THE SCHOOL OF PUBLIC POLICY

MASTER OF PUBLIC POLICY CAPSTONE PROJECT

A Geospatial Analysis: Low Childhood Immunization Rates In Alberta

Submitted by:

Anthony George David Johnson

Approved by:

Dr. Ronald Kneebone, 24 August 2015

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Capstone Executive Summary

Childhood immunization rates in Alberta do not meet national targets. Alberta does not have a mandatory program for routine immunizations, which results in both delayed immunizations and an under-immunized population. To identify demographic factors that contribute to these low vaccination rates National Census data collected for Alberta was analyzed. To make the sample more comprehensive data from community health centres and Hutterite colony locations were added. This analysis will use maps of immunization coverage rates to identify target areas for policy change. Separate maps for the demographic variables in those areas will be used to provide policy recommendations for improved rates in Alberta.

Immunization, one of the most important medical advances of the 20th Century, prevents life-threatening illness from once common diseases such as pertussis, measles, and mumps.[1] In the past 50 years, it is estimated that immunizations have saved more lives than any other health intervention.[2] Vaccinating children is a public service from which everyone benefits. When a community reaches a target vaccination threshold it offers

[1] CDC. Morbidity and Mortality Weekly Report. http://www.cdc.gov/mmwr/preview/mmwrhtml/00056803.htm
[2] Canadian Immunization Guide. Public Health Agency of Canada. http://www.phac-aspc.gc.ca/publicat/cig-gci/p01-02-eng.php#footnote2

protection for all through "herd immunity" and the chances of an outbreak are reduced.[3,4] Without "herd immunity" a population is vulnerable to infection should an outbreak occur. This relatively small financial investment in vaccination results in huge savings; the estimated cost-benefit ratio for the programs for the MMR (measles, mumps, rubella) vaccine is 16:1 and the DTaP (diphtheria, pertussis, tetanus) vaccine is 6:1.[5]

Provincial health departments set immunization schedules and delivery terms; however, the federal government influences immunization policy by leveraging the provinces through Federal health funding. The Alberta Immunization Strategy (AIS, 2007-2017), based on the national one, is a 10-year plan developed by Alberta Health and Wellness (AHW) to increase immunization rates, to identify barriers and to provide strategies to overcome them.[6]

Like Alberta, most provinces fail to meet Canadian target vaccination rates required to sustain herd immunity for most of the common childhood vaccines.[7] In Alberta, between 2008 and 2014, overall vaccination rates fell consistently below targets for four of the vaccines currently on the childhood vaccination schedule.

[3] Gordis, Leon. "Epidemiology". W.B. Saunders. 1938. 26-27.
[4] Harunor Rashid, Gualom Khandaker, and Robert Boy. Vaccination and herd immunity: what more do we know? Curr Opin Infect Dis. 25 (2012): 243-249.
[5] IBID
[6] Alberta Immunization Strategy 2007-2017. http://www.health.alberta.ca/documents/Immunization-Strategy-07.pdf
[7] Canada. 2014. Public Health Agency of Canada. Vaccine Coverage in Canadian Children: Results from the 2011 Childhood National Immunization Coverage Survey. Ottawa. http://www.phac-aspc.gc.ca/im/nics-enva/vccc-cvec-eng.php.

A number of factors may be contributing to low vaccination rates and they fall into two broad categories: parents' attitude towards immunizing their children and barriers to access. Canadians' attitudes regarding preventable diseases seem to have changed over the past decades possibly because many adults have not experienced the threat of potentially fatal illnesses such as measles and whooping cough. The huge success of vaccines in the past 100 years seems also to have resulted in parental apathy. Many parents mistakenly believe that vaccines potentially are more hazardous than the diseases they prevent.[8,9] Furthermore, some parents may choose to 'free ride', relying on others to vaccinate, thereby protecting their children through herd immunity.

The characteristics of an under-vaccinated population include: not having a family physician, living in a rural setting, they receive general welfare or provincial healthcare premium subsidy, residing in a household where the mother is under 30, unmarried, and/or with 3 or more children in the house.[10,11,12,13] In Alberta, low vaccination rates resulting in outbreaks are often associated with religious beliefs.[14] Immigrant and migrant

[8] Daniel Salmon, Lawrence Moulton, Saad Omer, et al., "Factors associated with refusal of childhood vaccines among parents of school-aged children: a case-control study," *Arch Pediatr Adolesc Med*. 159, no. 5 (2005): 470–476.
[9] Deborah Gust, Tara Strine, Emmanuel Maurice, et al., "Underimmunization Among Children: Effects of Vaccine Safety Concerns on Immunization Status," *Pediatrics* 114 (2004): 16-22.
[10] Chris Bell & Kim Simmonds, "An Exploration Into Childhood Immunization Coverage in Alberta: 2008 Birth Cohort Study", (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).
[11] Douglas Dover, "How can mapping augment our current knowledge of uptake?", (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).
[12] Christina Greenaway, Pierre Dongier, Jean.-Francois Boivin, et al. "Susceptibility to Measles, Mumps, and Rubella in Newly Arrived Adult Immigrants and Refugees." Annals of Internal Medicine 146 no. 1 (2007): 20–24.
[13] J Zhang, A Ohinmaa, TH Nguyen, et al. "Determinants for Immunization Coverage by Age 2 in a Population Cohort in the Capital Health Region, Edmonton, Alberta." Canada Communicable Disease Report 34 no. 9 (2008).
[14] Judith Kulig, Cathy Meyer, Shirley Hill, et al. "Refusals and delay of immunization within southwest Alberta". Canadian Journal of Public Health 93 no. 2 (2002): 109-112.

populations are not identified in current statistical coverage and their inclusion would likely have a negative impact on Alberta's performance rates.

Vaccination statistics are difficult to compare "because there is not an 'inter-provincial standard' for tracking leading to inconsistent data".[15] Geospatial analysis was conducted using publicly available Statistics Canada census data, Alberta Health's childhood immunization rates, Hutterite colony locations, and Community Health Centre locations. Data was exported to ArcGIS to view map layers both together and separately. A qualitative analysis was conducted to analyze low immunization trends in particular areas of the province to determine if a link exists between census variables and proximity to Community Health Centres for potentially vulnerable populations.

The MMR and DTaP geospatial analysis revealed that the type of vaccine does not greatly affect the rate of vaccination. When looking specifically at DTaP vaccination rates across the province a persistent trend is a progressive decline in rates from dose 1 to dose 4. Alberta's childhood coverage rates for both DTaP Dose 4 and MMR are declining over the seven-year period. The southeastern and northern parts of the province are under-serviced and travel could be a barrier to getting all four doses of DTaP. Higher per capita income, the ability to more easily absorb travel costs and the greater likelihood of having a family doctor establishes a population more disposed to gaining access to immunization. Further, lower Alberta coverage rates are found in regions with a greater

[15] Kelly Grant. Canadian Medical Association Journal editorial calls for national vaccination strategy. The Globe And Mail. Last Updated: May 27, 2014. http://www.theglobeandmail.com/life/health-and-fitness/health/canadian-medical-association-editorial-calls-for-national-vaccination-strategy/article18860260/

number of high school dropouts and with lower socio-economic conditions. Studies have shown that attitudes towards vaccines tend to cluster as in Southern Alberta where the highest numbers of Hutterite colonies exist.[16,17]

The comprehensive database for all children born in the province shows the success of the early intervention program and its outreach and education. Tracking could be improved by establishing a gate for those migrating to Alberta in order to have a more complete registry by including children born outside Alberta. Furthermore, the database is not linked to or compatible with those in other provinces and territories. A national database would allow doctors and public health officials' access to records of individual patients to determine their risk and would allow health departments to identify more vulnerable communities with low immunization coverage. Access would be improved through the use of mobile vaccination clinics that travel throughout the province. A universal financial incentive would encourage opting in to the vaccination schedule to receive government assistance through the Universal Child Tax Benefit. Alberta's record keeping would improve because parents would place more emphasis on the routine vaccination schedule, getting their children immunized earlier. The vaccination policy for admission to public and private schools currently used in Ontario and New Brunswick would be another useful measure provides a strong incentive to get a child immunized or to be required to go through a lengthy exemption process.[18]

[16] Tracy Lieu, Thomas Ray, Nicola Klein, et al., "Geographic Clusters In Underimmunization and Vaccine Refusal," *Pediatrics* 135 (2015): 289.
[17] Kacey Ernst, and Elizabeth Jacobs. "Implications of Philosophical and Personal Belief Exemptions on Re-emergence of Vaccine- preventable Disease: The Role of Spatial Clustering in Under-vaccination." Human Vaccines and Immunotherapeutics 8 no. 6 (2012): 838–841.

The recommended policies involve both the federal and provincial governments. Alberta's major strategy will be to continue with early intervention, to participate in national data tracking, to implement financial incentives, and to track in-migration. This will greatly improve coverage rates and reduce outbreaks. Restricting access to public schools to those refusing immunization without an exemption will provide further incentive. The proposals outlined above will achieve herd immunity and protect the public.

I. Introduction

Alberta's childhood immunization rates do not meet national targets. Alberta does not have a mandatory program for routine immunizations resulting in both delayed immunizations and an under-immunized population. To identify demographic factors that contribute to these low vaccination rates National Census data collected for Alberta was analyzed along with community health centre and Hutterite colony locations. This analysis, using maps of immunization coverage rates to identify target areas for policy change with separate maps for demographics of those target areas, will provide policy recommendations to improve rates in Alberta.

II. Relevant background

Immunization, one of the most important medical advances of the 20th Century, prevents illness and death from once common diseases such as pertussis, measles, and mumps.[19] In the past 50 years, it is estimated that immunizations have saved more lives than any other health intervention.[20] The impact of vaccination programs on the incidence of disease in Canada, comparing rates of disease before and after the vaccine era, is illustrated in Table 1.

Table 1

Table 1 – Incidence of select Vaccine preventable diseases in Canada – pre-vaccine era compared to 2007-2011.

	Pre-Vaccine Era	2007-2011

[19] CDC. Morbidity and Mortality Weekly Report. http://www.cdc.gov/mmwr/preview/mmwrhtml/00056803.htm

[20] Canadian Immunization Guide. Public Health Agency of Canada. http://www.phac-aspc.gc.ca/publicat/cig-gci/p01-02-eng.php#footnote2

Disease	Pre-vaccine period	5-year average annual incidence per 100,000	Peak annual number of cases Footnote *	5-year average annual incidence per 100,000	Peak annual number of cases
Diphtheria	1925-1929	84.2	9,010	0.006	4
Haemophilus influenzae type b (Hib) invasive disease (children less than 5 years of age)	1986-1990	30.1	671	0.49	18
Hepatitis B (HB)	1989-1993	9.1	3,378	5.3	2,011
Measles	1950-1954	372.7	61,370	0.6	752
Meningococcal serogroup C invasive disease	1997-2001	0.3	186	0.06	30
Mumps	1950-1954	251.2	43,671	1.84	1,110
Pertussis	1938-1942	156	19,878	3.88	1,961
Poliomyelitis	1950-1954	17.5	5,384	0	0
Rubella	1950-1954	106.3	37,917	0.01	10
Tetanus	1935-1939	0.13	25	0.01	6

Source: Reported in Canadian Immunization Guide, Part I, Page 9.

i. Vaccination: A Public Good

Vaccinating children is a public service by which everyone benefits. When a community reaches a target vaccination threshold it offers protection for all through "herd immunity" and the chances of an outbreak are reduced.[21,22] There often are individuals within a community who cannot be immunized for medical reasons or because of their young age (for example babies under 12 months are not yet protected from measles). Without "herd immunity" these individuals are vulnerable to infection should an outbreak occur. Vaccines are not 100% effective; one can catch chickenpox despite being immunized, however symptoms are often less severe and complications are less likely.

