MEASLES IMMUNIZATION IN SASKATCHEWAN – COVERAGE DISPARITIES AND CHALLENGES TO ACHIEVING HERD IMMUNITY THRESHOLD

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by

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ABSTRACT

Adequate immunization offers protection against vaccine-preventable communicable diseases. However, after being absent for years, measles is recurring in the province of Saskatchewan, Canada.. Measles is not endemic in Canada. There could be factors that make the province vulnerable to recurrent outbreaks. This study evaluated the disparity in immunization coverage for measles among children aged 12 to 24 months in Saskatchewan health regions between 2002 and 2013 and explored factors affecting measles immunization coverage rates and the barriers to the achievement of herd immunity threshold.

The research, a mixed methods design, used a cross-sectional total sample data of 24 month old clients of measles vaccination on eHealth Saskatchewan Immunization Registry platform between 2002 and 2013. A total of 169,852 two-year-olds were included in the study in the quantitative component. 65.5% lived in the 'city' (urban) and 31.3% in 'not city' (rural) locations. The study found a progressive increase in coverage rate from 56.32% in 2002 to 73.21% in 2013 with an Average Annual Percentage Change (AAPC) of 2.4 (C.I. 2.0 – 2.9, $P < .005$). Coverage rates increased progressively for both rural and urban locations, however coverage was higher in rural than urban locations. There was a progressive increase in the coverage rates for socio-economic deprivation quintiles 1 (least deprived) and 5 (most deprived) for both age groups studied. The coverage rates were higher in the socio-economic deprivation quintile 1 (least deprived) than in 5 (most deprived) for both on-time for first dose at 1-year and on-time for second dose at 2-year age groups between 2002 – 2013; however, the AAPC for socio-economic deprivation quintile 5 were higher both at the level of the province as well as among the RHA peer groups, an indication of progressive reduction of disparity from 2002 -2013 between the most and the least deprived groups. In-depth key informant semi-structured two-phase interviews with nine each of immunization coordinator/frontline vaccination staff and medical health officers uncovered enablers and barriers to improved uptake.

Barriers identified were access-related issues, caregivers' fears and hesitancy, anti-vaccination challenges, and systems and resource limitations. Strategies to improve coverage range from access improvement while reducing missed opportunities, increasing awareness and health care provider education, continuing reminder calls, as well as involvement of the primary health care physicians for client reminders on a general approach. Targeted approaches will increase

community engagement and communications to address the issue of hesitancy and anti-vaccination movements, and work on mitigating social determinants of health.

This research showed that individuals from deprived communities are less likely to achieve a higher coverage rate for measles immunization if the drivers of low uptake are not addressed. Continuous monitoring of coverage rates is essential to ensure higher uptake for better health outcomes. While socio-economic inequalities in measles immunization uptake can be a major public health problem in industrialized countries, uncovering factors responsible may provide platform for improved collaboration of interdisciplinary teams for immunization delivery efficiency, constructive stakeholder engagement and integrating clients and other systems for research.

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DEDICATION

…To the loving memory of my mother, Mary O Ilesanmi (a.k.a Màmá Tísà), my confidant and prayer warrior. Besides being my mother, you were also my class teacher. Thank you for nurturing me into what I am today, may your soul continue to rest in peace!

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LIST OF ABBREVIATIONS

BCCDC	British Columbia Centre for Disease Control
CANVax	The Canadian Vaccination Evidence Resource and Exchange Centre
CDC	Center for Disease Control
F/P/T	Federal/Provincial/Territorial governments
GAVI	Global Alliance for Vaccines and Immunization
GVAP	Global Vaccine Action Plan
HiAP	Health in All Policies
HIT	Herd Immunity Threshold
MHOCCOS	Medical Health Officers Council of Saskatchewan (MHOCOS)
MHOs	Medical Health Officers
MMR	Measles Mumps Rubella
MMRV	Measles Mumps Rubella and Varicella
NACI	National Advisory Committee on Immunization
OTFMI	On-Time for Measles Immunization
PAHO	Pan American Health Organization
PHAC	Public Health Agency of Canada
PHO	Public Health Observatory
RHA	Regional Health Authority
SDG	Sustainable Development Goals
SDoH	Social Determinants of Health
SEA	Saskatchewan Epidemiological Association
SHA	Saskatchewan Health Authority
SIMS	Saskatchewan Immunization Management System
SMS	Short Messaging System
S-EDQ	Socio-Economic Deprivation Quintile
SSPE	Sub-Acute Sclerosing Pan-Encephalitis
WHO	World Health Organization

