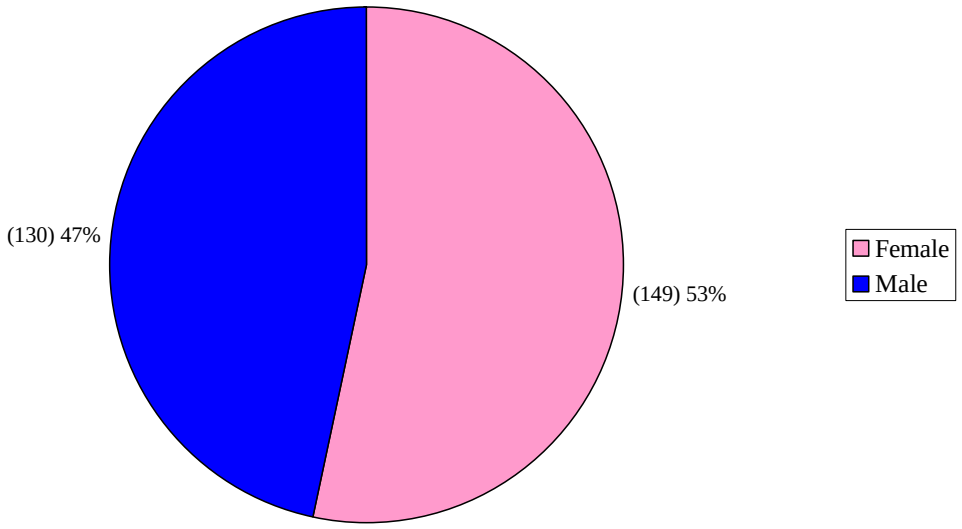


Sex

Sex distribution of the influenza cases is illustrated in **Figure 4.8**. Of the 279 cases, 149 (53.4%) were female, and 130 (46.6%) were male.

Figure 4.8: Distribution of Confirmed Male and Female Influenza Cases in the Calgary Health Region over the 2006-2007 Season

(n = 279)



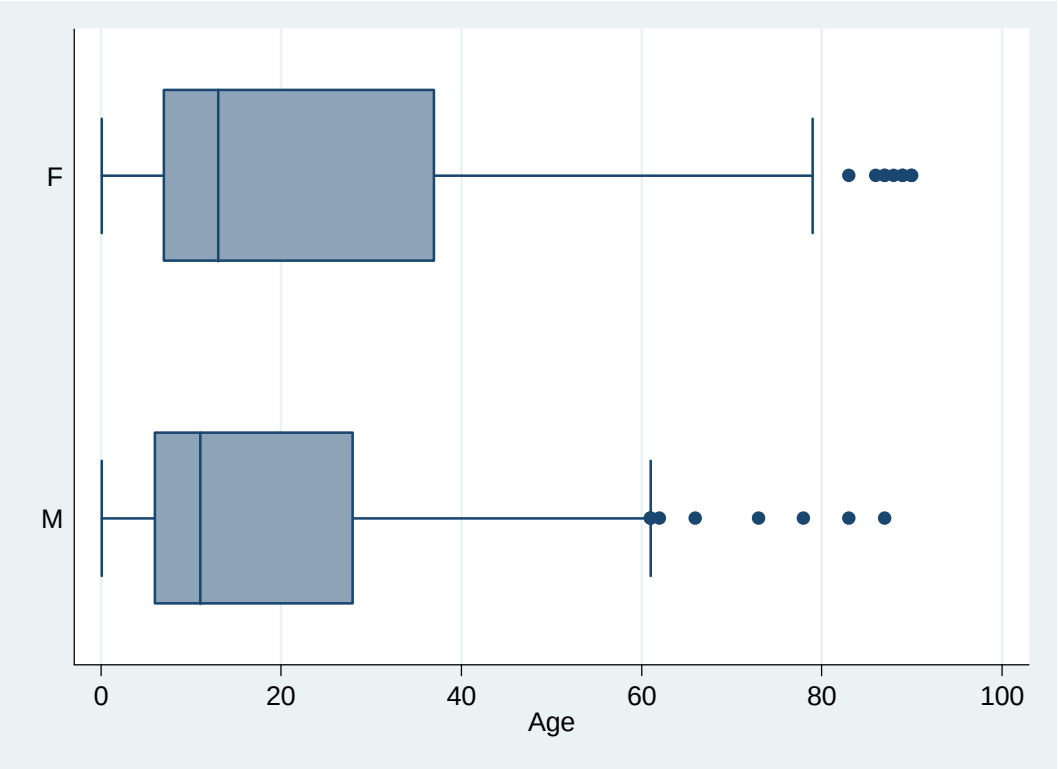
The distribution of males and females with influenza by month was quite similar to the overall distribution for most of the months of the season. Variation was seen in February 2007 which was the only month in which there were more male influenza cases than female cases (52.6% compared to 47.4% respectively). There was also variation in

March where the proportion of males was substantially lower than the overall value, and that of females was substantially higher (39.7% and 60.3% respectively) *(See **Appendix E** for the proportional distribution of male and female influenza cases by month).*

Sex and Age

The distribution of the influenza cases by sex and age is illustrated in **Figure 4.9**. The ages of the females were more widely distributed than those of the males. This is shown by the wider distance between the two inner fences of the boxplot for the females (about 0-80 years) than for the males (about 0-60 years). The outlying ages for the males were over a wider range (about 60-87 years) than those for the females (about 80-90 years). The interquartile range (which represents the middle 50% of the ages for each sex) was larger for the females than for the males. This is illustrated by the box for the females being longer than that for the males.

Figure 4.9: Age Distribution (in years) of Confirmed Male and Female Influenza Cases in the Calgary Health Region over the 2006-2007 Season



F = Females

M = Males

The male and female influenza cases had a similar age range, with the males having a slightly lower maximum age of 87 years, while that of the females was 90 years (**Table 4.2**). The females were slightly older than the males with a median age of 13 years compared to that of 11 years for the males, and a mean age of 23.9 years compared to 20.0 years for the males. The standard deviation of age for the females was larger than that for the males (23.9 years compared to 19.7 years).

Table 4.2: Age Distribution (in years) of Confirmed Influenza Cases by Sex in the Calgary Health Region over the 2006-2007 Season

	n (%)	Minimum	Maximum	Median	Mean (SD)
Male	130 (46.6)	0.08	87	11	20.0 (19.7)
Female	149 (53.4)	0.08	90	13	23.9 (23.9)

n = Number

% = Percentage of total

SD = Standard Deviation

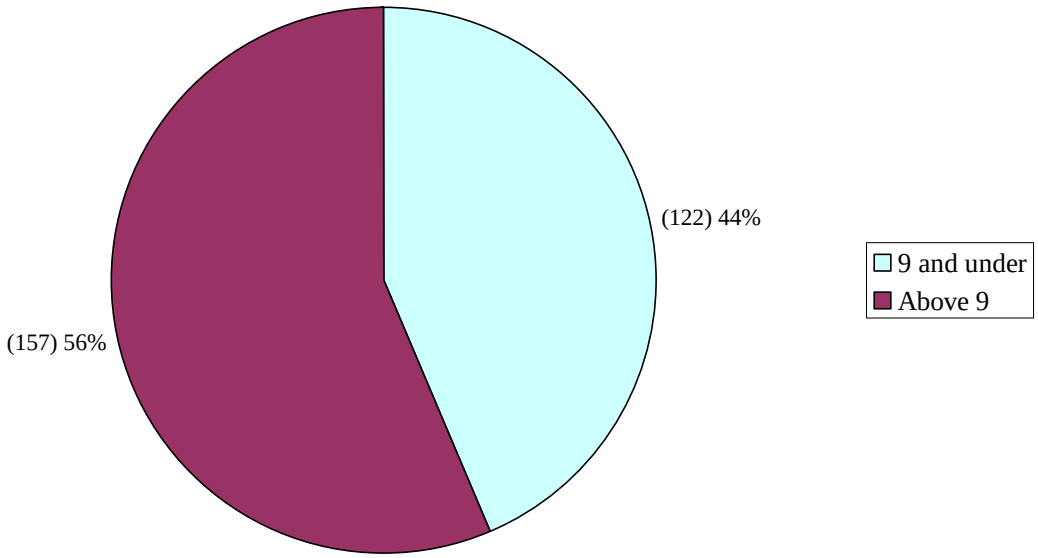
Cases Nine Years of Age and Younger

A large proportion of the confirmed influenza cases in the CHR over the 2006-2007 season were nine years of age and younger (**Figure 4.10)**. Of the 279 cases found, 122 (43.7%) were nine years of age and younger.

Data on influenza vaccination was available for 95 (77.9%) of the 122 cases that were nine years of age and younger. Of the 95 cases with known vaccination status, 11 (11.6%) were vaccinated, and 84 (88.4%) were not vaccinated for influenza in the 2006-2007 season. Of the 11 that were vaccinated, five (45.5%) were vaccinated before they got influenza, and six (54.5%) were vaccinated after. Of the 11 that were vaccinated, two (18.2%) received two doses of influenza vaccine, and nine (81.8%) received one dose of the vaccine over the season. Four (36.4%) of the 11 cases vaccinated over the 2006-2007 season had also been vaccinated in prior seasons.

Figure 4.10: Distribution of Confirmed Influenza Cases Above and Below Nine Years of Age in the Calgary Health Region over the 2006-2007 Season

(n = 279)

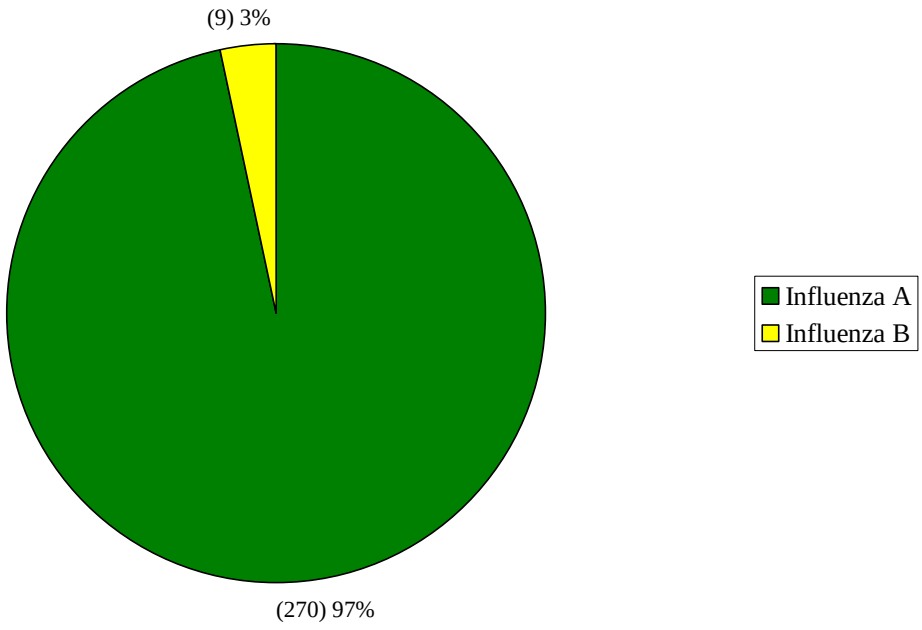


Types of Influenza

The distribution of the types of influenza detected over the season for the confirmed cases is illustrated in **Figure 4.11.** Of the 279 cases, 270 (96.8%) had influenza A, and 9 (3.2%) had influenza B. All of the reported influenza outbreaks that occurred in the CHR over the 2006-2007 season were caused by type A.

Figure 4.11: Distribution of Confirmed Influenza Cases by Type of Influenza in the Calgary Health Region over the 2006-2007 Season

(n = 279)



The age distribution of the influenza cases by type of influenza is shown in **Table 4.3** *(See **Appendix F** for figures of the number of influenza cases by age for each type of influenza).* The ages of the influenza A cases ranged from 0.08-90 years, with a standard deviation of 22.1 years. The ages of the influenza B cases covered a smaller range from 11-61 years, with a standard deviation of 16.2 years. The influenza A cases had a median age of 11 years and a mean age of 21.5 years. The influenza B cases had higher values for both of these measures, with a median age of 38 years and a mean age of 39.3 years.

Table 4.3: Age Distribution (in years) of Confirmed Influenza Cases by Type of Influenza in the Calgary Health Region over the 2006-2007 Season

Type	n (%)	Minimum	Maximum	Median	Mean (SD)
Influenza A	270 (96.8)	0.08	90	11	21.5 (22.1)
Influenza B	9 (3.2)	11	61	38	39.3 (16.2)

n = Number

% = Percentage of total

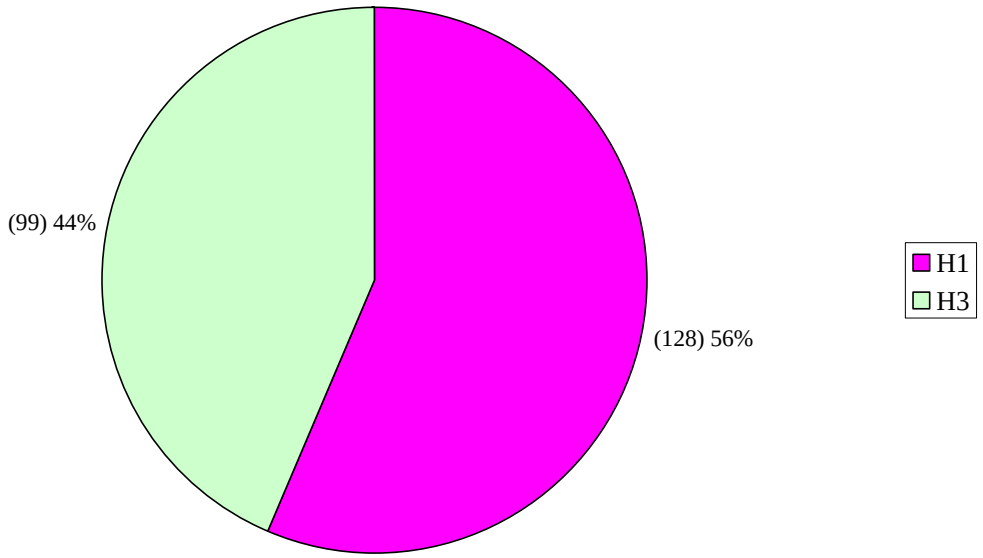
SD = Standard Deviation

Influenza A Subtypes

Two influenza A subtypes circulated in the CHR over the 2006-2007 season. The first, A/New Caledonia H1N1 was dominant in the early part of the season at the end of 2006. The second, A/Wisconsin H3N2 became the dominant circulating subtype from January 2007 to the end of the season (Influenza Sub-Committee, 2007). Influenza subtype data was available for 227 (84.1%) of the 270 influenza A cases. The distribution of influenza A subtypes for the typed cases is illustrated in **Figure 4.12.** Of the 227 cases with known influenza A subtypes, 128 (56.4%) had the H1 subtype, and 99 (43.6%) had the H3 subtype.

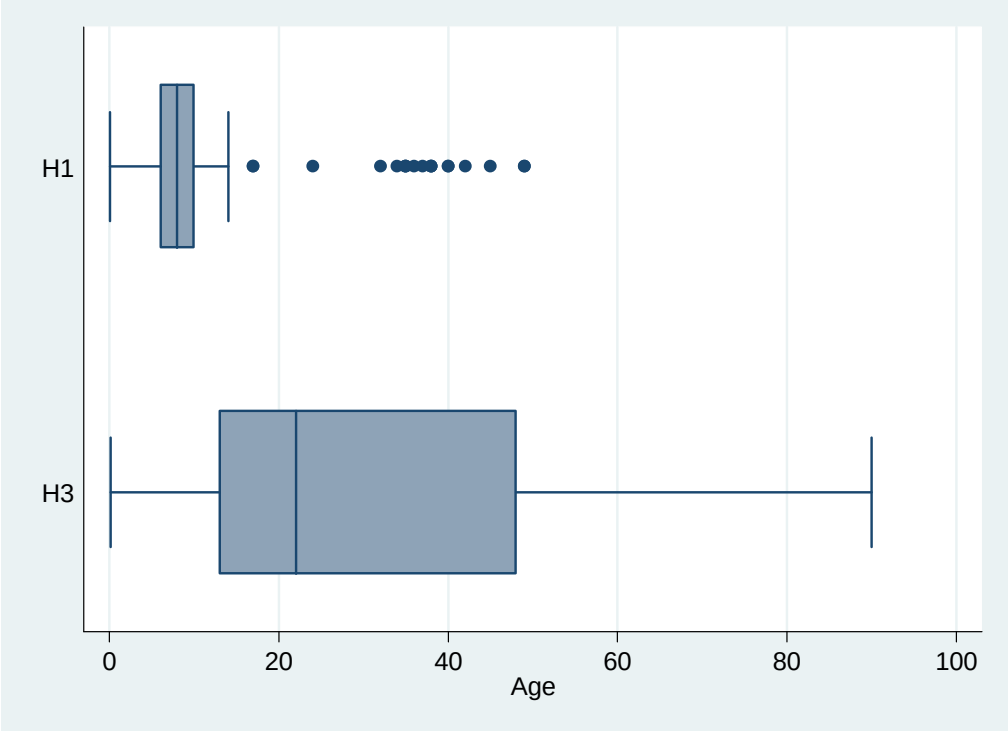
Figure 4.12: Distribution of Confirmed Influenza A Subtypes in the Calgary Health Region over the 2006-2007 Season

(n = 227)



The distribution of the typed influenza A cases by subtype and age is illustrated in **Figure 4.13.** The ages of the H3 cases were more widely distributed than those of the H1 cases. This is shown by the wider distance between the two inner fences of the boxplot for the H3 cases (about 0-90 years), than for the H1 cases (about 0-15 years). The H1 cases had a number of outliers from about 18-50 years, whereas the H3 cases had no outlying ages at all. The interquartile range was larger for the H3 cases than for the H1 cases. This is shown by the box for the H3 cases being longer than that for the H1 cases.

Figure 4.13: Age Distribution (in years) of Confirmed Influenza A Cases by Subtype in the Calgary Health Region over the 2006-2007 Season



The ages for the H1 cases ranged from 0.08-49 years, whereas the H3 cases had a wider age range from 0.13-90 years (**Table 4.4**). The H3 cases were older than the H1 cases with a median age of 22 years compared to that of eight years for the H1 cases, and a mean age of 31.5 years compared to 11.4 years for the H1 cases. The standard deviation of age for the H3 cases was larger than that for the H1 cases (26.5 years compared to 11.0 years).

There were 43 (15.9%) influenza A cases in the study sample that were missing subtype data (not all isolates are typed as this is an onerous process). The ages of these cases ranged from 0.08-87 years, with a median age of 23 years and a mean age of 28.4 years. This age distribution is similar to that observed for the H3 influenza A cases (an age range of 0.13-90 years, median age of 22 years, and a mean age of 31.5 years).

Table 4.4: Age Distribution (in years) of Confirmed Influenza A Cases by Subtype in the Calgary Health Region over the 2006-2007 Season

Influenza A Subtype	n (%)	Minimum	Maximum	Median	Mean (SD)
H1	128 (47.4)	0.08	49	8	11.4 (11.0)
H3	99 (36.7)	0.13	90	22	31.5 (26.5)
Missing	43 (15.9)	0.08	87	23	28.4 (22.9)

n = Number

% = Percentage of total

SD = Standard Deviation

Comparative Data Analysis

Sex and Age

A comparison was made to see if there was a significant difference between the proportions of males and females with confirmed influenza over the season (**Table 4.5)**. The proportion of males was 0.466 and the proportion of females was 0.534 (p = 0.281). There was no significant difference in the proportions of male and female influenza cases over the season.

The mean ages of the male and female influenza cases were compared using the Student's t-test to see if there was a significant difference between them. The mean age of the male influenza cases was 20.0 years and that of the female cases was 23.9 years (p = 0.143). There was no significant difference in the mean ages of the male and female influenza cases over the season.

Table 4.5: Comparative Analysis on Sex and Age of Confirmed Influenza Cases in the Calgary Health Region over the 2006-2007 Season

Variable	Male Cases (n = 130)	Female Cases (n = 149)	p-value
Proportion	0.466	0.534	0.281
Mean Age	20.0	23.9	0.143

Influenza Types and Subtypes

There were 270 cases with influenza A and only nine cases with influenza B. It was therefore not possible to do a meaningful comparison of the mean ages of the cases by type of influenza.

The mean ages of the typed influenza A cases were compared to see if there was a significant difference between the mean age of those with the H1 subtype and those with the H3 subtype (**Table 4.6)**. The mean age of the H1 influenza A cases was 11.4 years and that of the H3 cases was 31.5 years ($p < 0.000$). There was a statistically significant difference between the mean ages of the H1 influenza A cases and the H3 cases.

Table 4.6: Comparative Analysis of the Mean Ages of Confirmed Influenza A Cases by Subtype in the Calgary Health Region over the 2006-2007 Season

Variable	H1 Influenza Cases (n = 128)	H3 Influenza Cases (n = 99)	p-value
Mean Age	11.4	31.5	<0.000

CHAPTER 5: RESULTS OF SPATIAL ANALYSIS

Introduction

The results of the spatial data analysis for the study will be presented in this chapter. Aggregate values for the variables of interest from the 2001 and the 2006 Census of Canada will be shown, as well as those for the Census Tracts represented in the sample. All three sets of data will be for the Calgary Census Metropolitan Area.

The spatial distribution of the confirmed influenza cases and outbreaks will be described using a series of maps created with Geographic Information Systems software (ArcMap version 9.2). Maps of all the influenza cases and outbreaks in the Calgary Health Region over the 2006-2007 season will be presented, followed by those of the Influenza A subtypes and Influenza B cases in the Calgary Census Metropolitan Area. The monthly distribution of influenza cases and outbreaks will be illustrated in maps of the city of Calgary.

Correlation analysis on the relationship between influenza rates and the census variables will be presented in the form of scatterplots and correlation matrices.

Census Characteristics of the Influenza Cases

The Census of Canada variables of interest in this study were Age, Sex, Median Household Income, Unemployment Rate as a proxy for Employment Status, and Dominant Educational Attainment as a proxy for Education Level.

Table 5.1 shows the aggregate values for these census variables for all of the Census Tracts (CTs) in the Calgary Census Metropolitan Area (CMA) in 2001 and 2006, and for the CTs (in 2001) where confirmed cases of influenza were found over the 2006-2007 season. The Calgary CMA had 182 CTs in 2001. The total number of CTs for the 2006 Census had not yet been released at the time of data analysis.

The influenza cases over the season came from 96 (52.7%) of the CTs in 2001, and 99 of the CTs in 2006. The CTs with confirmed influenza cases represented a population of about 54.5% of the Calgary CMA in 2001. The proportions of males and females in all the CTs in 2001 and 2006, and in the CTs that had influenza cases were very similar at about 50.0% for each sex. The proportions of persons in all age groups in the three data sets were also very similar, with about 12.5% being from zero to nine years old, about 78.5% being from 10-64 years old, and about 9.0% being 65 years old and above.

The Median Household Income for the Calgary CMA was $58,861 in 2001 whereas that for the CTs with influenza cases was higher at $62,360. The Unemployment Rate was almost the same at 4.9% for the whole CMA in 2001, and 4.8% for the CTs that had influenza cases. The Dominant Educational Attainment was “University” for the entire Calgary CMA in 2001, and for the CTs represented in the sample. Aggregate

values for the three Socio-Economic Status (SES) variables had not yet been released for the 2006 Census of Canada at the time of data analysis.

Table 5.1: Comparison of Census Canada Variables for the Census Tracts in the Calgary Census Metropolitan Area

Census Variable	Census Tracts in 2001	Census Tracts in 2006	Census Tracts in the Study Sample
Total Population	951,395	1079,310	518,337
Males	49.9%	49.9%	49.6%
Females	50.1%	50.1%	50.4%
0 to 9 years old	12.7%	12.1%	12.7%
10 to 64 years old	78.3%	78.5%	78.2%
65 years old and above	9.0%	9.4%	9.1%
Median Household Income	$58,861	Not yet available	$62,360
Unemployment Rate	4.9%	Not yet available	4.8%
Dominant Educational Attainment	University	Not yet available	University

(2001 and 2006 Census of Canada Websites)

Spatial Distribution of Confirmed Influenza

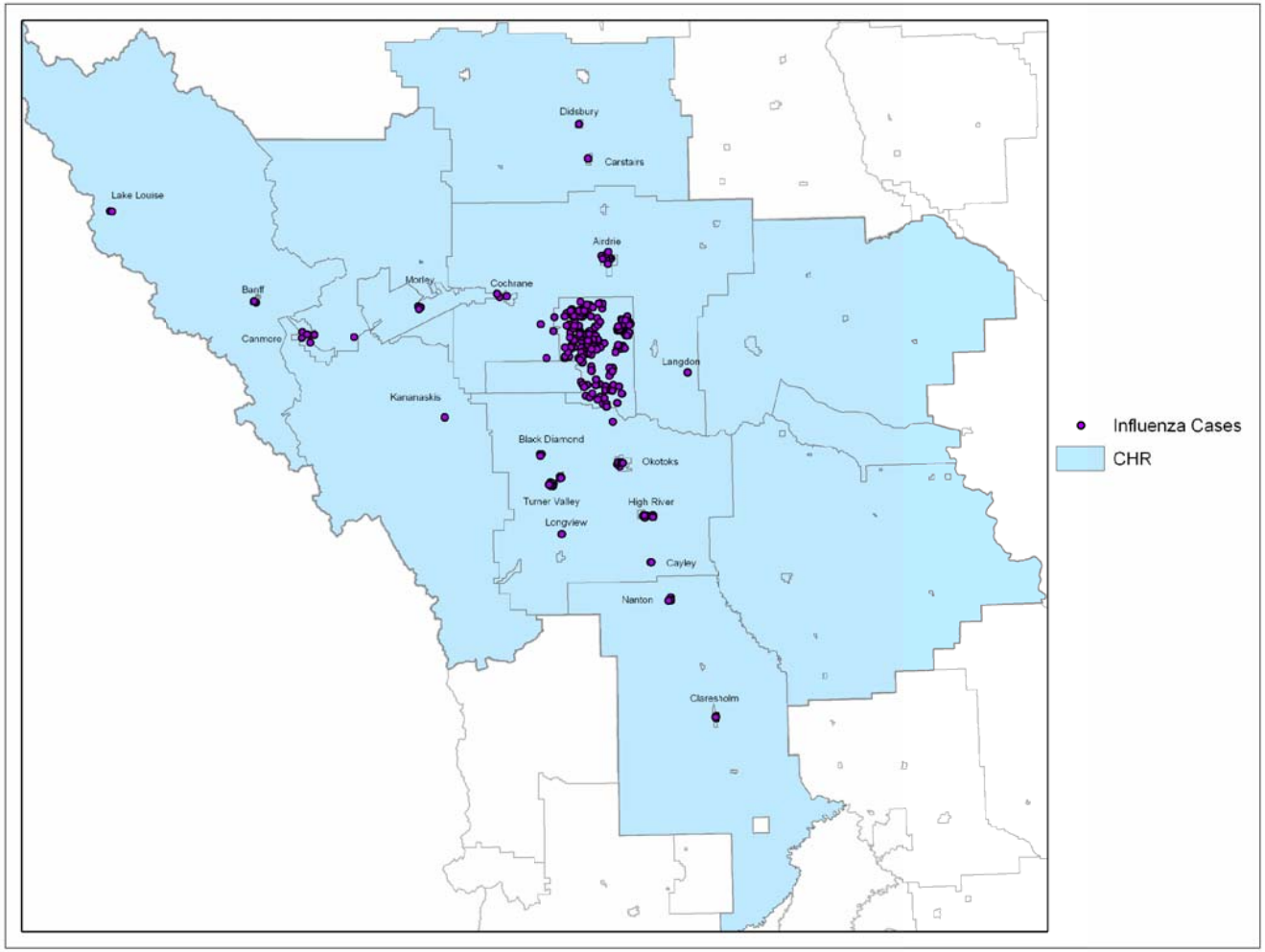
The spatial distribution of confirmed influenza cases and outbreaks in the CHR over the 2006-2007 respiratory season will be described using a series of maps created with Geographic Information Systems (GIS) software. ArcMap version 9.2 (2007) which is an application of ArcGIS version 9 ((Environmental Systems Research Inc, Redlands, USA) was used for mapping. The cases were mapped using the postal codes of their places of residence as reported on their virology requisition forms (and verified using the Canada Post postal code look-up webpage). The outbreaks were mapped using the postal codes of the locations where the outbreaks took place, such as a school or continuing care centre. The weeks of the year were determined using the 2006-2007 FluWatch Weeks Calendar (Public Health Agency of Canada, 2007). The weeks and months the individual cases were assigned to were determined using the date on which their influenza specimen was received at the ProvLab. The month and week that each outbreak was assigned to was determined using the date on which the outbreak began.