[21] Gordis, Leon. "Epidemiology". W.B. Saunders. 1938. 26-27.
[22] Harunor Rashid, Gualom Khandaker, and Robert Boy. Vaccination and herd immunity: what more do we know? Curr Opin Infect Dis. 25 (2012): 243-249.

Vaccination programs are important not only in terms of lives saved but also in terms of financial savings for Canadians including those associated with visits to the doctor, hospitalization, lost time at work by parents, and lost time at school for children. In 2008, annual vaccine sales in Canada were approximately $450 million, however this represents only 4% of Canadian public health expenses and <0.3% of national health care expenditures.[23] This small investment in vaccination results in a huge savings; the estimated cost-benefit ratio for the programs for the MMR (measles, mumps, rubella) vaccine is 16:1, and the DTaP (diphtheria, pertussis, tetanus) vaccine is 6:1.[24] The cost benefit analysis demonstrates there is significant return on investment for vaccination programs.

ii. Brief History

The Constitution Act, 1982 dictates the division of powers for healthcare, where the provincial government has legislative power to control delivery and services while the federal government has a great deal of influence over the province through it's financing role.[25] The provincial health departments set immunization schedules and delivery terms, however the federal government influences immunization policy levering the provinces using its spending power. The federal government uses federal tax revenue to pay for a fraction of provincial healthcare and the result is a semi consistent interprovincial immunization standard across the country.

[23] Canada. 2013. Public Health Agency of Canada. Canada Immunization Guide. Ottawa. http://www.phac-aspc.gc.ca/publicat/cig-gci/p01- 02-eng.php.
[24] IBID
[25] Jennifer Keelan. "Concurrency in Public Health Governance: The Case of the National Immunization Strategy." Special Series: The Role of Federalism in Protecting the Public's Health. Kingston, ON: Queen's University, School of Policy Studies, Institute for Government Relations (2008).

Since 1964, the National Advisory Committee on Immunization (NACI) made recommendations to the provinces on routine immunization schedules however it is up to each province and territory to determine its own policies for administering immunization programs. This results in challenges for immunization including: high cost of new vaccines, security of supply, the public's attitude, vaccine safety, fear of outbreaks, and regional disparity. In 2003, the National immunization Strategy (NIS) was developed to "set national goals and objectives, ensuring collaboration on immunization program planning, research, and evaluation, securing the vaccine supply and setting up a national vaccine registry".[26, 27, 28] The Canadian Immunization Committee (CIC), made up of representatives from each province and territory, was established in 2004 to implement the NIS. Many provinces, including Alberta, developed their own strategies to improve vaccination rates in response.

The Alberta Immunization Strategy (AIS, 2007-2017) based on the national one is a 10-year plan developed by Alberta Health and Wellness (AHW) to increase immunization rates, to identify barriers and to provide strategies to overcome them.[29] "This goal is to be achieved through seven evidence-based strategic directions to: enhance accessibility; improve enabling technology; strengthen parental education and counseling; strengthen

[26] Public Health Agency of Canada. Canadian National Report on Immunization. Can Commun Dis Rep 2006;3253(Supplement).
[27] Martin Lavoie, "Update on Canada's National Immunization Strategy" (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).
[28] Jennifer Keelan, Harvey Lazar and Kumanan Wilson. "The National Immunization Strategy: A Model for Resolving Jurisdictional Disputes in Public Health" Canadian Journal of Public Health 99, no. 5 (2008): 376-379.
[29] Alberta Immunization Strategy 2007-2017. http://www.health.alberta.ca/documents/Immunization-Strategy-07.pdf

partnerships; strengthen provider training/education; strengthen public education and awareness; and strengthen research and evaluation."[30]

iii. Childhood Immunization in Alberta

Onward from two months of age, children in Alberta are recommended to receive routine immunizations against a variety of illnesses. Children are at increased risk of infection and complications resulting from preventable illnesses because their immune systems have not fully developed. Vaccines are scheduled to provide immunity as early as safely possible to protect those most vulnerable.[31]This schedule of multiple inoculations to build up their immunity protects children from disease. They must receive the recommended number of inoculations to be protected from these serious diseases. For measles prevention, the National Immunization Strategy (NIS) guideline recommends a first dose of the MMR vaccine administered at 12 months and a second between 4-6 years old for maximum protection. For whooping cough prevention, 4 doses as part of the D-TaP vaccine by 18 months of age is recommended (see Appendix A for Alberta's immunization schedule).

Children born in hospitals are issued an immunization record and a community health nurse from the AHS program Healthy Beginnings is assigned to help baby and mother for the first two months. Within 14 days of birth the nurse will conduct a home visit to inform the mother of upcoming immunizations and to provide many other vital post-

[30] IBID
[31] Canada. 2013. Public Health Agency of Canada. Canada Immunization Guide. Ottawa. http://www.phac-aspc.gc.ca/publicat/cig-gci/p01- 02-eng.php.

partum services. For vaccinations the parent is expected to visit one of the 100 Community Health Centres where babies' physical health is also assessed.

If at two months the child has not begun routine vaccinations the parents will be sent a reminder. After three more attempts if no contact has been made, the record will be registered as refusal to immunize at the Community Health Centre. Centralizing vaccinations at the Community Health Centres is a positive aspect of Alberta's program because it assists the data collection process. The immunization records are kept and then forwarded to Alberta Health (the Ministry) to be recorded in a province-wide registry. This is a significant drawback since Alberta has a large migrant population. Alberta's robust program still manages to miss the national coverage targets.

iv. Vaccination Rates are Low across the Country and in Alberta

Like Alberta, most provinces fail to meet Canadian target vaccination rates required to sustain herd immunity for most of the common childhood vaccines.[32] In Alberta, between 2008 and 2014, overall vaccination rates fell consistently below targets for four of the vaccines currently on the childhood vaccination schedule (Figure 1). Immunization rates for each province are shown in the table below (Table 2) where cells coloured red identify immunization rates that are below the national target while cells coloured green

[32] Canada. 2014. Public Health Agency of Canada. Vaccine Coverage in Canadian Children: Results from the 2011 Childhood National Immunization Coverage Survey. Ottawa. http://www.phac-aspc.gc.ca/im/nics-enva/vccc-cvec-eng.php.

indicate rates that meet or exceed the national target. When rates dip below the level required for herd immunity, outbreaks can occur.[33,34,35,36]

Table 2 - Immunization Coverage, by Province, Percentage of Target Population

Region	(% of target population covered)				
	DTaP/IPV/HIB (all doses)*	Measles, Mumps, Rubellaa	Varicella (chicken pox)	Pneumococcal conjugate	Meningococcal C conjugate
Alberta (age 2, 2013)	74.2	85.2	84	83	81.2
British Columbia(age 2, 2013)**	74	86	83	84	86
Manitoba (age 2, 2010)	72.6	86.6	80.1	66.9	70.5
New Brunswick (on entering school, age 4 or 5, 2012/13)	78	69.3	N/A	N/A	75.7
Newfoundland and Labrador (age 2, 2011/12)	96.6	95.5	96.2	96.1	96.5
Nova Scotia (age 2, 2008)	82.4	66.4	N/A	79.5	57.6
Ontario* (age 7, 2011/12)**	82.3	90.9	75	96.9	72
Prince Edward Island (age 2, 2008)	81	79	93	81	93
Quebec (age 2, 2012)	85	83.9	92	93.1	94.4
Saskatchewan (age 2, 08/09)	78.9	79.3	89.3	77.3	89.7
Canada (age 2, 2011)	89.6	95.2	88.6	76.5	80.5
National Targets (2005)	**95**	**97**	**85**	**90**	**97**

Note: Each province collects data differently, making perfect cross-province comparisons impossible: coverage might be better because of a more successful program or because of incorrect data. Coverage rates refer to the number of children who have received the correct number of immunizations at the given age by that province's vaccination schedule. Importantly, at least by their own estimates, almost all provinces appear to be below national targets for coverage.

* In cases where some provinces give a combined vaccination and others give individual shots, for comparability we averaged the coverage for the individual shots.

** VCHA statistics not included due to incompatibility of survey methods.

Table taken from Colin and Busby, 2014[37]

[33] Daniel Salmon, Michael Haber, Eugene Gangarosa, et al., "Health consequences of religious and philosophical exemptions from immunization laws: individual and societal risk of measles," *JAMA* 282, no. 1 (1999): 47–53.

[34] Jason Glanz, David McClure, David Magid, et al., "Parental refusal of pertussis vaccination is associated with an increased risk of pertussis infection in children," *Pediatrics:* 123, no. 6 (2009): 1446–1451.

[35] Jason Glanz, David McClure, Sean O'Leary, et al., "Parental decline of pneumococcal vaccination and risk of pneumococcal related disease in children," *Vaccine* 29, no. 5 (2011): 994–999.

[36] Jason Glanz, David McClure, David Magid, et al., "Parental refusal of varicella vaccination and the associated risk of varicella infection in children," *Arch Pediatr Adolesc Med*. 164, no. 1 (2010): 66–70.

[37] Colin Busby, Nicholas Chesterley. A Shot in the Arm: How to Improve Vaccination Policy in Canada. C.D Howe Institute. Commentary NO. 421. http://www.cdhowe.org/pdf/commentary_421.pdf

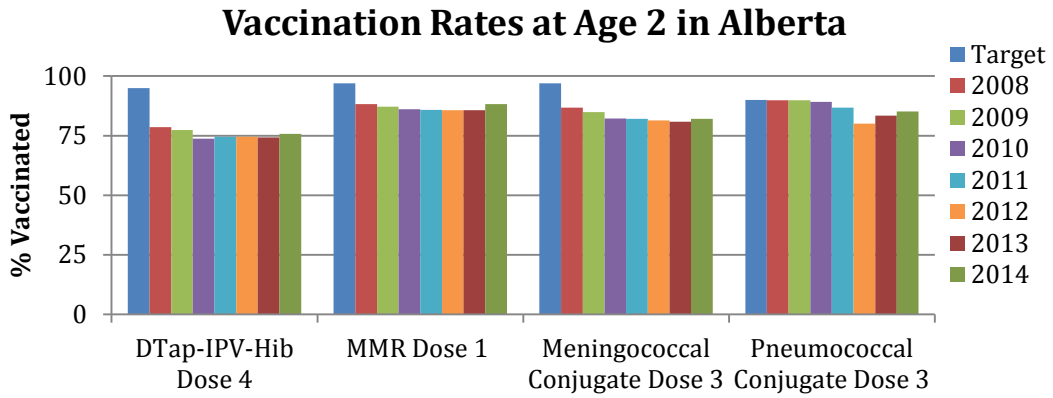

Figure 1 – Vaccination Rates by Age 2 compared to targets.
Vaccination rates between 2008-2014 by age 2 for DTaP-IPV-Hib Dose 4, MMR Dose 1, Meningococcal Conjugate Dose 3, and Pneumococcal conjugate Dose 3 from IHDA are graphed by year. The target rate for each vaccine is shown in blue. Rates for all four vaccines consistently fall below the target except for Pneumococcal, which has the lowest target rate of 85%.