Glossary

Health Region: A health region in Canada is an administrative area and defined by the provincial ministries of health, developed in 2013 (1). This term is used interchangeably in this document with the term Regional Health Authority (RHA)

Health region peer grouping: This is an algorithm to assemble Canada's health regions into peer groups based on similar characteristics which was developed by Statistics Canada using the data from Census of Population and updated regularly (2). The first release was in 2002, with updates in 2003, 2007, 2011 and 2018. Health regions were categorized into 10 peer groups identified by alphabets A to J. In Saskatchewan, the 13 health regions fell under A, D, F and H peer grouping, a classification that is based on grouping health regions with similar socio-economic characteristics together for ease of comparison. However, only A, D and H health region peer groups were included in this study.

Deprivation index: This is an index which measures deprivation at the level of dissemination areas (DAs), the smallest areas for which the Census data are available, comprised of approximately 400 to 700 residents living in the same location. This could translate to one or more neighboring blocks (3). The deprivation index looked at social and material dimensions. The proportion of single parents, of residents living alone, and marital status are the social component variables while the material components are measured using educational attainment, average income, and employment status variables. The index was determined at area-level by using the deprivation index developed at the Institut National de Sante Publique du Quebec (INSPQ) (3). The dissemination areas were subdivided into five quintiles, each quintile representing 20% of the population. (3) The degree of deprivation increases from 1 to 5, where 1 is the most privileged (least deprived) and the least privileged (most deprived) being quintile 5. These quintiles were referred to as socio-economic deprivation quintiles (S-EDQs) in the rest of this document.

Up-to-date for measles vaccine: To be regarded as up to date at 24 months, a child must have received two valid doses of measles vaccine between the ages of 365 and 731 days. The Saskatchewan routine immunization prescribes that any child receiving 2nd dose between 18

months and 24 months is considered to be on-time and with appropriate and complete measles containing protective vaccination.

On-time for measles immunization:

On-time for first dose at 1year: the child must have received 1 valid dose of measles vaccine between 365 and 425 days of age. All children receiving 1 dose of measles vaccine outside these ranges are not considered to be on-time and up-to-date and hence not included in the analysis.

On-time for second dose at 24 months: – the child must have received 2 valid doses of measles vaccine between 544 and 731 days of age. All children receiving a second dose of measles vaccination outside of 731 days are not considered on-time for 2nd dose of measles immunization.

Joinpoint: The Annual Percentage Change (APC) and Average Annual Percent Change (AAPC) are employed to summarize and offer comparison to the rates of changes that may not be constant over a given time period. The rate of change increases on average over the selected time period if the lower confidence limit of the AAPC is positive, or the rate of change decreases if the upper confidence limit of the AAPC is negative (4). It has been used by studies to identify any significant changes over a time period(5, 6) and to predict the outcome of diseases (7)

Anti-Vaccination: This is a state of being against, antagonistic to vaccines, vaccination and its procedures. Anti-vaccination wiles and guiles appeal to concerns, fears and social issues that bother citizens of nowadays which range from lack of trust in medical professionals, parenting regulation, cover-ups or pharmaceutical profiteering claims.(8)

Vaccine Hesitancy: This term is difficult to characterize. However, it may be described as a state of unwillingness, reluctance or refusal to vaccinate or allow one's child/children to be vaccinated or a disinclination towards vaccinating. It may also be used to describe delays in uptake. These actions may be directed to all vaccines or particular types of vaccines.

Chapter 1: Introduction

The chapter gives a general overview of the research study, the rationale for the study and discuss existing research gaps. It also states the objectives of the study, puts some context into the significance of the study while providing definitions of some of the terms and concepts used in the document.