Maps will be presented of all the influenza cases and outbreaks in the CHR over the 2006-2007 season. These will be followed by those of the cases and outbreaks in the Calgary CMA. The monthly distribution of influenza cases and outbreaks will be illustrated in maps of the city of Calgary.

All Influenza Cases and Outbreaks

Figure 5.1 shows all of the confirmed influenza cases in the CHR between October 1st 2006 and April 30th 2007 (each dot represents one case). Most of the cases were clustered within the city of Calgary. Clusters were also found in Canmore and Airdrie. Influenza cases were also detected in Lake Louise, Banff, Morley, Cochrane and Kananaskis west of Calgary; Didsbury and Carstairs to the north of Calgary; Langdon to the east; and Black Diamond, Turner Valley, Longview, Okotoks, High River, Cayley, Nanton, and Claresholm south of Calgary.

Figure 5.1: All of the Influenza Cases Confirmed within the CHR over the 2006-2007 Season



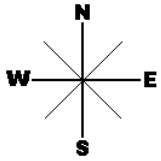
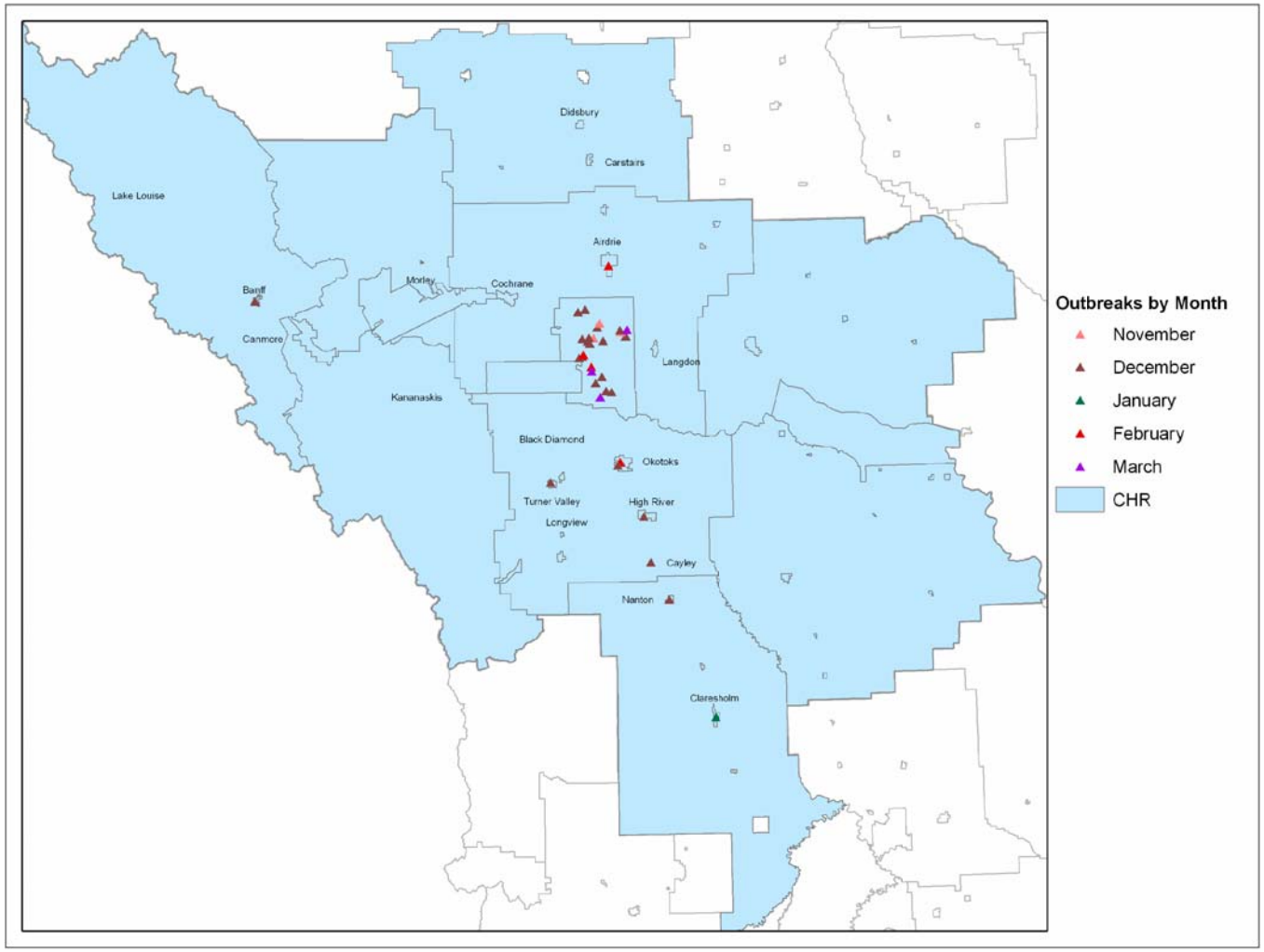


Figure 5.2 shows the influenza outbreaks that were reported in the region by month. Three outbreaks occurred within the city of Calgary in November 2006. Most of the influenza outbreaks took place in December. These outbreaks occurred in the city of Calgary, as well as in Banff, Okotoks, Turner Valley, High River, Cayley, and Nanton. One influenza outbreak occurred in Claresholm in January 2007. Four outbreaks were reported in the city of Calgary, Airdrie, and Okotoks in February. The influenza outbreaks reported in March were all in the city of Calgary. No influenza outbreaks were reported in the CHR in April 2007.

The type of facility in which the influenza outbreaks took place is illustrated in **Figure 5.3**. Most (28) of the outbreaks took place in schools. Four of the outbreaks occurred in continuing care centres in Calgary. One community outbreak occurred at a mental health and addictions centre in Claresholm, and one outbreak took place at a lodge in Okotoks.

Figure 5.2: Influenza Outbreaks Reported in the CHR by Month (2006-2007)



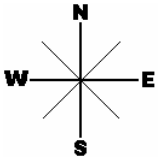
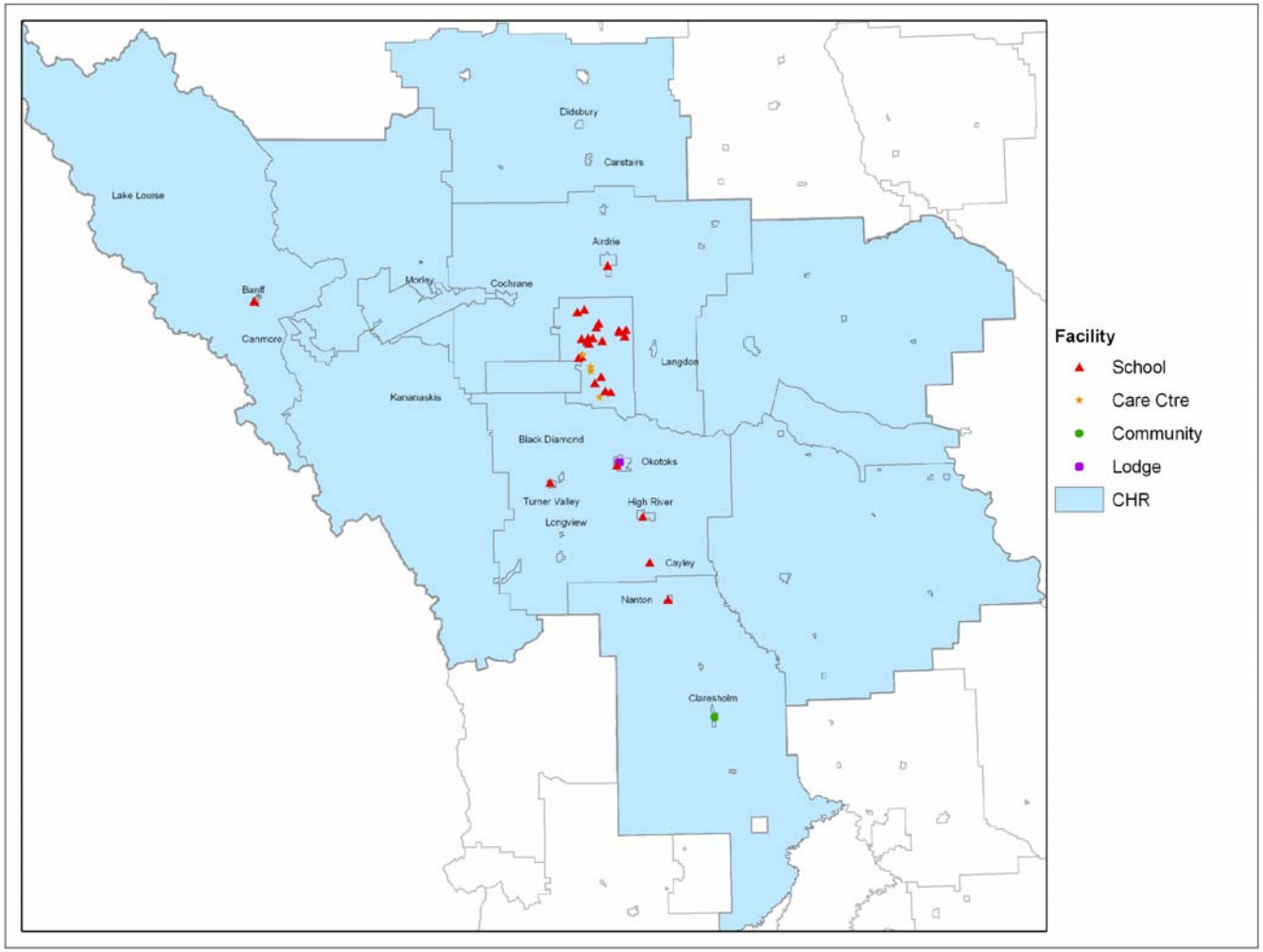
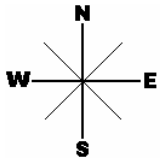


Figure 5.3: Influenza Outbreaks Reported in the CHR by Type of Facility (2006-2007 Season)

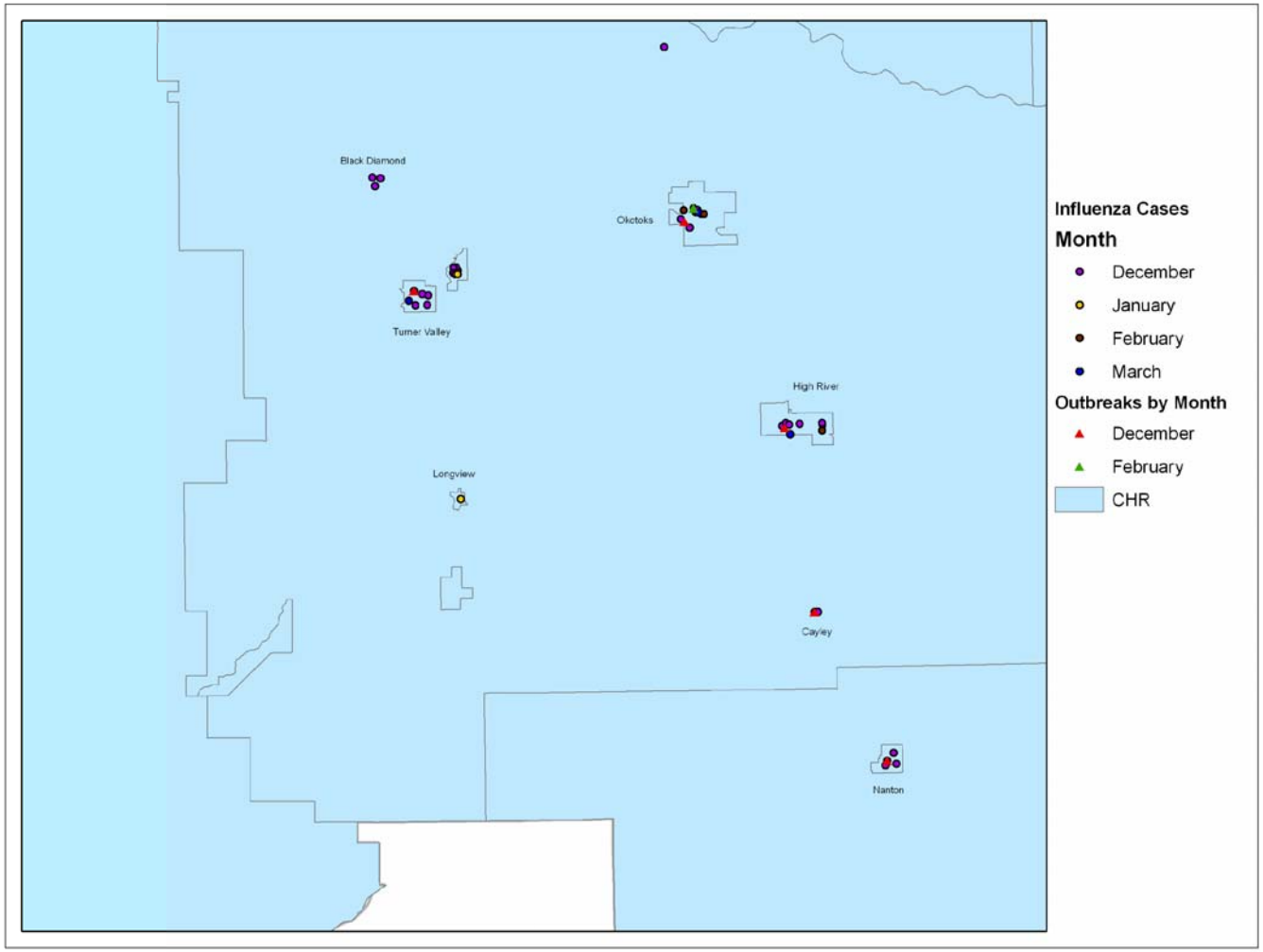


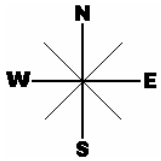


Cases and Outbreaks in the Rural Calgary Health Region

The distribution of the confirmed influenza cases and reported outbreaks in the areas south of Calgary within the CHR is illustrated in **Figure 5.4**. These areas are shown because they had a number of cases and outbreaks from December 2006 to March 2007. A total of 28 influenza cases were confirmed in December 2006 from Black Diamond, Turner Valley, Okotoks, High River, Cayley, and Nanton. There were also outbreaks in schools in all of these areas except Black Diamond over that month. There were two influenza cases in Turner Valley and Longview in January 2007. A total of four cases were confirmed from Turner Valley, Okotoks, and High River in February, as well as an outbreak at a lodge in Okotoks. A total of seven cases were also confirmed from these three areas in March of 2007. There were six influenza cases confirmed in Canmore (in the western part of the CHR) in December, January, and February, and seven cases in Claresholm (in the southern part of the CHR) in February, March, and April (not shown). An influenza outbreak at a mental health and addictions centre in Claresholm was reported in January 2007.

Figure 5.4: Confirmed Influenza Cases and Outbreaks in the southern CHR (2006-2007 Season)





Cases and Outbreaks in the Calgary Census Metropolitan Area

Figure 5.5 shows all of the confirmed cases and outbreaks in the Calgary CMA over the 2006-2007 season. Median Household Income (MHI) is divided up by CT. The CTs represented with a lighter green had a lower MHI in 2001, and those with a darker green had a higher MHI. Ten influenza cases were confirmed and an influenza outbreak was reported in Airdrie. Clusters of cases and outbreaks were confirmed in the North-East (NE) part of the city. These were in areas with the lower 60% of MHI in the Calgary CMA in 2001. Clusters of cases and outbreaks were also confirmed in the North-West (NW) quadrant. These were in areas that covered the entire range of MHI. Clusters of cases were confirmed and outbreaks reported in both the South-East (SE) and South-West (SW) parts of the city. These were also in a variety of areas that covered the entire range of MHI.

Influenza A Subtypes and Influenza B Cases in the Calgary Census Metropolitan Area

The distribution of the influenza A subtypes (for the typed cases), and the influenza B cases in the Calgary CMA is illustrated in **Figure 5.6**. All of the cases in Airdrie and Cochrane had the H3 influenza A subtype. Most of the cases (71.2%) in the NW of the city of Calgary had the H1 subtype. There were more influenza A cases with the H1 subtype (62.5%) than those with the H3 subtype (37.5%) in the NE quadrant of the city. Most of the cases (76.3%) in the SW had the H3 subtype, and those in the SE were mostly H1 (57.7%). The influenza B cases were almost evenly distributed among the four quadrants of the city of Calgary.

Figure 5.5: Confirmed Influenza Cases and Outbreaks in the Calgary CMA (2006-2007 Season)

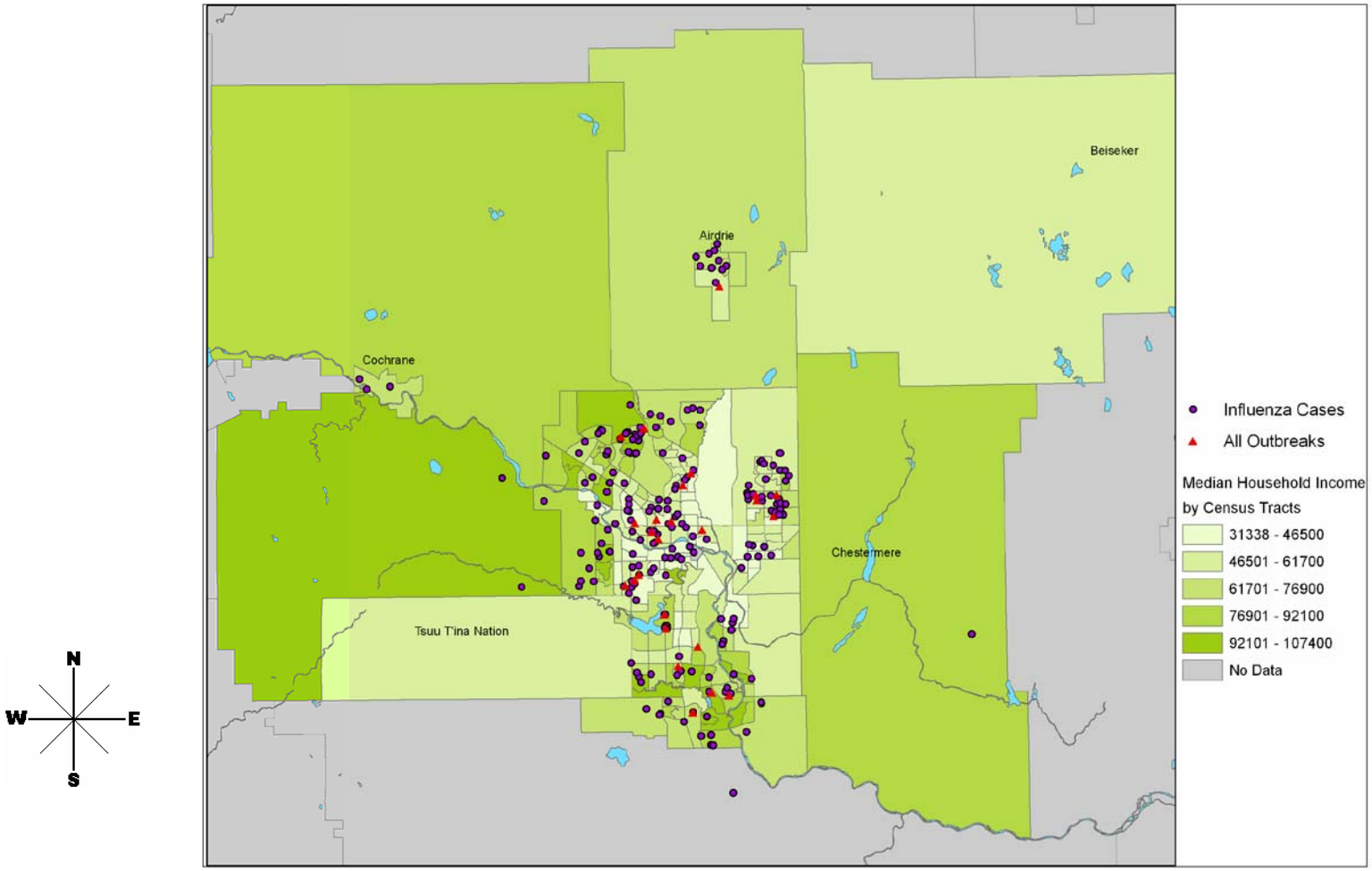
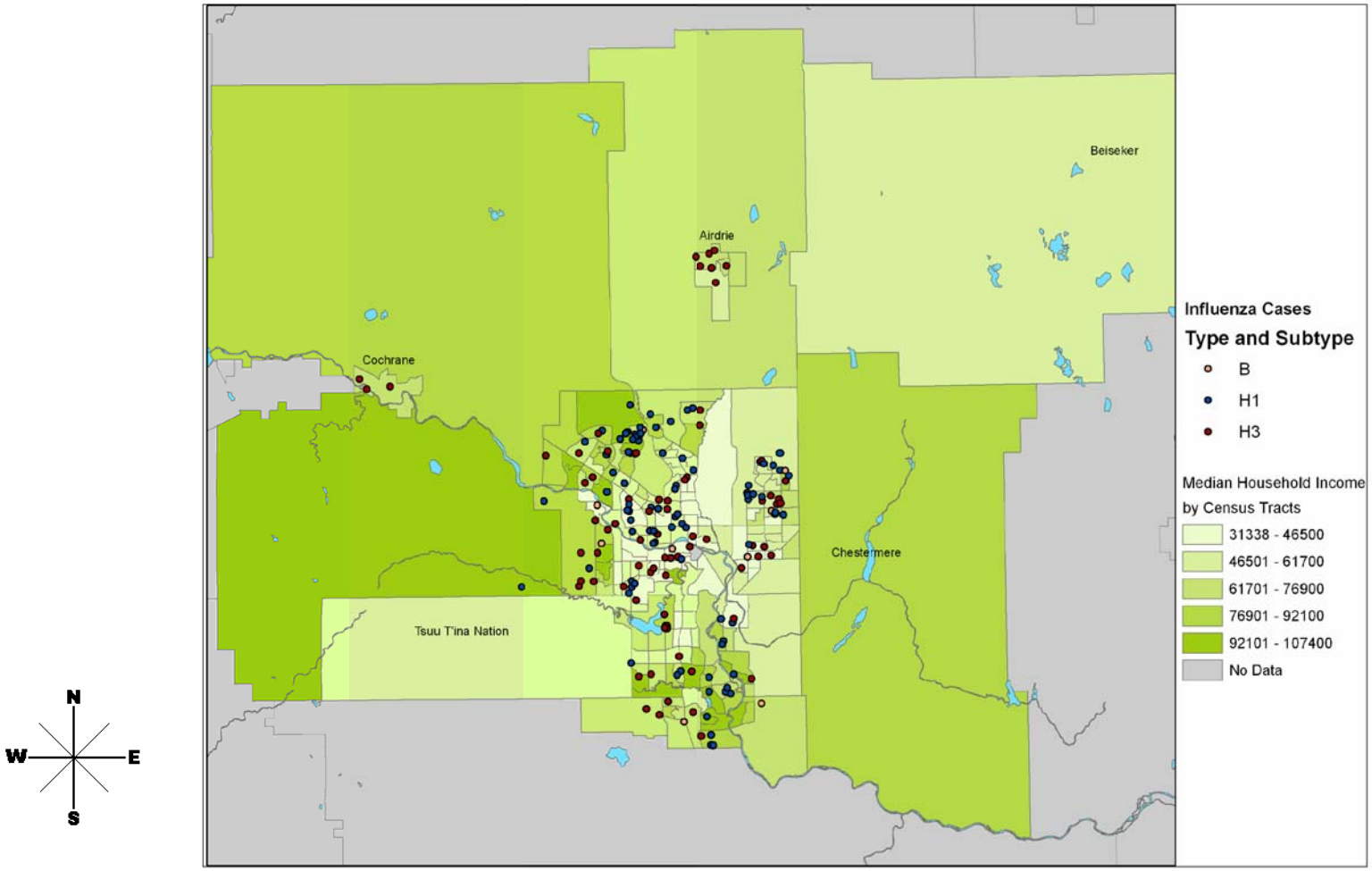


Figure 5.6: Distribution of Influenza A Subtypes and Influenza B Cases for Calgary CMA (2006-2007)



Influenza Cases and Outbreaks in the City of Calgary by Month

Confirmed influenza cases and reported outbreaks in the city of Calgary for November 2006 are shown in **Figure 5.7.** There were three school outbreaks over the month. All of them were in the northern parts of the city. Only a few influenza cases were confirmed in Calgary in November. One case was confirmed from the SW in week 44 of the year (the first week of November). There were three cases in week 47, one in the NW, one in the NE, and the other in the SE. Four cases were confirmed from the NW in week 48.