In 2013, there was a measles outbreak in Southern Alberta that originated from a non-immunized teen who visited the Netherlands where an outbreak was ongoing, returned to the region and infected 42 others who were also not immunized.[38] The Southern Alberta outbreak was attributed to pockets of unvaccinated individuals from Low-German-Speaking Mennonite communities and an influx of foreign workers in agriculture that came from endemic countries. Another outbreak occurred in Alberta's central zone in 2014, where whooping cough (Pertussis) spread amongst 107 individuals.[39] Recent outbreaks including these two have gained the attention of public health officials who have initiated focus on the low coverage rates in children and on how to deal with declining childhood immunization rates. There are a number of factors contributing to

[38] Tanis Kershaw, Vivian Suttorp, Kelly Simmonds, et al. "Outbreak of measles in a non-immunizing population, Alberta 2013". Canada Communicable Disease Report CCDR ISSN 1481-8531.
[39] Alberta Health Services. Whooping cough outbreak declared in AHS Central Zone. Public Health Announcement. December 4, 2014. http://www.albertahealthservices.ca/assets/news/psa/ne-psa-2014-12-04-whooping-cough-outbreak-central-zone.pdf

low vaccination rates and they fall into two categories: parents' attitude towards immunizing their children and barriers to access.

III. Literature Review

i. Parents' Attitudes Towards Vaccination

Canadians' attitudes regarding preventable diseases may have changed over the past decades because many adults have not experienced the threat of potentially fatal illnesses such as measles and whooping cough. The huge success of vaccines in the past 100 years may have resulted in parental apathy. This indifferent attitude in parents towards vaccines results in de-prioritization of the completion of the schedule. The time and effort necessary to book and keep an appointment may also be a burden for those who perceive little threat from disease. It requires the parents to take time off work, book appointments, fill out forms, and drive to the clinic. Many parents may intend to complete the vaccination process but procrastinate.

Furthermore, many parents are misinformed believing that vaccines potentially are more hazardous than the diseases they prevent.[40,41] Unscientific information circulating about side effects causes hesitancy in parents. Online pseudoscientists publish misinformation alleging cause-and-effect links from vaccination to autism, autoimmune diseases, sudden infant death syndrome, and cancer. Parents looking to make an informed decision can quickly become overwhelmed with the perceived threats and choose to put off

[40] Daniel Salmon, Lawrence Moulton, Saad Omer, et al., "Factors associated with refusal of childhood vaccines among parents of school-aged children: a case-control study," *Arch Pediatr Adolesc Med*. 159, no. 5 (2005): 470–476.
[41] Deborah Gust, Tara Strine, Emmanuel Maurice, et al., "Underimmunization Among Children: Effects of Vaccine Safety Concerns on Immunization Status," *Pediatrics* 114 (2004): 16-22.

vaccinating their children "just in case."[42]Some midwives, homeopaths, naturopaths, and chiropractors dole out "homeopathic vaccines" misleading some parents looking for a safer alternative.[43,44] These products, called nosodes, must now carry a disclaimer stating they are not vaccines, however some natural health practitioners claim they are a more effective and a safer alternative to traditional immunization. This gives parents a false sense of security believing their children are protected when they are actually susceptible to contracting the illness.

Some parents may also choose to free ride by relying on others to vaccinate, protecting their children through herd immunity. The problem with this approach is that when too many choose this strategy herd immunity will be no longer viable. The vaccination rate required to achieve herd immunity varies from disease to disease. Measles, which is highly contagious, requires 95% of the population to be vaccinated. Where pockets of under-vaccinated populations exist, vaccine preventable illnesses can spread swiftly resulting in outbreaks, hospitalizations, and deaths. It is each individual's responsibility to prevent outbreaks by being immunized and having their children immunized. When one chooses not to vaccinate themselves or their children, they are choosing to risk not only their own health but also the health of their community.

[42] EKOS Research Associates. 2011. Survey of Parents on Key Issues Related to Immunization. Ottawa. http://resources.cpha.ca/immunize.ca/ data/1792e.pdf.
[43] Eve Dubé, Vivion Maryline, Chantal Sauvageau, Arnaud Gagneur, Raymonde Gagnon, and Maryse Guay. 2013. "How Do Midwives and Physicians Discuss Childhood Vaccination with Parents?" Journal of Clinical Medicine 2 (4): 242–59.
[44] IBID

ii. Lack of Access

Apart from parents' attitudes and beliefs, the largest contributor to the under-vaccination population is the barrier to access.[45] American statistics show that children failing to complete the vaccination schedule (under-vaccination) have lower socioeconomic status.[46] This also seems to be the case in Alberta. The characteristics of an under-vaccinated population include: many do not have a family physician, they live in a rural setting, they receive general welfare or provincial healthcare premium subsidy, the mother is under 30, there are 3 or more children in the house, (and/or) the mother is unmarried.[47,48,49,50]

iii. Religious Beliefs

In the United States some of those who refuse vaccination (unvaccinated) are well off and educated.[51] This is not as significant a factor in Alberta where low vaccination rates are more often associated with religious beliefs.[52] Some communities of Dutch ethnic background and Low German speaking Hutterites object to immunization because it

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[45] Alberta. Alberta Immunization Strategy 2007-2017. http://www.health.alberta.ca/documents/Immunization-Strategy-07.pdf
[46] IBID
[47] Chris Bell & Kim Simmonds, "An Exploration Into Childhood Immunization Coverage in Alberta: 2008 Birth Cohort Study", (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).
[48] Douglas Dover, "How can mapping augment our current knowledge of uptake?", (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).
[49] Christina Greenaway, Pierre Dongier, Jean.-Francois Boivin, et al. "Susceptibility to Measles, Mumps, and Rubella in Newly Arrived Adult Immigrants and Refugees." Annals of Internal Medicine 146 no. 1 (2007): 20–24.
[50] J Zhang, A Ohinmaa, TH Nguyen, et al. "Determinants for Immunization Coverage by Age 2 in a Population Cohort in the Capital Health Region, Edmonton, Alberta." Canada Communicable Disease Report 34 no. 9 (2008).
[51] Philip Smith, Susan Chu, and Lawrence Barker. "Children Who Have Received No Vaccines: Who Are They and Where Do They Live?" Pediatrics 114 , no. 1 (2004): 187–195.
[52] Judith Kulig, Cathy Meyer, Shirley Hill, et al. "Refusals and delay of immunization within southwest Alberta". Canadian Journal of Public Health 93 no. 2 (2002): 109-112.

challenges the will of God and that man's sinful behaviour leads to illness. They believe God's will determines children's health status and that they will be cared for despite not being immunized.[53,54] Because people with these beliefs congregate into communities, the result is geographic clusters of low vaccination rates. However, some of the colonies are more progressive allowing their children to get immunized.

This paper's intent is to point out reasons behind low immunization rates, not to target specific religious beliefs. It identifies and advocates for universal policies to raise the immunization rates. It will not generate a philosophical debate about how or whether to force those small pockets of refusing parents to immunize their children.

iv. New Residents

New immigrants are required to produce vaccination records when entering Canada and are given information on how to meet requirements. However, when people migrate from other provinces, it is their responsibility to contact a community health centre, present their immunization records and participate in Alberta's immunization schedule. In contrast, Ontario and New Brunswick have implemented a mandatory choice model on school entry focusing on older children. This will be discussed in detail below. Immigrant and migrant populations are not identified in our current statistical coverage and including them would likely have a negative impact on Alberta's performance rates.

[53] Judith Kulig, Cathy Meyer, Shirley Hill, et al. "Refusals and delay of immunization within southwest Alberta". Canadian Journal of Public Health 93 no. 2 (2002): 109-112.
[54] Olivia Wenger, Mark McManus, John Bower, & Diane Langkamp, "Underimmunization in Ohio's Amish: Parental Fears Are a Greater Obstacle Than Access to Care," *Pediatrics* 128 (2011): 79-85.

v. Lack of a National Immunization Registry

The provinces and territories deliver immunization programs with each administering its own vaccination schedule, method of delivery, and record keeping. The National Immunization Strategy was formed to co-ordinate the provinces, however little progress has been made. In response to the SARS outbreak in 2003, the federal government promoted a program called "Panorama" as a means to set up a national vaccination registry, however only a few provinces become involved and record keeping in Canada remains inconsistent. Vaccination statistics are difficult to compare "because there is not an 'inter-provincial standard' for tracking leading to inconsistent data".[55] Some provinces track immunization from birth, while others use surveys that could miss vulnerable populations. This explains the variance in provincial averages, which ranges from 70-95% coverage.

IV. Methodology

i. Geospatial Analysis

A geospatial analysis was conducted using publicly available Statistics Canada census data, Alberta Health's childhood immunization rates, Hutterite colony locations, and Community Health Centre locations. The data was exported to ArcGIS to view the map layers together, and separately. A qualitative analysis was conducted to analyze low immunization trends in particular areas of the province and to determine if a link exists

[55] Kelly Grant. Canadian Medical Association Journal editorial calls for national vaccination strategy. The Globe And Mail. Last Updated: May 27, 2014. http://www.theglobeandmail.com/life/health-and-fitness/health/canadian-medical-association-editorial-calls-for-national-vaccination-strategy/article18860260/

between census variables and proximity to Community Health Centres, and to potentially vulnerable populations.

Alberta children's immunization records are updated following vaccination at AHS Community Health Centres (CHC) across the province. The data is compiled within the Alberta registry and made public using the Interactive Health Data Application (IHDA).[56] The IHDA reports on Childhood Immunization Coverage Rates for DTaP-IPV-Hib (DTaP), Meningococcal Conjugate Vaccine (MCV), Pneumococcal Conjugate Vaccine (PCV), Measles, Mumps & Rubella (MMR), and Varicella. Alberta Health immunization rates (2008-2014) for DTaP and MMR were viewed on a geospatial map dividing the province into 132 local geographic areas (LGS). Using ArcGIS Online Map Viewer, childhood coverage rates alone were represented in local areas that were colour-coded according to rate to allow comparisons to be made between different years of the vaccine (2008-2014), between different dose levels for DTaP, and the two vaccines against one another to look for similarities and spatial differences.[57]

Census data (2011) is available for geographic areas called dissemination blocks that are smaller than 'local areas'.[58] The dissemination block data is imported into ArcGIS, and the borders of the blocks are dissolved to have the dissemination data available on the same scale as the IDHA immunization data. Very little information is lost when the borders are dissolved because the larger local geographic areas were built using the

[56] Alberta. 2013. Alberta Health. "Interactive Health Data Application Geographic." Edmonton. http://www.ahw.gov.ab.ca/IHDA_Retrieval/
[57] ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute.
[58] Alberta Health Services and Alberta. Official Standard Geographic Areas. July 2013. http://www.albertahealthservices.ca/zones.asp

smaller dissemination blocks. The variables chosen for the project were median after-tax income, education (high school dropouts & university graduates), Hutterite colonies, and CHC locations.[59,60] These variables are represented as symbols and plotted on top of the immunization colour layer.

ii. Limitations

A major limitation of this data set represented geospatially is that coverage rates are only available at the local area level and do not allow the identification of target groups that cause outbreaks or refusals. Generally, smaller subsets of the population cause outbreaks but are too small to impact the larger population at the local area level. The data only represents those born in Alberta and does not identify those migrating to Canada or within Canada. Migration data should also be collected to recognize its impact but it was not available. Analysis of data available at the postal code level would also be of great benefit because it would allow the identification of more specific groups to target for policy intervention. Outbreaks in Alberta have been attributed to religious beliefs and to recent immigrants who have not had vaccines. However, the data available at the local area level is too broad to be useful to develop policy around this issue.