1.1 Overview

Canada is a world leader in public health practices and research. Its publicly-funded health care delivery system managed through dynamic reforms is rated among the best in the world. It provides universal coverage for necessary health care services based on need rather than ability to pay (9). The basic values of fairness and equity is demonstrated by the responsibility to share resources among the Canadians (10) and a great part of the channels of collective disease control well established in Canada is immunization services. Recent years have seen a rise in research on measles immunization. Awareness is also on the increase on the rights and responsibilities of provinces and territories to ensure adequate vaccination to prevent vaccine-preventable communicable diseases.

Despite Canada's progress in the area of immunization policy and research, the concept of herd immunity threshold (HIT) remains current in the light of measles resurgence in parts of North America in 2019 (e.g. British Columbia and New York). Many studies have looked at the challenges to achieving the concept of herd immunity threshold (11) with dominant emphasis on the challenge of incessant measles outbreaks (12-15) and resurgence in the recent past (14-16) . Some studies have also documented the specific actions taken by some countries to address outbreak. (17-20)

These studies and actions are signposts and evidences that measles, which remains a preventable disease, may be staging a comeback, even in some of those places where endemicity have been ruled out and where elimination status has been well established. This research touched on the relevant topics within the scope of available evidence and provided information on the study rationale and existing research gaps. It also put a searchlight on the province of Saskatchewan's progress, challenges and opportunities toward achieving measles herd immunity threshold from the providers' perspective.

1.2 Defining the problem

Among several infectious diseases, measles has received prominent attention internationally due to its high rate of infectivity (21-23). As an airborne infection caused by a highly contagious virus (24), it causes debilitations, morbidity and mortality among the infected (25, 26), with possible grave complications and sequelae such as sub-acute sclerosing pan encephalitis (SSPE)—a brain inflammation from persistent measles infection occurring in about 1 in 10,000 cases. It has been documented that death is a possible complication in about 1 in 1,000 cases and pneumonia in 1 out of 20 children with measles (27)

Core to reducing the impact of diseases both on the health care financing and for the well-being of the Canadians is disease prevention achieved through immunization, which has been proven to be useful in the control and elimination of life-threatening infectious diseases (26, 28, 29). Because of its proven ability to control diseases over the years, immunization is seen as the most successful public health measure to date (30, 31) and an advancement in disease prevention ever known, enabling prevention of disease at a population level and averting between 2 and 3 million deaths globally each year (29, 31). According to the World Health Organization (WHO) (2016), measles vaccine prevented about 20.3 million deaths between years 2000 and 2015 (32) resulting in 79% drop in measles cases within that period. Immunization is hence said to be the most cost-effective health investments of all times. (33-35)

1.3 Purpose and Objectives of the Study

The overall purpose of this research was to examine the measles immunization coverage among health regions in the province of Saskatchewan, Canada and explore the barriers and enablers to achieving herd immunity threshold in the province. The research further aims to analyze trends in coverage in various geographical quintiles of deprivation in different regions of the province using equity lens while bench-marking with programs and policy changes during this time period.

1.1.1 Specific objectives:

1. To evaluate the disparity in immunization coverage for measles among children aged 12 to 24 months in Saskatchewan health regions between 2002 and 2013.

2. To explore factors affecting measles immunization coverage rates within Saskatchewan health regions and barriers to the achievement of herd immunity threshold.

1.1.2 Research Questions

The two objectives above were addressed using the following research questions:

1. What demographic characteristics (age, socio-economic and locational characteristics) are associated with measles immunization coverage in Saskatchewan?
2. What are the differences between and within Saskatchewan health regions measles immunization coverage among children aged 12 and 24 months between year 2002 and 2013?
3. What are the facilitators and barriers to achieving herd immunity threshold (92 – 95% coverage) for measles immunization coverage in Saskatchewan health regions?
4. From healthcare provider's perspective, what policy interventions and innovations are required to improve equitable measles immunization coverage rates in Saskatchewan?