Separate maps were created for each week of December 2006 because there was a large number of cases and outbreaks during this month. **Figure 5.8** illustrates the spatial distribution of the cases and outbreaks in Calgary in week 49 of the year (the first week of December). All of the confirmed cases during this week were in the northern parts of the city. All of the reported outbreaks (which occurred in schools) were in the NW.

Figure 5.9 shows the confirmed influenza cases and outbreaks in week 50. All four of the city quadrants had influenza cases during this week. Most of the confirmed cases however, were from the NW. Seven influenza outbreaks occurred in schools all over the city in week 50.

The influenza cases confirmed and outbreaks reported in the city of Calgary in week 51 are shown in **Figure 5.10.** All four of the city quadrants had influenza cases in week 51, which is similar to what was observed in week 50. Most of the confirmed cases in week 51 were from the NW, which is similar to the findings for week 50. Five influenza outbreaks occurred in schools all over the city in week 51.

Figure 5.7: Confirmed Influenza Cases and Outbreaks in Calgary in November 2006

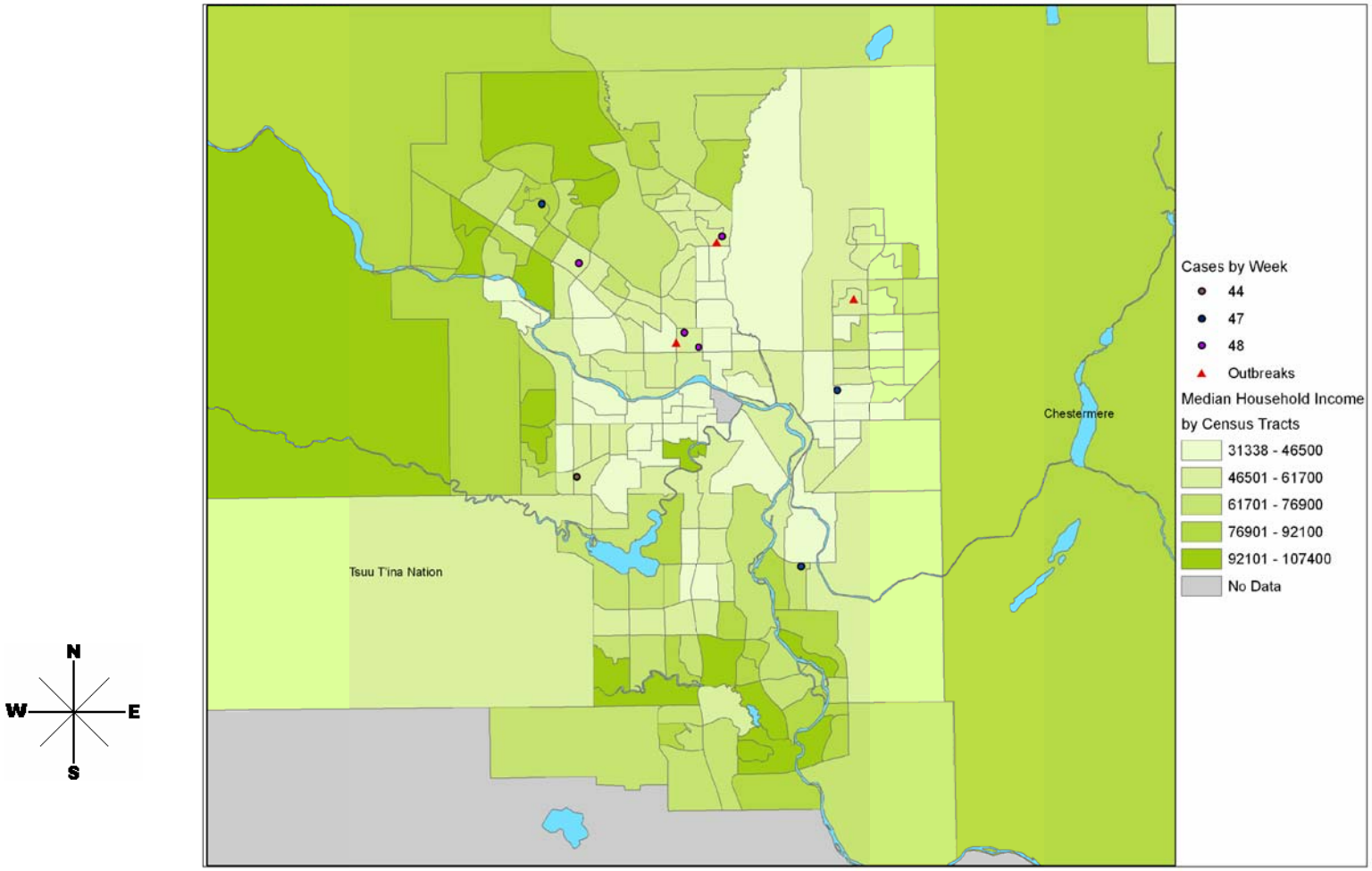
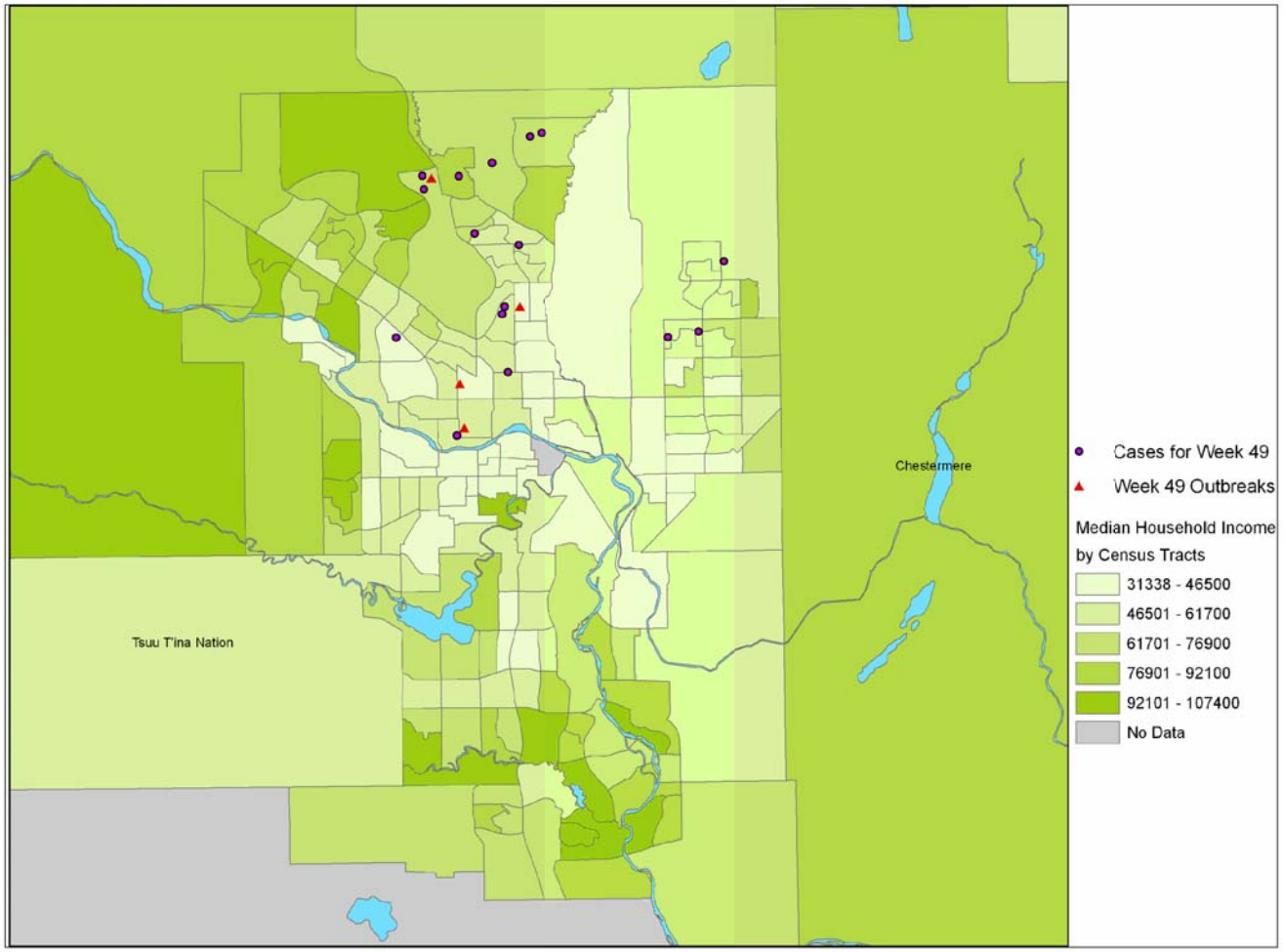


Figure 5.8: Confirmed Influenza Cases and Outbreaks in Calgary in Week 49 2006



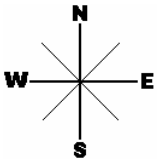


Figure 5.9: Confirmed Influenza Cases and Outbreaks in Calgary in Week 50 2006

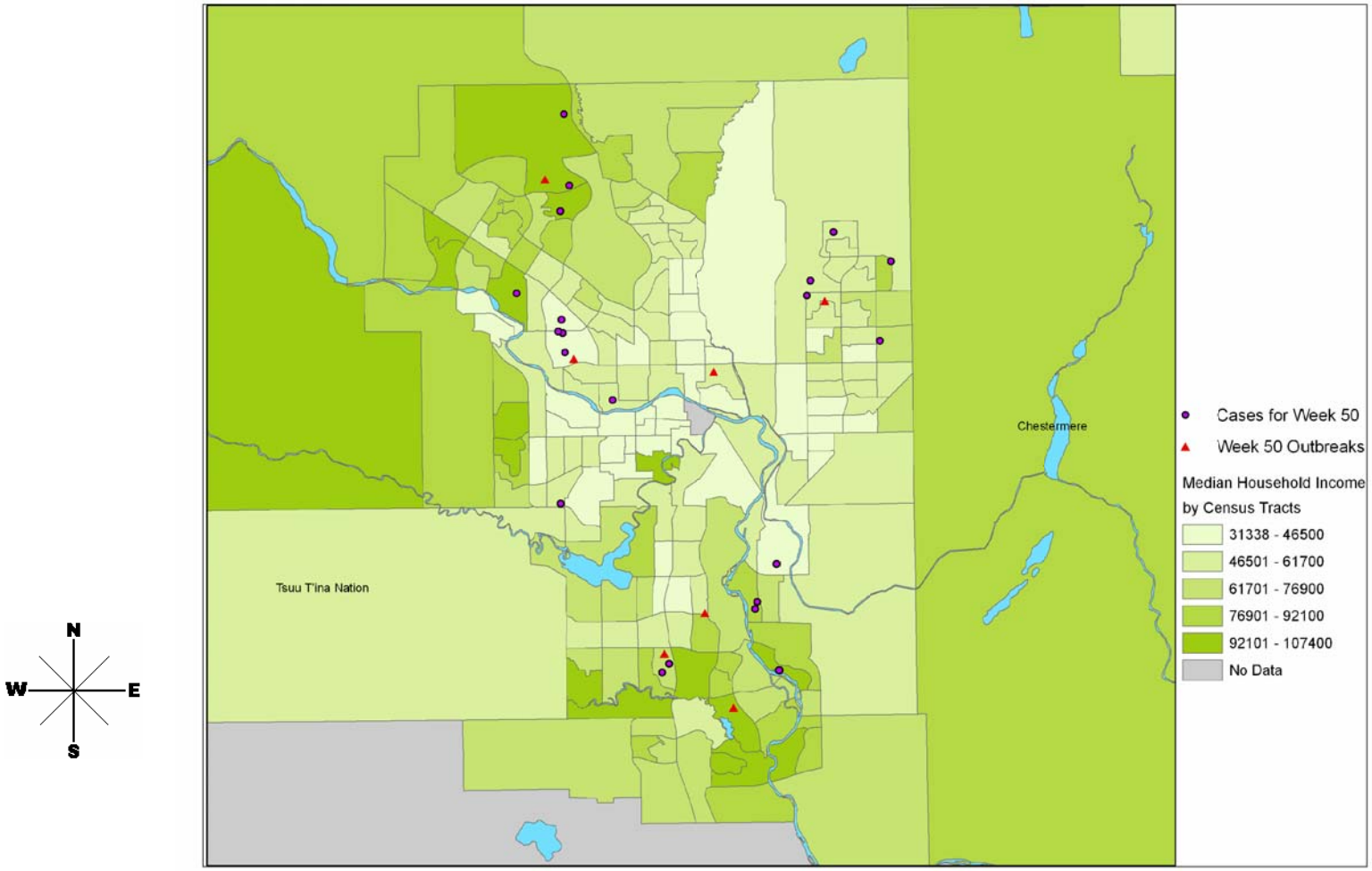
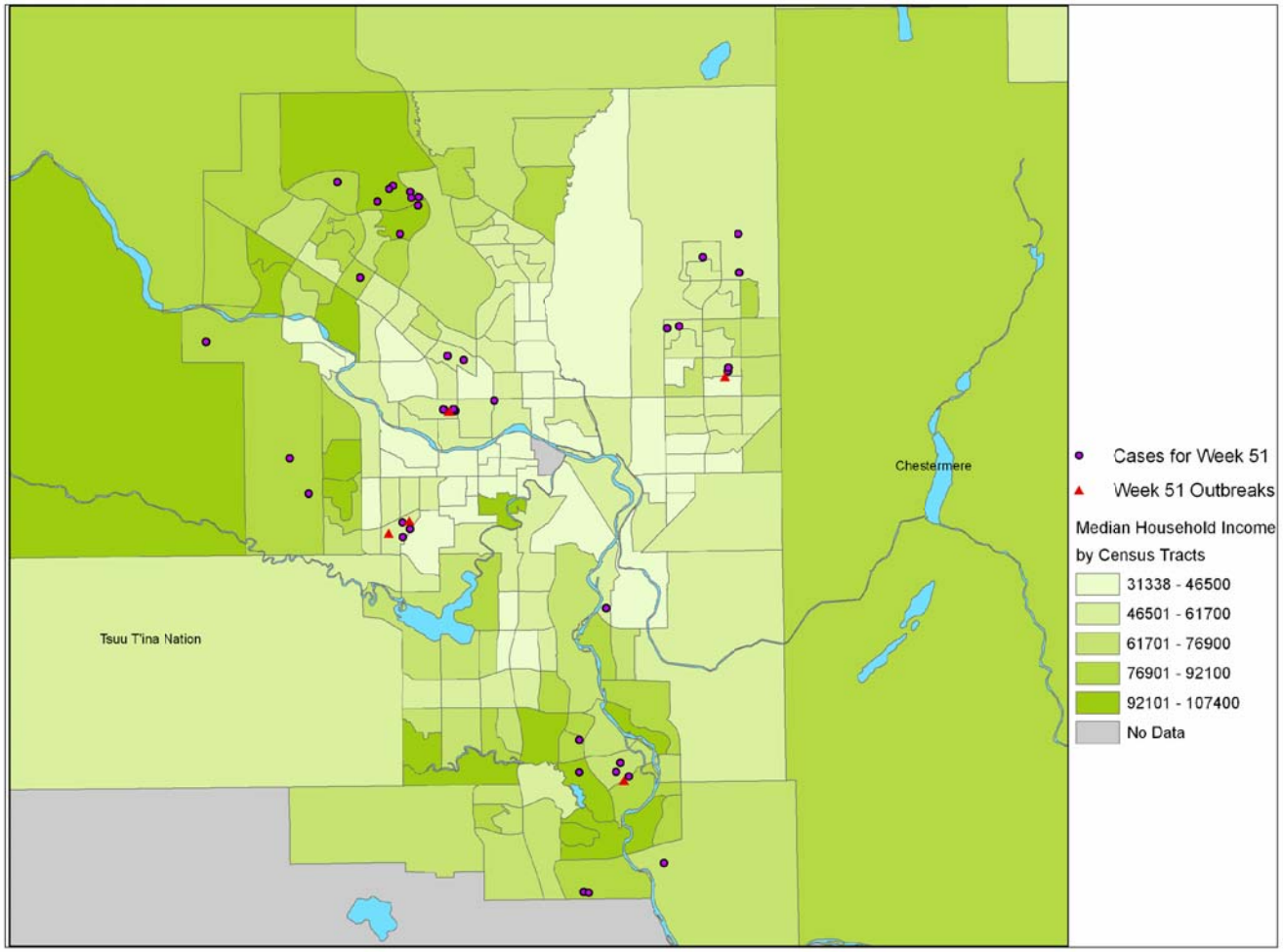


Figure 5.10 Confirmed Influenza Cases and Outbreaks in Calgary in Week 51 2006



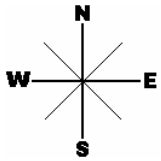
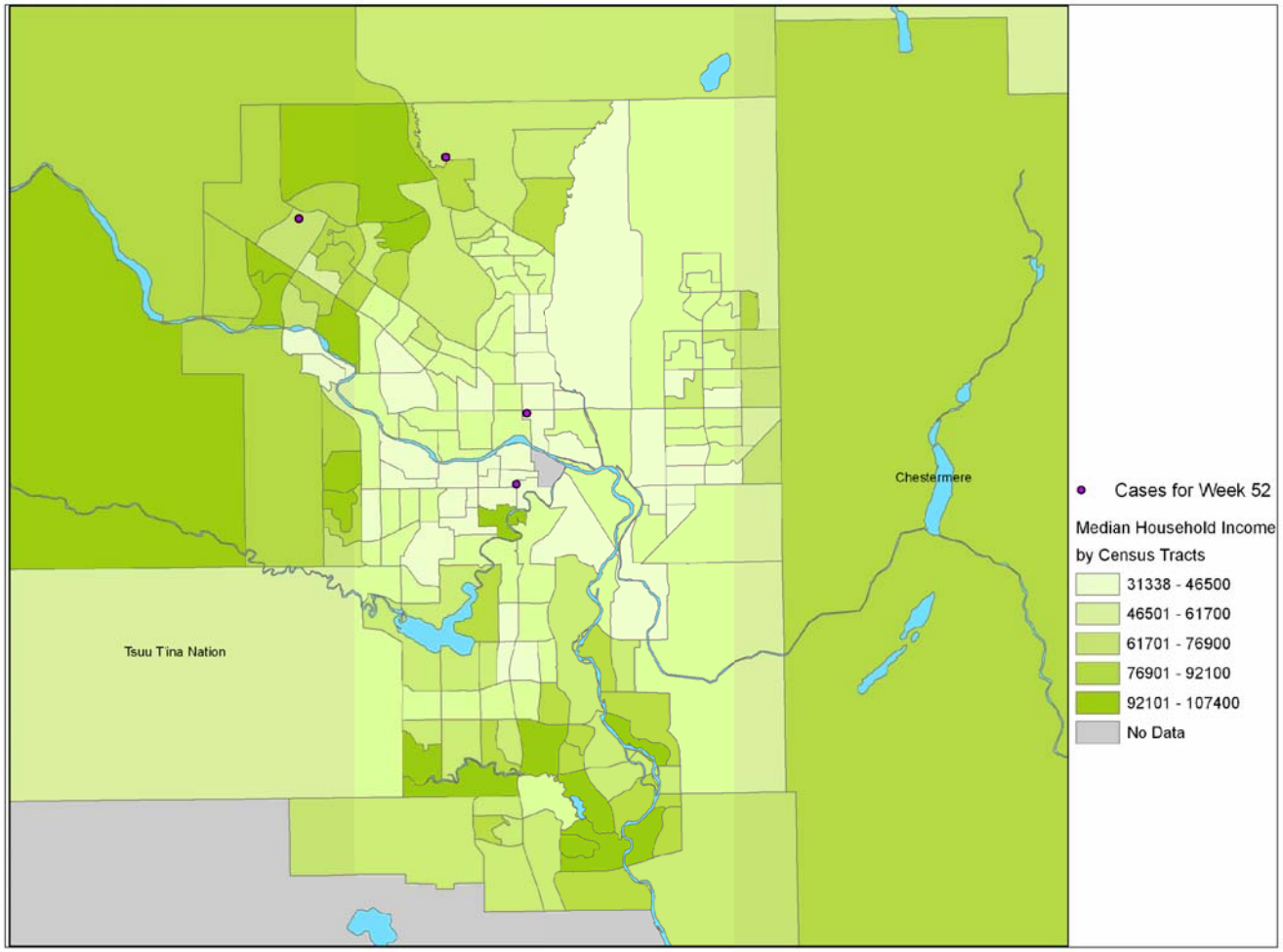


Figure 5.11 illustrates the spatial distribution of the influenza cases confirmed in the city of Calgary in week 52 of the year (the last week of December 2006). There were only four cases confirmed and all of them were in the western parts of the city. There were no outbreaks reported during this week.

The confirmed cases in January 2007 are shown in **Figure 5.12**. There were influenza cases in all parts of the city except the NE over this month. Most of the cases in week one were in the SW, but there were also cases reported in the NW and SE. There was one case in the NW in week two. The cases confirmed in week three were from all three of the city quadrants. Week four and week five had influenza cases only in the SW. No influenza outbreaks were reported in Calgary in January.

Figure 5.13 shows the confirmed influenza cases and outbreaks in the city of Calgary in February 2007. Week five had one influenza case in the NW quadrant. The confirmed cases in week six were from all parts of the city except the NE. There were influenza cases in week seven from the NW, SW and the NE, but none from the SE. The distribution of influenza cases in week eight was similar to that in week six, with no cases in the NE. Cases were confirmed in week nine from all parts of the city. There were two influenza outbreaks that occurred in Calgary in February. Both were in continuing care centres in the SW quadrant of the city. A school outbreak and seven cases were also reported in Airdrie over this month (not shown in map). There were some influenza cases in Airdrie in January and March of 2007 as well.

Figure 5.11: Confirmed Influenza Cases in Calgary in Week 52 2006



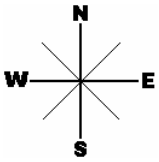
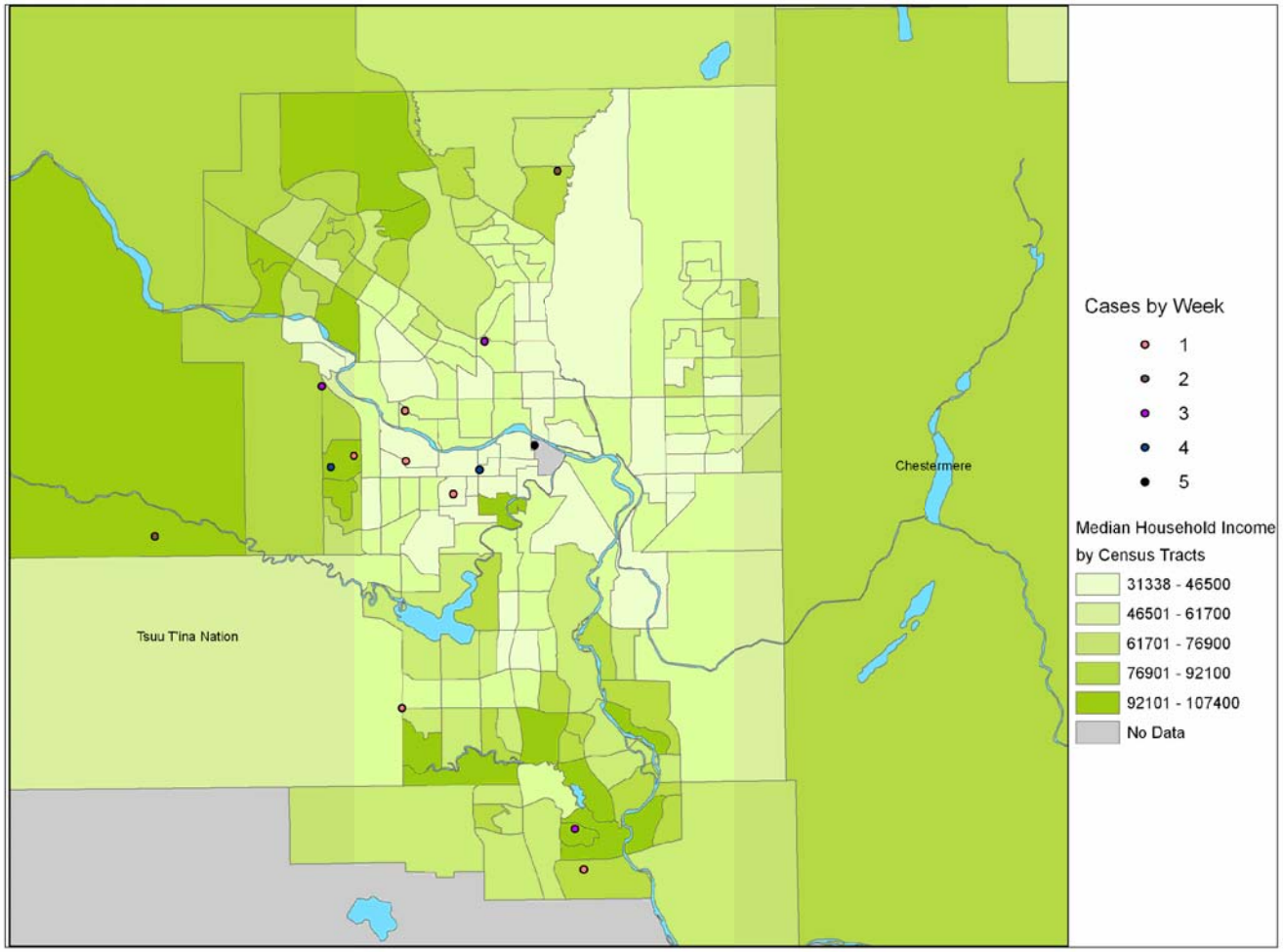