[59] Hutterite Colonies (Reference needed from Peter)
[60] Alberta Health Services. Public Health Centre Locations
http://www.albertahealthservices.ca/facilities.asp?pid=ftype&type=4

V. Findings

In Alberta, the MMR and DTaP geospatial analysis revealed that the type of vaccine does not greatly affect the rate of vaccination. For example, Figure 2 shows that that childhood coverage rates in the various local areas are generally the same for DTaP Dose 1 and MMR Dose 1. For both vaccines, only a few local areas meet the 95% coverage target (dark green), and a large portion of the province needs to increase rates to achieve public protection. This information is important for policy design and implementation; a universal approach to change is required to meet national targets.

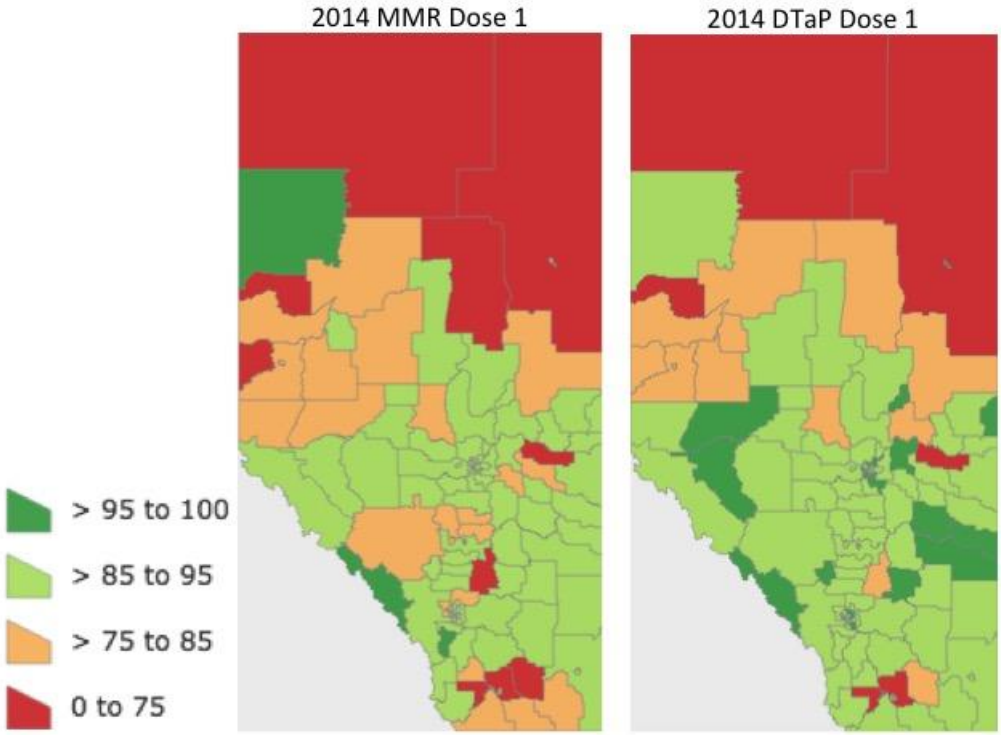

Figure 2 - Comparison between 2014 DTaP Dose 1 & MMR Coverage Rates
Vaccination rates by age 2 for DTaP Dose 1 and MMR from IHDA were mapped by percentage. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are orange, and 0% to 75% are red. Similar rates were seen for the two types of vaccines.

When looking specifically at DTaP vaccination rates across the province a persistent trend is a progressive decline in rates from dose 1 to dose 4. Figure 3 shows quite clearly in the

years 2008-2014, vaccination rates decline with each successive dose of DTaP. Alberta provincial data shows that in 2014, 92% of children get the first dose, but only 73% get the fourth dose by two years of age. A closer look at the 2014 data, DTaP dose 1 in
Figure 4 suggests that the early intervention program is working somewhat effectively; more densely populated parts of the province do relatively well. However, DTaP immunity requires four doses by the time a child reaches 18 months. The rates represent childhood coverage for four doses at 2 years of age. The left and centre map show the coverage rates for dose 1 and 4, and the right map shows that the majority of the local areas in the province do poorly at completing DTaP vaccine schedule for four doses. Barriers to access may influence the failure to comply with the full immunization schedule.

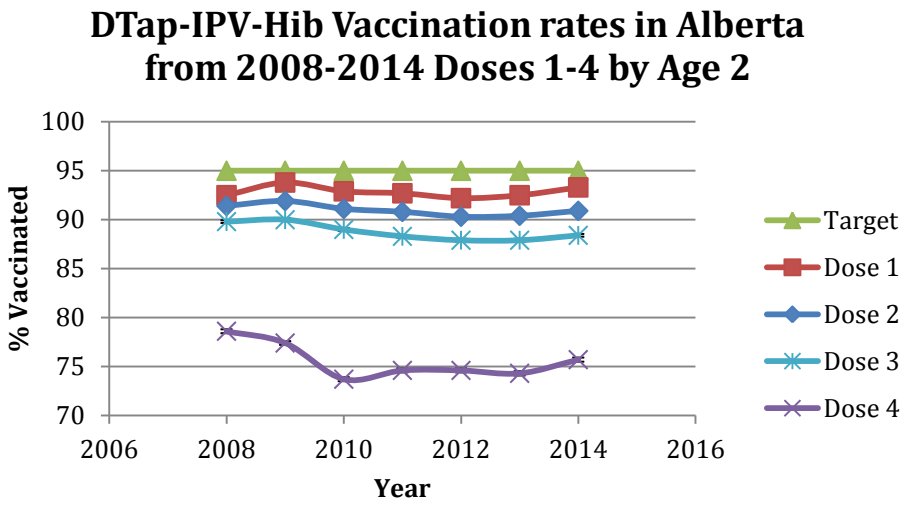

Figure 3 – DTaP-IPV-Hib Vaccination rates in Alberta by Age 2
Average provincial vaccination rates by age 2 taken from the IHDA for 2008-2014 are plotted in the graph for DTaP-IPV-Hib doses 1 through 4 compared to the target rate of 95%.

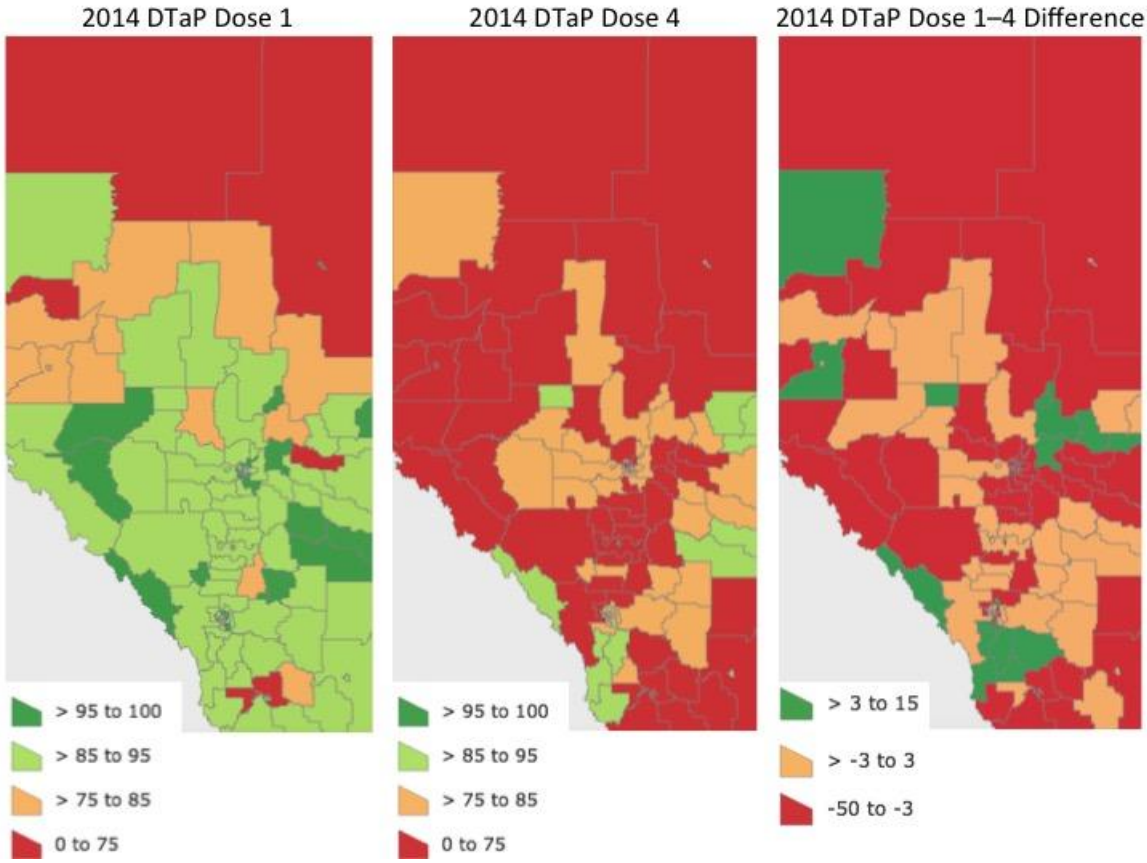

Figure 4 - Difference between DTaP Doses 1-4
Vaccination rates by age 2 for DTaP Dose 1 and DTaP dose 4 from IHDA were mapped by percentage in the two maps on the left. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are orange, and 0% to 75% are red. Similar rates were seen for the two types of vaccines. The map on the right is the difference in vaccination rate percentage between 2008 and 2014. Areas with a decrease in vaccination rate from 50% to 3% are coloured red, areas where the rate stayed within 3% are coloured orange, and areas where the vaccination rate increased by 3% or more are coloured green.

To determine whether vaccination rates have changed in the past seven years, the DTaP Dose 4 and MMR Dose 1 data was compared between 2008 and 2014. Figure 5 and Figure 6 highlight that Alberta's childhood coverage rates for both DTaP Dose 4 and MMR are actually declining over the seven-year period. Publicly available spatial data for childhood coverage rates at the local level is only available from 2008 onward.