The first two research questions (1 and 2) address the first objective while the second objective is addressed using the research questions 3 and 4.

1.4 Significance of the Study

Policy responses in Canadian provinces and territories have been to align practice with the 2-dose measles antigen-containing vaccination recommendation by World Health Organization (WHO) (36). Although this is often applied with some variation among the provinces, the spaced 2-dose approach is believed to offer adequate protection against future infection from measles virus exposure. While the first dose is consistently offered at the age of 12 months, the timing of the second dose varies across Canadian provinces and territories. For example, Saskatchewan and 6 other provinces offer the second vaccine dose at 18 months, while the rest of the jurisdictions administer the second dose ranging from 3 to 5 years of age (37).

Despite a strong institutional and organizational medical arrangement, immunization is not mandatory at the national level in Canada. However, some provinces such as Ontario, New Brunswick and Manitoba require proof of immunization for school entry through legislation, while a greater number of other provinces do not (38). With the variations in the legal, policy and practice approach to vaccination, measles infection remains a source of concern in

preventive medicine practice and research communities. The recent re-emergence in some pockets of the population in Canada casts a doubt on possible elimination. (37, 39, 40) Some studies have linked the re-emergence with a low level of herd immunity threshold (HIT) for the disease. (41) In particular, low population coverage with the recommended 2-dose regimen for measles vaccine by age of 2 years has been flagged as a causal factor. (19)

It is believed that infection with measles virus induce humans with life-long immunity, however, it is not uncommon for natural booster infections to support this immunity. (42) A study compared the immunity levels of vaccine-induced measles antibodies over a 12-year period using Hemaglutinin Inhibition and Neutralization tests and found that the primary doses induced 99.4% sero-conversion (43). It is to be noted that the role of the booster immunity which is believed to exist is not very clear and was said not to have been taken into account in that particular study.

The WHO advocates a 92-95% HIT for a feasible population health protection against measles infection (26, 44). While reflecting the commitment to the WHO disease elimination commitments, Canada set the goal of achieving 95% for one dose of measles vaccination by 2 years and 2 doses by 7 years (45). In Saskatchewan, available reports revealed measles coverage in 2014 was 75.3% for 1-dose at 2 years and 91% for 2-doses at the age of 7 years (46). The 2016 Childhood Immunization Quarterly Report available in September 2016 indicated 2-year old measles coverages ranging between 63.6% and 86.4% among the various regional health authorities (47) and for 2018, 79.9% with a range of 69.1% to 93.2% (48).

Efforts have been made to unravel some of the factors that may be responsible for measles reappearance (15). The WHO's release on the top 10 threats to global health in 2019, noted that the factors rated as numbers 7 and 8 respectively were weak primary health care and vaccine hesitancy (49). Immunization is one of the major prerogatives and gratuities of a virile primary health care sector of any health system. With emerging vaccine hesitancy and a re-surfacing of weak primary health care, to cope with routine immunization, population health education and awareness, a compounding challenge may be brewing. This is because a prolific primary health care system is required and core to develop a sustainable framework for tackling vaccine hesitancy and to conceptualize and implement an effective immunization program

Immunization coverage rates disparities in a population is one of the prominent indicators of health inequity (50, 51). The United States Center for Disease Control (CDC) regards childhood immunization activities as one of the programs through which health inequities can be targeted for reduction (52, 53). When there is equitable coverage and high level of coverages, vulnerable populations with supposed higher predisposition to infection from disease causing pathogens will have protection since the chain of vaccine-preventable and communicable disease spread is broken (54). The vulnerable populations in this instance include the pregnant women, the children under the age of one year, the immune-compromised, people on cytotoxic medications and people on medical exemptions. Working to achieve equity requires a decisive approach to address the choke-points of existing policies, programs and targeted activities. In a like manner, working to improve coverage among the low-coverage groups has been demonstrated to be more efficient at addressing equity in the short term and ultimately on the longer run. From a population health perspective, the greatest danger of measles is not the sporadic or isolated cases that occur, but the possibility of spread to susceptible population groups especially the non-immune in places with lower than 95% coverage. This required level of coverage to prevent the spread of vaccine-preventable infections from turning to epidemic is referred to as the required herd immunity threshold for prevention (41, 55).