Figure 5.12: Confirmed Influenza Cases in Calgary in January 2007



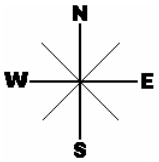
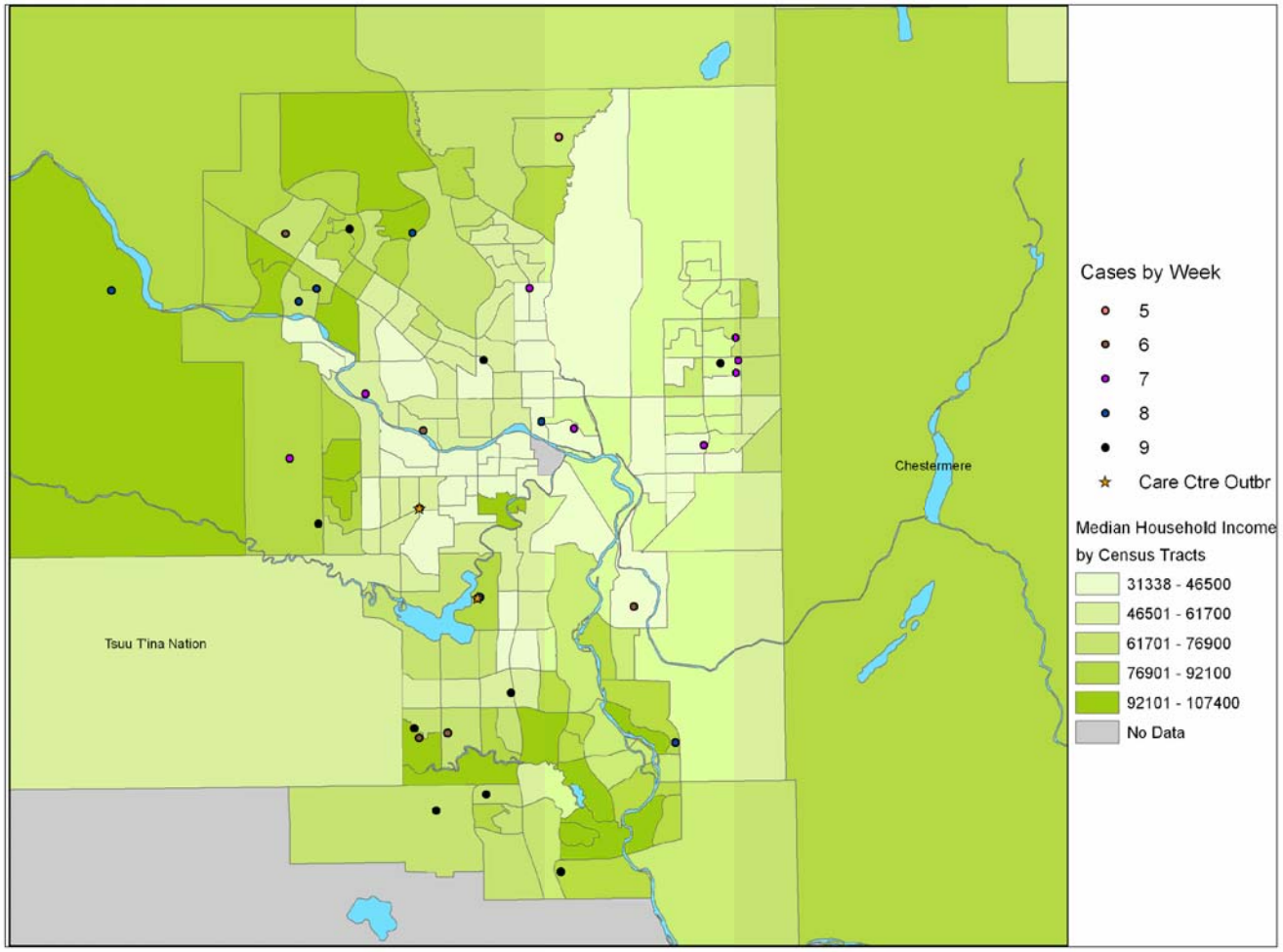
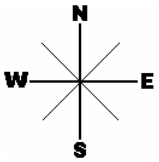


Figure 5.13: Confirmed Influenza Cases and Outbreaks in Calgary in February 2007

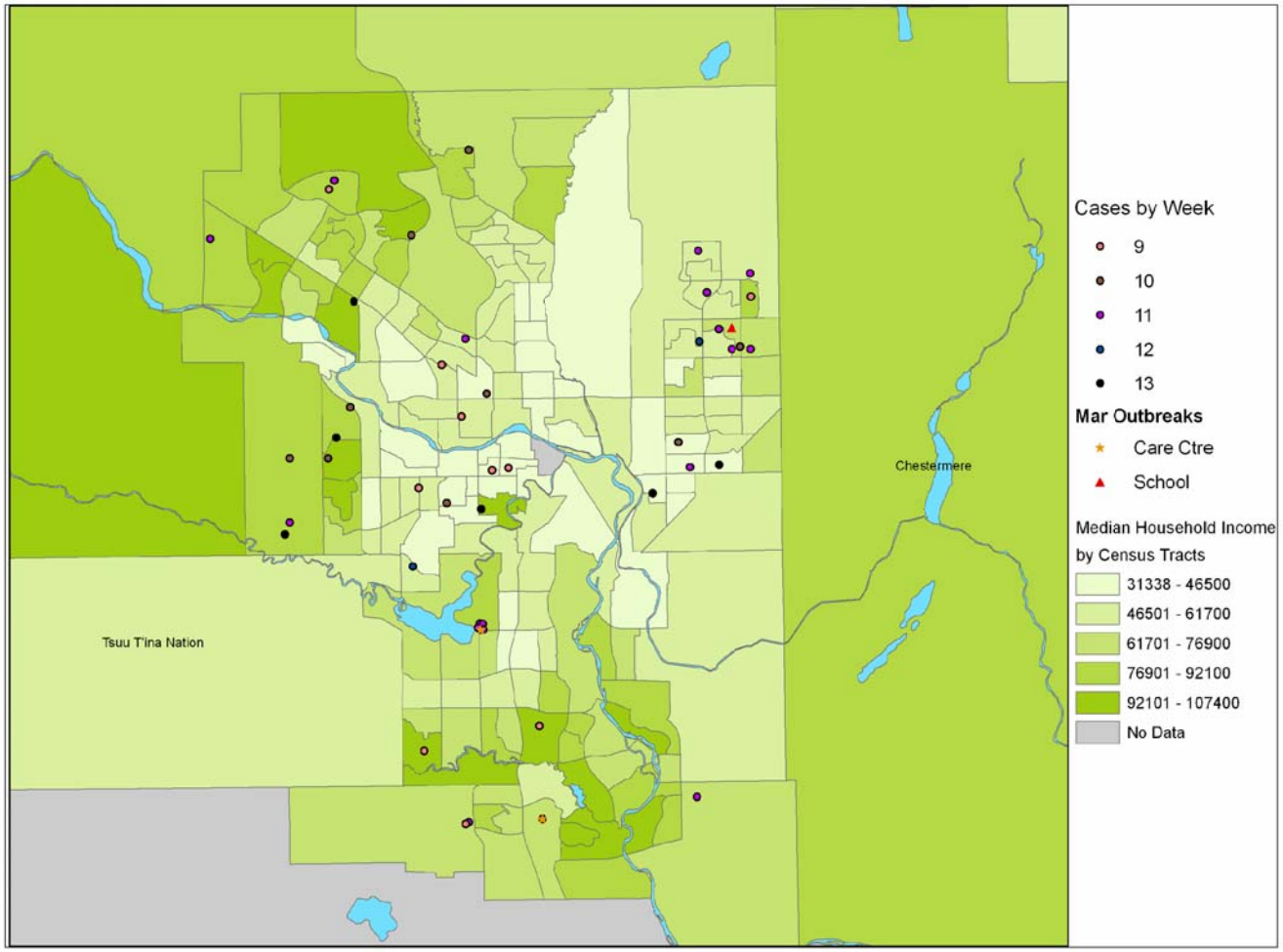




The influenza cases confirmed and outbreaks reported for the city of Calgary in March 2007 are shown in **Figure 5.14.** There were confirmed cases from all four quadrants of the city in week nine. Cases were confirmed from all parts of the city except the SE in week 10. Similar to week nine, there were cases identified from all parts of the city in week 11. In this case however, most of the cases were in the SW and NE parts of the city where influenza outbreaks also took place. There were very few influenza cases in week 12 of the season. These were also in the SW and NE. Influenza cases were found in all parts of the city in week 13 except the SE, which is similar to what was seen in week 10. Three influenza outbreaks were reported in Calgary in March. Two of them were in continuing care centres, one in the SE and another in the SW. A school outbreak was reported in the NE.

Only nine cases of influenza were confirmed in the city of Calgary in April 2007 (**Figure 5.15**). The influenza cases were distributed all over the city over the month. There were two cases in week 14, one in the NW and one in the SW. Two cases were found in the SW in week 15. There was one case, also in the SW in week 16. In week 17, two cases were found in the NE and the NW. There were two cases in the SE and the SW in week 18. No influenza outbreaks were reported in the city of Calgary in April.

Figure 5.14: Confirmed Influenza Cases and Outbreaks in Calgary in March 2007



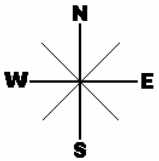
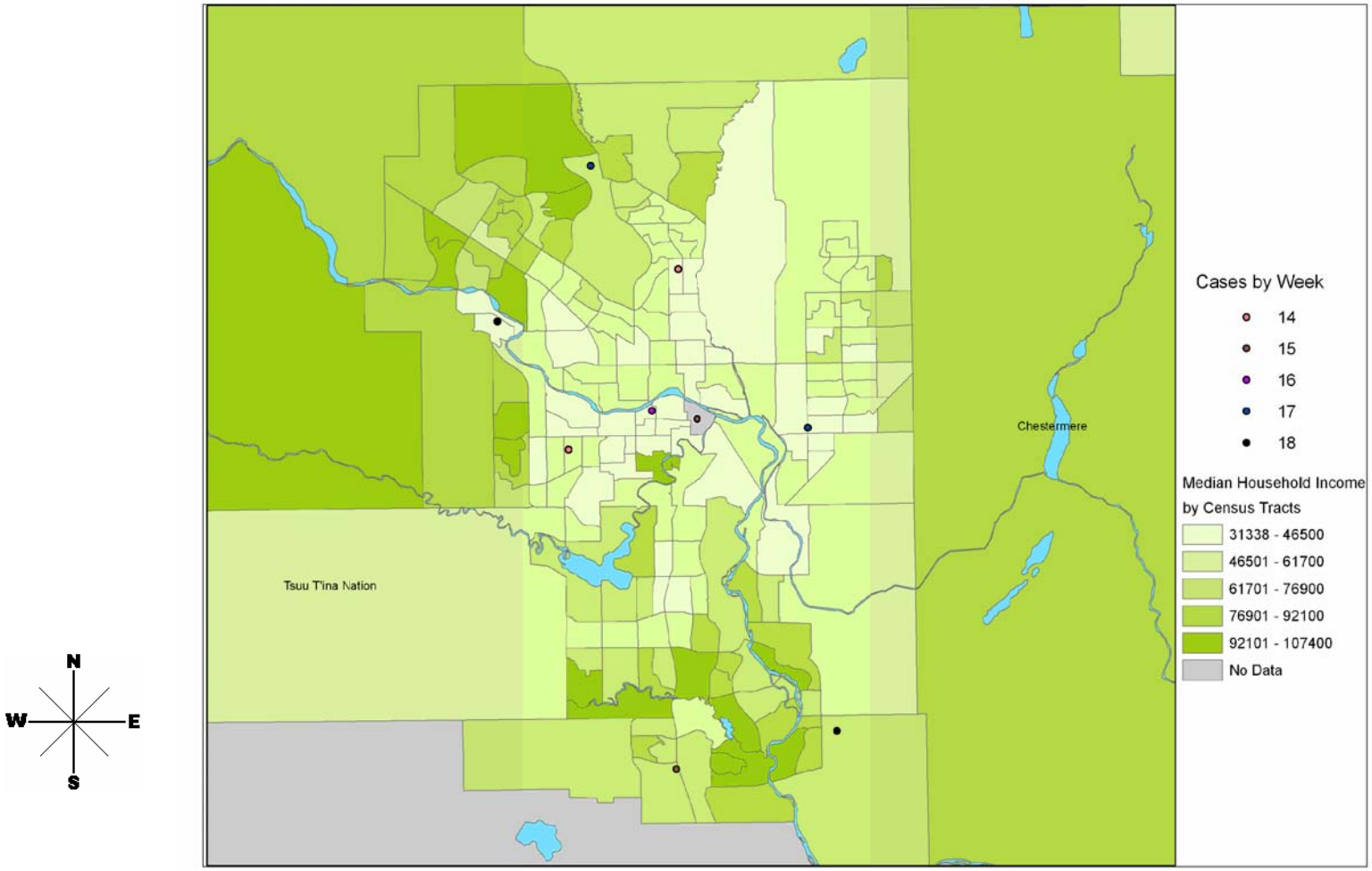


Figure 5.15: Confirmed Influenza Cases in Calgary in April 2007



Influenza Rates

Influenza rates for the Calgary CMA were calculated using Census Canada data from both 2001 and 2006. This was done because the populations in these areas and the manner in which the CTs were divided changed between the census in 2001 and the one in 2006. The influenza rates for each CT were calculated as follows:-

(Number of influenza cases in a CT/Total population for that CT) x 10,000 = Influenza Rate Per 10,000 people

The influenza rates obtained using the 2001 Census data are illustrated in **Figure 5.16.** The highest rates of influenza (between 10.01 and 14.18 cases per 10,000 people) were observed in five CTs in Airdrie and in the NW, SW, and NE parts of the city of Calgary. The areas with the highest rates in the three city quadrants also had some outbreaks that occurred there over the season (four school outbreaks in the NW and NE, and two continuing care centre outbreaks in the SW).

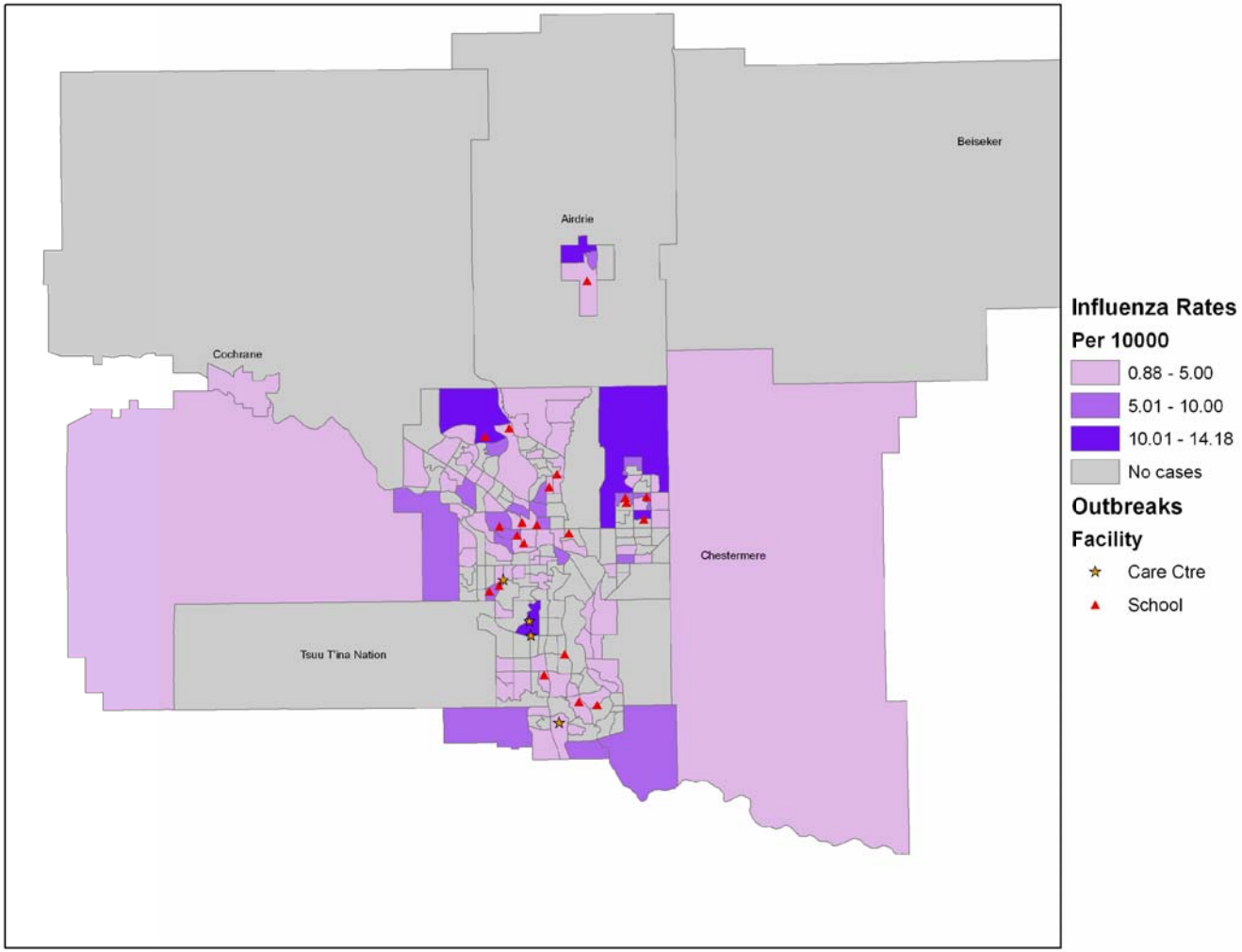
Influenza rates at the middle level (5.01 to 10.00 cases per 10,000 people) were observed in all four quadrants of the city of Calgary and in Airdrie. Seven school outbreaks were also observed in these areas in the NW, NE, and SW parts of the city over the season.

The lowest rates of influenza (0.88 to 5.00 cases per 10,000 people) were also observed all over the city and in Airdrie, as well as in Cochrane and Chestermere. Eight school outbreaks occurred in Airdrie and in the four city quadrants in these areas. Two influenza outbreaks also took place in continuing care centres, one in the SE and one in

the SW. There were no individual influenza cases confirmed in 86 (47.3%) of the 182 CTs in the Calgary CMA in 2001.

The influenza rates calculated using the 2001 Census data and the influenza outbreaks are summarized in **Table 5.2.**

Figure 5.16: Rates of Influenza (2006-2007) in the Calgary CMA Using 2001 Census Canada Data



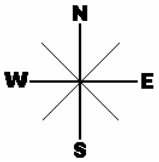


Table 5.2: Influenza Rates and Outbreaks for the Calgary Census Metropolitan Area over the 2006-2007 Season using 2001 Census Canada Data

Influenza Rates	Calgary Census Metropolitan Area	Number of Census Tracts	Number of Outbreaks
10.01 to 14.18 confirmed influenza cases per 10,000 people	NW Calgary	1	2 schools
	SW Calgary	1	2 care centres
	NE Calgary	2	2 schools
	SE Calgary	0	0
	Airdrie	1	0
5.01 to 10.00 confirmed influenza cases per 10,000 people	NW Calgary	9	3 schools
	SW Calgary	3	2 schools
	NE Calgary	3	2 schools
	SE Calgary	4	0
	Airdrie	1	0
0.88 to 5.00 confirmed influenza cases per 10,000 people	NW Calgary	23	3 schools
	SW Calgary	20	1 school; 1 care ctre
	NE Calgary	11	1 school
	SE Calgary	14	2 schools;1 care ctre
	Airdrie	1	1 school
	Cochrane	1	0
	Chestermere	1	0

Influenza rates in the Calgary CMA using the 2006 Census Canada data are illustrated in **Figure 5.17**. The rates of influenza observed were lower using this data than when using the 2001 data, with a maximum rate of 12.99 cases per 10,000 people. The highest rates of influenza (10.01 to 12.99 cases per 10,000 people) were observed in four CTs in the NE, NW, and SW quadrants of the city of Calgary. Four school outbreaks were reported in these areas. Two influenza outbreaks in continuing care centres in the SW were also observed.

The middle level of influenza rates (5.01 to 10.00 cases per 10,000 people) was observed in 16 CTs in Airdrie and in the NE, NW, and SW quadrants of the city. Eight school outbreaks were reported in these areas in the NE and the NW. A continuing care centre outbreak was reported in the SW.

The lowest rates of influenza cases (0.67 to 5.00 cases per 10,000 people) were observed in Airdrie, Cochrane, Chestermere, and in all four quadrants of the city of Calgary. Seven school outbreaks were reported in these areas in Airdrie, and in all four of the city quadrants. A continuing care centre outbreak was reported in the SE. There were no individual influenza cases confirmed in quite a few of the CTs in 2006 in the Calgary CMA. The total number of CTs in the Calgary CMA in 2006 was not yet available at the time of data analysis.

The influenza rates calculated using the 2006 Census data and the influenza outbreaks are summarized in **Table 5.3.**

Figure 5.17: Rates of Influenza (2006-2007) in the Calgary CMA Using 2006 Census Canada Data

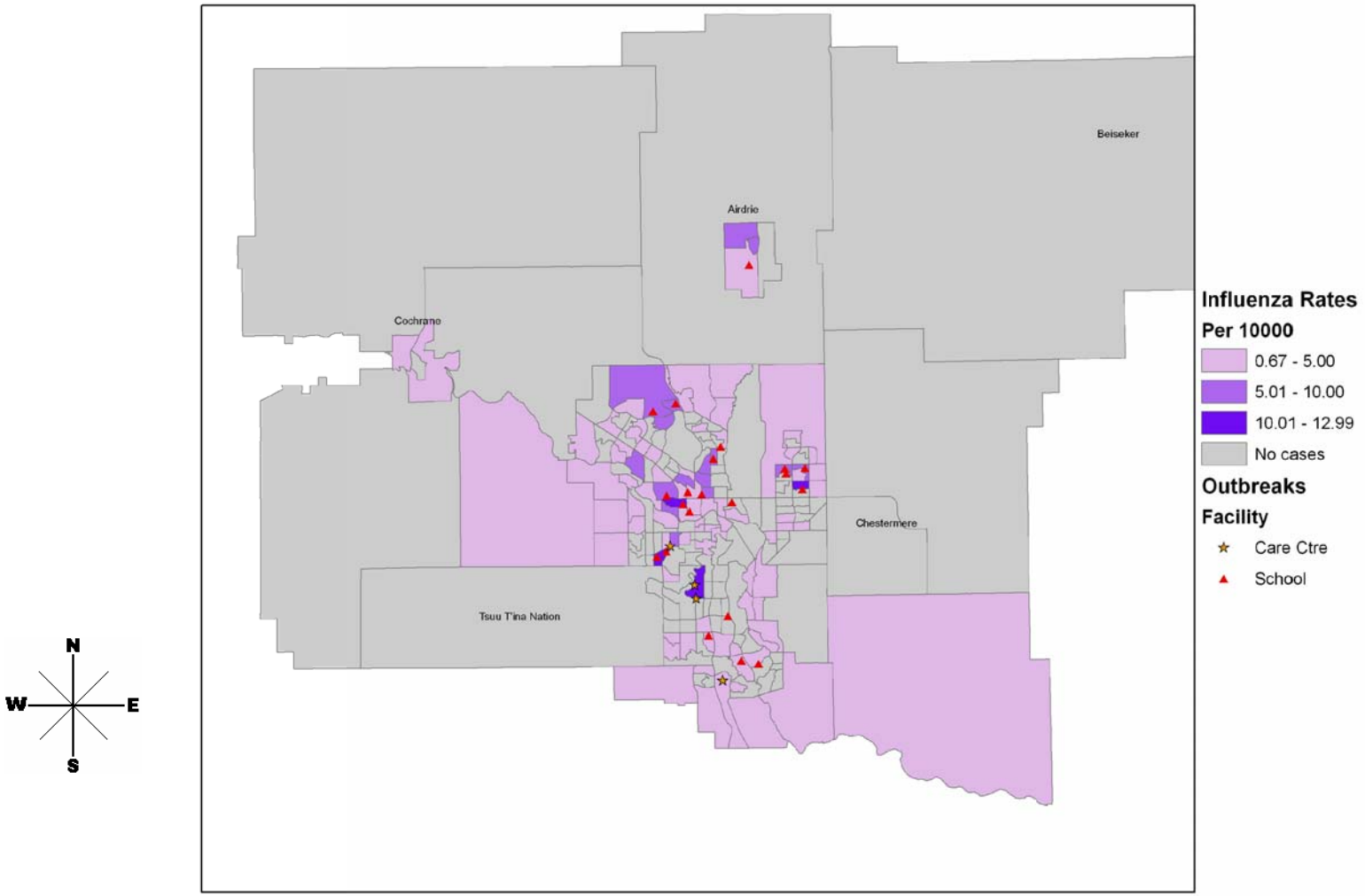


Table 5.3: Influenza Rates and Outbreaks for the Calgary Census Metropolitan Area over the 2006-2007 Season using 2006 Census Canada Data

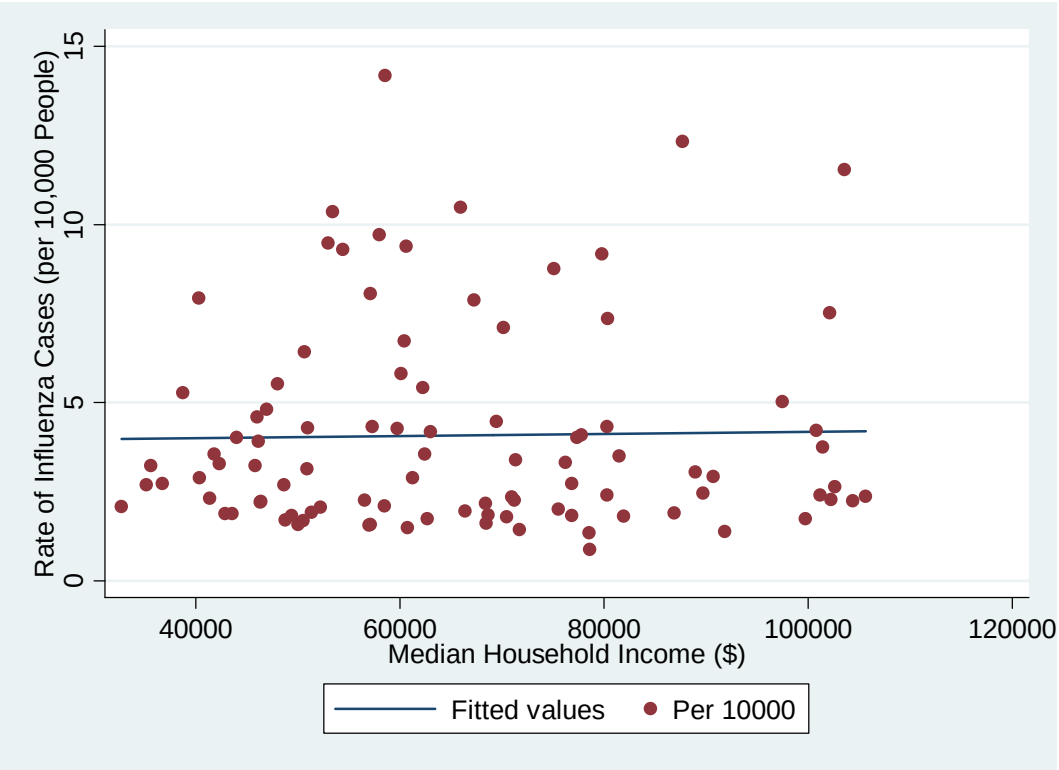
Influenza Rates	Calgary Census Metropolitan Area	Number of Census Tracts	Number of Outbreaks
10.01 to 12.99 confirmed influenza cases per 10,000 people	NW Calgary	1	1 school
	SW Calgary	2	2 schools; 2 care centres
	NE Calgary	1	1 school
	SE Calgary	0	0
5.01 to 10.00 confirmed influenza cases per 10,000 people	NW Calgary	11	5 schools
	SW Calgary	1	1 care centre
	NE Calgary	2	3 schools
	SE Calgary	0	0
	Airdrie	2	0
0.67 to 5.00 confirmed influenza cases per 10,000 people	NW Calgary	24	2 schools
	SW Calgary	19	1 school
	NE Calgary	12	1 school
	SE Calgary	19	2 schools;1 care ctre
	Airdrie	1	1 school
	Cochrane	3	0
	Chestermere	1	0

Correlation Analysis

Spearman's Rank Correlations were used for the correlation analysis. There were 201 influenza cases (72.0% of the total study sample) that fell within the Calgary CMA CTs for the 2001 Census of Canada. Using the 2001 Census data, the influenza rates ranged from 0.88 to 14.18 cases per 10000 people. The scatterplot of the Rate of Influenza Cases per 10,000 people in relation to the Median Household Income values for the CTs in the Calgary CMA in 2001 is illustrated in **Figure 5.18**. No particular pattern seemed to emerge between these two variables.