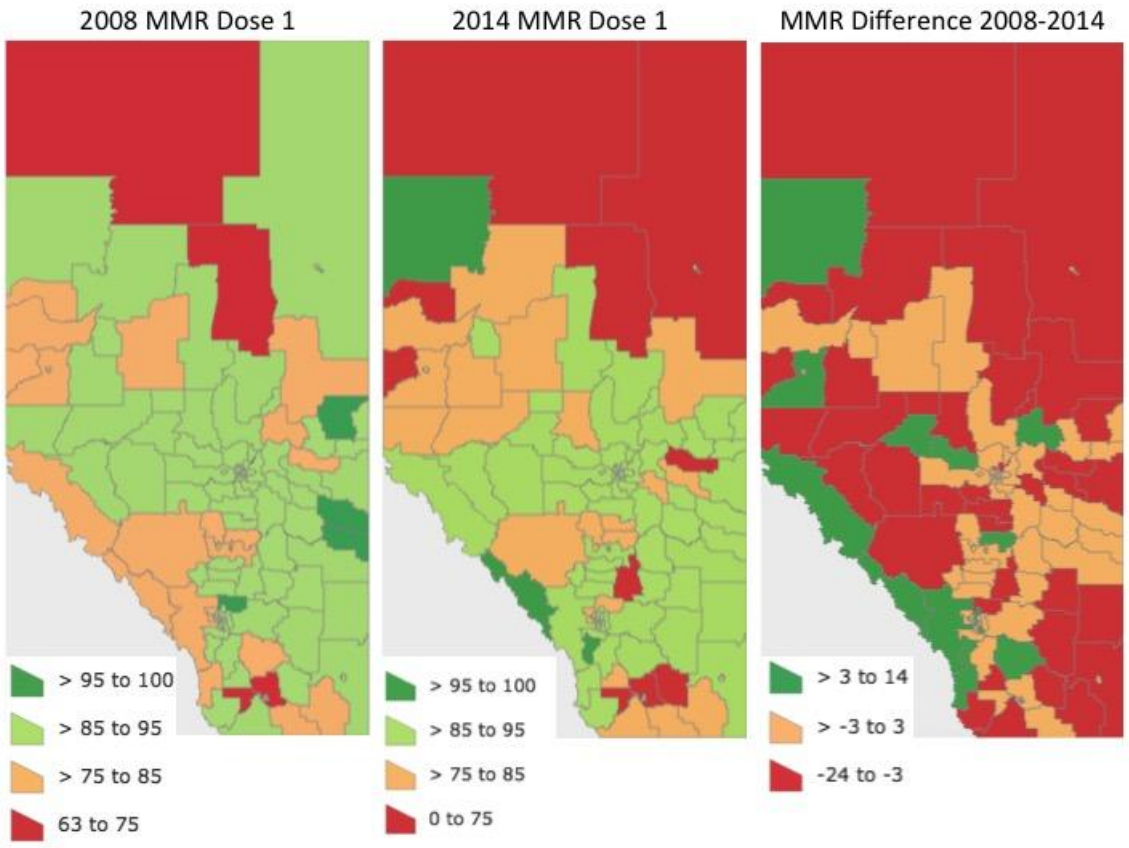

Figure 5 - MMR Dose 1 Coverage Rate Change between 2008 and 2014
Vaccination rates by age 2 for MMR Dose 1 in 2008 and MMR dose 1 in 2014 from IHDA were mapped by percentage in the two maps on the left. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are orange, and 0% to 75% are red. Similar rates were seen for the two types of vaccines. The map on the right is the difference in vaccination rate percentage between 2008 and 2014. Areas with a decrease in vaccination rate from 24% to 3% are coloured red, areas where the rate stayed within 3% are coloured orange, and areas where the vaccination rate increased by 3% or more are coloured green.

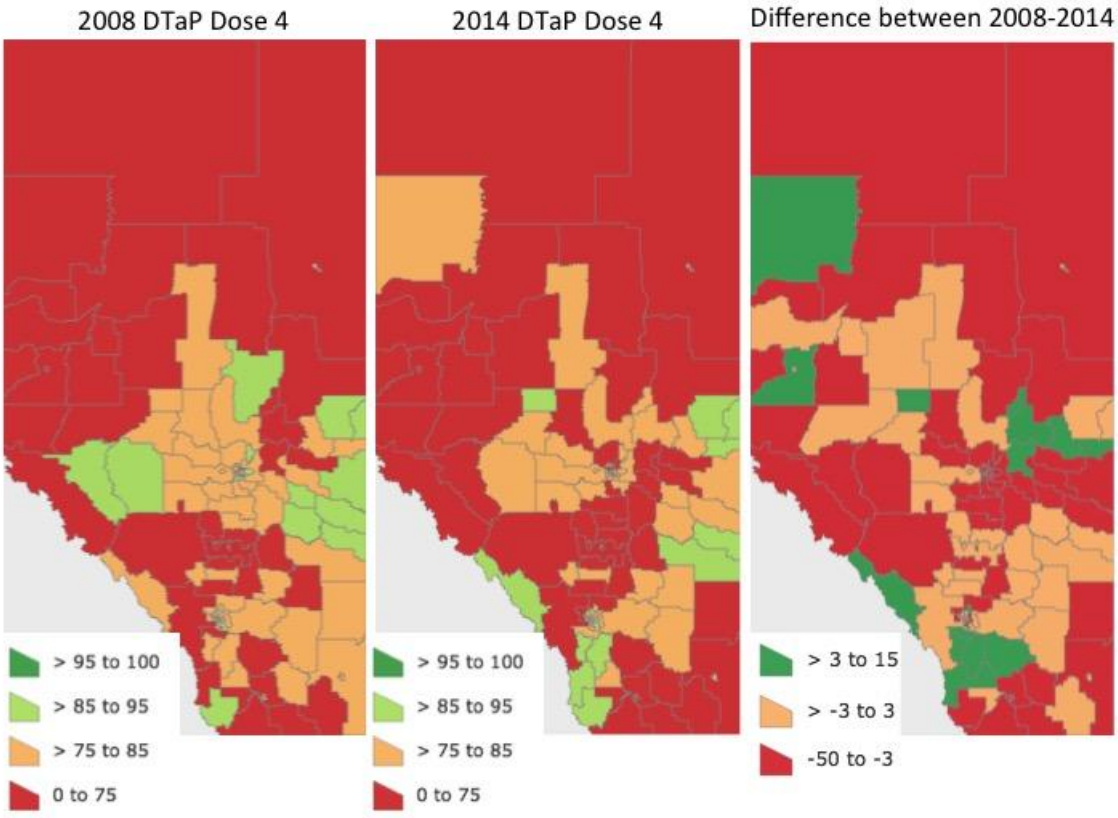

Figure 6 - DTaP Dose 4 Coverage Rate Change between 2008 and 2014
Vaccination rates by age 2 for DTaP Dose 4 in 2008 and DTaP dose 4 in 2014 from IHDA were mapped by percentage in the two maps on the left. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are orange, and 0% to 75% are red. Similar rates were seen for the two types of vaccines. The map on the right is the difference in vaccination rate percentage between 2008 and 2014. Areas with a decrease in vaccination rate from 50% to 3% are coloured red, areas where the rate stayed within 3% are coloured orange, and areas where the vaccination rate increased by 3% or more are coloured green.

To examine whether proximity to a community health centre might affect vaccination rates, locations were plotted on the DTaP Dose 4 vaccination rate map in Figure 7. This illustrates that the southeastern and northern parts of the province are under-serviced and that travel could be a barrier to getting all four doses of DTaP. Centralizing community health centres for childhood vaccination has streamlined the process of data collection in Alberta. However, it also leaves rural areas without vaccination sites, and in highly populated urban areas the clinics are overburdened. Both effects – whether having to

travel to get shots or having to wait in queues to get shots -- may discourage vaccinations.

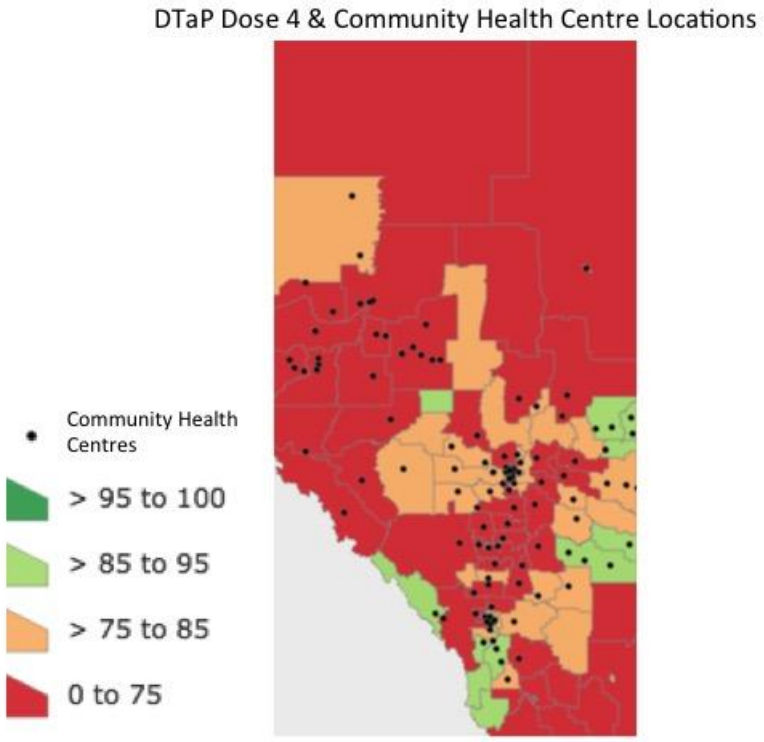

Figure 7 - Community Health Centre Locations layered on 2014 DTaP Dose 4 Immunization
Vaccination rates by age 2 for DTaP Dose 4 from IHDA were mapped by percentage in the two maps on the left. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are orange, and 0% to 75% are red. This is overlaid with the location of community health centres where Albertans can access vaccinations.

To estimate whether socioeconomic status affects childhood coverage rates, median after-tax family income was plotted over the DTaP Dose 4 coverage rate map in Figure 8 below. Those with higher income might be more disposed to gaining access because they can more easily absorb travel costs, and are more likely to have a family doctor. The red regions have the lowest childhood coverage rate and typically have the two lowest levels of income. This supports the studies conducted across the United States and in Edmonton that have shown that lower socioeconomic status correlates with low coverage rates. This

will be an important factor when considering universal policy options such as financial incentives to influence the rates.

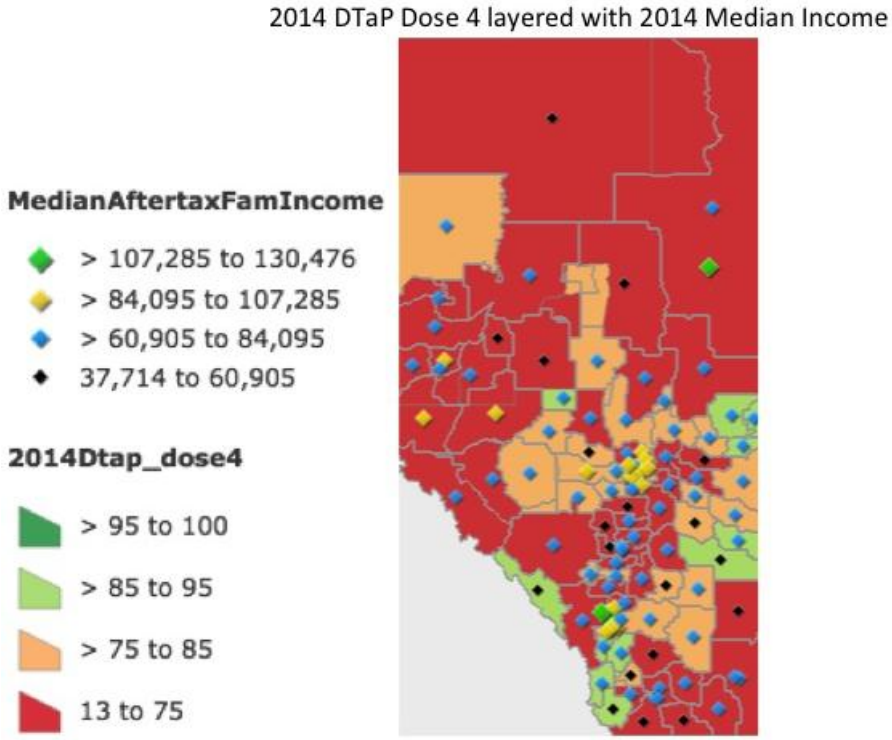

Figure 8 - Median Income layered on DTaP Dose 4 Immunization Coverage Level
Vaccination rates by age 2 for DTaP Dose 4 from IHDA were mapped by percentage in the two maps on the left. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are orange, and 0% to 75% are red. This is overlaid with the median after tax family income (see legend).

