ASSESSING THE VANCOUVER COASTAL HEALTH AUTHORITY'S PANDEMIC INFLUENZA VACCINE PROGRAM:

A CASE STUDY OF THE 2009-2010 H1N1 INFLUENZA PANDEMIC

by

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Abstract

Due to the looming threat of an influenza pandemic, global investment was been placed into pandemic preparedness and response planning in order to mitigate and reduce the associated negative impacts. In June 2009, the first influenza pandemic of the 21st century was declared; however, the negative consequences that transpired were not as dire as those projected. As such, the 2009 H1N1 influenza pandemic provided an opportunity to test current pandemic preparedness plans in order to identify and close gaps between actual and ideal performances. This paper chose to assess the execution of the Vancouver Coastal Health pandemic vaccine program plan, comparing it with the events of the latest pandemic. Areas for improvement identified include: issues surrounding implementation and enforcement of policies regarding priority groups; expansion of activities aimed at increasing vaccine uptake; increasing public support of vaccines in general; and building in adaptation capacity within preparedness plans. Recommendations were made to address these issues.

Keywords: H1N1; Pandemic influenza; Emergency Preparedness; Pandemic Preparedness; Vancouver Coastal Health; Vaccination

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" People don't rise from nothing....It is only by asking where they are from that we can unravel the logic behind who succeeds and who doesn't."
- Outliers: The Story of Success by Malcolm Gladwell

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Chapter 1: Introduction to the Public Health Problem

Influenza experts had been warning over the past few years that we are overdue for an influenza pandemic and that the emergence of a novel strain of influenza with pandemic potential is imminent [1]. This fear has been perpetuated by the transmission of novel, virulent influenza strains in isolated human populations over the past few years [1]. Thankfully none of those strains possessed all the required characteristics to start a global influenza pandemic [2]. Nevertheless, these outbreaks, along with the widespread prevalence and circulation of virulent strains of influenza among birds, and the longest recorded lag between influenza pandemics in the 20th century, had some experts in the field on edge and calling for increased investment in pandemic preparedness in order to mitigate the profound international consequences projected to transpire should a global influenza pandemic occur [2]. As was exemplified in the 2003 global outbreak of severe acute respiratory syndrome (SARS), infectious diseases are no longer solely of national concern, but affect the global population, requiring that all countries be adequately prepared to respond to an event should it occur.

Pandemic preparedness planning is considered critical in order to mitigate and/or reduce human suffering and the negative side effects on the economy and society associated with influenza pandemics [3]. As such, the World Health Organization (WHO) has encouraged expedited worldwide investment in pandemic influenza preparedness planning. Through the publication of its Influenza Pandemic Preparedness Plan and instigation of a global agenda for influenza surveillance and control, the WHO has provided countries with support and ideas to help facilitate preparation of their own pandemic influenza preparedness plans [2]. As of 2008, 47 countries had developed and published national pandemic influenza preparedness plans [4]. However, due to the fortunate rarity of influenza pandemics, these plans are written and based on incomplete understanding of the actual pandemic virus and estimates of impact. As such, they require testing and assessment in order to identify gaps and help strengthen their effectiveness.

In March 2009, Mexican authorities noticed an increase in cases of severe respiratory illness affecting otherwise healthy young adults. Similar illness spread to the United States and Canada and was subsequently identified as a novel strain of H1N1 influenza [5]. As the outbreak progressed, sustained human-to-human transmission of H1N1 was demonstrated globally and

concern at the international level was raised as fears of a global pandemic were provoked. On June 11th, 2009, the WHO declared this the first influenza pandemic of the 21st century [6].

In the end, this H1N1 influenza strain was not as virulent as was expected and the negative consequences projected to transpire were limited. However, just as the advances in science and technology helped inform our current pandemic influenza preparedness plans, this less virulent influenza pandemic has allowed us to put our preparedness and response plans into action. From this experience we will be able to identify gaps, strengths, and lessons learned, in order to strengthen and advance our current plans in preparation for the next pandemic.

The purpose of this report is to compare and contrast the Vancouver Coastal Health (VCH) pandemic vaccine program as outlined in the VCH Regional Pandemic Influenza Response Plan with the events that transpired during the 2009 H1N1 influenza pandemic in order to identify those gaps and lessons learned. The identification of these will add to our evidence base and provide insight for improvement of the VCH pandemic influenza response plan.

Chapter 2: Background

Influenza

First isolated in 1933, influenza is an enveloped single-stranded RNA virus of the *Orthomyxoviridae* family [2, 7]. There are three types of influenza viruses (A, B and C) which are classified based on the identity of their matrix and nucleoproteins [8-9]. These three virus types differ in pathogenicity and host range, with all three types able to infect humans, but only influenza A with the ability to infect other animals [9]. Influenza A viruses are further classified into subtypes based on which Hemagglutinin (HA) and Neuraminidase (NA) glycoproteins are present on the surface of the virus [10]. There are 16 different HA antigens and 9 NA antigens known to exist in Influenza A viruses that infect a wide range of animals [2]. All subtypes of Influenza A viruses exist in populations of wild waterfowl, gulls and shorebirds, which represent one of the natural reservoirs for this virus [10-11]. Only viruses containing one of these three different HA antigens (H1, H2 and H3) and one of these two different NA antigens (N1 and N2) are known to circulate within human populations [2].

Influenza A viruses are continually evolving and accumulating changes in the HA and NA surface proteins. Non-deleterious minor genetic changes, as a result of replication errors due to RNA polymerase's lack of proofreading ability, lead to changes in the resulting HA and NA proteins [12]. Accumulation of these minor changes within the HA and NA surface proteins, known as antigenic drift, results in selective advantage and amplification within the population as these viruses possess the ability to evade the immunity of the population [9]. Antigenic drift is responsible for the emergence of new viral strains each year leading to annual influenza epidemics [9-10].

Periodically larger dramatic genetic changes in the HA and NA viral proteins occur and introduce new surface antigens to the viruses circulating in the human population in a process called antigenic shift [13]. Introduction of novel surface antigens to humans can occur in two manners [7]. One method is through a process called re-assortment, where a cell is infected with two or more different influenza strains allowing genetic material to be exchanged between them [10]. Re-assortment often transpires after a period in an intermediate host, such as swine, since avian, swine and human influenza viruses can readily replicate in this host increasing the potential for co-infection, interaction and exchange of genetic material [13]. Introduction of a

new surface antigen can also occur without re-assortment, when a virus from a natural host is transmitted directly to humans and then acquires the ability to replicate [7]. These large genetic changes produce viruses to which the human population has no prior immunity and have the potential to induce an influenza pandemic [10].

Clinical Presentation

Influenza viruses infect the epithelium of the upper and lower respiratory tracts [9-10]. Infection typically results in: abrupt onset of chills, fever, cough, generalized aches and pains especially in the back and legs, and headaches [8, 10]. Acute symptoms usually last between two to seven days, though fatigue, weakness, and cough may persist for longer [8]. While the majority of cases of influenza infection are not serious, complications can occur, most commonly in certain vulnerable populations. The elderly (>65 years of age), those with underlying chronic diseases, pregnant women and the very young (<4 years of age) are at greater risk of complications from influenza infection resulting in increased morbidity and mortality [8-9]. Morbidity and mortality in these populations is often associated with exacerbation of the underlying illness, pneumonia or acute respiratory distress syndrome [8].

Virus Transmission

The influenza virus can be spread in three different ways: through airborne droplets, person-to-person contact or through contact with a contaminated item [8]. Respiratory droplets are produced by infected individuals and introduced into the environment when that individual coughs or sneezes [14]. These droplets spread through the air and can directly infect other individuals (if they land directly on their mouth or nose or are directly inhaled) or can settle on surfaces contaminating them. The influenza virus is quite hardy and can survive on nonporous surfaces for 24 – 48 hours [15]. Contact with contaminated surfaces can lead to infection if individuals subsequently touch their own mouth or nose prior to washing their hands [14]. Due to this mode of transmission, epidemics of influenza are typically associated with the winter months, since the cold weather results in individuals spending more time indoors in close proximity increasing the likelihood of encountering infected persons and/or contaminated surfaces [16]. The period of time between infection and development of symptoms, known as the incubation period, can range between one to four days [8]. Infected individuals are contagious and can infect others beginning one day prior to and up to seven days after symptom development [14]. Those infected are most infectious in the first three days of illness. The robust

nature of the virus, the ease with which it is spread and the fact that the period of communicability commences before an individual knows that s/he is infected, results in easy and widespread transmission of this virus. It is estimated that influenza infection affects 20% of the general population each year [17].

Treatment of Infection

In the majority of cases, influenza infection is not associated with severe illness. Therefore, recommended treatment is symptomatic and includes rest, hydration and the use of antipyretics as needed [8]. Antiviral treatment can reduce the morbidity and potential mortality associated with influenza infection and may be most useful for high-risk individuals [8]. However, for antiviral treatment to be effective, it must be administered within two days of symptom onset in order to reduce the duration and severity of the infection [8]. Widespread use of antiviral drugs is not recommended in seasonal influenza epidemics, as this could lead to the evolution of drug-resistant strains of the virus and limit the future effectiveness of these drugs [18].

Control and Prevention of Infection

Non-pharmaceutical Interventions

Limited scientific evidence is available on the efficacy and effectiveness of non-pharmaceutical methods for controlling the spread of Influenza infection [19]. This could be due to readily accessible pharmaceutical interventions in inter-pandemic Influenza seasons which are chosen and evaluated instead of the non-pharmaceutical interventions. However, it is generally accepted within the expert community that certain measures can reduce human-to-human influenza transmission and ought to be promoted for general use [19]. These non-pharmaceutical interventions include, but are not limited to: good hand hygiene, meaning rigorous and routine washing of hands with soap and water, or the use of alcohol-based hand sanitizers in situations where soap and water are unavailable; respiratory etiquette, meaning that individuals should cover their mouth and nose with either a kleenex or with the upper portion of their sleeve when coughing or sneezing; voluntary self isolation, meaning that sick individuals should limit their social contact until their symptoms have subsided; and the use of masks for health care workers in order to reduce exposure of potentially susceptible populations [19]. While these interventions can be helpful in all influenza seasons, they may be most useful

in a pandemic setting since pharmaceutical interventions may not be readily available at the start of the outbreak.