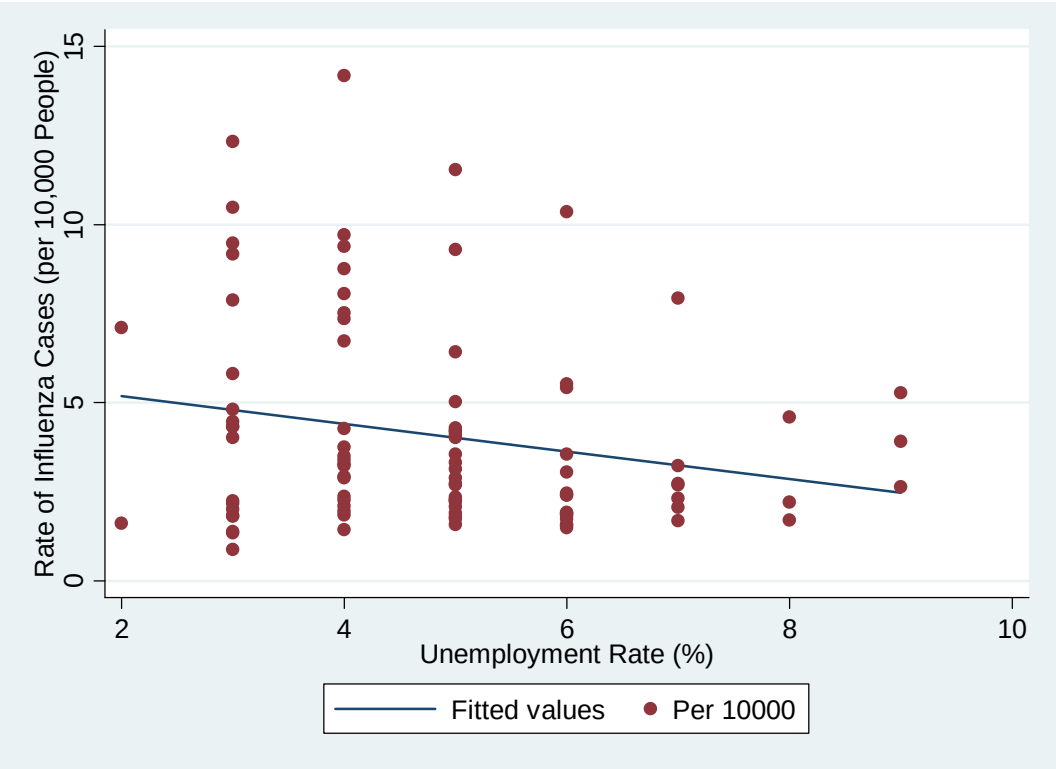
Figure 5.18: Scatterplot of Influenza Rates per 10,000 People for the 2006-2007 Season and Median Household Income in 2001 in the Calgary Census Metropolitan Area

(r_s = -0.021)



The scatterplot of the Rate of Influenza Cases per 10,000 people in relation to the Unemployment Rate (employment status variable expressed as a percentage) for the CTs in the Calgary CMA in 2001 is shown in **Figure 5.19**. No particular pattern seemed to emerge between these two variables.

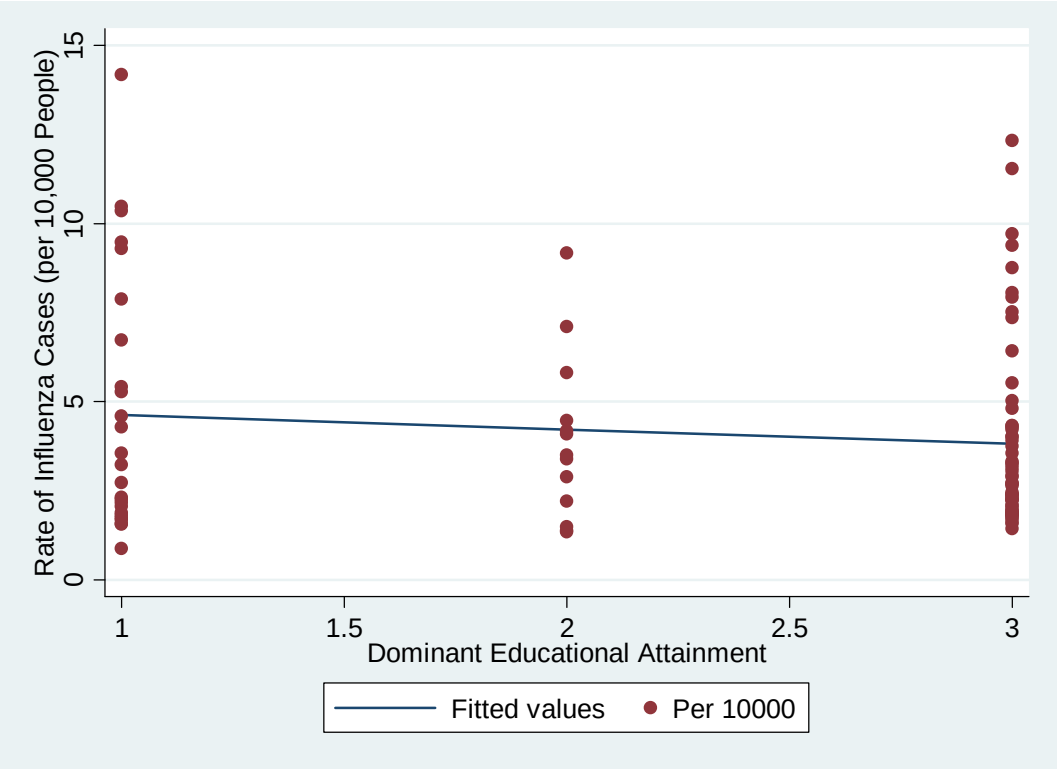
Figure 5.19: Scatterplot of Influenza Rates per 10,000 People for the 2006-2007 Season and Unemployment Rate in 2001 in the Calgary Census Metropolitan Area (r_s = -0.174)



The scatterplot of the Rate of Influenza Cases per 10,000 people in relation to Dominant Educational Attainment (education level variable) for the CTs in the Calgary CMA in 2001 is illustrated in **Figure 5.20**. No particular pattern seemed to emerge between these two variables.

Figure 5.20: Scatterplot of Influenza Rates per 10,000 People for the 2006-2007 Season and Dominant Educational Attainment in 2001 in the Calgary Census Metropolitan Area

(r_s = -0.038)



Median Household Income, Unemployment Rate, and Dominant Educational Attainment values had not yet been released for the 2006 Census of Canada at the time of data analysis, and were therefore not included in the scatterplot analysis. (*Refer to* ***Appendix G*** *for scatterplot matrices created for the variables of interest using both the 2001 Census Canada data and the 2006 data (where available)).*

The results of the correlation analysis on the rates of influenza in relation to the 2001 Census Canada variables are shown in the form of a correlation matrix in **Table 5.4.** The values that are shown in bold are those where $r_s > 0.550$ or $r_s < -0.550$ indicating that a positive or a negative relationship exists. No major associations emerged between the influenza rates and the SES variables. There was a strong negative relationship between the 65 years of age and above variable, and the nine years of age and below variable ($r_s = -0.710$ and $p < 0.000$). This means that the larger the population of persons 65 years of age and older, the smaller the population of persons nine years of age and younger. The males and females were directly and negatively correlated ($r_s = -1.00$ and $p < 0.000$). This means that the larger the population of males in a CT, the smaller the population of females.

Table 5.4: Correlation Matrix of Influenza Rates per 10,000 People for the 2006-2007 Season and 2001 Census Canada Variables

	Influenza Rate per 10,000	**Median Income**	**Unemployment Rate**	**Educational Attainment**	**Males**	**Females**	**Nine years of age and below**	**10-64 years of age**	**65 years of age and above**
Influenza Rate	1								
Median Income	-0.021 0.838	1							
Unempl Rate	-0.174 0.089	-0.411 0.000	1						
Educ Attainmt	-0.038 0.711	0.236 0.021	-0.049 0.637	1					
Males	0.082 0.428	0.071 0.493	-0.015 0.885	-0.217 0.034	1				
Females	-0.082 0.428	-0.071 0.493	0.015 0.885	0.217 0.034	**-1.000** **0.000**	1			
Nine and below	0.018 0.860	0.428 0.000	-0.258 0.011	-0.427 0.000	0.190 0.064	-0.190 0.064	1		
10-64 yrs	-0.166 0.107	0.156 0.130	0.112 0.279	0.138 0.179	0.438 0.000	-0.438 0.000	-0.131 0.202	1	
65 yrs and above	0.074 0.473	-0.440 0.000	-0.440 0.000	0.208 0.042	-0.435 0.000	0.435 0.000	**-0.710** **0.000**	-0.512 0.000	1

Cells: top value: Spearman's correlation coefficient (r_s), significant at $r_s > 0.550$ or $r_s < -0.550$

bottom value: p-value

There were 202 cases (72.4 %of the total study sample) that fell within the Calgary CMA CTs for the 2006 Census of Canada. Using the 2006 Census data the influenza rates ranged from 0.67 to 12.99 cases per 10,000 people.

The results of the correlation analysis on the rates of influenza in relation to the 2006 Census of Canada variables are shown in the form of a correlation matrix in **Table 5.5.** Median Household Income, Unemployment Rate, and Dominant Educational Attainment variables had not yet been released for the 2006 Census at the time of data analysis and were therefore not included in the matrix. The values that are shown in bold in the table are those where $r_s > 0.550$ or $r_s < -0.550$. No major associations emerged between the influenza rates and the SES variables. There was a strong negative relationship between the 65 years of age and above variable and the nine years of age and below variable ($r_s = -0.616$ and $p < 0.000$). This means that the larger the population of persons 65 years of age and older, the smaller the population of persons nine years of age and below. The males and females were directly and negatively correlated ($r_s = -1.00$ and $p < 0.000$). This means that the larger the population of males in a CT, the smaller the population of females.

Table 5.5: Correlation Matrix of Influenza Rates per 10,000 People for the 2006-2007 Season and 2006 Census Canada Variables

	Influenza Rate per 10,000	**Males**	**Females**	**Nine years of age and below**	**10-64 years of age**	**65 years of age and above**
Influenza Rate	1					
Males	0.047 0.648	1				
Females	-0.047 0.648	**-1.000** **0.000**	1			
Nine yrs and below	-0.090 0.376	-0.002 0.986	0.002 0.968	1		
10-64 yrs	-0.120 0.236	0.437 0.000	-0.437 0.000	-0.189 0.061	1	
65 yrs and above	0.185 0.067	-0.371 0.000	0.371 0.000	**-0.616** **0.000**	-0.523 0.000	1

Cells: top value: Spearman's correlation coefficient (r_s), significant at $r_s > 0.550$ or $r_s < -0.550$

bottom value: p-value

CHAPTER 6: DISCUSSION

Introduction

The role of influenza surveillance will be discussed in this chapter, with particular emphasis on the characteristics of GIS as a system for influenza surveillance. The spatial and non-spatial results of the study will be discussed. The strengths and limitations of the study, including its validity and the study design will also be discussed. Recommendations and future research ideas stemming from the study will be presented. These include the feasibility of using GIS for influenza surveillance in the future, the advantages of mapping influenza over many seasons, and the expansion of the mapping process to include various factors.

Goals and Functions of Influenza Surveillance

Influenza surveillance has a number of important goals and functions. The primary goals of influenza surveillance in the Calgary Health Region (CHR) are to provide information for the optimal prevention and management of influenza, and to reduce the impact of seasonal influenza on acute care facilities. To accomplish these goals, influenza surveillance has a number functions.

One of these functions is to track the activity of influenza and Influenza-Like-Illness (ILI) and to rapidly detect when and where there is an increase in disease. Surveillance is also used to detect outbreaks and to determine when, where, and in whom they occur. This information is important so that early interventions can be put into place before the outbreak gets out of control.

Another crucial function of influenza surveillance is to provide data on the circulating subtypes and strains of influenza. This helps in detecting the emergence of novel strains of influenza, and in tracking antiviral resistance of influenza strains. These data are also very important to influenza prevention as they assist in determining which strains will be in the influenza vaccine the following year when combined with global surveillance data. All of these characteristics of influenza surveillance help in the prevention and control of seasonal influenza and in pandemic planning. Syndromic, sentinel, and laboratory-based surveillance all play an important part in meeting the goals of influenza surveillance.

Geographic Information Systems and Influenza Surveillance

The use of Geographic Information Systems (GIS) could also assist in meeting the goals of influenza surveillance. GIS would help in the rapid determination and visualization of where influenza, ILI activity, and outbreaks are occurring. The use of GIS also makes it very easy to share this information over the internet locally, and with other health jurisdictions. It can also help in detecting patterns of disease transmission that may not have been obvious before. GIS could make it possible to determine whether particular strains or subtypes of influenza are circulating in certain areas more than others, and if there are areas of particular concern in the emergence of antiviral resistance.

The potential for geomapping (specifically GIS) to contribute to the goals of influenza surveillance can be analysed using the criteria used to evaluate a surveillance system.

The first characteristic of a surveillance system is whether or not it accomplishes its purpose. In this study, the use of GIS software did meet its purpose to describe the spatial and temporal distribution of influenza in the CHR. The acceptability of using GIS for influenza surveillance will be determined over time by the willingness of stakeholders to participate in this type of surveillance.

Another important characteristic is the ease of operation of the system. The use of GIS does have a steep learning curve which initially reduces the ease of operation. Once past this initial stage, it is quite simple to use GIS to produce a series of maps to describe the distribution of influenza and ILI using different data sources.

GIS is quite flexible to changes in the information needed as the variables in the maps produced can be altered and combined in a variety of ways according to what factors may be of interest. A wide variety of data types can be used as long as they are spatially referenced. The need for the data to be spatially referenced is a limitation of GIS surveillance.

The use of GIS for influenza surveillance is dependent on other surveillance systems such as sentinel, syndromic, and laboratory-based surveillance which provide the data for mapping. The quality of mapped data is therefore dependent upon data quality in these surveillance systems, as are the sensitivity, positive predictive value, and representativeness of the data used.

The timeliness of the data dissemination from influenza surveillance using GIS is very good because the maps can be produced quickly and continuously once the base maps and shapefiles have been combined. When the system is automated, these maps can be produced in real-time and shared immediately over the internet.

In summary, this study shows that geomapping has many of the characteristics that are considered important for a surveillance program. It has the potential to contribute significantly to influenza surveillance by providing another dimension (i.e. spatiotemporal mapping) of information about both seasonal and pandemic influenza, and can be used to assist in its prevention and management.

Non-Spatial Analysis

This section discusses the non-spatial results of this study relative to pertinent literature when available. The outbreaks detected will be discussed first, followed by the relevant demographic characteristics and vaccination status of the cases. Finally, the circulating influenza strains are characterized.

Influenza Outbreaks

The largest number of reported influenza outbreaks (22) in the CHR over the 2006-2007 season occurred in December 2006. This corresponded with the largest number of confirmed individual influenza cases (115) over one month. The majority (65.2%) of the individual cases in December were part of an outbreak which may have been the reason why the influenza cases and outbreaks peaked within the same month.

About 82% of the influenza outbreaks over the season occurred in schools. This is likely to be because generally, the highest influenza attack rates occur among children of school-going age during community outbreaks (Committee on Infectious Diseases, 2008). All of the outbreaks that occurred in November and December of 2006 were in schools. This is similar to what was observed over the 2005-2006 influenza season, where most of the outbreaks that occurred in November and December of 2005 were in schools (Influenza Sub-Committee, 2006). These outbreaks were mostly caused by influenza B virus, while in the 2006-2007 season, the outbreaks in schools were all caused by influenza A virus.

Approximately 12% of the reported outbreaks over the 2006-2007 season occurred in continuing care centres. All of these outbreaks were caused by influenza A virus. This is similar to what was observed for the outbreaks in continuing care centres over the 2005-2006 season (Influenza Sub-Committee, 2006).

All of the continuing care centre outbreaks over the 2006-2007 season occurred in February and March of 2007. This is similar to what was observed for the rest of the country as 71% of the continuing care centre outbreaks in Canada occurred between late January and the middle of March 2007 (Reyes et al, 2008).

Age

Although the age range of the influenza cases was very wide (0.08-90 years), the mean and median ages were quite skewed towards children (22.1 years and 11 years respectively). Most of the cases detected during the 2006-2007 season were very young, with 43.7% of the sample being nine years of age and younger. The proportion observed for all of Canada was lower, with only 33% of the confirmed influenza cases being below 10 years of age. This is in contrast to what was observed over the 2005-2006 season in Canada, where 45% of the confirmed influenza cases were below 10 years of age (Reyes et al, 2008).

The ILI attack rate was also highest in children of school-going age in the ILI morbidity study conducted in France (Carrat et al, 1998). This trend is to be expected as children are the main agents of the dissemination of influenza in the community. Children usually have higher viral loads and are infectious for longer periods of time than adults (Moscona, 2005).

In this study, influenza mainly affected children earlier in the season and then more and more adults were affected as the season progressed. This may have been a result of the majority of school outbreaks occurring earlier in the season. A large number of the individual influenza cases earlier in the season were children who were a part of these outbreaks.

There were very few influenza cases among seniors which was unexpected because influenza is known to primarily affect the very young and the elderly. Only 6.1% (17) of the cases in the study were 65 years of age and above. In contrast, during the 2006-2007 season in Canada, 20.6% of the confirmed cases were above the age of 64 years (Reyes et al, 2008).

The small proportion of confirmed cases in seniors in the CHR may have been a result of the extensive vaccination program for residents of continuing care centres and their staff. Residents of continuing care centres had a vaccination rate of 95.3%, and staff in these centres had a vaccination rate of 82.2% during the 2006-2007 influenza season (Influenza Sub-Committee, 2007). The influenza vaccine for this season was a very good match to the circulating influenza A strains which greatly enhanced the protection it was able to provide. Both the A/New Caledonia/20/1999 (H1N1) and the A/Wisconsin/67/2005 (H3N2) circulating strains were in the vaccine. One of the circulating strains of influenza B was not in the vaccine (Reyes et al, 2008). This did not have a major impact on influenza infection in the CHR however, as 96.8% of the confirmed cases had influenza A

The vaccination of staff members in continuing care centres was also a very important factor in preventing outbreaks as they have been implicated as the usual source of influenza when outbreaks occur in these centres. McLeod and Lau (2001) showed that as many as 60% of the residents of a nursing home or continuing care centre may become infected with influenza when it is circulating within the community. Vaccination of residents and staff members has been shown to significantly reduce the numbers of cases and outbreaks in these institutions, as well as cases of pneumonia, hospital admissions, and deaths (Oshitani et al, 2000).

Sex and Age

The female influenza cases were slightly older than the males, with a median age of 13 years for the females compared to that of 11 years for the males. The mean age was 23.9 years for the females and 20.0 years for the males. There were more females in the study (70.6%) who were above the age of 64 years than there were males (29.4%). This may be the reason for the higher median and mean ages for the females.

According to Statistics Canada (2005), the life expectancy of females in Alberta in 2005 was 81 years, and that of males was 75 years. This may help to explain why there were more females than males above the age of 64 years in the study, as females tend to live longer.

The Student’s t-test showed that there was no statistically significant difference between the mean ages of the males and the females in the study. This was likely because there were not enough cases, and therefore not enough power (only 31.9%) to detect a statistical difference between the mean ages of the male and female influenza cases at a

5% significance level. In this study, there were 149 female influenza cases and 130 male cases. A sample size calculation was carried out to see how large the sample would have had to be for the four-year mean age difference to be considered statistically significant at a 5% significance level and with 80% power. The sample size needed would be 996 (498 males and 498 females).

Influenza Vaccination

Of the 11 cases in the study that were vaccinated for influenza over the 2006-2007 season, five (45.5%) were vaccinated before they got influenza, and six (54.5%) were vaccinated after. Those who were vaccinated before they got influenza may have suffered from influenza regardless of vaccination for a number of reasons. Firstly, influenza vaccine effectiveness is not 100%. A study conducted on vaccine effectiveness in children 6-23 months of age found the vaccine to be 49% effective in preventing laboratory-confirmed influenza and pneumonia (Centers for Disease Control and Prevention, 2006). In a four-year study of children 1-15 years of age, influenza vaccine effectiveness ranged between 77% and 91% (Centers for Disease Control and Prevention, 2006).

Another reason may be the amount of time between influenza vaccination and influenza infection. One of the five cases in the study who was vaccinated before they got influenza suffered from influenza illness less than two weeks after vaccination. This may not have been sufficient time for the body to build an effective immune response against influenza. Another case received influenza vaccination for the first time during the 2006-2007 season and did not get a booster dose. It is recommended that children under nine

years of age receive two doses of the vaccine the first year that they get it in order to build a strong immune response (Centers for Disease Control and Prevention, 2006).

Influenza immunization is recommended for all children (six months of age and older) with high-risk conditions such as cystic fibrosis, diabetes mellitus, chronic renal disease, congenital heart disease, and asthma. It is also recommended for all healthy children 6-23 months of age. This is because young children below the age of 24 months have the same or higher risk of hospitalization due to influenza than the high-risk groups at any age, such as those with chronic illnesses (Committee on Infectious Diseases, 2008).

Types of Influenza

Of the 279 laboratory-confirmed cases, 96.8% (270 cases) had influenza A, and only 3.2% (9 cases) had influenza B. This is similar to what was observed in Alberta between October 2006 and April 2007 where 96.7% (1155) of the positive influenza isolates tested were influenza A, and 3.3% (40) of the isolates were influenza B. The distribution of influenza types was slightly different in Canada. Of the 7871 isolates that tested positive for influenza between October 2006 and April 2007, 89.2% (7023) were influenza A, and 10.8% (848) were influenza B (Public Health Agency of Canada, 2007).

The influenza distribution by type was quite different in Alberta for the 2005-2006 season. The types of influenza were more evenly distributed with 53.2% (687) of the positive influenza isolates being influenza A, and 46.8% (605) of the isolates being influenza B, between October 2005 and April 2006. The distribution of positive influenza isolates in Canada during this time period was 60% (4142) of influenza A, and 40%

(2758) of influenza B (Public Health Agency of Canada, 2006). The changes in proportions of influenza A and B isolates over the two seasons shows how the distribution of influenza changes from one season to the next.

In this study, the ages of the influenza A cases ranged from 0.08-90 years, and the ages of the influenza B cases covered a smaller range from 11-61 years. The influenza A cases had a median age of 11 years and a mean age of 21.5 years. The influenza B cases had higher values for both of these measures with a median age of 38 years and a mean age of 39.3 years. The largest proportion of influenza A cases (23%) in Canada for the season was less than five years of age, and the majority of influenza B cases (68%) occurred among those above the age of 24 years (Reyes et al, 2008).

In the 2005-2006 season, the age distribution for the influenza B cases in the CHR was mainly children 2-14 years of age (Influenza Sub-Committee, 2006). The first case of influenza B in the CHR over the 2006-2007 season was confirmed in February 2007 when a general increase in the ages of the influenza cases had been identified.

Influenza A Subtypes

Two influenza A subtypes circulated in the CHR over the 2006-2007 season. The distribution of these subtypes for the typed influenza A cases in the study was similar, with 43.6% having the H3N2 subtype, and 56.4% having the H1N1 subtype. The distribution of these subtypes in Canada however, was quite different. The H3N2 subtype was more dominant in the typed influenza A isolates for the country (69.5%) compared to the H1N1 subtype (30.5%) (Reyes et al, 2008).

In the CHR, the H1N1 subtype was dominant in the early part of the season (November and December of 2006). The H3N2 subtype first appeared in November 2006, and became the dominant subtype from January 2007 to the end of the season (Influenza Sub-Committee, 2007). The change in the influenza A subtypes from H1 to H3 corresponded with the rise in mean and median age of the influenza cases identified over the season. The H3 cases were generally older than the H1 cases. The ages of the H3 cases were more widely distributed (0.13-90 years) than those of the H1 cases (0.08-49 years). The H3 cases had a median age of 22 years as compared to that of eight years for the H1 cases. Many of the H1 cases were therefore very young.

The H3 cases had a mean age of 31.5 years compared to 11.4 years for the H1 cases. The mean age of the H3 cases was higher because of their wider age range which went all the way up to 90 years, whereas that for the H1 cases went up to only 49 years.

All of the typed influenza A cases in the study sample who were 65 years of age and older had the H3 subtype. The mean ages for the two subtypes were compared using the Student's t-test. It was concluded that there was a statistically significant difference between the mean ages of the H1 influenza A cases and the H3 cases (p-value < 0.000) at a 5% significance level. It seems, therefore, that the H3 influenza A strain was more likely to attack older individuals, and the H1 strain children, during the 2006-2007 season.

Spatial Analysis

This section discusses the spatial results of this study. Comparisons to the literature are made when there are publications available. However, given the broad scope of available geomapping approaches to data analyses, and the newness of the geomapping approach for infectious diseases, there is very little literature for comparison to the study results.

The census characteristics of the Calgary population and the confirmed cases are discussed first followed by the spatial distribution of all the cases and outbreaks, those in the rural CHR, those in the Calgary Census Metropolitan Area (CMA), and those in the city of Calgary. Finally, the spatial distributions of the influenza rates and outbreaks for the Calgary CMA, followed by the Socio-Economic Status (SES) and correlation analysis are discussed.