In Figure 9, the analysis examines whether education level might be implicated in childhood coverage rates for MMR. Research in the United States showed that lower MMR rates correlated with populations that were well-off, white, and educated. This phenomenon is not replicated in Alberta. It appears that the lower Alberta rates are represented more by regions with more high school dropouts and lower socio-economic conditions.

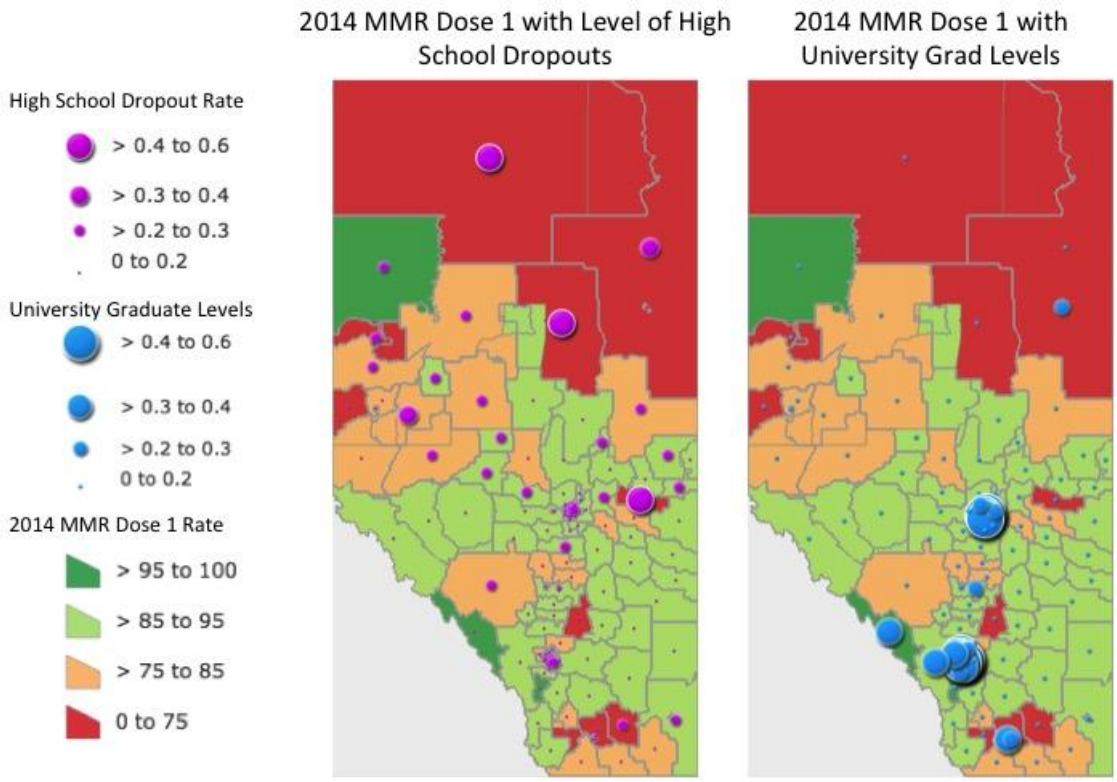

Figure 9 - Education Level compared to MMR Dose 1 Immunization Level
Vaccination rates by age 2 for MMR Dose 1 from IHDA were mapped by percentage in the two maps on the left. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are orange, and 0% to 75% are red. In the map on the left this data is overlaid with the number of people who did not complete high school and in the map on the left the number of those who completed a University degree (see legends).

The 2013 measles outbreak in Southern Alberta involved Hutterite colonies. Hutterite colonies were plotted on the MMR coverage map to provide visualization of this scenario in Figure 10. Studies have shown that attitudes towards vaccines tend to cluster.[61,62] This might be the case in Southern Alberta where the highest numbers of colonies exist, but in the rest of the province where they are more diffuse, their presence has less effect. Also, a higher proportion of communities refusing vaccination might account for a larger portion of the total population (some are more progressive and accept vaccination) and that is

[61] Tracy Lieu, Thomas Ray, Nicola Klein, et al., "Geographic Clusters In Underimmunization and Vaccine Refusal," *Pediatrics* 135 (2015): 289.
[62] Kacey Ernst, and Elizabeth Jacobs. "Implications of Philosophical and Personal Belief Exemptions on Re-emergence of Vaccine- preventable Disease: The Role of Spatial Clustering in Under-vaccination." Human Vaccines and Immunotherapeutics 8 no. 6 (2012): 838–841.

why we see lower coverage rates in Southern Alberta. This is important for policy consideration because the intent here is not to confront religious beliefs but rather design a universal program for the entire province. AHS has policies in place to deal with local populations for measles outbreaks. Essentially, parents are free to choose their children's health plans and to deal with the burden of disease in their communities. Alberta maps show a clustering of vaccine hesitancy that is typical of this behavior.[63, 64] Parents conform to the behaviours of the community in which they reside. In Alberta, there is clustering around Lethbridge, Central Zone, and near Grande Prairie may indicate the location of vulnerable populations.

[63] Kacey Ernst, and Elizabeth Jacobs. "Implications of Philosophical and Personal Belief Exemptions on Re-emergence of Vaccine- preventable Disease: The Role of Spatial Clustering in Under-vaccination." Human Vaccines and Immunotherapeutics 8 no. 6 (2012): 838–841.
[64] Alberta. 2013. Alberta Health. "Interactive Health Data Application." Edmonton. http://www.ahw.gov.ab.ca/IHDA_Retrieval/

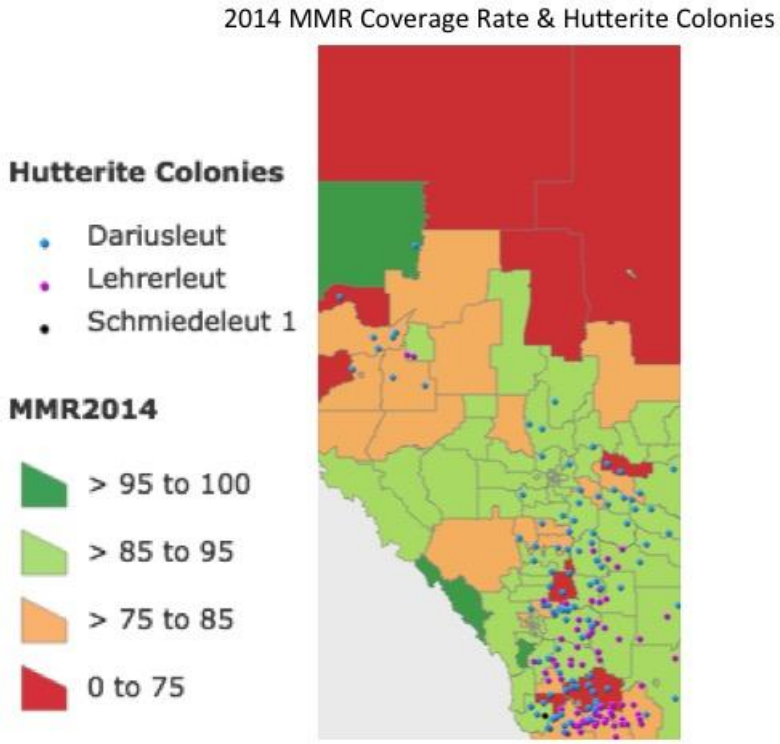

Figure 10 - Location of Hutterite Colonies compared to MMR Dose 1 Immunization Level Immunization coverage by age 2 for DTaP Dose 4 from IHDA was mapped by percentage in the two maps on the left. Areas with rates 95% and greater are coloured dark green, >85% to 95% are light green, >75% to 85% are location of Hutterite colonies median after tax family income (see legend).

VI. Policy Implications, Consultation, Communication and Implementation

Alberta does not reach the national childhood immunization target, and the results of spatial analysis show the provincial rates are declining in the majority of local areas. Canada as a whole is not doing well either, "UNICEF ranks Canada 28/29 countries for childhood immunization rates" and therefore, immunization policy should be standardized across provinces.[65] The basic philosophy of public health is to "to prevent disease, promote health, and prolong life among the population as a whole" to provide

[65] Kristin Klein, "Contributors to Low Vaccine Coverage" (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).

conditions in which people can be healthy. They focus on entire populations, not on individual patients or diseases. To achieve national targets that would reduce childhood disease, a new set of policies should be adopted targeting the entire population as opposed to small subsets that refuse vaccinations. Busby & Chesterley believe that the key to increasing coverage rates is to target those who do not actively object to vaccines - those who are not vaccinating because of "barrier to access, complacency, or procrastination".[66] While the universal approach will not eradicate the disease or stop all outbreaks, it will greatly reduce the likelihood of spreading disease throughout the general population. The aim is to create herd immunity without challenging the Charter of Rights and Freedoms. Current policies do not overrule the religious beliefs of those who choose not to vaccinate. Implementing a series of universal policies as opposed to the single early intervention program should be adopted to vaccinate the willing and to target those who are not refusing.

i. Early Intervention Program

Currently, Alberta's policy to address low vaccination rates utilizes a "nurse-driven" model that begins with early intervention, registering and tracking children to remind them of upcoming vaccinations and inform them of health benefits. Alberta and Newfoundland have similar childhood vaccination strategies. However, Newfoundland has considerably higher vaccination rates. Colin & Busby authors believe that Newfoundland's system has two key advantages over Alberta's; one is including mandated choice; parents have to formally sign up for vaccinating their children making

[66] Colin Busby, Nicholas Chesterley. A Shot in the Arm: How to Improve Vaccination Policy in Canada. C.D Howe Institute. Commentary NO. 421. http://www.cdhowe.org/pdf/commentary_421.pdf

the parents live up to the agreement, and the other has the nurse led model which works more effectively in less densely populated areas because the target population often has personal connections to the nurse.[67, 68] Alberta has a disadvantage: a higher level of immigration and migration, making it difficult to track all children.

Alberta's system is not without significant achievements; the early intervention program has demonstrated success by maintaining a comprehensive database of all children born in the province and providing an excellent opportunity for outreach and education. The education map shows that the less educated do not vaccinate as readily, compared to the higher level educated do vaccinate. In fact, the rest of Canada should adopt Alberta's early intervention program.

The key to improving coverage rates amongst Canadian children is the ability to track each child's vaccination records electronically from birth allowing public health to target parents for reminders and education, allowing statistical analysis between provinces, and identifying areas with particularly low rates where the probability of an outbreak is higher.[69] An improvement could be made to tracking by establishing a gate to those migrating to Alberta in order to have a more complete registry because children born outside Alberta are not currently part of the database. Furthermore, the database is not linked to or compatible with those in other provinces and territories.