Pharmaceutical Interventions

Antiviral drugs and influenza vaccines are two pharmaceutical interventions used for the control and prevention of influenza infections. Antiviral drugs can be prophylactically, however, as mentioned previously, widespread use could lead to the development of resistant strains and is therefore not highly recommended [20]. In pandemic situations where vaccines may not be readily available, the use of antiviral drugs may be the only option available.

Influenza vaccination remains one the of the most cost effective primary prevention methods against influenza infections [21]. Due to the constantly evolving nature of the influenza virus, development of new vaccines and their administration is required annually in order to induce protection against the morbidity and mortality associated with infection [22]. In 1947, the World Health Organization (WHO) established an international surveillance system that monitors the strains of Influenza viruses circulating in human and animal populations worldwide [23]. From the data collected, the WHO makes predictions as to which strains will be circulating in the coming influenza season and makes recommendations as to the composition of the annual influenza vaccine [4]. Variation in vaccine protection is a result of the degree to which strains in the vaccine match the circulating strain in that season [24]. Once the strains have been selected, seed stocks of these viruses are made by WHO collaborating centers and are sent to manufacturers in order to produce vaccine for the global population [23]. It takes approximately four to six months from the time that the vaccine strains are identified, to develop the vaccine and start distribution [4]. This process from identification, to manufacturing, to distribution, requires a highly coordinated and controlled effort in order to ensure that vaccines are made available in time. Since vaccines are manufactured in embryonated eggs, careful planning must be taken to ensure that manufacturers obtain enough eggs prior to production [23]. Lack of planning could lead to either gross over- or under-production of vaccine. Additionally, vaccines must be ready for administration to the population before the expected circulating period commences in order to be effective [23]. Delays in the production process could lead to delays in vaccine availability and reduce the overall effectiveness of vaccination programs.

Though vaccines represent a primary prevention method against Influenza infection, the uptake of Influenza vaccines varies among countries [25]. This makes the business of developing

and producing Influenza vaccines very uncertain, since demands are unpredictable and can vary from year to year [26]. At present, it is estimated that the global vaccine-manufacturing capacity is 565 million doses per year, enough for annual Influenza vaccination demands, but without enough for the surge capacity that would be required in the event of a pandemic [4].

In contrast to the annual vaccine production which is based on the previous year's experience, preparation of a vaccine in a pandemic situation is difficult. Since an Influenza pandemic is instigated when a novel virus is introduced into the human population to which there is limited or no pre-existing immunity, production of a vaccine cannot commence until the strain has emerged and a pandemic is underway [4]. Moreover, pre-production of a vaccine against all strains that could potentially cause a pandemic is neither logistically nor economically feasible [27]. Furthermore, some of the strains that are thought to have pandemic potential, specifically H5 and H7 strains, are difficult to produce with traditional vaccine technologies [1, 4]. Further research into vaccine development will be required in order to overcome these obstacles.

Pandemic Influenza

In order for an Influenza pandemic to occur, the novel Influenza virus that emerges must meet three conditions: infection in humans must cause clinical illness; infection must be readily transmissible from person-to-person; and a large population worldwide must lack immunity to the strain that emerges [28]. Additionally, pandemic strains are associated with multiple waves of infection which often do not occur within the regular "Influenza Season" [2]. There are accounts of Influenza pandemics as early as the 12th century. However, most of the lessons about pandemic Influenza have been learned from the well documented pandemics of the 20th century [2]. The 20th century saw three Influenza pandemics.

The first pandemic of the 20th century occurred in 1918-1919 and was the most lethal of the three [9]. It has been estimated that 1/3 of the world's population was infected [29]. It killed an estimated 50 million people worldwide and induced 20-40% morbidity in most communities [9, 29]. Not only was infection with this strain of Influenza associated with severe disease and increased mortality, but the infection and mortality rates disproportionately affected healthy young adults between the ages of 20 – 40 compared with seasonal epidemics [7, 29]. This pandemic was comprised of three waves of infection [29]. The first wave occurred in the spring of 1918, the second in the fall of 1918 and the third in the winter of 1918-1919 [29]. The origins

of the 1918 pandemic Influenza strain, H1N1, often referred to as the "Spanish Flu", remains disputed [30]. It has been estimated that if a strain with similar pathogenicity were to infect our population today, it would kill approximately 175-350 million people worldwide [4].

The second pandemic of the 20th century occurred in 1957 and was caused by a novel Influenza A virus which was a product of genetic re-assortment between an avian and human strain [7]. This novel virus, H2N2, contained novel HA and NA surface antigens which were unlike any antigens circulating within the human population [30]. Emerging from southern China in February 1957, this novel virus spread worldwide by November and caused two waves of infection associated with increased mortality [7].

The third and final pandemic of the 20th century occurred in 1968 and was caused by a novel H3N2 Influenza A virus, again a product of genetic re-assortment between avian and human strains [29]. Emerging from Hong Kong, this virus was associated with variable impact, most likely due to some pre-existing immunity within the population to the N2 surface antigen [30].

Since this last pandemic, we have seen the emergence of novel strains of Influenza A, some of which have demonstrated transmission to humans inducing small outbreaks of illness [1]. Three of these novel strains are of particular interest due to their pandemic potential, since they meet some of the necessary conditions required to instigate a pandemic. These three influenza strains are being closely monitored and are thought to be the strains which will instigate the next influenza pandemic. The novel strain of avian Influenza, H5N1, was associated with severe disease development in commercial poultry and some direct human transmission was documented, mainly in individuals who had close contact with poultry [28]. Human Infection with this strain of Influenza A is associated with high mortality, causing death in 60% of confirmed cases [4]. Surveillance of this highly pathogenic strain has demonstrated that it remains in high circulation within the avian populations and is considered to be the most likely candidate for the next pandemic [4, 26]. Another avian strain of Influenza A, H9N2, demonstrated direct transmission to humans in 1999 in Hong Kong [7]. Surveillance of this strain demonstrates that it is widespread in Asian poultry and as such, also poses a pandemic threat [31]. Moreover, H9N2 has also been detected in swine populations, increasing the potential for re-assortment and transmission to the humans [1]. The presence of an avian strain of influenza in the swine population is particularly concerning since swine populations can also be co-

infected with and allow for replication of human and swine influenza viruses [13]. This co-infection ability increases the potential for antigenic shift resulting in the production of a novel influenza virus to which the human population has no prior immunity, but contains aspects of the human virus that allow for easy transmission to and between humans. The third strain that is being closely watched for its pandemic potential is H7N7 [1]. While it has yet to demonstrate severe disease in humans, it has demonstrated the ability to transmit directly to humans. It is highly lethal in poultry and has the genetic predisposition to mutate easily [1]. Fortunately none of these new strains of avian influenza A have gained the ability for widespread human-to-human transmission, and thus have not induced an influenza pandemic to date [1].

Influenza Pandemic Preparedness

The identification of these pandemic potential strains of Influenza has given us as a global community an unprecedented opportunity to prepare for the next pandemic threat [26]. Advance planning is required in order to enhance response capacity to attempt to mitigate the impact of an Influenza pandemic and to help calm public fears [28]. In 1999 the WHO published its Influenza Pandemic Preparedness Plan. This plan defined the role that the WHO will play in an Influenza pandemic and provided guidelines for national and regional pandemic planning [28]. This plan was updated in 2005, prompted by the endemic presence of avian H5N1 associated with human cases and the lessons learned from SARS [32]. This revised plan redefined the phases associated with influenza infections with corresponding objectives and actions associated with each phase [32]. Four years prior, in 2001, the WHO also initiated the Global Agenda for Influenza Surveillance and Control in an attempt to raise awareness about the severe economic and public health consequences induced by influenza [33]. This global agenda brought together experts in both the public and private sectors and developed 17 activities targeted at four main objectives: to strengthen surveillance, to gather more information on the burden of influenza infections, to increase vaccine use, and to accelerate pandemic preparedness planning worldwide [1, 33].

As of 2008, 47 countries had developed and published national Influenza Pandemic Preparedness plans [4]. The first Canadian Pandemic Influenza plan was drafted in 1988 and was called the Canadian Contingency Plan for Pandemic Influenza [34]. This plan was updated in 2004 and then again in 2006 and is now called the Canadian Pandemic Influenza Plan for the Health Sector [34]. The purpose of this plan is to provide guidance and support for planning at

the Provincial, Territorial, regional and local levels [34]. Since provision of health care and essential services, which comprise the majority of services required during a pandemic, are under the jurisdiction of the Provincial and Territorial governments, this plan recommends that separate plans be developed at all these levels and that they include more relevant operational details [34]. As such, each province as well as local and regional health authorities have separate Influenza pandemic preparedness plans. Of particular importance for this paper is the Vancouver Coastal Health Regional Pandemic Influenza Response Plan.

The 2009 H1N1 Influenza Pandemic

Increased attention has been paid to the strains of influenza currently circulating in Asian avian populations. This is most likely due to the emergence of novel pandemic potential strains of avian influenza A in these regions which have demonstrated transfer to humans and severe illness [29]. Indeed, most pandemic influenzas develop in Asia and spread from there. This fact increases concern with the current circulation of severe strains of avian influenza in Asian poultry [29]. However, while the world watched Asia for the next pandemic strain of influenza, a novel strain of H1N1 influenza A virus emerged from swine in another part of the world and initiated the first influenza pandemic of the 21st century.