Census Characteristics

The census characteristics of the study sample were quite representative of the population in the Calgary CMA in three respects. Firstly, there were almost equal proportions of males and females (about 50% each) in the Calgary Census Tracts (CTs) for the 2001 Census, the 2006 Census, and for the CTs with confirmed influenza cases. Secondly, the proportions of persons in each age group were similar for all the CTs in 2001 and 2006, and for the CTs with confirmed influenza cases. The age distribution was similar in all three datasets with 12.5% of individuals being aged from zero to nine years old, 78.5% aged from 10-64 years old, and 9.0% aged 65 years old and above. Thirdly,

the Unemployment Rate was almost the same at 4.9% for the whole CMA in 2001, and 4.8% for the CTs that had influenza cases. The Dominant Educational Attainment was "University" for all the CTs in the Calgary CMA in 2001, and those CTs with confirmed influenza cases. The Unemployment Rate and Dominant Educational Attainment were not available for the 2006 Census at the time of data analysis.

The Median Household Income for the families residing in the Calgary CMA in 2001 was slightly different from that of families from CTs with confirmed influenza cases. The Median Household Income for the Calgary CMA was $58,861 in 2001. The CTs with influenza cases had a higher median family income at $62,360.

The characteristics of the sample were quite similar to those of the population of the Calgary CMA as shown by the distribution of males and females, distribution by age, the Unemployment Rate, and the Dominant Educational Attainment. There was however, a $3,500 difference in Median Household Income between the sample (which had the higher Median Household Income), and the population of the Calgary CMA in 2001. Overall, the study sample was quite representative of the population from which it was derived in aggregated census characteristics.

Spatial Distribution of All Influenza Cases and Outbreaks

Most (72%) of the confirmed influenza cases in the CHR over the 2006-2007 season were found within the urban Calgary area. Fewer (28%) were found in the more rural areas of the CHR. There are several likely reasons for this distribution of cases. Firstly, there are a larger number of individuals living in urban areas of the CHR than those in the rural areas. Secondly, the population in the city of Calgary lives, works, and

transits in closer proximity which would facilitate the transmission of the disease. Finally, access to health care facilities varies for those living in urban and rural areas. The rural areas have less access to medical and laboratory services so a larger proportion of influenza cases are more likely to be missed than those occurring in the city and its surrounding areas.

Spatial Distribution of Influenza Cases and Outbreaks in the Rural Calgary Health Region

Individual influenza cases were confirmed in the rural areas of the CHR over the 2006-2007 season. School outbreaks were reported in Turner Valley, Okotoks, High River, Cayley, and Nanton in December 2006. This is similar to what was observed for the city of Calgary where all of the outbreaks in December were also in schools.

Influenza cases were confirmed in Turner Valley in January, and in Okotoks, High River, and Turner Valley in February and March of 2007. An influenza outbreak was reported at a retirement lodge in Okotoks in February. Some of the individual cases identified in Okotoks over this month were residents of the lodge.

Influenza cases were also confirmed in Canmore, Black Diamond, and Claresholm over the season. An influenza outbreak was reported from a mental health and addictions centre in Claresholm in January 2007.

The individual cases in the rural areas of the CHR were found around the locations of the outbreaks. This distribution may just represent where the majority of people in these areas live (around the towns). Some of the cases from the rural CHR had post office box addresses and postal codes. This would also have led to multiple cases being mapped close together in some areas.

Spatial Distribution of Influenza Cases and Outbreaks in the Calgary Census Metropolitan Area

Median Household Income (MHI) was mapped along with the confirmed influenza cases and outbreaks in the Calgary CMA over the season. The cases and outbreaks that were identified in the North-East (NE) part of the city were in CTs with the lower 60% of MHI in the Calgary CMA in 2001. This may have just been a result of there being a large number of communities with lower MHI in the NE part of the city.

The cases and outbreaks from the rest of the CMA were identified in CTs that covered the entire range of MHI for the CMA in 2001 ($31,338 to $107,400). There was therefore no indication of an association between the MHI of CTs in the CMA in 2001, and the spatial distribution of confirmed influenza cases and reported outbreaks for the 2006-2007 season.

The MHI for the CTs in the Calgary CMA was not yet available for the 2006 Census at the time of data analysis. The 2001 MHI used for this analysis was not truly representative of the economic status of the CTs in the Calgary CMA over the 2006-2007 season because the CMA has changed considerably since the census in 2001.

Spatial Distribution of Influenza Cases by Type and Subtype in the Calgary Census Metropolitan Area

Cases with the H1 and H3 influenza A subtypes, and those with influenza B were distributed over the Calgary CMA over the 2006-2007 season. All of the typed influenza A cases in Airdrie and Cochrane had the H3 subtype. This included cases that were part of the school outbreak that occurred in Airdrie in February 2007 when the H3 subtype had become the dominant influenza A subtype in the CHR.

Most (71.2%) of the typed influenza A cases in the North-West (NW) quadrant of the city of Calgary had the H1 subtype. This suggests that a larger proportion of the influenza cases in the NW part of the city were generally younger as the maximum age of the H1 cases in the study was 49 years. The largest proportion (40%) of the influenza outbreaks that took place in schools in the city of Calgary over the season also occurred in the NW quadrant which also suggests a large population of younger influenza cases. The majority of the school outbreaks took place in November and December of 2006 when the dominant subtype in the CHR was the H1 subtype.

Most (76.3%) of the typed cases in the South-West (SW) quadrant of the city had the H3 subtype. Some of these cases were seniors who were residents of continuing care centres. This supports the observation that cases with the H3 influenza A subtype were significantly older than those with the H1 subtype.

Spatial Distribution of Influenza Cases and Outbreaks in the City of Calgary

The first influenza cases confirmed in the city of Calgary during the 2006-2007 season were identified in November 2006. The first reported outbreaks for the season were all in schools in the northern quadrants of the city.

Most of the confirmed influenza cases and outbreaks in the city of Calgary over the season were identified in December 2006. All of the cases in week 49 of 2006 were in the northern quadrants of the city, similar to those in week 48. All of the reported outbreaks in week 49 were in NW Calgary. Most of the confirmed influenza cases in weeks 50 and 51 were also in the NW. It therefore seems that influenza over the 2006-2007 season started in the northern parts of Calgary then spread to other areas of the city.

Only four influenza cases were identified in the western areas of the city in week 52. There were no outbreaks reported during that week. This was likely to have been because schools, where all of the influenza outbreaks occurred in November and December, were closed for Christmas break starting late in week 51 of 2006, until the end of week one of 2007. People are more likely to stay home over the holidays, thus reducing influenza transmission. Physician offices were also closed over the holidays, reducing the opportunity to detect influenza in the community.

The majority of the influenza cases identified from January to April 2007 were found in the SW quadrant of the city of Calgary. These included a few of the residents of three continuing care centres in which influenza outbreaks took place in February and March of 2007. This corresponded with the general increase in mean and median age of the influenza cases identified at this time of the season.

Influenza Rates and Outbreaks for the Calgary Census Metropolitan Area

Rates of influenza for the Calgary CMA over the 2006-2007 season were calculated using the 2001 and 2006 Census data. The rates calculated using the 2006 Census data were slightly lower and observed over smaller areas than those calculated using the 2001 data. This was likely the result of the significant increase in the population of Calgary. This led to census subdivisions that covered smaller areas than those in the 2001 Census so that the maximum stipulated population for a CT could be maintained.

The highest rates (10.01 cases per 10,000 people and above) were observed in some of the CTs in the NW, SW, and NE quadrants of Calgary using both sets of data, and also in Airdrie using the 2001 data. Some influenza outbreaks were reported from the areas with the highest rates. Four school outbreaks were reported in the NW and NE, and two continuing care centre outbreaks in the SW using the 2001 data. With the 2006 data, four school outbreaks were distributed over the NW, NE, and SW city quadrants, but the two continuing care centre outbreaks were still identified in the SW in areas with the highest influenza rates.

Influenza rates at the middle range (5.01 to 10.00 cases per 10,000 people) were observed in CTs in Airdrie, and in all four quadrants of Calgary using the 2001 data. Using the 2006 data, Airdrie and all the quadrants except the South-East (SE) had rates within this range. Seven school outbreaks were observed in these areas in the NW, NE, and SW using the 2001 Census data. Eight school outbreaks in the NE and NW, and one continuing care centre outbreak in the SW, were observed in these areas using the 2006 Census data.

The lowest rates of influenza (0 to 5.00 cases per 10,000 people) were observed in Airdrie, Cochrane, Chestermere, and in all four quadrants of the city of Calgary using both 2001 and 2006 Census data sets. Eight school outbreaks were identified using the 2001 data, and seven school outbreaks were identified using the 2006 data in Airdrie and in the four city quadrants in these areas. Two influenza outbreaks were identified in continuing care centres in the SE and SW using the 2001 data. One continuing care centre outbreak was identified in the SE using the 2006 data. There were no individual influenza cases confirmed in 86 (47.3%) of the 182 CTs in the Calgary CMA in 2001. The total number of CTs in the Calgary CMA in 2006 had not yet been released by Statistics Canada at the time of data analysis.

The distribution of influenza outbreaks in areas with both high and low rates of influenza shows that there was no clear association between rates of influenza from individual case identification and the occurrence of influenza outbreaks. Cases that were part of an outbreak were also included in the count of individual influenza cases identified over the season.

Socio-Economic Status and Correlation Analysis

No patterns were observed in the scatterplots of the influenza rates per 10,000 people against the three Socio-Economic Status (SES) variables of interest from the 2001 Canadian Census (Median Household Income, Unemployment Rate, and Dominant Educational Attainment). No significant associations emerged between the influenza rates and these SES variables in the correlation analysis. There was however, a strong negative relationship between the 65 years of age and above variable, and the nine years of age and below variable using both sets of census data ($r_s = -0.7$ and $p < 0.000$ for 2001, and $r_s = -0.6$ and $p < 0.000$ for 2006). This means that the larger the population of persons 65 years of age and older, the smaller the population of persons nine years of age and younger. A community with a large population of seniors would not be expected to have a large population of children as the seniors are above the normal child-bearing age.

Limited information is available on how SES disparities may influence the risk for influenza (Brownstein, 2007). A study was conducted in Florida where influenza activity in children was monitored from 2001-2006 in relation to ZIP code and Median Household Income. The data used for the study was from emergency department visits. The results of the study showed that there was a direct increase in the number of hospital visits for influenza with a decrease in Median Household Income (Brownstein, 2007).

This observation may have been because individuals with lower SES may be more likely to live in crowded conditions and therefore to transmit influenza. Individuals with lower SES may also be more likely to suffer from influenza or influenza related complications that need medical attention as they may not be able to afford annual influenza vaccinations.

People in the United States are less likely to have a regular medical doctor than those in Canada as a result of the higher costs of health care in the United States (Lasser et al, 2006). Those with lower SES would therefore be more likely to visit the emergency department for their health care needs in the United States than in Canada, and to only do so when they are very ill. This may account for the increase in the number of hospital visits with a decrease in Median Household Income in the study.

It is more difficult to observe an association between SES and health events in Canada than in the United States. Canadians are significantly less likely to report that their health care needs are unmet because of the cost of health care than Americans are (Lasser et al, 2006). SES may therefore not have as large an impact on the trends seen in health events such as influenza infection in Canada as it does in the United States.

The results of the study in Florida could also have been affected by the use of ZIP codes as the level of spatial aggregation for the analysis. Using a smaller level of aggregation could make it easier to pick up differences in SES than using larger aggregations such as CTs. A possible association between influenza and SES could be illustrated in the CHR if these variables are monitored over a longer period of time, and/or using different aggregations such as by community instead of CT.

Strengths and Limitations of the Study

This section discusses the study results relative to validity including both confounding and bias, study strengths and weaknesses.

Validity

Internal validity addresses whether or not the results of a study are true for the individuals under study, and not likely due to confounding or bias (Gay, 1999).

Confounding

Confounding occurs when there is a distortion in the results of a study because of the presence of another risk factor for disease which is associated with both the risk factor under study and the outcome, but is not a part of the causal pathway (Gay, 1999). A possible confounder in this study was age as influenza is known to primarily affect the very young and the elderly. It was therefore expected that there would be outbreaks of influenza in continuing care centres, lodges, and schools. An important aspect of the study was to collect data on the ages of the individuals included in the study, so that these would be taken into account when the results of the study were analyzed.

Bias

Bias is systematic error whereby the results that are obtained for a study differ systematically from the truth (Gay, 1999). It was important to assess whether the influenza cases that were not reported (cases that did not seek medical attention) differed systematically from those that were reported, and if the results of the study were therefore biased (differential bias) (Gay, 1999).

The age and sex characteristics of the CTs represented in the study sample were very similar to those of the populations in all the CTs in the Calgary CMA in 2001 and 2006. The proportions of males and females, and the distribution of the various age groups were almost the same for all three data sets. This suggests that the study sample was quite representative of the population in the area.

It was likely that cases of influenza in the very young and the elderly would be reported as their caregivers would take them to seek medical attention. On the other hand, young to middle-aged adults would be less likely to go and seek treatment for their illness. One reason for this is that the disease is more severe in the very young and the elderly (Nguyen-Van-Tam and Hampson, 2003). The prevalence of influenza in young to middle-aged adults may therefore have been underestimated in the study.

Another reason for the possible bias towards more cases of the very young and the elderly may be the data sources for these age groups. Influenza data on children is primarily obtained through influenza outbreaks in schools and from family physicians. Also, all of the swabs submitted from the Alberta Children's Hospital for upper respiratory symptoms are tested for influenza (E. Henderson, personal communication).

Data on the elderly is primarily obtained from hospitals, from outbreaks in continuing care centres and lodges, as well as from family physicians. The elderly are significantly more likely to be admitted to hospital due to influenza and its complications than those of other age groups. They are therefore more likely to be tested for influenza and recorded as positive cases.

The study was dependent on surveillance data so there may have been reporting bias. This bias can occur anywhere between the tendency of a patient to seek health care and the recording of the patient as a case in the surveillance data. The presence of disease clusters may therefore only be a reflection of differences in reporting in various geographic regions (Pearl et al, 2006). Sentinel physicians are not evenly distributed over the CHR, and the tendency of different physicians to report on cases of ILI varies. The number of, and access to health care facilities in the rural areas of the CHR may also have affected the number of cases of influenza that were actually reported, and their distribution in those areas.

Study Strengths

The use of a descriptive, population-based design was a study strength. The study sample included individuals with a variety of characteristics and from various sectors of the population in the CHR. It was therefore quite representative of the population in the CHR. Using a descriptive study design allowed influenza to be characterized according to a number of important factors. Influenza was described in terms of the distribution of males and females with the illness. The variation in the age groups affected by the different types and subtypes of influenza was also described. The changes in the temporal

and spatial distribution of confirmed influenza cases were shown. Using a non-experimental study design meant that none of the study variables were altered by a possible intervention. The study was conducted prospectively which helped in the collection of missing data in a timely manner from a number of data sources.

A major strength of the study was that data on all of the confirmed cases of influenza in the CHR over the season came from one central source. In the CHR, all of the samples obtained from those who have a respiratory illness that may be influenza are sent to the Alberta Provincial Laboratory for Public Health (ProvLab) for testing. The ProvLab is therefore well-connected with various surveillance programs within the region, and receives specimens for testing for influenza from a variety of sources, such as acute and continuing care facilities, and physicians' offices (Downing and Fonseca, 2005). This data included all confirmed cases for the region, and was therefore much more representative of what was going on within the community than using data from insurance companies as was done in the study by Gierl and Schmidt (2005). The ProvLab is the most comprehensive source of surveillance data on influenza within the region.

The use of secondary data from the ProvLab for the study was advantageous, as most of the data on the variables of interest was already available in the ProvLab databases. It therefore took less time to collect data for the study and data collection costs were minimal (Bryman, 2001). Data cleaning is important in a study, especially when secondary data is being used. The data cleaning process in this study was conducted by one individual, using rules that had been set before the beginning of the process, and therefore remained consistent throughout.

Some of the ProvLab data on influenza cases over the season came from sentinel physicians who are a part of The Alberta Recording and Research Network (TARRANT). There were TARRANT physicians providing influenza data from both the urban and rural areas of the CHR. Physicians participating in the TARRANT surveillance system submit two patient specimens per week from patients seen with acute respiratory syndromes (TARRANT, 2006). This provides a much more accurate picture of what is going on with influenza within the region than that provided by the study conducted by Turner et al (2005), which only required five specimens from each sentinel practitioner over the entire influenza season. The submission of two specimens per week may however, lead to the underestimation of cases of laboratory-confirmed influenza if the sentinel physicians are seeing large numbers of individuals with ILI.

The use of GIS to describe the spatial and temporal distribution of influenza cases and outbreaks in the CHR was highly advantageous. Using GIS allowed for the integration of data from different data sources, such as the ProvLab and Statistics Canada. The ability of GIS to combine different forms of data that share the same geography helps to enhance surveillance. It allowed for influenza case and outbreak data to be analysed in relation to other factors such as SES.

GIS software combines data in the form of layers that can be stacked on top of each other and viewed together. This helped in the analysis of the rates of individual influenza cases in relation to outbreaks of the disease. Aggregate data was used for the influenza outbreaks so that the locations of the facilities where the outbreaks took place, such as a school or continuing care centre, could be mapped. The individual influenza case data also had outbreak information (the outbreak number for individual cases that

were part of an outbreak). All of the cases that were part of an outbreak were only used for individual case mapping, and not for the mapping of outbreaks, as the postal codes available for them were for their residential addresses. These cases were therefore mapped using the postal code of where they lived (as with all the other individual cases in the study). One major advantage of using GIS to describe and summarize data is that the data is presented in a visual format which makes it easier to understand.

The individual residential postal codes of the cases in the study were used for mapping. Residential postal codes gave a much better estimate of the areas of disease transmission than using the postal code of the sentinel practitioner who collected the influenza specimen, as was done in the study by Carrat et al (1998). The location of the physician's practice may be in a different area from where the case lives. Using residential postal codes also allowed for the identification of more specific areas of disease transmission than using the geographic coordinates of the main offices of the legislative areas, as was done in the study by Carrat and Valleron (1992).

A major strength of the study was the use of laboratory-confirmed cases of influenza. All of the cases included in the study actually had influenza. The use of cases with ILI would have provided a larger sample size. ILI symptoms however, can be caused by a number of upper respiratory tract infections that are not influenza. An example of this is the study conducted by Turner et al, (2005), where specimens from patients with ILI were submitted for laboratory testing. Of the 267 specimens tested for influenza over the season, only 13.9% tested positive for influenza A, and 4.1% for influenza B. The largest proportion of specimens (30%) tested positive for other respiratory viruses (Turner et al, 2005). Another example is of the samples submitted by

TARRANT physicians over the 2006-2007 season. Of the 400 samples submitted, only 106 (26.5%) tested positive for influenza (Influenza Sub-Committee, 2007). Using only confirmed cases of influenza for the study ensured that it was only influenza that was being tracked and not other illnesses. Another advantage of using confirmed cases is that the diagnosis of ILI may not always be made with the same criteria (Oshitani et al, 2000).

Study Limitations

One limitation of the study was that the influenza rates presented were lower than the true rates of influenza in the region over the season. One reason for this is that specimens are not taken for every patient that presents with ILI at their practitioner's office or at the hospital, or for every individual who is considered to be part of an outbreak. Also, not everyone who has influenza will seek medical attention as the illness may be milder in some cases than others. All of the confirmed cases of influenza in the region over the season were used in this study to try and obtain rates that were as representative as possible, but these rates still underestimated the true rates of influenza incidence in the region.

Another limitation of the study was that as the data came from a variety of sources, some may have provided data to the ProvLab more regularly than others. This may have led to greater representation of illness in some areas than others. The differences in the geographic distribution of health services and in their utilization, may have also led to spatial patterns that did not accurately describe the distribution of disease in the region. There was also variation in the amount of data that was provided on the virology requisition forms. Some of the forms (about 30%) were missing address and

postal code data, which were critical to the mapping process. This data had to be collected after the data from the ProvLab had been compiled.

As this was an ecological study, the results that were obtained can only be interpreted on the level of the community as a whole, and cannot be used to make any inferences about characteristics that may have affected infection with influenza at the individual level. Making inferences about individuals from aggregated statistics (such as the Census Canada variables used in this study) is called ecological fallacy.

The study also had limitations that were related to the mapping process. The boundaries of geographic units such as CTs, are somewhat arbitrary and do not actually represent an immediate change in community-based characteristics from one area to the next. This is known as the “modifiable area unit problem.” The results of a study may therefore vary if the spatial data is aggregated in a different way (Bush, 2004). An example of this was the change in the census subdivisions of the Calgary CMA between the census in 2001 and the one in 2006. The divisions of the CTs changed such that it was not possible to directly compare the results obtained using the 2001 data and those obtained using the 2006 data.

The dates when the influenza samples were received at the ProvLab for testing were used to determine the week in which the cases would be mapped. This did not represent the initial manifestation of influenza symptoms in the cases. The date of onset of illness could not be used however, as it was missing from 22.2% of the virology requisition forms submitted to the ProvLab. The date the samples were received at the ProvLab was therefore used consistently for mapping.

The location where the cases lived was not necessarily where they were infected with influenza. The area where they lived however was the best representation of the distribution of influenza that could be used in the study. The mapping of the locations of influenza outbreaks helped to show possible areas of influenza infection such as schools.

Some of the cases in the more rural areas of the CHR had post office boxes as part of their addresses and therefore common postal codes. This may have led to the false clustering of influenza cases on the maps. The post office boxes did not represent where the cases actually lived. Also, the postal codes in rural areas cover a large area and the locations are therefore not precise.

The use of 2001 Census Canada data for the SES correlation analysis was a major study limitation, as the Calgary CMA has changed considerably since then due to a significant increase in population in the last few years. An example of this is the change in total population from 951,395 in 2001 to 1079,310 in 2006 (a 13.4% increase). Unfortunately, data on SES variables from the 2006 Census of Canada was not yet available from Statistics Canada at the time of data analysis.

The use of CTs instead of Dissemination Areas (DAs) meant that only the cases within the Calgary CMA could be used for correlation analysis. This is because CTs are census subdivisions that are used for large urban centres with a population of 50,000 people or more. Most of the cases in the study however, were from within the Calgary CMA (about 72%), therefore a large proportion of them were included in the analysis. DAs were also not used because these census subdivisions are very small, and census data on some of them were suppressed by Statistics Canada because individuals/families may have been identifiable.

The CHR is quite small compared to other areas that have been studied using GIS to describe the distribution of infectious disease. Most of the examples that were presented in the background to this study dealt with the spatial distribution of disease over an entire country or province. It therefore may not have been possible to identify patterns in disease transmission because the area under study was too small. It is important however, to know how a disease is distributed and potentially being transmitted locally within an area, and repeated mapping over five years or more may provide a better picture of disease transmission over time. This may make it easier to understand the effects of factors that may affect disease transmission such as locations of schools, transport systems, and SES variables.

Recommendations and Future Research

Feasibility of Using Geographic Information Systems for Mapping Influenza in the Calgary Health Region

The use of GIS to map influenza in the CHR is feasible for the future. The shapefiles that would be used for mapping could be obtained and linked together at any time of the year. It would be important to update these after each Canadian Census as the census subdivisions may change for a number of reasons, such as to adjust for an increase in population in an area. A file of the postal codes of individual influenza cases or locations of outbreaks could be linked to the shapefiles to create maps.

To make mapping feasible, it would be important to create a system where the addresses and postal codes of interest are easily available, as collecting them could be time-consuming. This data was missing for about 30% of the cases in this study and had to be collected for each individual. One way to reduce the amount of missing data could be to make this data mandatory on the requisition forms that are submitted with the samples to be tested for influenza. Another aspect that could be made mandatory is for the onset of illness dates to be recorded on the requisition forms so that they could be used for mapping. These dates would be very useful in understanding the transmission of influenza and the characteristics of influenza outbreaks.

Once these data are available, it is feasible to create maps of influenza for each week as new cases and outbreaks emerge. If the mapping process is automated so that the disease data can be updated frequently, this will help to provide health practitioners with real-time maps of disease distribution. These could be created using different spatiotemporal conditions to assist in understanding the distribution and movement of disease (Gao et al, 2008).

There are some limitations however, to the use of GIS for mapping influenza distribution. One limitation is that there is a steep learning curve in the use of GIS software. Training and user support would have to be provided for all those who would be using this software for influenza surveillance, such as researchers and public health staff. The costs for these endeavours, and for upgrades and maintenance of GIS software may become substantial (Richards et al, 1999).

Mapping Influenza over Many Seasons

GIS could be used in the future to map the spatiotemporal patterning of influenza over a number of respiratory seasons. This would allow for the analysis of trends in influenza transmission throughout the region.

The investigators in the study conducted in Japan used GIS to assess the spatiotemporal patterning of influenza transmission through Japan over seven respiratory seasons. They were able to show that particular trends emerged on where ILI peak activity originated each season and how it spread through the country over the season (Sakai et al, 2004).

Engaging in this type of study over a longer period of time would also help to assess whether or not certain types of influenza are more likely to affect particular age groups than others. It would assist in understanding the political, economic, and social determinants that may affect why influenza may follow a particular pattern of transmission each season. All of this information could prove to be very important when making decisions on how resources should be allocated throughout the region for prevention and control of seasonal influenza, and in pandemic planning.

The true incidence of influenza in a population is never actually known. The interpretation of data on the disease in any particular season is therefore based upon comparing it with prior seasons. As a result, it is very important that a stable and reliable surveillance system is maintained so that long-term changes in trends can be identified (especially in the non-epidemic periods). Long-term changes in the epidemic periods can only be identified after many years because of high yearly variation in influenza infection and distribution (Uphoff et al, 2004).

Information obtained from this study will enable longer studies in the future which will help in predicting the pathway that influenza transmission is likely to follow during seasonal influenza epidemics and possibly during a pandemic. Being able to identify key areas of transmission in a pathway would allow for a more rapid response which is crucial in the prevention and control of a communicable disease (Barrett et al, 2005).

Information from this type of study could also be used for influenza pandemic simulation studies which incorporate day-to-day societal networks on an individual level in helping to predict pandemic transmission of disease (Barrett et al 2005). This type of information is very important, as the careful allocation of resources such as antiviral agents would be crucial in the event of a pandemic. The results of the study conducted by Longini et al (2004) suggested that resources should be targeted to the areas where influenza is likely to be circulating, instead of uniformly throughout a region. They were able to come to this conclusion by simulating the transmission of influenza through the population by infected individuals to close and casual contacts.

The expansion of research using GIS in the CHR could augment influenza pandemic plans made to address the shortages of influenza vaccine and antivirals that will occur during a pandemic. Countries will have to be able to identify the populations and risk groups that should be the first to receive antivirals and vaccines that are available. GIS can assist in identifying these groups (Cox et al, 2003).