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[67] Colin Busby, Nicholas Chesterley. A Shot in the Arm: How to Improve Vaccination Policy in Canada. C.D Howe Institute. Commentary NO. 421. http://www.cdhowe.org/pdf/commentary_421.pdf

[68] Newfoundland and Labrador. 2013. Department of Health and Community Services. Newfoundland and Labrador Immunization Coverage Report 2005-2012. St. John's. http://www.health.gov.nl.ca/health/publichealth/cdc/CDR%20Vol%2030%20Number%201%20March%202013.pdf.

[69] Colin Busby, Nicholas Chesterley. A Shot in the Arm: How to Improve Vaccination Policy in Canada. C.D Howe Institute. Commentary NO. 421. http://www.cdhowe.org/pdf/commentary_421.pdf

ii. National Policy for Integrated Database

A recent report by the C.D. Howe Institute suggests Canada and the provinces should create an inter-provincial database to facilitate statistical analysis to locate geographic gaps in immunization coverage that is vital to managing outbreaks.[70] A national database would allow doctors and public health officials' access to records of individual patients to determine their risk and would allow health departments to identify more vulnerable communities with low immunization coverage. Alberta has a comprehensive provincial database registry that was used in this Capstone analysis. The data is well maintained and up-to-date. However the C.D Howe institute believes IBM's Panorama program is the program of choice.

Following the 2003 SARS outbreak, the Canadian Medical Association called for a national registry that would improve national co-ordination for disease management and is currently being used by other provinces. The Panorama System would accomplish this by addressing immunization management, disease surveillance, vaccine supply inventory, reporting, and outbreak management. It would standardize reporting, and account for migration between provinces, and immigration, which is another limitation of the Alberta registry.[71,72,73] It also would carry specific functions for vaccine supply management and a registry for newborns. Of the Canadian provinces, five provinces are using Panorama,

[70] IBID
[71] The IBM Panorama System document. http://www-03.ibm.com/industries/ca/en/healthcare/files/panorama_application_overview_final.pdf
[72] Manitoba. Manitoba Health, Healthy Living and Seniors. *Panorama Fact Sheet*. Epidemiology and Surveillance. Accessed June 25, 2015. http://www.gov.mb.ca/health/publichealth/surveillance/docs/panorama_factsheet.pdf
[73] Kelly Grant. Canadian Medical Association Journal editorial calls for national vaccination strategy. The Globe And Mail. Last Updated: May 27, 2014. http://www.theglobeandmail.com/life/health-and-fitness/health/canadian-medical-association-editorial-calls-for-national-vaccination-strategy/article18860260/

two have put their participation on hold, and three including Alberta have no commitment to adopt the program. Alberta and the other provinces should be part of the national registry.

iii. Accessing Rural and Colony Locations

The spatial analysis conducted in this paper suggests that community health centres leave rural areas underserviced causing a barrier to access. Immunization rates in these areas could be increased if access was improved through the use of mobile vaccination clinics that travel throughout the province. These types of clinics set up during influenza epidemics in the United States were successful at reaching residents of rural areas. For example, during the H1N1 outbreak, where access was limited, mobile immunization teams vaccinated rural areas for influenza.[74,75] Although these examples are for the influenza vaccine, the idea should be viable for childhood immunizations as well. The teams would not only vaccinate but also use the opportunity to reach out and provide education as well. This may be great outreach method to deal with vaccine refusers clustered in rural communities.

[74] Centre for Infectious Disease Research and Policy, "Mobile vaccination clinic reaches rural areas". http://www.cidrap.umn.edu/practice/mobile-vaccination-clinic-reaches-rural-areas-wv

[75] Centre for Infectious Disease Research and Policy, "Mobile vaccination clinic for reaching a South Dakota reservation". http://www.cidrap.umn.edu/practice/mobile-vaccination-clinic-reaching-south-dakota-reservation

iv. Vaccination Requirement for the Federal Child Tax Benefit

Studies in the United States and Edmonton show that socioeconomic status is a primary determinant, affecting parents immunizing their children.[76, 77] The spatial analysis in this report is consistent with that finding indicating that Alberta's lowest immunized local areas have lower income, and a less educated population. A universal financial incentive would encourage parents to opt-in to the vaccination schedule in order to receive government assistance through the Universal Child Tax Benefit. The financial incentive model is ideal. Because the child tax benefit begins at birth parents will have incentive to make the choice early, getting their children vaccinated according to the schedule, benefiting the child and the entire population, and improving herd immunity.

This strategy worked well in Australia, which incorporated a successful campaign by tying immunizations to childcare benefits.[78 , 79] Australia boosted its two year old childhood immunization coverage rate from 73% to 92% coverage from 1999 to 2008 based on a campaign beginning in the mid-1990s.[80] The Australian Childcare Allowance is partially conditional upon child immunization.

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[76] J Zhang, A Ohinmaa, TH Nguyen, et al. "Determinants for Immunization Coverage by Age 2 in a Population Cohort in the Capital Health Region, Edmonton, Alberta." *Canada Communicable Disease Report* 34 no. 9 (2008). http:// www.phac-aspc.gc.ca/publicat/ccdr-rmtc/08vol34/ dr-rm3409a-eng.php.
[77] Philip Smith, Susan Chu, and Lawrence Barker. "Children Who Have Received No Vaccines: Who Are They and Where Do They Live?" *Pediatrics* 114 , no. 1 (2004): 187–195.
[78] Australia. 2013. Department of Health. "Immunize Australia Program: History of the Program." Canberra. http://www.health. gov.au/internet/immunise/publishing.nsf/Content/ history-of-ia-prog
[79] Australia. 2014. Department of Health. "Immunize Australia Program: ACIR – Current Data." Canberra. http://www.immunise. health.gov.au/internet/immunise/publishing.nsf/ Content/acir-curr-data.html
[80] Australian Government – Department of Health. Immunize Australia Program. ACIR - Annual Coverage Historical Data. Page last updated: 20 April 2015. http://www.immunise.health.gov.au/internet/immunise/publishing.nsf/Content/acir-ann-cov-hist-data.htm

This is a strong incentive to get a child immunized and would begin at birth. The policy would also improve Alberta's record keeping because parents would place more emphasis on the routine vaccination schedule getting their children immunized earlier. It would target those in lower to middle socioeconomic status, providing a reward for keeping a child's immunizations up to date.

v. Vaccination Requirement for School

The vaccination requirement to enter public and private schools currently being used in Ontario and New Brunswick is another recommended policy. Ontario's physician-driven model has vaccines being administered by doctors, nurses, and midwives.[81,82] Schools are the bottleneck, where they gather children's records in a mandated choice model.[83] The child must either be vaccinated or be exempt for medical or philosophical reasons to attend school. This provides a strong incentive to get a child immunized or to be required to go through a lengthy exemption process.[84]

Adopting this policy alone is not recommended because, as is seen often in Ontario, parents will wait until their children are nearly school aged to vaccinate, putting them at risk early in life. They also miss an opportunity to inform and educate parents at the child's early age. It places an unnecessary burden on parents to keep track of the

[81] Ontario. 2014. Auditor General of Ontario. Immunization. Toronto. http:// www.auditor.on.ca/en/reports_en/en14/304en14. pdf.
[82] Ontario. 2014. "Ontario's Publicly Funded Immunization System: Building on Today's Strength's, Innovating for the Future." Report of the Advisory Committee for Ontario's Immunization System Review. Toronto: Ministry of Health and Long-Term Care.
[83] Erin Walkinshaw. "Mandatory Vaccinations: The Canadian Picture." Canadian Medical Association Journal 183, no. 16 (2011): 1165–1166.
[84] Colin Busby, Nicholas Chesterley. A Shot in the Arm: How to Improve Vaccination Policy in Canada. C.D Howe Institute. Commentary NO. 421.

immunization records making it impossible for the province to keep up-to-date data of immunization coverage. It is recommended that the implementation of this model be done in conjunction with the other policies outlined here while maintaining Alberta's current early intervention program.

vi. Consultation, Communication and Implementation

The recommended policies involve the federal and provincial governments. Alberta's major strategy will be to continue with the early intervention and to participate in national data tracking, to implement financial incentives, and to track in-migration. This will greatly improve coverage rates, and reduce outbreaks. Those small pockets choosing to refuse immunization will be disadvantaging their children leaving them susceptible to disease and restricted from access to school. The proposal outlined above will achieve herd immunity and protect the public.

Canada Health Infoway, a federally funded not-for-profit organization has been tasked to work with the federal and provincial governments to create and implement Panorama. The federal government contributed $130M to the initiative but it does not cover the costs for the provinces.[85] Approving the funding would be the most difficult task especially in Alberta's current economic climate. Panorama is costly, Ontario spend $133M essentially matching the federal funding portion to implement the new registry. Perhaps a new provincial-federal funding model should be pursued to finance the project. Once funding has been approved, Alberta would need to coordinate with Canada Health Infoway to

[85] Kelly Grant. Canadian Medical Association Journal editorial calls for national vaccination strategy. The Globe And Mail. Last Updated: May 27, 2014.

transfer data, and implement the program in the province. Once implemented, Alberta Health Services, Alberta Health, and the Public Health Agency of Canada would use Panorama for a variety of purposes including immunizations. The implementation of a national registry would be essential for coordinating eligibility for the financial incentives proving successful completion of routine vaccinations.

Financial incentive to increase immunization coverage rates would rely on the Panorama system where the provincial database feeding the national database with up-to-the-minute immunization records would trigger childcare payments. At birth, applying for the benefits online would require the parent to opt-in to or opt-out of the routine vaccination schedule. If parents choose to opt-out without medical exemption they would not receive federal childcare assistance under the UCCB. The CCTB provides additional non-taxable funding to eligible families with children under the age of 18. [86] Under the UCCB, each primary care giver with a child under the age of 6 is eligible.[87] The non-taxable Canada Panorama would need to be linked with the Canada Revenue agency because they govern the Child Care Tax Benefit (CCTB) & the taxable Universal Child Care Benefit (UCCB). The consultation process should involve the Australian government model for the financial incentive model.

A provincial committee involving health and education members should be coordinating talks with the Ontario health and education provincial departments for the mandated

[86] Canada. Canada Revenue Agency. Child and family benefits. Canada Child Tax Benefit (CCTB). Date modified: 2015-05-06. http://www.cra-arc.gc.ca/bnfts/cctb/menu-eng.html
[87] Canada. Canada Revenue Agency. Child and family benefits. Universal Child Care Benefit (UCCB). Date modified: 2015-07-03. http://www.cra-arc.gc.ca/bnfts/uccb-puge/menu-eng.html

choice model for school entry. Their input on the ideas for best outcomes based on the exemption and school programs would be essential to setting a successful program here in Alberta.

References

Alberta. 2013. Alberta Health. “Interactive Health Data Application.” Edmonton. http://www.ahw.gov.ab.ca/IHDA_Retrieval/

Alberta. Alberta Immunization Strategy 2007-2017. http://www.health.alberta.ca/documents/Immunization-Strategy-07.pdf

Alberta Health Services and Alberta. Official Standard Geographic Areas. July 2013. http://www.albertahealthservices.ca/zones.asp

Alberta Health Services. 2014. Annual Report 2012- 2013. Edmonton. http://www. albertahealthservices.ca/Publications/ahs-pub-2012- 2013-annual-report.pdf.