In March 2009, Mexican health officials noticed an increase in cases of severe respiratory illness. Coinciding with the end of the seasonal influenza epidemic, little attention was paid to these cases until an atypical case of pneumonia was reported which prompted increased surveillance [35]. In mid April, two cases of febrile respiratory illness in children were reported in California and were linked to infection with a swine influenza A (H1N1) virus [5]. Several cases of the severe respiratory illness in Mexico were tested and subsequently discovered to be caused by the same novel influenza A strain as was identified in California [5]. In Canada, in mid-April, a cluster of cases of acute respiratory illness was reported in a private school in Nova Scotia [36]. Further investigation of these cases revealed that the group had recently returned from a trip to Mexico [36]. Testing of samples from these cases confirmed that the illness was caused by this same novel H1N1 influenza A strain [36]. Spread of infection was being demonstrated within the school population and were the first known cases of pandemic H1N1 influenza in Canada [36]. Further national and international spread of the virus was started by travelers seeding their respective home countries with the infection and subsequent spread of infections due to person-to-person transmission [35]. Beginning mid-April, the WHO declared

that the situation was a public health emergency of international concern. Within the following two months, we would see the WHO pandemic alert increase from Phase 4 to Phase 6, in the end declaring the first influenza pandemic of the 21st century.

Ultimately this Influenza pandemic did not reach the same levels of morbidity and mortality as was observed in previous pandemics. However, it did serve as a real-life test of our influenza pandemic preparedness plans and ought to be assessed in order to garner lessons learned and better our current plans and practices. This project will attempt to compare and contrast the VCH pandemic vaccine program as outlined in the VCH Regional Pandemic Influenza Response Plan with the events that transpired during the 2009 H1N1 influenza pandemic.

Chapter 3: Methods

This assessment will utilize the pandemic vaccine program as outlined in the VCH Regional Pandemic Influenza Response plan as the basis of comparison against the corresponding events of the 2009 H1N1 Influenza pandemic within VCH authority. Due to length restrictions, this analysis will focus on identifying gaps and areas of positive improvement in the execution of the vaccine program only. This will allow for insight into the utility of pandemic influenza preparedness plans in terms of vaccine delivery programming.

Media reports, scholarly journals and government sources will be utilized in order to reconstruct the events of the pandemic that are pertinent to the four sections of the pandemic vaccine program outlined in the VCH regional pandemic influenza response plan. Due to the regional focus of this analysis, the Vancouver Sun will be the primary media source and the BC Center for Disease Control (BC CDC) influenza surveillance reports and the VCH website will be the primary government sources of information to help reconstruct the event.

The Vancouver Coastal Health Regional Pandemic Influenza Response Plan

The VCH regional pandemic influenza plan was written in accordance with the advice obtained from the provincial, national and international pandemic influenza response plans in conjunction with information obtained from VCH community health administrators and managers and was published in its current form in 2006 [37]. Information has been presented in the form of an information manual. It attempts to define the roles, responsibilities and key actions for all stakeholders involved within all stages of an influenza pandemic [37]. As per the national recommendations, this plan includes enhanced information surrounding the logistical and operational plans required at the regional level, and is customized to meet the specific needs and culture of the region which it serves. This regional plan is supplemented with even more detailed logistical and operational plans for each of the four health service delivery areas within the health authority (Coastal, Richmond, Vancouver Acute and Vancouver Community) which are aimed at further supporting local planning and response [37]. The regional plan covers various topics, ranging from background information on pandemic influenza viruses to handling and disposal of the deceased [37]. For a complete listing of the topics covered in the VCH regional pandemic influenza response plan, see Appendix 1. Of particular interest for this

assessment is chapter 10 on vaccines and antivirals and more specifically the pandemic vaccine program outlined within this chapter.

VCH Pandemic Vaccine Program

The most direct method of minimizing morbidity and mortality associated with pandemic influenza is through the administration of vaccines and antiviral drugs [37]. The VCH regional pandemic influenza plan states that the main objective of the vaccine initiative is "…to provide the public, as rapidly as possible, with a safe and effective vaccine. This entails allocating, distributing and administering the vaccine to appropriate groups and to monitor the safety and effectiveness of the program." [37]. The specifics of the VCH pandemic vaccine program and outlining how the region hopes to achieve this result were based on the immunization targets outlined in the national preparedness plan [37]. The VCH pandemic vaccine program is broken down into the following sections: vaccine priority groups, increasing vaccine uptake, pneumococcal vaccine, possible vaccine reactions and mass vaccination clinics. Since this pandemic did not have large concurrent cases of pneumococcal infections, a severe secondary infection in people already infected with influenza, all but this section of the pandemic vaccine program will be described as per the plan and then compared with the events that transpired during the 2009 H1N1 influenza pandemic.

Limitations

This analysis was done based on publically available data, and as such, certain limitations were encountered. Though this analysis was done on a pandemic vaccine program based at the health authority level, the available data utilized were at the provincial level. For example, the date of vaccine delivery was to the province as a whole, and would not have been available to VCH until later. Thus the observations made as to the length in time between delivery and distribution is exaggerated due to this discrepancy. Readers should be mindful of this discrepancy and its possible effects on the observations and recommendations made within this text.

Chapter 4: Results

Vaccine Priority Groups

The national pandemic influenza response plan (The Canadian Pandemic Influenza Plan for the Health Sector) indicates that if vaccine supplies are not limited, vaccine initiatives should aim to vaccinate the entire population within a four month period. However, in the more realistic situation where vaccine supplies are limited, anticipated priority groups with accompanying definitions have been listed within the VCH pandemic vaccine program plan in order to maximize the utility of the vaccine (see Table 1). The VCH response plan does acknowledge that redefining groups may be required during the actual event.

During the 2009 influenza pandemic, vaccine supplies were in fact limited, with distribution to the provinces occurring in weekly allotments as the vaccine became available from the manufacturer. As such, groups were prioritized to receive the vaccine in order to maximize the vaccine's utility. While the VCH pandemic vaccine program had already established priority groups, the epidemiology of this particular pandemic led the federal government to establish its own sequencing information and it urged provinces, territories and local health regions to adopt these new guidelines (aimed at helping target the timing and location of the influenza vaccination clinics) (see Table 2) [38]. The sequencing information provided was not listed in priority sequence, leaving the responsibility of prioritization to the discretion of the provinces and territories taking into account their local circumstances and realities [38]. This new sequencing information led to the development of priority groups that differed from the ones outlined within the VCH regional pandemic influenza response plan (see Table 3). Thus the priority groups that were utilized in VCH during this event were set by the province taking into consideration the federal recommendations. Eligibility to receive the vaccine was expanded within VCH over a four week period starting October 26th, 2009.

During the vaccine campaign, certain events highlighted gaps in the program plan where positive improvement can be introduced. Alleged queue jumping by non-priority groups can lead to public outrage and demonstrate the need for enforcement of the prioritization process. For example, a report of queue jumping by local hockey players and hospital board members left many public members outraged [39-40]. The responsibility of enforcement of priority groups at the vaccination clinics during this event fell on the shoulders of the public health nurses and

administration staff, a role for which they have little prior experience or skills. Furthermore, some medical professionals found it difficult to enforce priority groups that didn't seem to reflect the idea that influenza infections spread in clusters of people who are in close and constant contact with each other. Additionally, at times enforcing the groups themselves undermined the goal of vaccinating the entire population. For example, during this pandemic, if a pregnant woman went to get vaccinated during the first week with her two year old son and her six year old daughter, the pregnant woman would be vaccinated but not the two children. This woman would have to return an additional two times in order for everyone in her family to receive the vaccine. In order to avoid this hassle, the woman may decide to wait until a time when her entire family is eligible to receive the vaccine, which in this case would mean she would wait an additional two weeks before receiving the vaccine, placing herself at risk for an additional two weeks.

> *"As a clinician, when you have a family and only one of them is on a priority list, it's very hard to say, 'You get the vaccine and the rest of you don't,' because it makes no sense. Infections spread in families."* [41]

Lastly, the priority sequence that the province established and was utilized in VCH during this event reflected a prioritization to vaccinate those individuals at high risk of severe illness, infection induced health complications and potential death. While this strategy can help mitigate increased morbidity and mortality and reduce the potential of overwhelming the health care system, these high risk individuals do not always represent the ones that contribute to the rapid spread of disease.

Increasing Vaccine Uptake

Ensuring that individuals are willing and able to comply with the advice to receive the influenza vaccine in the event of a pandemic is a challenging task and requires prior preparation and effort. The VCH pandemic vaccine program only describes one method through which they will attempt to address this issue, by increasing interpandemic vaccine uptake [37]. This strategy attempts to eliminate the barrier of limited vaccine production capacity, a barrier which undermines pandemic influenza initiatives. Increased demand for interpandemic vaccine will hopefully stimulate increased investment into influenza vaccine production capacity and subsequently ensure the existence of sufficient surge capacity in terms of vaccine production

[28]. The provincial influenza plan for BC increasing interpandemic vaccine uptake as a responsibility of the regional and local levels [37].

In this regard, the VCH pandemic vaccine program describes how it holds annual influenza campaigns. While promotion of influenza vaccination is done each year at the beginning of the influenza season, only certain high-risk groups are eligible to receive the vaccine for free (see Table 4). Beyond these high-risk groups, VCH has implemented a health care workers influenza vaccination policy where workers not receiving the vaccination could be excluded from work if an influenza outbreak were to arise [37]. To facilitate vaccine uptake within health care workers, vaccination clinics are held on site in order to increase convenience and eliminate that as a barrier to uptake [37]. Vaccines are also provided on site to long term care facilities in an attempt to increase uptake with that population as well [37]. Vaccine provision for the remainder of the population is done through physician offices and community clinics [37].

The percentage of the provincial population receiving the seasonal influenza vaccine in BC has increased over time, from 17% of the population aged 12 or older in 1996/1997 to 33% in 2005 [42]. These percentages are close to the national average, which rose from 15% of the population aged 12 or older in 1996/1997 to 34% in 2005 [42]. However, vaccination coverage in BC is low compared with other provinces, most notably Ontario, whose percentages were 18% of the population aged 12 or older in 1996/1997 and rose to 42% in 2005. (See Figure 2 for a comparison of percentage of population aged 12 or older receiving influenza vaccine between provinces and territories).

The pandemic vaccine program plan does not outline strategies to promote pandemic influenza vaccine uptake itself. However, during the 2009 H1N1 influenza pandemic, vaccines were provided free of charge to all individuals, eliminating the financial barrier to vaccine uptake.