Future Studies

A possible study that could be carried out in the CHR is to link data from Calgary Health Link to confirmed influenza case data. Calgary Health Link is a health information and telephone advice program that is available 24 hours a day. Registered nurses are available to provide information and advice on symptoms and other health concerns. Individuals who call in are asked to provide their postal code at the end of the call. (Calgary Health Region, 2008). The calls received are coded according to various criteria such as symptom complaints, where calls come from, and age (D. Strong, personal communication). A study could be done to assess whether or not areas with confirmed influenza cases correspond with where influenza syndromes are being detected through Health Link. This could be expanded to include all of Alberta as Health Link is a province-wide service.

Another possible study could be to use the surveillance of pharmaceutical sales of medications that reduce the symptoms of influenza for mapping. The pharmacies could be asked to report monthly on the sales of products that are commonly used to reduce the symptoms of influenza, such as Tylenol or other analgesic products, and Tylenol Flu or Flu-FX (Surveillance Working Group, 2008). The locations of the pharmacies that have an increase in the sales of these types of medication could be mapped along with confirmed influenza cases and outbreaks. This may be advantageous in detecting possible illness in individuals who choose to self-treat instead of seeking medical attention, and therefore would not be picked up by other types of surveillance (Vergu et al, 2006).

It would also be useful to investigate the creation of influenza maps using ILI instead of, or in collaboration with confirmed influenza cases. Visits of patients with ILI to physicians spike considerably when influenza is circulating within the community. Physician visits can increase by 150-450% during influenza outbreaks (Monto, 2000). Sentinel physicians could be asked to record the postal codes of patients with ILI from whom swabs are not taken. It may also be possible to use the number of ILI cases per sentinel practitioner per week for mapping as was done in the study by Sakai et al (2004).

Another possible source of data on patients with ILI could be physician billing data from Alberta Health and Wellness. Patient diagnoses are recorded according to their symptoms, as well as their Personal Health Numbers (PHN). The PHN for patients with ILI could be used to link patients to Electronic Health Record databases that contain demographic data and addresses and postal codes which would be used for mapping (E. Henderson, personal communication).

Maps of ILI and confirmed influenza cases could also be created using spatial aggregations other than CTs and DAs. One method could be to map according to school districts to see if there are more school influenza outbreaks in particular districts than others. Data on the district divisions may be available from the Calgary Board of Education and other school boards. Another type of spatial aggregation could be to map according to the communities in the city of Calgary. It may be possible to find correlations between influenza incidence and SES variables at this level rather than at the CT level. Statistics Canada will be providing data on census variables at the community level in the near future (R. Shahid, personal communication).

Expanding the Mapping Process

Co-ordinated studies could be carried out in which influenza was mapped over a larger area such as the province of Alberta. This may make it easier to identify patterns in disease transmission because of the increased number of cases and the larger areas under study. It may also lay the groundwork for studies that involve mapping influenza over the entire country. The creation and sharing of disease maps would help in collaborative decision-making on preparing for, and responding to outbreaks. The sharing of disease maps could help in disease surveillance, spatial epidemiology, health care planning, vaccine distribution, emergency coordination, public education, and policy initiatives. Sharing of disease maps on the internet could be used to foster more effective collaboration, and help in a faster response to emergency situations (Gao et al, 2008).

Spatial models could be developed that incorporate the dynamics of infectious diseases such as influenza. These could help in testing alternative strategies so that the best strategy or combination of strategies for the control of diseases can be identified. This would require the creation of accurate databases that are incorporated into GIS, and a detailed understanding of the disease processes (Glass, 2004).

GIS could be used to assist in the development of rules for monitoring, planning, and the delivery of health care. An example of this is the malaria control decision support system instituted by the Medical Research Council of South Africa. GIS is used for the integration of epidemiologic data, surveillance of mosquito vector populations, clinical surveillance, and demographic data, for the monitoring and planning of interventions in South Africa and Mozambique. This decision support system has allowed for the careful use of limited resources (Glass, 2004).

Future research could be conducted by combining GIS analysis with spatial scan statistics. Spatial scan statistics are statistical methods used to detect disease clusters and see if they are statistically significant. A cluster is a collection of cases with an unusually high or low rate of the outcome variables that are being studied in an area (Jung et al, 2007). Spatial scan statistics detect whether or not a disease is randomly distributed over space, time, or over space and time. Spatial scan statistics software adjusts for the underlying spatial distribution of the population under study. This is important as populations are not evenly distributed over an area (SaTScan, 2005). Spatial scan statistics use a variety of statistical models, two of which are the Bernoulli and Poisson models. The Bernoulli model is used when assessing a dichotomous variable, such as those who do and those who do not have a disease, or cases with two different disease characteristics such as early and late stage cancer. The Poisson model is used to assess the cases of a disease in relation to the underlying population at risk such as when looking at mortality or the incidence of disease (Jung et al, 2007).

Future research could also be done to quantify clusters of disease that are shown on a map. This would help in assessing how clustered or dispersed they are, and perhaps enable the identification of areas of high disease transmission. The Nearest Neighbour Index (NNI) is often used for the calculation of distribution patterns. Numerical values are used to show how clustered or dispersed measurements are in a given area (Ehlers et al, 2003). The NNI is expressed as a ratio of the distance that is observed divided by the distance that would be expected between points. The distance that would be expected is the average distance between points in a hypothetical random distribution (ArcGIS 9.2 Desktop Help, 2007). An NNI of less than one indicates a clumped/clustered distribution,

and an NNI greater than one indicates a random/dispersed distribution (Ehlers et al, 2003).

Spatiotemporal studies that focus on quantifying the geographic spread and distribution of influenza would improve our understanding of some factors in transmission such as the following: 1) the identification of geographic areas of concern; 2) the identification of key variables that may explain the distribution and spread of disease; and 3) the interaction of risk factors and geographic locations over space and time. This would assist in the production of disease maps that show the role of different variables in a spatial model of disease, and that also show areas of disease occurrence and spatial patterns that may be of interest (Oyana et al, 2006).

It would be important when doing spatiotemporal studies to take into account the meaning of any disease clustering that may occur. The occurrence of disease clustering may not be significant in some cases as most populations are spatially clustered any way. The spatial distribution of the population at risk of a disease must therefore also be taken into account before disease clustering is considered to signify an important characteristic in the spatial distribution of the disease (Glass, 2004).

Conclusion

This study examined the use of GIS to describe the spatiotemporal distribution of laboratory-confirmed influenza in the CHR over the 2006-2007 respiratory season. December 2006 was the peak of the influenza season, with the most confirmed cases and outbreaks in any one month. Most of the influenza outbreaks that occurred over the season were in schools. Almost half of the influenza cases were nine years of age and

younger. Influenza cases with the H3 influenza A subtype were significantly older than those with the H1 subtype. The influenza cases identified over the season were scattered all over the CHR, with the largest proportion of cases being within the Calgary CMA. Cases with the H1 and H3 influenza A subtypes were almost evenly distributed in the Calgary CMA, except in Cochrane and Airdrie where all of the typed cases had the H3 subtype. Influenza outbreaks occurred in areas with both high and low rates of individual influenza cases. There was no significant correlation between the rates of influenza and the 2001 SES variables.

GIS could be used in the future for influenza surveillance in the CHR. It could help in providing baseline patterns of influenza distribution, and identifying changes in these patterns over time. It could also help with the identification of possible disease clusters, and in the monitoring of epidemics (Elliott et al, 2000) Trends that were previously undetected may become obvious when multiple data sources are merged electronically using GIS, and presented in an intuitive visual format (Kho et al, 2006).

The use of GIS could allow policy makers to more easily identify areas affected by influenza, or any other infectious disease. It could also help them to better visualize problems in existing health services, and therefore more effectively direct resources for prevention and control (Glass, 2004). Being able to follow the time and space dynamics of an influenza strain will help in assessing the decisions that are made on preventive measures such as the closing of schools, the use of antivirals, and mass immunization (Flahault et al, 2006).

The best way to prepare for an influenza pandemic is in strengthening the response to yearly epidemics of influenza. It is important that plans focus on increasing the vaccine coverage of high risk groups, developing routine prevention and control activities, enhancing influenza surveillance, and pursuing research that will help to strengthen the response to a pandemic. Effective communication at local and national levels will be crucial in the implementation of a successful pandemic response (Cox et al, 2003). The use of GIS applications could prove to be very important in all of these areas.

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Appendix A: Provincial Laboratory Virology Requisition Form

VIROLOGY

DIRECTOR:
DR. J. PREIKSAITIS

PROVINCIAL LABORATORY FOR PUBLIC HEALTH (MICROBIOLOGY)
PHONE 944-1200 3030 HOSPITAL DRIVE NW, T2N 4W4 FAX 270-2216
CALGARY, ALBERTA

ACC. #

ID# 547726

DATE REC'D

ADDRESS TO RETURN REPORT TO: (PLEASE PRINT LEGIBLY)
DR. _____
ADDRESS: _____
POSTAL CODE
PHONE # _____ ULI # _____

PHN (if any)
PATIENT NAME LAST FIRST
SEX ☐ M ☐ F DATE OF BIRTH YY / MM / DD
SENDER LAB NUMBER _____

SPECIMEN COLLECTED:
DATE YYYY / MM / DD
TIME hr

SPECIMEN &/OR SITE

☐ BLOOD	☐ AUGER SUCTION	☐ GENITAL SWAB (Specify) _____	☐ STOOL
☐ SERUM	☐ NASOPHARYNGEAL	☐ Non GENITAL (Specify) _____	☐ URINE
☐ CORD BLOOD	☐ BRONCHIAL ALVEOLAR LAVAGE	☐ URETHRAL SWAB	☐ SLIDE (Vesicular Fluid For EM only)
☐ BUFFY COAT	☐ THROAT SWAB	☐ CERVICAL SWAB	☐ OTHER (specify) _____

INVESTIGATION / *HISTORY REQUIRED*

☐ SEROLOGY (Indicate suspected virus/antibodies to be tested for.)
☐ VIRUS CULTURE
☐ ELECTRON MICROSCOPY
☐ CHLAMYDIA
☐ SYPHILIS SEROLOGY
☐ Routine
☐ Prenatal
☐ Suspect
☐ Follow-up
✱ ☐ Non-medical
☐ RUBELLA SEROLOGY &/OR ☐ VARICELLA ZOSTER SEROLOGY
☐ PRE VACCINATION ✱
(COMPLETE)
Immune Status ☐Yes ☐No
Pregnant ☐Yes ☐No
Rash (Complete History) ☐Yes ☐No
☐ RABIES
DATE OF IMMUNIZATION REQUIRED:
YYYY / MM / DD

HISTORY
History Must be completed or testing will not be done!
DATE OF ONSET: YYYY / MM / DD
RECENT TRAVEL: YYYY / MM / DD
☐ Stat (MUST CONTACT LABORATORY)
STAT FAX /PHONE #:

THE INFORMATION PROVIDED DETERMINES ANTIGENS TESTED
SIGNS: (Circle and add where appropriate)
☐ FEVER: Intermittent, continuous, low grade
☐ RASH: Macular, papular, vescular, purpuric
LOCATION: Face, trunk, arms, legs, genital, conjunctival
☐ RESPIRATORY: Coryza, cough, wheezing, sore throat, pneumonia, croup, bronchitis, bronchiolitis
☐ ADENOPATHY Size: <2 cm, > 2 cm ____ cervical, axillary, inguinal, splenomegaly
☐ NEUROLOGICAL Confusion, headache, meningismus, dizzyness
☐ GENERAL Fatigue, nausea, myalgia, arthralgia, jaundice, chills, effusion (site), diarrhea, vomiting
☐ IMMUNE STATUS (Specify) _____
☐ PRE TRANSPLANT
☐ DONOR
☐ RECIPIENT
☐ POST TRANSPLANT
☐ OTHER COMMENTS:

HEPATITIS SEROLOGY (Complete History)
History Must be completed or testing will not be done!
PREVIOUS SAMPLE SENT: ☐ YES ☐ NO
LAB #:

☐ ALT RESULT _____ IU/L

TESTING FOR SUSPECTED
☐ CHRONIC ☐ ACUTE ☐ IMMUNE STATUS

HEPATITIS A
☐ Anti-HAV IgM (IgM antibody to HAV)
☐ HAV Total (Total antibody to HAV)

HEPATITIS B
☐ HBsAg (Surface antigen)
☐ anti-HBs (Antibody to surface antigen past exposure
☐ anti-HBc (Total Antibody to Core)

HEPATITIS C
☐ anti-HCV (Antibody to HCV)

☐ OTHER TESTS (Specify)

☐ PERSON EXPOSED TO BLOOD/BODY FLUIDS
☐ "SOURCE" OF EXPOSURE/BLOOD/BODY FLUIDS
☐ "POST TRANSFUSION
☐ INJECTION DRUG USER
☐ OTHER RISK FACTORS

HIV / HTLV I/II
History Must be completed or testing will not be done!
PREVIOUS SAMPLE SENT: ☐ YES ☐ NO
LAB #:

☐ HOMOSEXUAL ☐ BI-SEXUAL
☐ SEXUAL PARTNER OF PATIENT WITH AIDS, POSITIVE HIV SEROLOGY OR RISK FACTOR FOR HIV INFECTION
☐ Homosexual ☐ Heterosexual
☐ MULTIPLE SEXUAL PARTNERS (Includes prostitutes)
☐ Homosexual ☐ Heterosexual
☐ SEXUAL CONTACT IN OR WITH PERSON FROM GLOBAL ENDEMIC AREA
☐ ANXIETY
☐ ORGAN DONOR ☐ ORGAN/TISSUE RECIPIENT
☐ SEXUAL ASSAULT CASE
☐ PERSON EXPOSED TO BLOOD/BODY FLUIDS
☐ "SOURCE" OF EXPOSURE/BLOOD/BODY FLUIDS
☐ INJECTION DRUG USER
☐ HEMOPHILIAC
☐ CHILD OF MOTHER WITH AIDS OR POSITIVE HIV SEROLOGY
☐ TB CASE / TB SKIN TEST POSITIVE
☐ RECIPIENT OF BLOOD / BLOOD PRODUCTS
✱ ☐ VISA / NON-MEDICAL ✱ ☐ INSURANCE
✱ ☐ FOREIGN EMPLOYMENT REQUIREMENT
☐ SPECIFY OTHER REASONS FOR TESTING /CLINICAL INFORMATION:

190134 (R 2002/01)
✱ THE LABORATORY MAY CHARGE FOR THESE TESTS
VIROLOGY REQUISITION

Appendix B: Script for Telephone Calls to the Physicians' Offices

"My name is Linda Kamhuka and I am calling on behalf of Dr Henderson from the Department of Community Health Sciences at the University of Calgary, and Dr Fonseca from the Alberta Provincial Laboratory for Public Health. We are currently working on a project to map the distribution of influenza in the Calgary Health Region. I am calling to follow up on information that was provided to the Provincial Laboratory with the swab specimens taken at your office."

"Some of the requested information is not available on the requisition form(s) that you submitted and I was hoping to collect it from you if possible."

"All of the information that you provide on a patient will be kept confidential. The results of the study will be presented in aggregate form, and there will be no information available that will make it possible to identify a patient."

"The name of the patient is X. May I please have their Personal Health Number?"

"As we are mapping the distribution of influenza in the region, I will need the patient's address and postal code."

"We are also looking at the distribution of influenza according to age and sex. May I please have the date of birth and sex of the patient?"

“Would you happen to know if this child has been vaccinated for influenza this season? When did the vaccination take place?” (If the patient is a child up to nine years of age).

“I will also need the date when the influenza specimen was taken from the patient.”

“Thank you very much.”

Data Collection Form for Telephone Calls to the Physicians' Offices

Physician's Name:

Physician's Phone Number:

Patient Name:

Personal Health Number:

Address:

Postal Code:

Sex: _____ (Male/Female)

Date of Birth (eg. October 7, 2006):

If child up to nine years of age:-

Vaccinated? : _____ (Yes/No)

Date of Vaccination (eg. October 7, 2006):

Date of Specimen Collection (eg. October 7, 2006):

Appendix C: Mapping Process Using ArcMap 9.2

Individual Influenza Cases

Open “ArcMap.” Use “+” to add data.

1) DMTI_2007-CanMep – Province = AB (Canada shapefile). Remove CanMep then just have shapefile of Alberta.

2) Alberta Unique Enhanced Postal Code (AB_UEP) – all the postal codes in Alberta (A Postal Code Conversion file may be in the form of a text file or a dBase (.dbf) file that has to be converted into a shapefile in ArcMap). Add postal codes for all of Alberta (Alberta DMTI postal codes), then link to the postal codes in the study sample saved as a dBase file. Right click on Alberta postal code shapefile – Joins and Relates – Join – Select attributes to be joined – click OK (Check attributes beforehand to ensure that they are the correct ones and spelt and spaced in exactly the same way so that they can be linked). In this case the attributes are the columns that contain postal code data in both the Alberta postal code file and the study sample database. Scroll over in the linked table to the postal codes – sort descending – select all of the ones for the study sample. Right click on Alberta postal code file – Data – Export – save the file under a new name. Used the Single Link Indicator (SLI) = 1 (one) unique postal code. This does not link duplicate postal codes (postal codes that were in the database more than once because multiple cases had the same postal code). Had to add in duplicate postal codes manually.

3) Adding in duplicate postal codes: Postal codes with multiple cases only appeared once in the newly formed linked database. Needed to use Dissemination Area shapefiles to add in duplicate postal codes because a lot of these cases were outside the Calgary CMA. To add in the duplicates – Editor – Start Edits - right click on the name of the new map that was created in step 2 – open attribute table – right click on postal code column – sort ascending – click at the beginning of the line of the postal code that needs to be duplicated – highlight it – right click on the name of the new map – selection – zoom to selected features – click hand to pan – click on sketch tool then add duplicate points around original point – click arrow to remove sketch tool – new points are added at the bottom of the attribute table – add in the postal code for the duplicates and the rest of the data for each case. Editor – Save Edits – Editor - Stop Editing.

Another method to add in duplicate postal codes would be to count how many duplicates there are for each postal code then create a table that shows the postal code and the number of cases that have it. This table would then be linked to a Postal Code Conversion File and shapefile to create the map. The numbers of cases per postal code could be shown by using different shapes for different values, or by varying the size of the symbol used to represent the postal code points on the map according to the number of cases that have that postal code.

4) Had to go into the file of retired postal codes to add in two of the postal codes that had been retired from the Alberta DMTI since the 2001 Census.

Influenza Outbreaks

Join AB_UEP to the outbreaks database saved as a dBase table (in the same way that the link was made for the individual influenza cases table) - sort descending in AB_UEP – select – export selected features – save with a new file name.

Creating Separate Maps for Each Month of the Influenza Season

Go into the attributes table for the map layer of all of the influenza cases (or the layer of all of the influenza outbreaks) - sort by month - highlight the cases (or outbreaks) wanted in a specific map – Data – Export – highlight the name of the layer of all of the cases (or all of the outbreaks) – Browse – go to the folder icon– give a new name eg November 2006 – save - Clear Selected Features.

Separating Out the Cases for Each Week of the Month

Click on the map layer of interest (eg November 2006) – Symbology – Categories – Unique Values – Value Field – select the name of the column that contains the weeks of interest – Add All Values – remove tick on “all other values” – Apply – OK.

Legend

Insert – Legend. Use arrows to decide which layers should be in the legend and which should not. Change the names of the layers in the layer section of the ArcMap window under “Display” then press enter for them to be changed in the legend. Legend parts can also be created as graphics but these are difficult to edit.

Labelling the Areas on a Map

Click on arrow next to “A” text button at the bottom of the ArcMap window - select the labelling symbol - Manual Selection of Points - zoom in before labelling. Move cursor over area until name lights up then click on it. To edit the name, click on the left-tilted arrow at the bottom of the ArcMap window then double click on the name. To go back to labelling, click on the label symbol.

Additional Mapping Notes

- Click on the boxes next to the names of the layers wanted in a specific map to turn them on. Remove the tick to turn off layers that are not wanted in a particular map.
- To export a map (do this from the **layout view** in ArcMap): - File – Export Map – save as jpeg, pdf, or tif (gives the highest quality pictures of the three).
- Added in rivers using an Alberta rivers shapefile.
- Used the Alberta Census Subdivision (AB_CSD) shapefile layer to create boundaries for the Calgary CMA, and the CHR shapefile to create boundaries for the CHR.

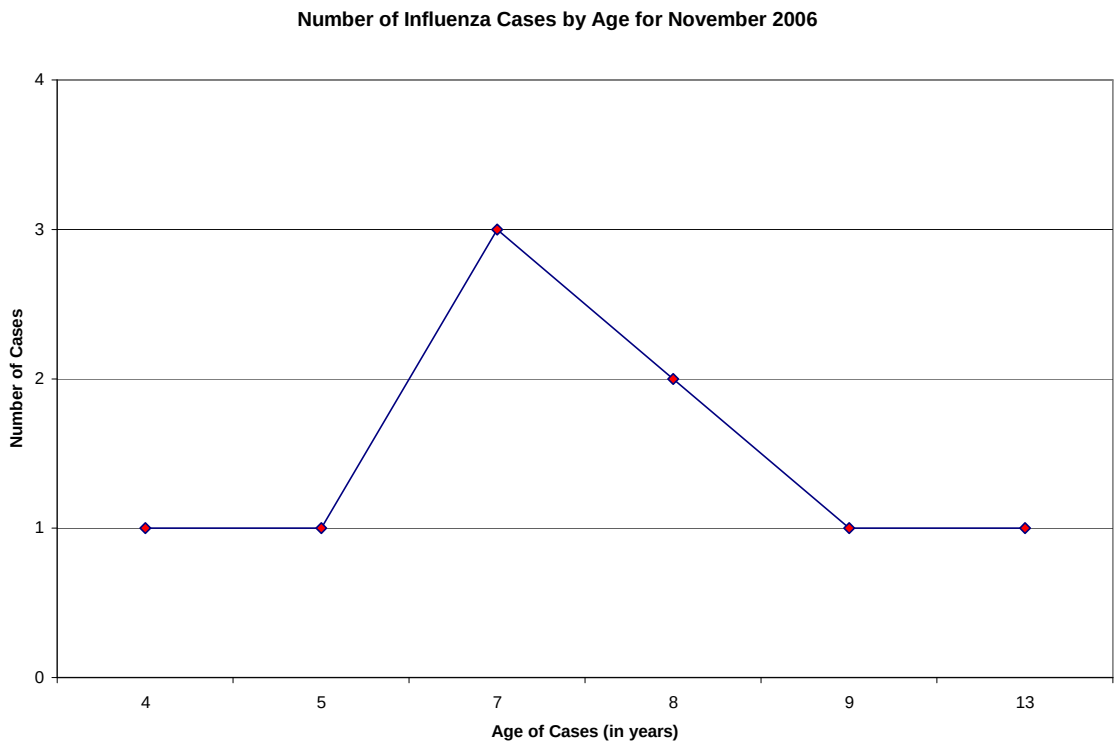
Linking Census Canada Data to Sample Data

Census Canada files with the variables of interest for each Calgary CMA CT, as well as the files with the sample data were first projected in ArcMap before they could be linked together. Projection is the process used to represent the curved surface of the earth on a flat surface (Richards et al, 1999). The data files had to be at the same projection so that

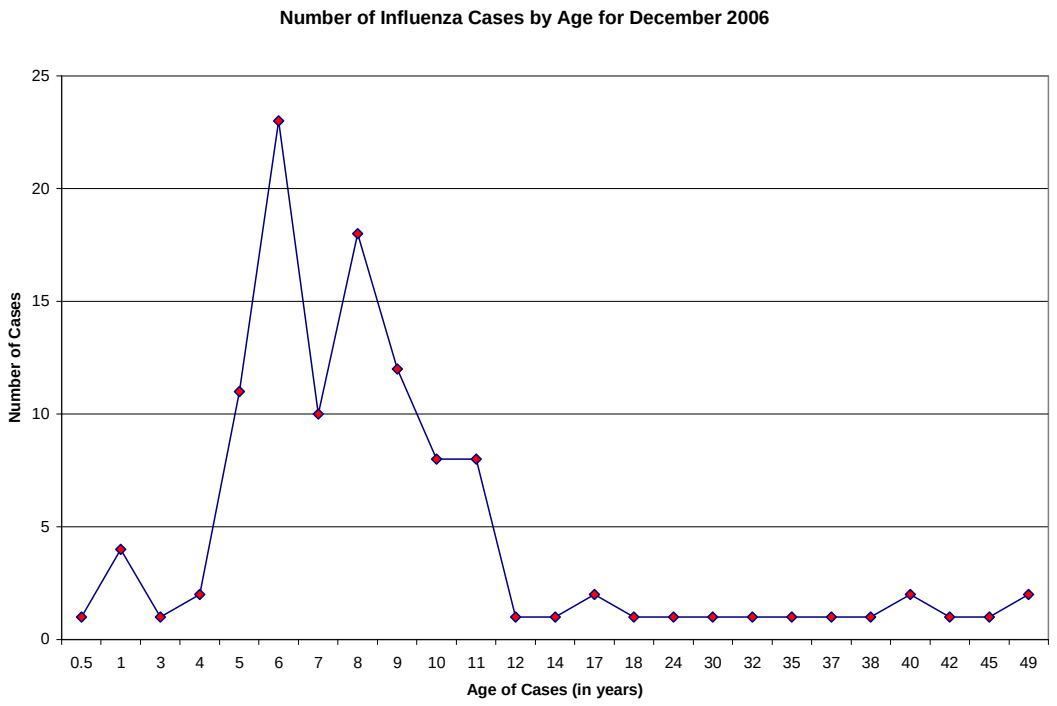
the coordinates of the two sets of data would be the same and the files could be joined. A spatial join was made such that all of the sample points were joined to the census attributes for the particular polygon (CT) in which they fell.

- Right click on the projected file of the sample data– Joins and Relates – Join (make sure the correct projected Census Canada file has been selected) – OK (will give the file a new name) – Save as a Map Layer – Yes. Open the attribute table for the joined layer to make sure the join has worked. Close the attribute table – right click on the joined table – Export – give it a new name. Export again as the dBase table that will be converted to an Excel workbook for correlation analysis.