Alberta Health Services. Measles Outbreak. http://www.albertahealthservices.ca/9842.asp

Alberta Health Services. Public Health Centre Locations http://www.albertahealthservices.ca/facilities.asp?pid=ftype&type=4

Alberta Health Services. Routine immunization schedule. http://www.health.alberta.ca/health-info/imm-routine-schedule.html. Accessed April 26, 2015.

Alberta Health Services. Whooping cough outbreak declared in AHS Central Zone. Public Health Announcement. December 4, 2014. http://www.albertahealthservices.ca/assets/news/psa/ne-psa-2014-12-04-whooping-cough-outbreak-central-zone.pdf

Alberta Treasury Board and Finance. About Alberta’s economy and demography. http://www.finance.alberta.ca/aboutalberta/index.html

Australia. 2013. Department of Health. “Immunize Australia Program: History of the Program.” Canberra. http://www.health. gov.au/internet/immunise/publishing.nsf/Content/ history-of-ia-prog

Australia. 2014. Department of Health. “Immunize Australia Program: ACIR – Current Data.” Canberra. http://www.immunise. health.gov.au/internet/immunise/publishing.nsf/ Content/acir-curr-data.html

Chris Bell & Kim Simmonds, “An Exploration Into Childhood Immunization Coverage in Alberta: 2008 Birth Cohort Study”, (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).

Colin Busby, Nicholas Chesterley. A Shot in the Arm: How to Improve Vaccination Policy in Canada. C.D Howe Institute. Commentary NO. 421. http://www.cdhowe.org/pdf/commentary_421.pdf

Canada. 2013. Public Health Agency of Canada. Canada Immunization Guide. Ottawa. http://www.phac-aspc.gc.ca/publicat/cig-gci/p01- 02-eng.php.

Canada. 2014. Public Health Agency of Canada. Vaccine Coverage in Canadian Children: Results from the 2011 Childhood National Immunization Coverage Survey. Ottawa. http://www.phac-aspc. gc.ca/im/nics-enva/vccc-cvec-eng.php.

Canada. 2015. Canada Revenue Agency. Child and family benefits. Canada Child Tax Benefit (CCTB). http://www.cra-arc.gc.ca/bnfts/cctb/menu-eng.html

Canada. 2015. Canada Revenue Agency. Child and family benefits. Universal Child Care Benefit (UCCB). http://www.cra-arc.gc.ca/bnfts/uccb-puge/menu-eng.html

Centre for Infectious Disease Research and Policy, "Mobile vaccination clinic reaches rural areas". http://www.cidrap.umn.edu/practice/mobile-vaccination-clinic-reaches-rural-areas-wv

Centre for Infectious Disease Research and Policy, "Mobile vaccination clinic for reaching a South Dakota reservation". http://www.cidrap.umn.edu/practice/mobile-vaccination-clinic-reaching-south-dakota-reservation

Douglas Dover, "How can mapping augment our current knowledge of uptake?", (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).

Eve Dubé, Vivion Maryline, Chantal Sauvageau, et al., "How Do Midwives and Physicians Discuss Childhood Vaccination with Parents?" Journal of Clinical Medicine 2 no. 4 (2013): 242–259.

EKOS Research Associates. 2011. Survey of Parents on Key Issues Related to Immunization. Ottawa. http://resources.cpha.ca/immunize.ca/ data/1792e.pdf.

ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute.

Jason Glanz, David McClure, David Magid, et al., "Parental refusal of pertussis vaccination is associated with an increased risk of pertussis infection in children," *Pediatrics:* 123, no. 6 (2009): 1446–1451.

Jason Glanz, David McClure, Sean O'Leary, et al., "Parental decline of pneumococcal vaccination and risk of pneumococcal related disease in children," *Vaccine* 29, no. 5 (2011): 994–999.

Jason Glanz, David McClure, David Magid, et al., "Parental refusal of varicella vaccination and the associated risk of varicella infection in children," *Arch Pediatr Adolesc Med*. 164, no. 1 (2010): 66–70.

Jason Glanz, Sophia Newcomer, Kormal Narwaney, et al., "A population-based cohort study of undervaccination in 8 managed care organizations across the United States," *JAMA Pediatr*. 167, no. 3 (2013): 274–281.

Leon Gordis. "Epidemiology". W.B. Saunders. 1938. 26-27.

Kelly Grant. Canadian Medical Association Journal editorial calls for national vaccination strategy. The Globe And Mail. Last Updated: May 27, 2014.

http://www.theglobeandmail.com/life/health-and-fitness/health/canadian-medical-association-editorial-calls-for-national-vaccination-strategy/article18860260/

Christina Greenaway, Pierre Dongier, Jean.-Francois Boivin, et al. "Susceptibility to Measles, Mumps, and Rubella in Newly Arrived Adult Immigrants and Refugees." *Annals of Internal Medicine* 146 no. 1 (2007): 20–24.

Deborah Gust, Tara Strine, Emmanuel Maurice, et al., "Underimmunization Among Children: Effects of Vaccine Safety Concerns on Immunization Status," *Pediatrics* 114 (2004): 16-22.

The IBM Panorama System document. http://www-03.ibm.com/industries/ca/en/healthcare/files/panorama_application_overview_final.pdf

Kacey Ernst, and Elizabeth Jacobs. "Implications of Philosophical and Personal Belief Exemptions on Re-emergence of Vaccine- preventable Disease: The Role of Spatial Clustering in Under-vaccination." *Human Vaccines and Immunotherapeutics*. 8 no. 6 (2012): 838–841.

Harunor Rashid, Gualom Khandaker, and Robert Boy. Vaccination and herd immunity: what more do we know? *Curr Opin Infect Dis*. 25 (2012): 243-249.

Jennifer Keelan. "Concurrency in Public Health Governance: The Case of the National Immunization Strategy." Special Series: The Role of Federalism in Protecting the Public's Health. Kingston, ON: Queen's University, School of Policy Studies, Institute for Government Relations (2008).

Tanis Kershaw, Vivian Suttorp, Kelly Simmonds, et al. "Outbreak of measles in a non-immunizing population, Alberta 2013". Canada Communicable Disease Report CCDR ISSN 1481-8531.

Kristin Klein, "Contributors to Low Vaccine Coverage" (presented at Western Canada Immunization Forum 2014. March 5–6, 2014, Fantasyland Hotel, Edmonton, Alberta).

Judith Kulig, Cathy Meyer, Shirley Hill, et al. "Refusals and delay of immunization within southwest Alberta". *Canadian Journal of Public Health* 93 no. 2 (2002): 109-112.

Tracy Lieu, Thomas Ray, Nicola Klein, et al., "Geographic Clusters In Underimmunization and Vaccine Refusal," *Pediatrics* 135 (2015): 289.

Manitoba. Manitoba Health, Healthy Living and Seniors. *Panorama Fact Sheet*. Epidemiology and Surveillance. Accessed June 25, 2015. http://www.gov.mb.ca/health/publichealth/surveillance/docs/panorama_factsheet.pdf

Newfoundland and Labrador. 2013. Department of Health and Community Services. Newfoundland and Labrador Immunization Coverage Report 2005-2012. St. John's. http://www.health.gov.nl.ca/health/publichealth/cdc/CDR%20Vol%2030%20Number%201%20March%202013.pdf.

Saad Omer, Kyle Enger, Lawrence Moulton, et al., "Geographic clustering of nonmedical exemptions to school immunization requirements and associations with geographic clustering of pertussis". *Am J Epidemiol*. 168, no. 12 (2008): 1389–1396.

Ontario. 2014. Auditor General of Ontario. *Immunization*. Toronto. http:// www.auditor.on.ca/en/reports_en/en14/304en14. pdf.

Ontario. 2014. "Ontario's Publicly Funded Immunization System: Building on Today's Strength's, Innovating for the Future." *Report of the Advisory Committee for Ontario's Immunization System Review*. Toronto: Ministry of Health and Long-Term Care. March.

Public Health Agency of Canada. Measles-containing vaccination rates in southern Alberta. http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/14vol40/dr-rm40-12/dr-rm40-12-surv-2-eng.php

Daniel Salmon, Michael Haber, Eugene Gangarosa, et al., "Health consequences of religious and philosophical exemptions from immunization laws: individual and societal risk of measles," *JAMA* 282, no. 1 (1999): 47–53.

Daniel Salmon, Lawrence Moulton, Saad Omer, et al., "Factors associated with refusal of childhood vaccines among parents of school-aged children: a case-control study," *Arch Pediatr Adolesc Med*. 159, no. 5 (2005): 470–476.

Philip Smith, Susan Chu, and Lawrence Barker. "Children Who Have Received No Vaccines: Who Are They and Where Do They Live?" *Pediatrics* 114 , no. 1 (2004): 187–195.

Erin Walkinshaw. "Mandatory Vaccinations: The Canadian Picture." *Canadian Medical Association Journal* 183, no. 16 (2011): 1165–1166.

Olivia Wenger, Mark McManus, John Bower, & Diane Langkamp, "Underimmunization in Ohio's Amish: Parental Fears Are a Greater Obstacle Than Access to Care," *Pediatrics* 128 (2011): 79-85.

Craig White, Jeffrey Koplan, and Walter Orenstein. "Benefits, risks and costs of immunization for measles, mumps and rubella." *American Journal of Public Health, 75* no. 7 (1985): 739–744.

J Zhang, A Ohinmaa, TH Nguyen, et al. "Determinants for Immunization Coverage by Age 2 in a Population Cohort in the Capital Health Region, Edmonton, Alberta." *Canada Communicable Disease Report* 34 no. 9 (2008). http:// www.phac-aspc.gc.ca/publicat/ccdr-rmtc/08vol34/ dr-rm3409a-eng.php.

Appendix A

Alberta Routine Immunization Schedule[88]

Age	Vaccine
2 months	• DTaP-IPV-Hib *[1] • Pneumococcal conjugate (PCV13)
4 months	• DTaP-IPV-Hib • Pneumococcal conjugate (PCV13) • Meningococcal conjugate (Men C)
6 months	• DTaP-IPV-Hib • Pneumococcal conjugate (PCV13) (for high risk children only)
6 months and older	• Influenza *[2]
12 months	• MMRV *[3] • Meningococcal conjugate (Men C) • Pneumococcal conjugate (PCV13)
18 months	• DTaP-IPV-Hib
4–6 years	• DTaP-IPV *[4] • MMRV *[3] • Pneumococcal conjugate (PCV13) only for children up to 71 months (catch up program)
Grade 5	• Hepatitis B (3 doses) • HPV *[5] (3 doses)
Grade 9	• DTaP *[6] • MCV4 *[7] • HPV (3 doses – catch up program for boys)

Note: Each bullet represents one vaccine/injection unless otherwise noted.
*[1] Diphtheria, tetanus, acellular pertussis, polio, haemophilus influenzae type b
*[2] Annually, during influenza season
*[3] Measles, mumps, rubella, and varicella
*[4] Diphtheria, tetanus, acellular pertussis, polio
*[5] Human papillomavirus
*[6] Diphtheria, tetanus, acellular pertussis
*[7] Meningococcal Conjugate Vaccine (Groups A, C, W-135 and Y)

[88] Alberta Health Services Website. Accessed March 10, 2015. http://www.health.alberta.ca/health-info/imm-routine-schedule.html