Possible Vaccination Reactions

The VCH pandemic vaccine program plan states that the side effects associated with the influenza vaccination are usually mild including slight fever, and/or soreness/redness at the injection site which can be treated with acetaminophen [37]. The plan acknowledges that similar to every drug or vaccine, there is the possibility of major side effects including anaphylactic shock [37]. In an attempt to mitigate the severity associated with this side effect the plan

recommends that individuals remain in the vaccination clinic for 15 minutes post injection in order to be monitored for this potential severe side effect [37]. No other side effects associated with influenza vaccination were mentioned in the plan. While the Canadian pandemic influenza plan outlines that a mechanism should be in place at the local level to monitor vaccine safety, no specific plans were included within the VCH pandemic vaccine program in this regard. This could be due to the fact that surveillance systems for the seasonal vaccines are already in place and do not need to be reiterated within this program plan. However, additional surveillance mechanisms may be required during the event in order to obtain immediate information required for decision making.

Adverse Events Following Immunization (AEFIs) were monitored during the 2009 H1N1 influenza pandemic through collaborative efforts between the Public Health Agency of Canada (PHAC), Health Canada, the provinces and territories, and the Canadian Paediatric Society using the Canadian Adverse Events Following Immunization Surveillance System (CAEFISS) [43]. Additional projects were implemented during this event in order to increase the amount of detail collected and include: The Immunization Monitoring Program-Active (IMPACT); the Severe Outcomes Surveillance (SOS) Network; and additional smaller projects funded by the PHAC/CIHR Influenza Research Network (PCIRN) [43]. The national data in combination with international data were combined to assess the overall occurrence of AEFIs and vaccine safety. As of March 6th, 2010, 6 518 AEFIs have been reported to the PHAC. Of those AEFIs, 269 met the criteria and were deemed a serious event. Half of these serious adverse events (134) were cases of anaphylaxis [44]. The majority of AEFIs reported were not serious and included injection site reactions, vomiting, headache, fever and nausea [44]. Further analysis of the information obtained on AEFIs has not revealed any specific pattern amongst the serious adverse events [44]. Frequency and types of AEFIs (bother serious and non-serious) have been consistent with those seen in the clinical trials with this vaccine [44].

Despite the low occurrence of AEFIs during this pandemic, public opinion surrounding the safety of H1N1 vaccine was mixed. Widespread bias and/or misinformation surrounding the safety of squalene, thimerosal (components included in the vaccine vial) and the increased occurrence of AEFIs associated with a previous influenza vaccine (such as Guillian-Barre Syndrome), increased individual scepticism and confusion. Some of this confusion and frustration led to decreased compliance and avoidance of immunization.

> *"What's fuelling my anger is feeling like I'm between a rock and a hard place, not knowing what to do. … I feel like the government is pushing us to do this – like, 'Just be quiet and take it.' But I don't know enough to feel secure with the vaccine."* [41]

Further confusion may have stemmed from the initial recommendations put forth by Health Canada for pregnant women to receive the vaccine without an adjuvant. This recommendation was made because safety tests utilizing the adjuvanted vaccine had not been conducted among pregnant women. Thus the associated risks were not known. However, unadjuvanted vaccine was not available initially and therefore pregnant women who wanted to receive the unadjuvanted vaccine had to wait to receive the vaccine. This became an issue, as the severity of disease in pregnant women was found to be significantly greater with this strain of influenza, placing pregnant women in the high-risk category [45]. Therefore the recommendation was changed, causing confusion amongst the population as well as the community of health care workers who were supposed to be advising these women. This incident also eroded public trust in the safety of the vaccine. Individuals began questioning why only pregnant women were being advised to take the unadjuvanted vaccine, bringing into question the risks associated with the adjuvant. Moreover, changing of the recommendation undermined the message of safety and increased scepticism as to the thoroughness of the safety testing. Individuals questioned whether or not the tests done were valid if a recommendation could be changed so quickly.

Mass Vaccination Clinics

The VCH regional pandemic influenza response plan indicates that vaccine distribution will occur through mass vaccination clinics in order to effectively handle the large number of expected individuals wanting to receive the vaccine [37]. The plan then notes that there are a lot of variables that affect the need for and proper functioning of mass vaccination clinics, such as the size of the population, vaccine availability and the epidemiology of the pandemic. The plan further emphasizes the importance of having this information readily available during the pandemic in order for plans to reflect the events which are transpiring [37]. The plan explicitly outlines relevant data that would be required as a basis for decision-making, such as: the estimated number of people in each priority group, the number of vaccines required under different assumptions or immunization targets, the number of staff required and potential sites and the site requirements to hold a mass vaccination clinic [37].

While there is ample information as to how to calculate how much vaccine and the number of clinics that will be required, there is no information as to what should be done if there is limited supply of the vaccine nor any indication as to how this limited supply should be rationed amongst the VCH population (besides implementing prioritization). During this pandemic, the amount of vaccine being delivered varied (see Figure 3). Manufacturing complications instigated by poor seed stocks and the request to switch part of the production capacity to non-adjuvanted vaccine mid-way through the production resulted in delays and shortages of vaccine. Some clinics at the height of their campaign had to close due to vaccine shortage [46].

Vaccine availability was also affected by the date when vaccine supply was delivered. Vaccines first arrived in the provinces during the upswing of the second wave of infections. By the time vaccine clinics were prepared and operational, the second wave of infections had peaked and the number of cases was on the decline. When the entire population became eligible to receive the vaccine, the second wave of infection was near completion (see Figure 1). The utility of the vaccine campaign was put into question due to this fact.

Demand for the vaccine varied significantly. Accumulated anticipation at the beginning of the vaccine campaign resulted in long queues and wait-times at vaccination clinics within VCH [47]. Demand continued to increase, causing a slight problem when vaccine supplies temporarily ran out. By the time the entire population was eligible to receive the vaccine, demand had decreased. While the plan states that to vaccinate the entire population of BC, clinics would be open and functional for 17 weeks, clinics during this pandemic were closed at the end of the eighth week due to lack of demand. At that point, responsibility of vaccine delivery was shifted entirely to physicians.

Chapter 5: Discussion

In order to prevent, protect against, quickly respond to, and recover from health emergencies, coordinated planning and response is required [48]. This preparedness requires the integration of efforts and support from a variety of sectors and stakeholders [49]. However, due to the fortunate rarity of emergency situations, emergency preparedness and response plans are based on limited knowledge and evidence base [48]**.** Moreover, the field of public health emergency preparedness and response is constantly changing and evolving, requiring continuous testing and improvement of response plans [50].

For many years, influenza experts have been warning that we are long overdue for an influenza pandemic. This has been supported by the influenza activity being monitored in Asia, which has confirmed the presence of novel pandemic-potential influenza strains in avian populations which induce severe disease but which have shown limited transfer to humans [1]. As such, countries have been encouraged by the WHO to prepare pandemic influenza response plans. Implementation of these plans has been limited to table-top exercises and drills. However, in June 2009, the first influenza pandemic of the 21st century was declared and countries, provinces and local health authorities implemented their pandemic influenza response plans.

As mentioned, due to the rarity of emergency situations, plans are based on assumptions, predictions and historical experience. The evidence base utilized in the writing of the current pandemic influenza plans is a combination of the information from the past three influenza pandemics of the 20th century as well as current information collected from global influenza surveillance. From this evidence base, it is fairly clear that it was assumed that the next pandemic influenza strain would come from an avian population, would most likely start in Asia, and if started by the currently circulating strains of influenza in the avian population, would induce severe disease in a large proportion of the human population resulting in high demand for the vaccine by the public which would be administered in an orderly manner. Even though history has demonstrated that influenza pandemics can occur with varying disease severity, the built up anticipation combined with the current information on influenza led many to believe that the next influenza pandemic would be quite severe. However, the 2009 influenza pandemic didn't meet any of these assumptions. The pandemic was started by a virus of swine origin which, emerged from Mexico, and was associated with less severe disease in a smaller

proportion of the human population. Furthermore, while scepticism led some individuals to question the safety and utility of the vaccine resulting in their non-compliance, others could not wait to get the vaccine, resulting in problems with vaccine administration.

In the end, this pandemic of influenza did not quite reach the anticipated "damage". However, this experience allowed us to implement and run through the pandemic influenza plans that we had been working on for so long. The experiences garnered from this "real-life test" should not be squandered, and instead should be used to improve our preparedness and response plans, closing the gap between actual and ideal performances. To this end, this report sought to compare the VCH pandemic vaccine program as outlined in the VCH regional pandemic influenza response plan with the actual events of the 2009 H1N1 influenza pandemic. Four aspects of the VCH pandemic vaccine program were analyzed and compared to events that transpired during the 2009 H1N1 influenza pandemic and will be discussed below.

The original decision to choose only one aspect of the VCH regional pandemic influenza response plan to assess was based on a logistical limitation. The length of this paper is limited and as such, a proper assessment of the entire plan could not be achieved within that limitation. However, upon reflection, this decision revealed an additional barrier to this plan and ought to be noted for all emergency response plans - the length of the plan itself. It is unrealistic to expect front line responders to read the entire 475 page plan, especially during a crisis situation. Some might argue that individuals need not read the entire plan, but only those sections that are pertinent to their particular function. However, I would say that within an emergency response, all areas are interconnected, with decisions in certain areas of the response affecting other areas of the response. As such, individuals ought to have an understanding of how the plan functions as a whole. Future emergency response plans ought to take this into consideration and strive to limit their length and complexity.

Vaccine Priority Groups

When comparing the priority groups as described in the VCH regional pandemic influenza plan, the sequencing information that was distributed by the federal government and the eventual eligibility criteria that were implemented during the 2009 H1N1 pandemic, the groups are quite different. A positive aspect of the new federal government sequencing information during the 2009 H1N1 influenza pandemic was that it utilized current information on who was suffering from severe disease during this pandemic, to adjust its sequencing

recommendations. Therefore the fact that the VCH plan and the priority groups that were established during the pandemic differed was not a detrimental issue. This change demonstrated positive adaptation and use of data to inform decision making. This also demonstrates that while we may think that we know which groups would benefit most from being vaccinated first, the epidemiology from the current outbreak could be very different from the assumptions or evidence base originally used to make these recommendations. Adaption to the current circumstance is of importance in order to achieve the overall objective of controlling the spread of infection and reducing morbidity and mortality associated with influenza infection.