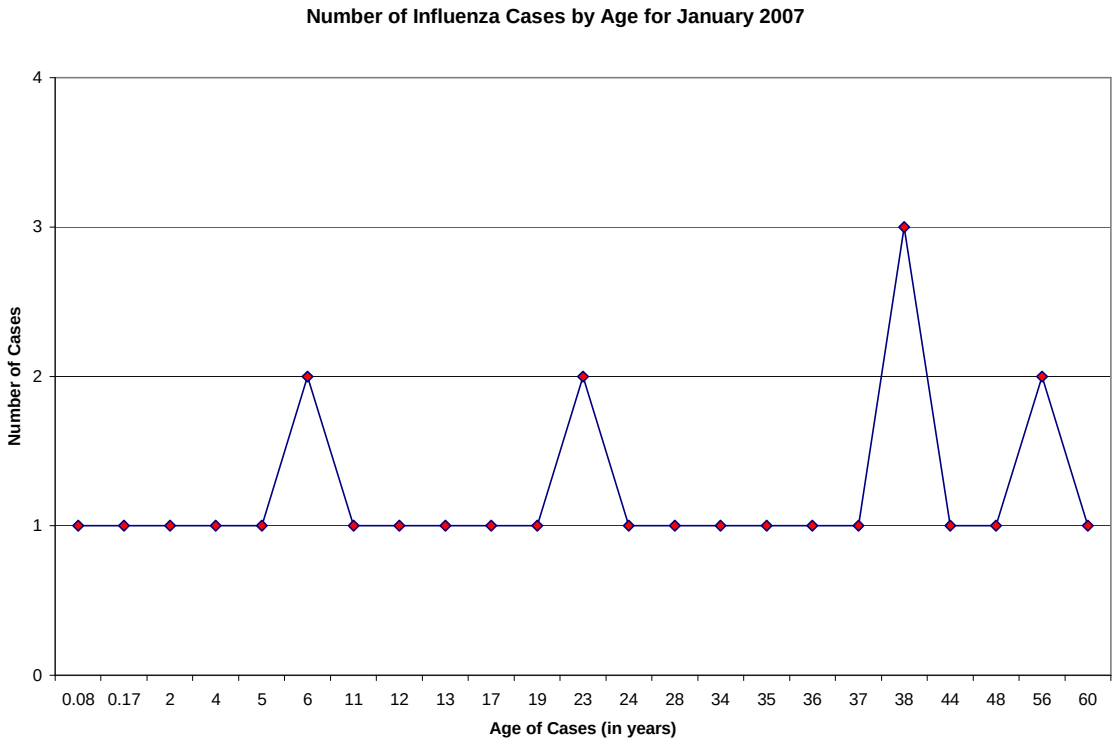
Appendix D: Number of Confirmed Influenza Cases by Age for Each Month of the 2006-2007 Season



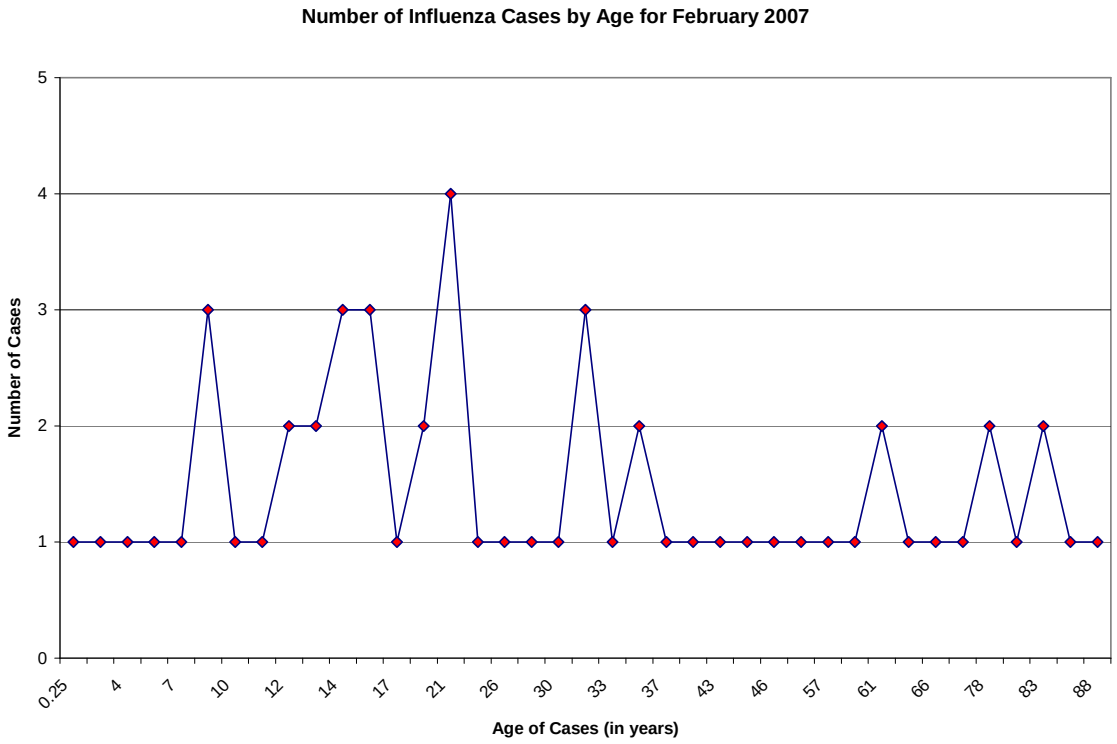
The ages of the cases in November 2006 ranged from 4-13 years. The highest frequency (three cases) was at seven years of age.



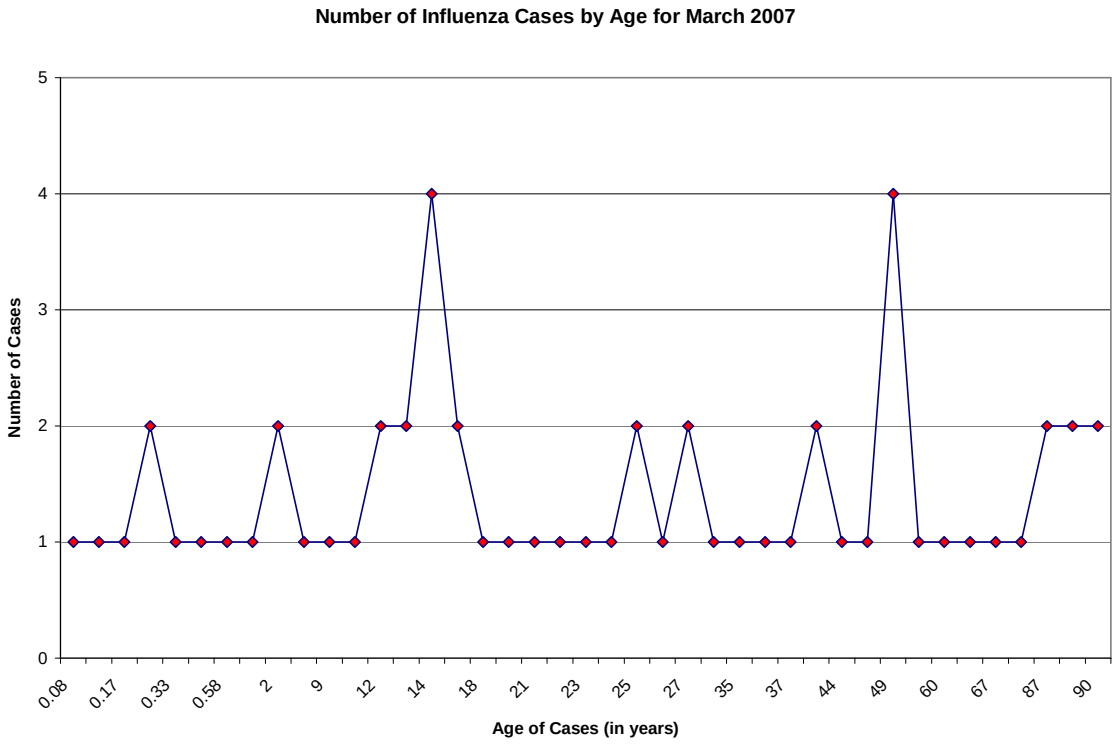
There were 115 influenza cases identified in December 2006. Their ages ranged from 0.5-49 years. The highest frequency of cases (23) was at six years of age. There was another significant peak of about 18 cases at eight years of age.



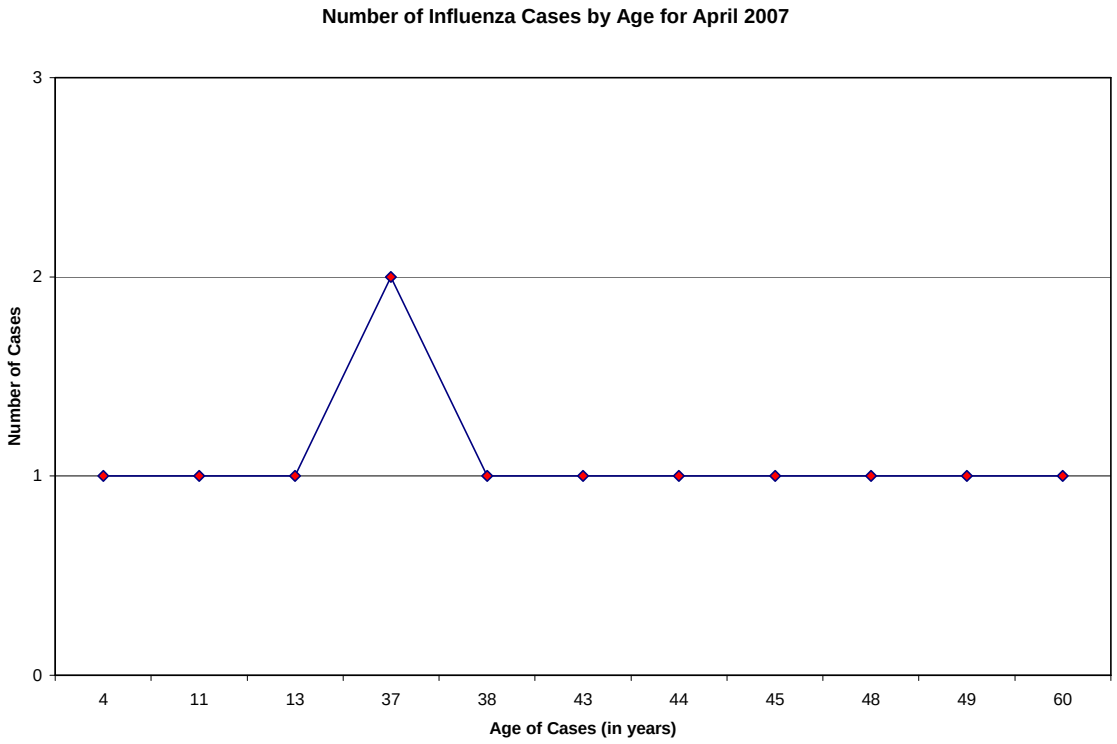
A wider age range was observed for the influenza cases confirmed in January 2007. The cases ranged from 0.08-60 years of age. The highest frequency of three cases was at 38 years of age. There were two cases each at six, 23, and 56 years of age.



The ages of the influenza cases ranged from 0.25-88 years of age in February 2007. The highest frequency of four cases was at 21 years of age.



The widest age range for the influenza cases was observed in March 2007. The cases ranged from 0.08-90 years of age. The highest frequency of four cases was at both 14 and 49 years of age.

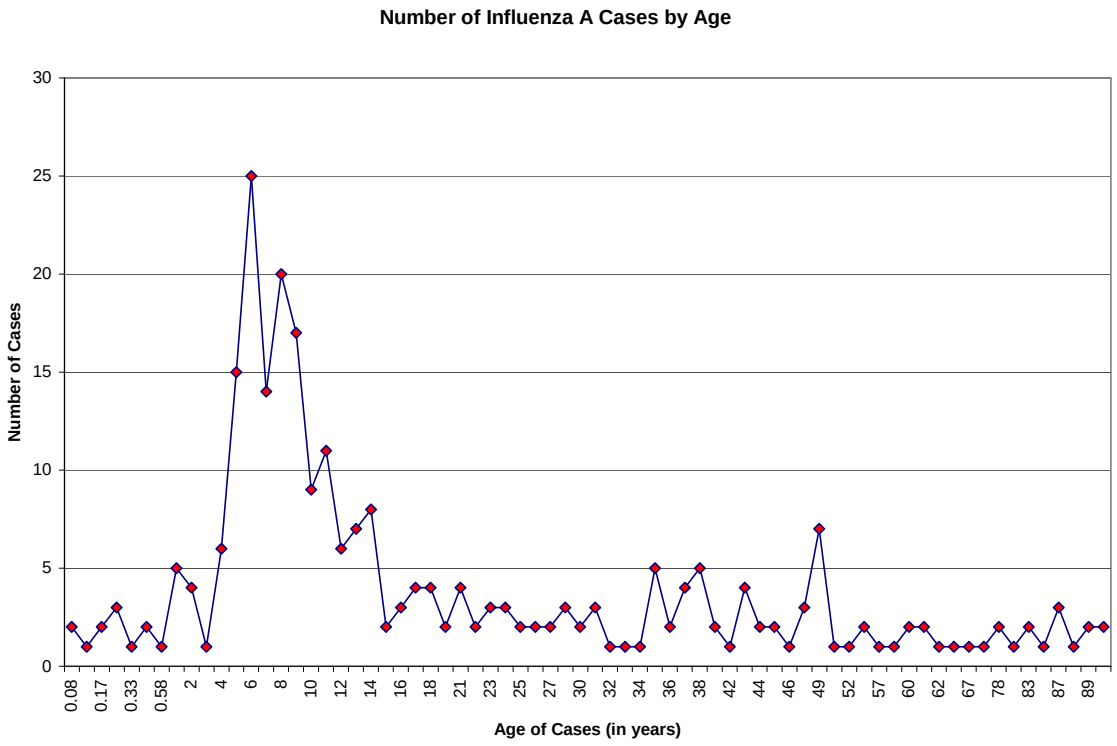


The ages of confirmed influenza cases ranged from 4-60 years in April 2007. There were two cases that were 37 years of age.

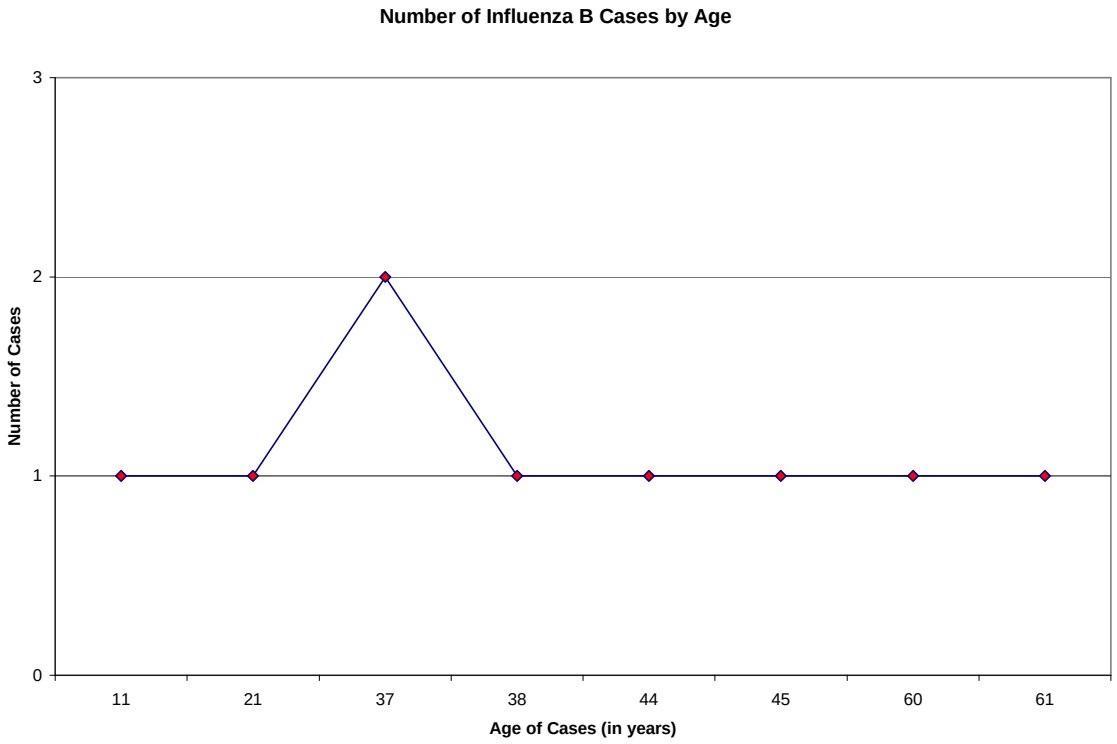
Appendix E: Proportions of Confirmed Male and Female Influenza Cases by Month (2006-2007)

Month	Males (%)	Females (%)
November	44.4	55.6
December	48.7	51.3
January	42.9	57.1
February	52.6	47.4
March	39.7	60.3
April	41.7	58.3

Appendix F: Number of Confirmed Influenza Cases by Age for Each Type of Influenza



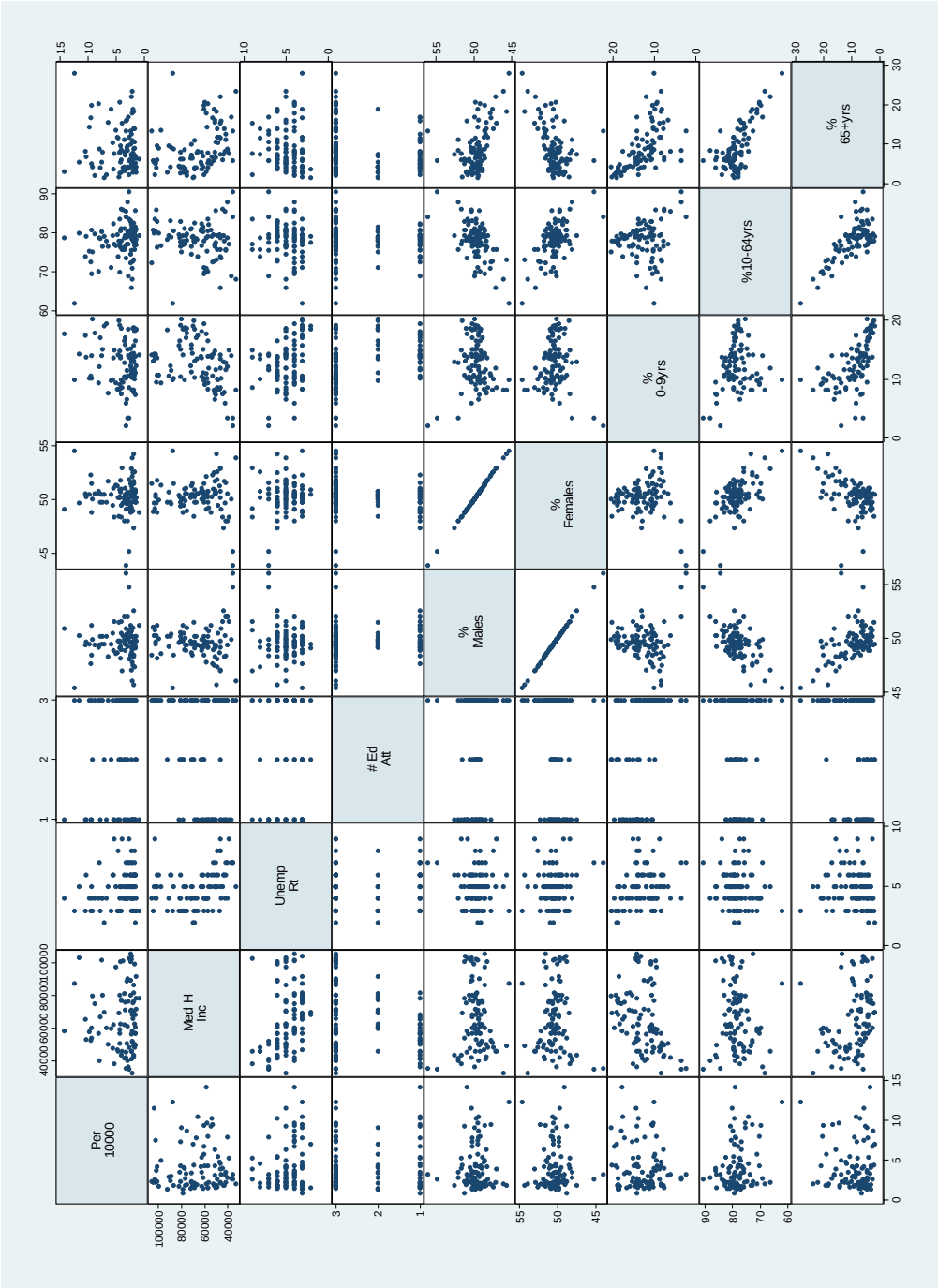
Most (96.8%) of the confirmed influenza cases in the CHR over the 2006-2007 influenza season had influenza A. The ages of the influenza A cases ranged from 0.08-90 years. The highest frequency of 25 cases was observed at six years of age.



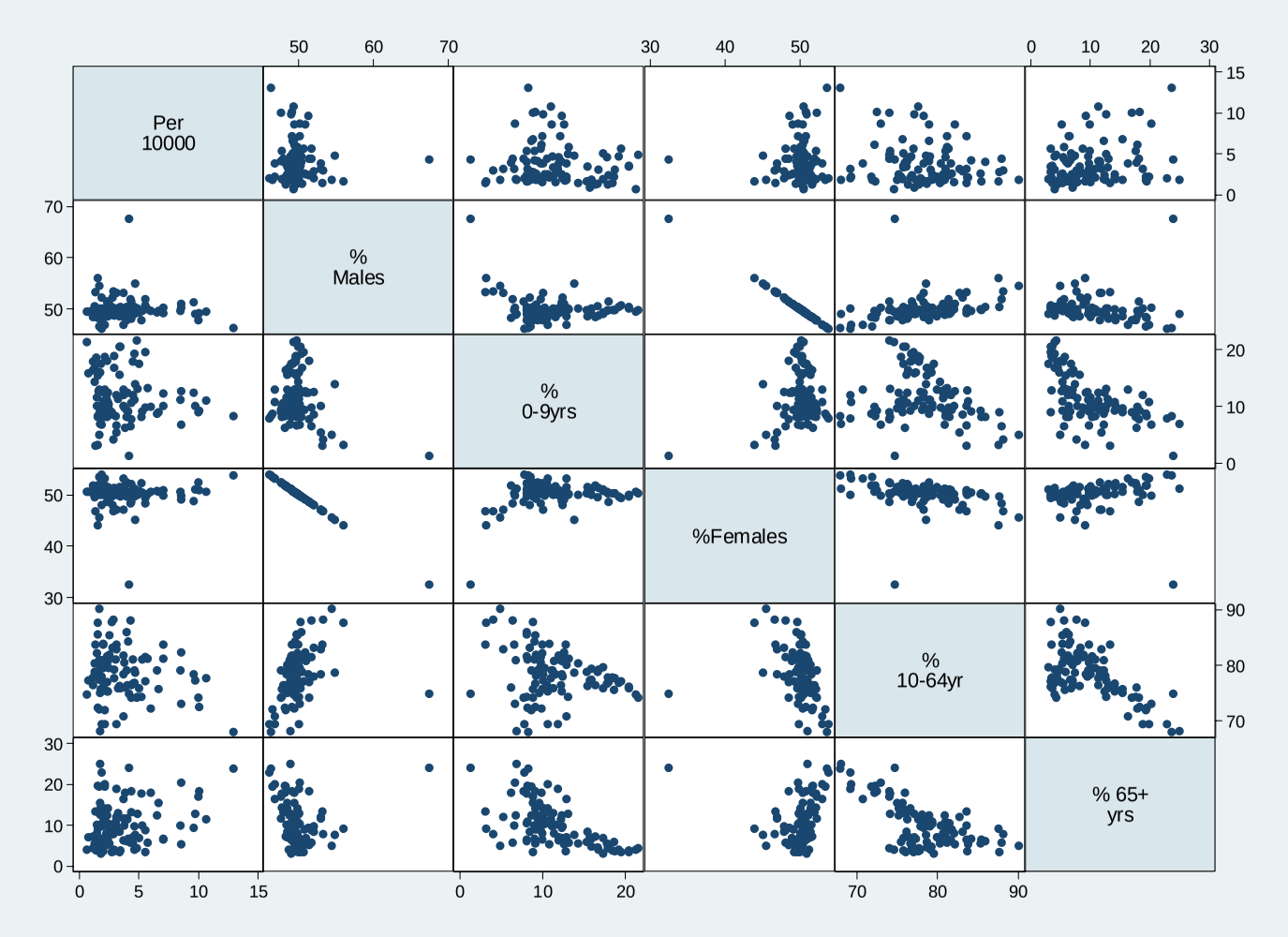
The ages of the nine influenza B cases ranged from 11-61 years, with a peak of two cases at 37 years.

Appendix G: Scatterplot Matrices of Census Variables

Scatterplot Matrix for the 2001 Census of Canada Variables



Scatterplot Matrix for the 2006 Census of Canada Variables



Appendix H: Ethics Board Approval

FACULTY OF MEDICINE | UNIVERSITY OF CALGARY

OFFICE OF MEDICAL BIOETHICS
Room 93, Heritage Medical Research Bldg
3330 Hospital Drive NW
Calgary, AB, Canada T2N 4N1
Telephone: (403) 220-7990
Fax: (403) 283-8524
Email: omb@ucalgary.ca

2007-01-18

Dr. Elizabeth A. Henderson
Department of Community Health Sciences
HMRB
Calgary, Alberta

Dear Dr. Henderson:

RE: Geomapping the Transmission of Influenza through the Calgary Health Region

Ethics ID: E-20624

Student: Linda Kamhuka

The above-noted proposal including the Research Protocol , Data Collection Sheet , and Telephone Scripts has been submitted for Board review and found to be ethically acceptable.

Please note that this approval is subject to the following conditions:
(1) consent for access to personal identified health information in chart review is not required on grounds considered under Section 50 of the Health Information Act,
(2) access to personal identifiable health information was not requested in this submission;
(3) a copy of the informed consent form must have been given to each research subject, if required for this study;
(4) a Progress Report must be submitted by **January 18, 2008**, containing the following information:
- i) the number of subjects recruited;
- ii) a description of any protocol modification;
- iii) any unusual and/or severe complications, adverse events or unanticipated problems involving risks to subjects or others, withdrawal of subjects from the research, or complaints about the research;
- iv) a summary of any recent literature, finding, or other relevant information, especially information about risks associated with the research;
- v) a copy of the current informed consent form;
- vi) the expected date of termination of this project.

5) a Final Report must be submitted at the termination of the project.

Please note that you have been named as the principal collaborator on this study because students are not permitted to serve as principal investigators. Please accept the Board's best wishes for success in your research.
Yours sincerely,

Glenys Godlovitch, BA(Hons), LLB, PhD
Chair, Conjoint Health Research Ethics Board

GG/emcg
c.c. Dr. T. Noseworthy (information) Research Services Linda Kamhuka (Student)
Office of Information & Privacy Commissioner