Prioritization is required when there is limited vaccine supply and the idea to prioritize vaccination delivery is made with the best intentions. However, prioritization means that one must allow access to certain individuals while limiting access to others. In order for prioritization to achieve the anticipated intentions, and to ensure the maintenance of a sense of fairness to support the public's faith in the whole process, one must be able to enforce and ensure the implementation of this prioritization, which can be difficult to do. Nowhere in the discussion of prioritization of vaccine delivery within the VCH pandemic vaccine program does it mention who is responsible for enforcing priority groups. In the vaccination clinics, this responsibility fell to the public health nurses and administration staff who were ill equipped to take on this role, as it requires skills which lie outside the scope of practice for these professions. Potentially increasing the scope of practice of these professionals is one method in which to solve this issue. Incorporation of enforcement skills into their initial training or providing additional training opportunities would ensure that these professionals are equipped with the tools required to deal with enforcement issues. Conversely, incorporating other professionals who are already trained with these skills, such as security guards or administrative staff, into a pandemic response could be another method to solve this issue. Consideration as to who could best fulfill this role, how they can be incorporated into future pandemic vaccine programs, or other mechanisms that could be utilized to ensure this enforcement should be taken and reflected in updates of the emergency response plan.

Prioritization itself ought not represent a significant barrier or nuisance to obtaining the vaccine. For the individuals who are single, rolling eligibility poses no barriers or nuisances, since they are only responsible for themselves. However, in situations where individuals are responsible for more than just themselves, this rolling eligibility may produce a barrier to vaccine uptake and compliance and reduce the ability to achieve the goal of vaccinating the entire

population. While individuals may have the patience to wait in long lines and the dedication to attend a vaccination clinic once, their willingness to wait a second or third time may not be quite as abundant. This situation is often manifested when caregivers or household contacts find themselves in differing priority ratings than those in their care. As was seen in the example of the pregnant lady with the two year old son and a six year old daughter, a high risk individual could delay seeking vaccination until such time as all individuals within her party are eligible to receive the vaccine in order to make only one trip to the vaccination clinic. This needlessly placed the pregnant woman at risk for an additional two weeks, a situation which prioritization tried to circumvent. Conversely, a healthy adult with an elderly mother might take her to the clinic as soon as seniors become eligible for the vaccine, but fail to return when healthy adults become eligible, undermining the goal to vaccinate all individuals.

The idea that caregivers and household contacts should be vaccinated at the same time as those at high risk of complications was partially reflected in the recommendations from the federal government, however was not translated into the priority groups implemented in VCH. This omission is contradictory to the policies that the health authority has in place to try and increase compliance with the seasonal influenza vaccine campaign. Within the seasonal campaign, the eligibility criteria indicate that those who are at high risk as well as their caregivers and household contacts can receive the vaccine for free, to encourage increased compliance amongst these populations and overall control of infection spread. This discrepancy could have been a result of the limited supply of vaccine during this pandemic that restricted what the healthy authority was able to do.

Prioritization is an approach utilized to achieving the goals of decreasing the morbidity and mortality and controlling the spread of the disease when vaccine availability is limited (as is often the case in pandemics, due to the unpredictable onset of the outbreak and the time required for vaccine production). However, it must be recognized that these goals are achieved through different strategies; either by vaccinating those at high risk of complications versus vaccinating those that are high transmitters of the infection. As mentioned, during this event, the priority groups that were implemented in VCH decided to give priority to those individuals at high risk of severe illness, infection induced health complications and potential death. However, these individuals do not always contribute to the rapid spread of disease. Prioritization of who should receive the vaccine first may be a difficult choice and will be different depending on the strategy chosen. For example, there is significant evidence that children and adolescents are

major contributors to influenza spread, but that they are often left low in prioritization for influenza vaccine delivery since they are not at high risk of developing complications due to influenza infection [51]. A recent randomized control trial demonstrated that immunization of this population can interrupt influenza transmission and provide protection for those unimmunized within the population [51]. The utility of this type of strategy is dependent on the epidemiology of the disease outbreak at the time which dictates whether or not halting transmission is possible and the availability of vaccine. The VCH pandemic vaccine plan estimates that there are between 166 200 to 275 200 high risk individuals within VCH. Considering that the first deliveries of vaccine only contained 232 500 doses for the entire province, vaccine supply was significantly limited during this pandemic which subsequently limited the strategy that could be implemented. This highlights the idea that strategies are highly dependent on vaccine supply and that certain strategies cannot be employed should vaccine supply be limited. Clear communication around which strategy should be used and which circumstances influence this decision should be communicated within the influenza response plans.

Increasing Vaccine Uptake

In a pandemic situation, large quantities of vaccine are required within a short period of time requiring the availability of surge production capacity. However, the manufacturing of optional vaccines is a risky business. Since the quantity of vaccine to produce must be decided well in advance and demand can fluctuate, manufacturers can be left with a lot of unusable product if demand does not equal or exceed supply and may lose financially [2]. This uncertainty doesn't provide an incentive to increase production capacity. Increasing overall demand for seasonal influenza vaccinations has been suggested as a method in which to ensure that the manufacturing capacity to produce the large amount of influenza vaccines that will be demanded and required during a pandemic exists [2].

Vaccine coverage for seasonal influenza in BC has been on the rise in the recent past [42]. However, the rate at which this rise is taking place is significantly slower and the overall percentage of the population vaccinated is less compared with other provinces, most notably Ontario [42]. In 2000 Ontario introduced a universal influenza immunization policy, which provides seasonal influenza vaccines to the entire population, not just high-risk individuals, free of charge [52]. The sharper increase in Ontario's vaccine uptake compared to the national (and BC's) percentages cannot definitively be attributed to this policy initiative. However,

implementation of this policy which reduced one of the barriers to obtaining the vaccine and increasing its availability is associated with the increased coverage [42]. This policy strategy may be a method to increase interpandemic vaccine coverage and demand.

However, this policy tactic is not the only strategy that can be used to increase vaccine uptake. Nova Scotia also saw a steady and dramatic increase in seasonal vaccine uptake during interpandemic years (See Figure 2). This increase, reaching levels similar to that seen in Ontario was achieved without implementation of the universal influenza immunization policy. This demonstrates that there are other strategies that can be taken in order to achieve the same outcome. There are various methods for increasing influenza vaccine uptake such as: increasing general awareness regarding the benefits of being vaccinated, providing financial incentives for health care professionals to administer the vaccine, and eliminating barriers which prevent the population from obtaining the vaccine (such as cost and convenience) [42].

The policies listed within the VCH pandemic vaccine program are limited to providing vaccination clinics onsite for health care workers and employees of long term care facilities as well as instigating a policy that entices health care workers to receive the seasonal influenza vaccine. While no information could be found as to the effectiveness of these policies and initiatives, they are still only focusing on a targeted population instead of increasing uptake in the population as a whole. Moreover, these policies only aim at reducing one barrier to vaccine uptake, while still maintaining others. This could be a product of insufficient resources provided by the provincial government to implement these desired changes. Conversely there could be strategies to increase seasonal influenza vaccine uptake.

The strategies outlined in the VCH pandemic vaccine program under increasing vaccine uptake only addressed increasing interpandemic influenza vaccine demand and delivery. No aspects as to how to increase pandemic vaccine uptake were outlined in the plan, representing an area requiring improvement. This omission could have been due to the assumption that the next influenza pandemic would be associated with severe illness, thus individuals would be ready and willing to obtain the vaccine in order to mitigate the chance of succumbing to the disease. Regardless, plans ought to include methods in which to eliminate barriers to or methods to promote vaccine uptake.

During this event, the financial barrier that might have impeded vaccine uptake was eliminated by providing the pandemic H1N1 influenza vaccine free of charge to the entire

population. While overall vaccine coverage was higher during this event compared to seasonal situations in BC, it is unclear if it was this policy initiative or the situation itself that influenced vaccine uptake. Further research into this topic is warranted. A unique opportunity exists within this event to assess barriers to vaccine uptake, such as costs and convenience. Some of the vaccination clinics during this event were offering both the pandemic and seasonal vaccine concurrently. The pandemic vaccine was free of charge to the entire population, while the seasonal vaccine (for most of the population) was associated with a small fee. Assessment of the number of individuals who opted to pay the fee and concurrently receive the seasonal vaccine since it was convenient could reveal if vaccine associated fees do in fact pose a barrier. Additionally, assessment as to the number of high risk individuals who opted to concurrently receive the seasonal vaccine could help gauge whether convenience poses a significant barrier to vaccine uptake. Information garnered from these assessments could inform seasonal influenza vaccine campaigns and elucidate areas for policy initiatives to help increase overall influenza vaccine uptake.

Possible Vaccination Reactions

In comparing the pandemic vaccine plan, which only lists minor adverse reactions to vaccination, with the events of the 2009 H1N1 influenza pandemic, it became clear that this plan was written with the assumption that the benefits associated with the vaccine would significantly outweigh the risks of the disease and as such, individuals would want the vaccine. No planning was put into the idea that the public would have to be convinced to receive the vaccine and that plans would have to be put into motion that would actively recruit individuals for vaccination. Even in the communications section of the VCH regional pandemic influenza response plan, there is no dedication to strategies for communicating vaccine safety and utility to the general public.

Most reactions to vaccinations are mild and transient and in general the benefits associated with prevention of the disease for which the individual is being vaccinated for outweigh the risks of perceived AEFIs [53]. However, concern surrounding AEFIs are high and tolerance for their occurrence is low compared with tolerance for adverse events following medication [53]. This lack of tolerance is most likely due to the fact that immunizations are administered to healthy individuals, thus any adverse medical condition seemingly resulting from this act is not well received [53]. Moreover, with the absence of vaccine-preventable

diseases (for the most part) in the general population, the threat of these diseases is also lost, and the threat from the vaccine itself (spurred by the presence of AEFIs) has greater presence in the individual's mind [53-54]. In recent past, vaccine safety has been brought increasingly into question along with a rise in the anti-vaccination movement. Most likely started by the proposed causative association between the Measles, Mumps and Rubella vaccination and the development of pervasive developmental disorders such as autism, the public's confidence in vaccine safety in general has been eroded [55]. Overall lack of confidence in vaccine safety led many individuals to question the safety of the pandemic influenza vaccine due to its rapid production and the seeming lack of safety testing. Moreover, the critical nature of the sceptic members of the general population led them to question the components in the vaccine itself, specifically the safety of: squalene and thimerosal. Furthermore the flip-flop between recommendations to pregnant women (non-adjuvanted versus adjuvanted) led these individuals to question safety testing of this vaccine for all populations. This increased questioning in combination with increased media coverage and the widespread bias or mis-information provided on the internet led to confusion and anger and may have affected compliance to recommendations to receive the vaccine. In high risk situations, individuals are more apt to listen to negative messaging that raises worry and concern as opposed to positive messaging. This should be recognized in communication plans for pandemics.

One of the challenges to protecting and re-instating public trust in immunizations has been the rise of Web 2.0, which has increased the prevalence and ease of access to user generated information creating a competition between reputable and non-reputable sources of information, especially health information [56-57]. This rise, in combination with the push for patients to assume more responsibility for their health decisions (which requires them to have an increased understanding of health issues and stimulates them to seek out information and learn more on a topic) in the absence of providing the skills to assess the quality of the information that they are utilizing, has contributed to increased erosion of public trust in vaccinations. Methods to ensure that the public are receiving credible information are numerous and can include ideas such as: establishing a credible authority and utilizing popular routes of communication to disseminate messaging. For example, establishing someone, be it a health authority or an individual spokesperson/figure head as the credible authority on influenza and influenza vaccinations during interpandemic years ensures that the public associates the organization/figure head with that particular topic. As such, during a pandemic situation, the

public will be primed to seek out advice and information from that source. This will enable dissemination of “correct” information to large numbers of people. Establishment of a credible authority can also be done during the pandemic situation itself to aid in the dissemination of “correct” information. Furthermore, utilization of the routes of communication that are popular in today’s society is one method to mitigate the spread of mis-information and ensure the dissemination of “correct” information. Establishing and maintaining a presence on popular communication tools such as facebook, twitter and youtube, will help get the desired messaging out in a way that is accessible and highly utilized by the general public.

Mass Vaccination Clinics

The information for mass vaccination clinics within the VCH regional pandemic influenza response plan was very thorough, outlining the information required as a basis for decision-making. For example, information on staff rotation outlines the number of staff required to run a single mass vaccination clinic in either 12 or eight hour shifts, how much that corresponds to in paid hours and indicates how to use this information to estimate the total staff requirement for a health area. By providing the information in this way, VCH acknowledges that there is uncertainty and that plans may change based on the actual situation. As such, VCH outlines how to think as opposed to what to think, providing the information to help facilitate the decision making process. Much could be learned from how this section is set up in terms of how lay out other sections of the plan in order to better facilitate and encourage the response to adapt to the events of the actual pandemic.

While this section of the plan is quite thorough, it lacked information on what to do if the supply of vaccine is variable (and in fact decreases) while the demand increases (a possible consequence of rolling out different priority groups over time thus increasing the proportion of the population eligible to receive the vaccine). While Canada is fortunate enough to have a local vaccine manufacturer, experts question the decision to entrust all vaccine production to one company [40]. Local production means that meeting the vaccine needs of the country are the first and foremost priority. However, this doesn’t protect us from delays due to production problems. As was seen during this event, initial problems with the seed stocks compounded with the decision to switch some production capacity to a non-adjuvanted vaccine, caused significant delays and vaccine shortages [40]. Moreover, the recommendation by the WHO to complete seasonal influenza vaccine production before commencing pandemic influenza production could

have contributed to the delay. Problems with production also affected the delivery timing and vaccine availability. Vaccines arrived in BC during the height of the second wave of infections and by the time there was enough supply to vaccinate the entire population it was arguably too late for the vaccine to have much of an effect. While these issues could be isolated events particular to this pandemic, there is no guarantee that other production problems will not arise during the next pandemic. Splitting vaccine production between two companies may be a way to mitigate this issue and warrants further investigation. While this issue reflects a national policy change, assessments at the local level can help inform these higher up policy decisions and could be utilized to instigate change.

Even though increasing proportions of the population became eligible to receive the vaccine, demand decreased. Delivery of vaccine through mass vaccination clinics may have had a role in deterring individuals from seeking out the vaccine. Long lines and wait times are not easily incorporated into daily schedules and as such may create a barrier, deterring individuals from seeking the vaccine. Individuals may be more apt to line up for a vaccine if they know ahead of time how long the process will take. Methods for publicizing wait times at various clinics, or methods to book appointments may increase compliance. For example, in Sault Saint Marie, utilization of electronic health records and a telephone appointment system meant that individuals only had an average 15 minute wait [58]. Best practices employed in other areas of the country should be studied and potentially utilized if the situation here is comparable. Lessons learned in these different areas can help planning and future response in BC.

The epidemiology of the disease may also have contributed to the lack of demand for vaccine as time progressed. By the time that the vaccine programs were underway, the population of BC was well into the peak of the second wave of illness (see figure 2). Just as the vaccine programs were being implemented, the largest number of individuals was infected and ill due to pandemic H1N1 influenza. Therefore the likelihood that an individual knew someone infected (increasing their perceived risk of infection) was high and could have motivated them to seek vaccination. However, by the time healthy individuals were eligible to receive the vaccine, the peak of infections had passed and numbers of infected and ill individuals were declining, bringing with it the perceived threat of infection. It was fortunate that there was no third wave of infection during this pandemic, or the apathy and lack of vaccine uptake at the end of the second wave could have been a problem.

Near the end of the pandemic vaccine program, mass vaccination clinics closed and the responsibility of vaccinating individuals fell solely to physicians. Problems were encountered when physicians refused to open and prepare vials of pandemic H1N1 vaccine for a single individual since the vaccine comes in 10-dose vials, each costing $80.00 with only a 24 hour shelf-life one mixed [59]. This discouraged and outraged individuals who were seeking the vaccine, but were being denied easy access and could have become a larger issue if a third wave of infections had occurred in this pandemic. Creating of a registry where interested individuals could sign up and groups of 10 could be created could be utilized in order to avoid these situations.

Lessons Learned and Recommendations

This analysis identified a variety of areas for improvement within the VCH pandemic vaccine program plan, which are summarized below along with suggested recommendations.

Area for improvement	Recommendation
In a pandemic situation, vaccine supply will be limited and priority groups will be implemented. The development of these prioritization groups should be reactive to the actual event.	Response plans should be written in a process flow manner in order to facilitate flexibility and real-time reactivity of programming and decision making.
Enforcement of priority groups at vaccination clinics is required. This role should not be the responsibility of public health nurses and administration staff.	Consider who would best be suited to fulfill the role of enforcement. Develop clear roles and responsibilities for this position. Incorporate this position into future response plans.
Priority groups themselves may represent a barrier to vaccine uptake.	Consideration as to how to eliminate the barrier that priority ranking provides should be taken and reflected in future plans.
BC is lagging behind in its contribution to increasing influenza production capacity due to its low interpandemic influenza vaccine uptake	Utilize information from this event to inform which barriers to influenza vaccine uptake are pertinent to this population. Implement policies and activities that help eliminate this barrier. Look to other provinces for best practices.

Area for improvement	Recommendation
There is lack of confidence in the safety of vaccines within the general public resulting in decreased compliance and vaccine uptake	Plans should reflect the need for increased messaging regarding vaccine safety. Reliable educational materials should be provided to the general public to increase their understanding of the benefits of vaccination in pandemic situations.
Production problems lead to delayed availability of vaccine supply in relation to the epidemiology of the disease leading to questionable requirements for a vaccine campaign. This highlights the pitfalls of a single supplier.	Consider sharing production responsibilities between two companies
High initial interest in vaccine resulting in long wait lines and subsequent declined in interest even with increasing eligibility.	Assess best practices in other jurisdictions to find methods to eliminate uptake barriers and increase interest in vaccine uptake.
Low and variable demand increases wasting of resources (10-dose vial with 24 hour expiry).	Consider methods to decrease waste, such as alternative packaging or strategies to group interested individuals.

The implementation of these recommendations can take many different forms. However, through this analysis I believe that a shift from a prescriptive response plan to a plan written in a decision making process flow format would be beneficial. A decision-making process flow style of response plan would guide users through the pertinent questions to ask and information to seek in order to make sound and rational decisions. This style of plan would also allow for the flexibility required to adapt decisions to specific and changing characteristics of the problem being faced and allow for future decisions to be made from accumulated knowledge. For example, instead of specifically describing the priority groups within the plan as was done in this case, indicating that priority groups will most likely have to be implemented and highlighting how to come to the decision as to who is prioritized depending on the epidemiology of the outbreak could facilitate this flexibility and adaptive capacity.

Chapter 6: Conclusion

While the 2009 H1N1 influenza pandemic didn't reach the magnitude of prior predictions, the largest immunization campaign in BC's history was mounted. Resulting from that, 40% of British Columbians were immunized against pandemic H1N1 influenza, covering a larger percentage of the population than has historically been covered in an influenza vaccine campaign in this province [60]. While the exact cause of this increased vaccine uptake and mitigation of mortality cannot be determined, increased awareness by the general public as to the non-pharmaceutical methods of controlling the spread of infection were most likely partially responsible. These successes should be celebrated and applauded, however, it should also be noted that there is still room for improvement. Action should be taken to learn from the lessons experienced during this pandemic and applied to help refine the current pandemic response plans.

The VCH regional pandemic influenza response plan was well thought out and in general provided a vast amount of information required to successfully implement a pandemic vaccine program. A few areas that require further attention and clarification within the pandemic response plan were: assigning responsibility for enforcement of priority groups at mass vaccination clinics; expanding on activities aimed at increasing interpandemic vaccine uptake; implementing measures to increase pandemic vaccine uptake; and development of communication strategies to convey the benefits and safety of vaccination in order to increase overall public support.

Learning from experiences and developing accountable action plans to implement the lessons learned will ensure that these lessons are not lost and will benefit those who will be dealing with the next influenza pandemic. It is unclear when the next influenza pandemic will arise, but we can be assured that future public health workers will be slightly more prepared thanks to these collective experiences.

Table 1: Priority Groups as per the VCH Regional Pandemic Influenza Plan

Group	Description of Eligibility	
Group 1: **Health care workers, paramedics/ambulance attendants and public health workers**	• Acute care hospitals • Long term care facilities/nursing homes • Private physicians' offices • Home care and other community care facilities	• Public Health offices • Ambulance and paramedic services • Pharmacies • Laboratories
Group 2: **Essential Services Providers**	• Police • Fire-fighters • The armed forces • Key emergency response decision makers	• Utility workers • Funeral services/mortuary personnel • People who are employed in public transportation and the transportation of essential goods (such as food)
Group 3: **Persons at high-risk of severe or fatal outcomes following influenza infection**	• Adults and children with chronic cardiac or pulmonary disorders (including bronchopulmonary dysplasia, cystic fibrosis, and asthma) severe enough to require regular medical follow-up or hospital care. • People of any age who are residents of nursing homes and other chronic care facilities • People ≥ 65 years of age	• Children aged 6-23 months of age (current vaccines are not recommended for children under 6 months of age) • Adults and children with chronic conditions, such as diabetes mellitus and other metabolic diseases, cancer, immunodeficiency, immunosuppression (due to underlying disease and/or therapy), renal disease, anemia and haemoglobinopathy. • Children and adolescents (aged 6 months to 18 years) with conditions treated for long periods with acetylsalicylic acid.
Group 4: **Healthy Adults**		
Group 5: **Children 24 months to 18 years of age**		

SOURCE: Adapted from [37]

Table 2: Vaccine Sequencing as per the Federal Government

Group	Description of Eligibility
Group 1: **Those who will benefit most from immunization and those who care for them**	• Individuals with chronic diseases ≤ 65 years of age • Pregnant women • Children 6 months – 5 years of age • Persons residing in remote and isolated regions • Health care workers involved with pandemic response and essential health service workers • Household contact/care givers of infants < 6 months of age and persons who are immunocompromised • High-risk populations
Group 2: **Others who will benefit from immunization.**	• Children 5 – 18 years of age • First responders • Poultry and swine workers • Adults 19 – 64 years of age • Adults 65 + years of age

SOURCE: Adapted from [38]

Table 3: Priority groups for vaccine delivery in British Columbia during the 2009 H1N1 influenza pandemic

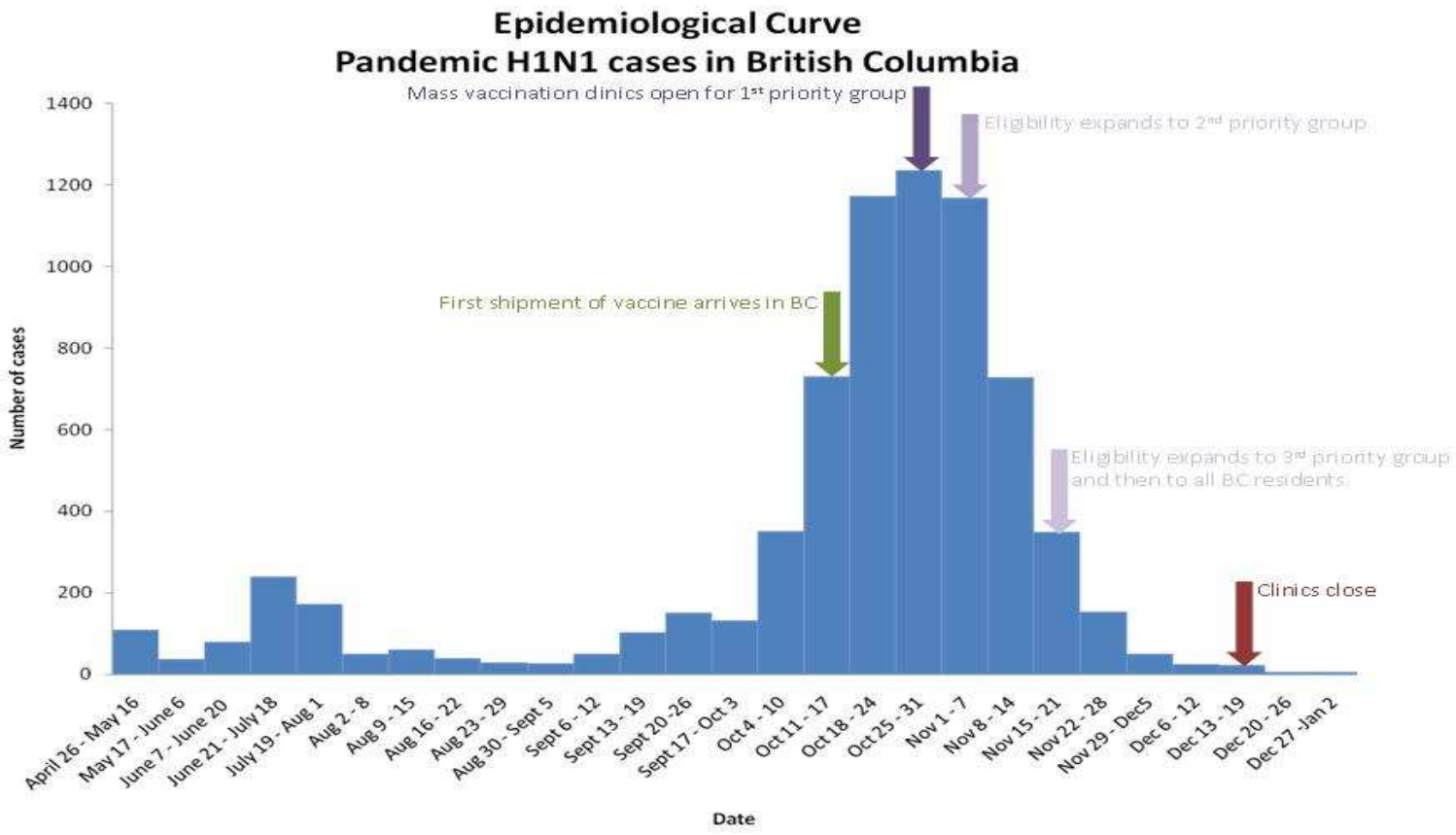
Date eligibility commenced	Eligibility criteria
October 26th, 2009	• High-risk priority groups • Individuals ≤ 65 years of age with chronic health conditions • Pregnant women • Individuals living in rural and isolated locations
November 2nd, 2009	• Children 6 months – 5 years of age • Front-line health care workers (selected due to vaccine shortage) • Individuals who live with or care for infants less than 6 months of age or individuals who are immunocompromised
November 16th, 2009	• Children 5 – 18 years of age • Individuals ≥ 65 years of age with a chronic health condition • First responders in the medical health field • Health care workers in: acute care, long term care, home care and public health services
November 20th, 2009	• All British Columbians

Table 4: Eligibility criteria for provision of free seasonal influenza vaccine

- Individuals ≥ 65 years of age and their caregivers/household contacts
- Residents of nursing homes and other chronic care facilities
- Individuals with chronic health conditions and their household contacts
- Individuals 6 months to 18 years of age with conditions treated for long period of time with acetylsalicylic acid and their household contacts
- Children 6 to 23 months of age
- Household contacts/caregivers of infants 0 to 23 months of age
- Pregnant women who will be in their third trimester during influenza season and their household contacts
- Health care and other care providers in facilities and community settings who are capable of transmitting to those at high risk of influenza complications
- Essential service providers (first responders, correctional officers, etc)
- Poultry workers

SOURCE: http://www.vch.ca/public_health/staying_healthy/immunization_&_vaccination/flu_shots/flu_shots

Figure 1. Epidemiological Curve of Laboratory Confirmed Cases of H1N1 Infection in British Columbia and the Dates of Vaccine Delivery



SOURCE : Compiled from [61]

Week of Oct. 11th – First set (232 500 doses) of adjuvanted H1N1 vaccines are shipped to the province of BC

Oct. 26th – Mass vaccination clinics open. First group of eligible individuals: high-risk priority groups, individuals ≤ 65 years of age with chronic conditions, pregnant women and individuals living in rural and isolated locations.

Oct. 30th – Some clinics close due to vaccine shortage

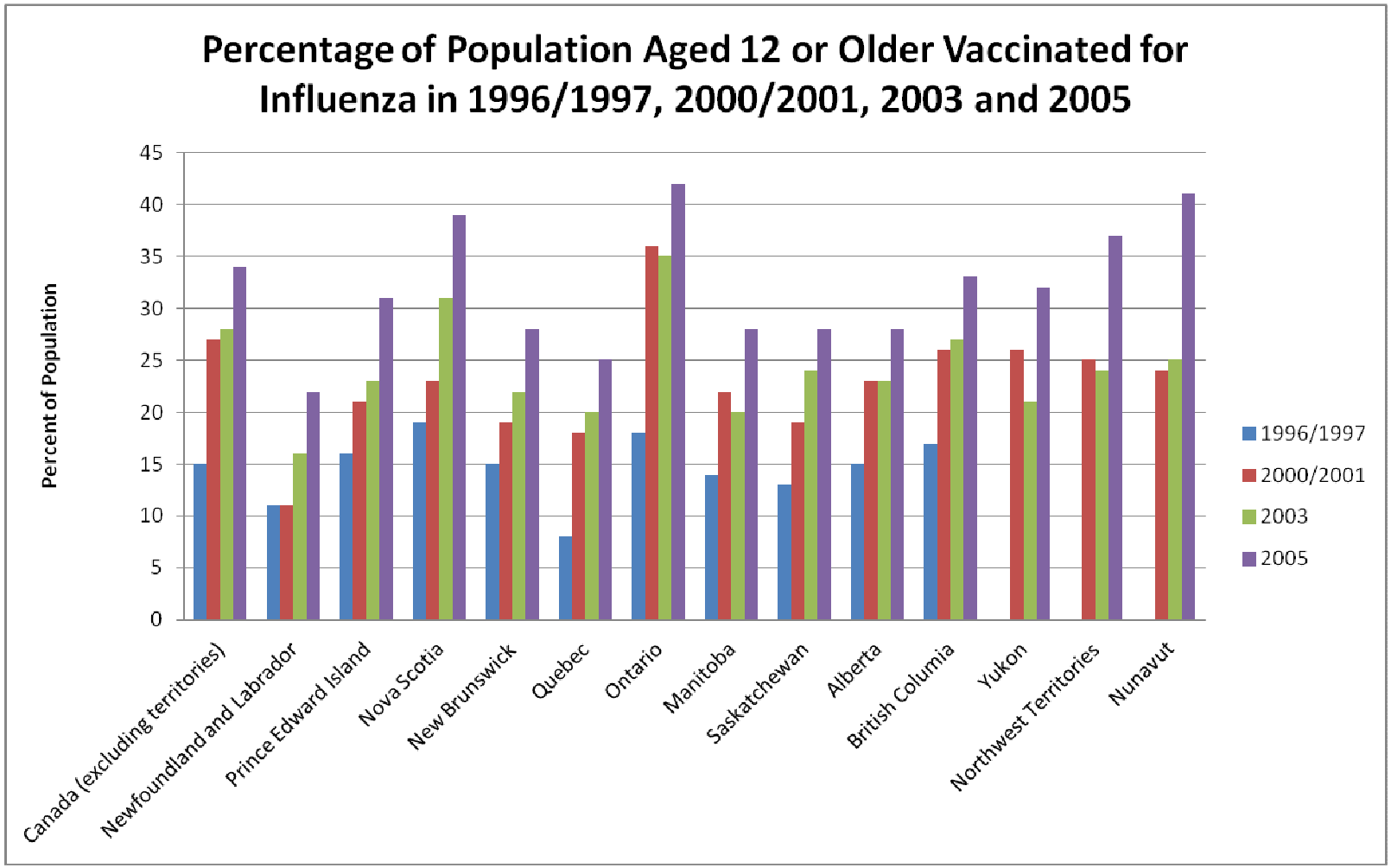
Nov. 2nd – Eligibility expands to include: children 6 months – 5 years of age, front-line health care workers (only select due to vaccine shortage), and individuals who lives with or cares for infants less than 6 months of age or individuals who are immunocompromised

Nov. 16th – Eligibility expands to include: children 5 – 18 years of age, individuals ≥ 65 years of age with chronic conditions, first responders in the medical health field and health care workers in acute care, long term care, home care and public health services

Nov. 20th – Eligibility expands to include all British Columbians.

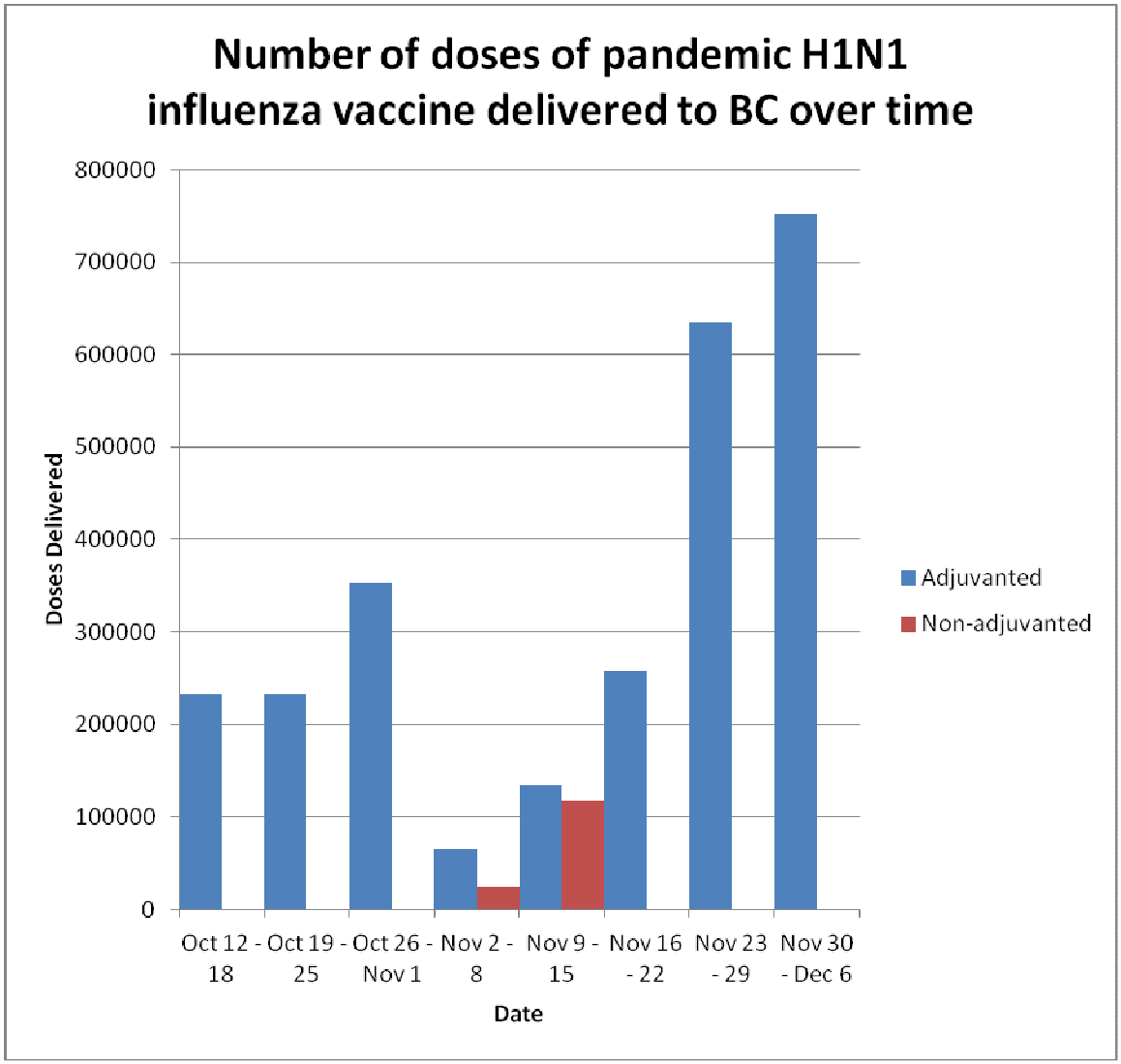
Dec. 18th – Mass vaccination clinics close

Figure 2. National and Provincial Seasonal Influenza Vaccination Rates in Individuals Aged 12 and Older for 1996/1997, 2000/2001, 2003 and 2005



SOURCE: Adapted from [42]

Figure 3. Number of Doses of Pandemic H1N1 Influenza Vaccine Delivered to British Columbia Over Time



SOURCE: Adapted from [62]

Appendices

Appendix 1:
List of Subjects Covered within the VCH Regional Pandemic Influenza Response Plan

- The health impact of pandemic influenza
- Surveillance
- Infection and environment control
- Self care during an influenza pandemic
- Clinical management and health care facilities
- Public health measures
- Vaccine and antivirals
- Communications
- Handling and disposal of the deceased

Appendix 2: WHO Pandemic Phase Descriptions and Main Actions by Phase

PHASE	DESCRIPTION	MAIN ACTIONS				
		PLANNING AND COORDINATION	SITUATION MONITORING AND ASSESMENT	COMMUNICATIONS	REDUCING THE SPREAD OF DISEASE	CONTINUITY OF HEALTH CARE PROVISION
PHASE 1	No animal influenza virus circulating among animals have been reported to cause infection in humans.	Develop, exercise, and periodically revise national influenza pandemic preparedness and response plans.	Develop robust national surveillance systems in collaboration with national animal health authorities, and other relevant sectors.	Complete communications planning and initiate communications activities to communicate real and potential risks.	Promote beneficial behaviours in individuals for self protection. Plan for use of pharmaceuticals and vaccines.	Prepare the health system to scale up.
PHASE 2	An animal influenza virus circulating in domesticated or wild animals is known to have caused infection in humans and is therefore considered a specific potential pandemic threat.					
PHASE 3	An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks.					
PHASE 4	Human to human transmission of an animal or human-animal influenza reassortant virus able to sustain community-level outbreaks has been verified.	Direct and coordinate rapid pandemic containment activities in collaboration with WHO to limit or delay the spread of infection.	Increase surveillance. Monitor containment operations. Share findings with WHO and the international community.	Promote and communicate recommended interventions to prevent and reduce population and individual risk.	Implement rapid pandemic containment operations and other activities; collaborate with WHO and the international community as necessary.	Activate contingency plans.
PHASE 5	The same identified virus has caused sustained community level outbreaks in two or more countries in one WHO region.	Provide leadership and coordination to multisectoral resources to mitigate the societal and economic impacts.	Actively monitor and assess the evolving pandemic and its impacts and mitigation measures.	Continue providing updates to general public and all stakeholders on the state of pandemic and measures to mitigate risk.	Implement individual, societal, and pharmaceutical measures.	Implement contingency plans for health systems at all levels.
PHASE 6	In addition to the criteria defined in Phase 5, the same virus has caused sustained community level outbreaks in at least one other country in another WHO region.					
POST PEAK PERIOD	Levels of pandemic influenza in most countries with adequate surveillance have dropped below peak levels.	Plan and coordinate for additional resources and capacities during possible future waves.	Continue surveillance to detect subsequent waves.	Regularly update the public and other stakeholders on any changes to the status of the pandemic.	Evaluate the effectiveness of the measures used to update guidelines, protocols, and algorithms.	Rest, restock resources, revise plans, and rebuild essential services.
POST PANDEMIC PERIOD	Levels of influenza activity have returned to the levels seen for seasonal influenza in most countries with adequate surveillance.	Review lessons learned and share experiences with the international community. Replenish resources.	Evaluate the pandemic characteristics and situation monitoring and assessment tools for the next pandemic and other public health emergencies.	Publicly acknowledge contributions of all communities and sectors and communicate the lessons learned; incorporate lessons learned into communications activities and planning for the next major public health crisis.	Conduct a thorough evaluation of all interventions implemented.	Evaluate the response of the health system to the pandemic and share the lessons learned.

World Health Organization

SOURCE: [63]

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