Internationally, research into how widespread equity gaps are in childhood immunizations exists but very little is known from the Saskatchewan context. The persisting existence of a significant percentage of unimmunized population leads to a state of high susceptibility and infectivity among those vulnerable groups with unplanned public health expenditure and unimaginable outcomes (56). In the light of social determinants of health as affecting health outcomes coming into prominence, public health institutions are becoming more aware of the effect of health inequalities and hence inequities, however, evidence is not rife as to whether the efforts, if any, has had impact on the equity gaps. Understanding trends in small-area geographical differences that occur in measles immunization coverage and identifying factors and drivers of higher coverage in some other geographical sub regions than others will be a valuable contribution to improving immunization policy development and implementation practices in the province, in contextually similar Canadian and international jurisdictions.

Previous studies looking at immunization uptake in the province of Saskatchewan have examined the perspectives of the caregivers (54), but none has looked at the perspectives of the health care providers as an important contributor to understanding coverage issues. Also, while previous studies in Saskatchewan have reported on the coverage, they have not reported on the on-time for age for measles immunization which is one of the layers this study is adding to the existing information. Timeliness of immunization is shown to be a key indicator in program performance (57). To underscore the importance of assessing for vaccine delays, the impact of such delays on subsequent vaccines and hence compromised protection from vaccine-preventable diseases have been looked at in other jurisdiction in Canada (58). Publicly-available statistics data show an unequal measles immunization coverage distribution among health regions in the province of Saskatchewan and within different geographical quintiles within health regions. Apart from the large regional health authorities such as Saskatoon and Regina Qu'Appelle Health Regions that had carried out studies to document the coverage within their jurisdictions, no other previous study has looked into coverage rates among all the health regions within the province at a sub-regional level and analyzing trends in these coverages within various quintiles of deprivation. There has also not been any study carried out at the provincial level that looked at program and policy change during this time period with the aim of matching factors responsible for improved coverage in a particular geographical location as compared with others; to inform on what could be done differently to achieve a better coverage in others with lower coverages.

In the light of the above gaps in knowledge and literature, it thus becomes imperative to investigate how coverage disparity and low herd immunity is understood by decision makers, how such evidences are communicated through policy and health care providers to the public, consensus on modalities and interventions and how this affect measles vaccine containing antigen uptake with overall effect on the herd immunity threshold for the immunization against measles infection.

This thesis follows a traditional approach with literature review in chapter two.

Chapter 2: Literature Review

2.1 General Scope of the Literature Review

The section provides an overview of health equity as it relates to immunization and coverage. It starts off with the global action towards achieving health equity and then explores the Canadian effort and the Saskatchewan experiences. It provides information on measles epidemiology, burden of the disease while addressing the current issues surrounding the herd immunity threshold. It addresses specifically the Saskatchewan platform for data management and the various constellations of groupings that were used in understanding the analytical frameworks used in later chapters. Since measles outbreaks are at the centre of the burner currently, effort was made to look at the various theories that impact measles immunization coverage and the achievement of herd immunity threshold.

2.2 Global Action for health equity

The World Health Organization (WHO) defines equity as follows:

> Equity is the absence of avoidable, unfair, or remediable differences among groups of people, whether those groups are defined socially, economically, demographically or geographically or by other means of stratification. 'Health equity' or 'equity in health' implies that ideally everyone should have a fair opportunity to attain their full health potential and that no one should be disadvantaged from achieving this potential (59)

The organization further defined health inequities as systematic differences in the health status of different population groups and with its attendant economic and social costs to individuals and societies. Kawachi et al. (2002) and the Canadian NCCDH (2011) both distinguish between health inequality and health inequities. While (NCCDH, 2001, p.7) refers to *health inequality* as the "generic term used to designate differences, variations, and disparities in the health achievements of individuals and groups", *health inequity* "refers to those inequalities in health that are deemed to be unfair or stemming from some form of injustice" (60)

The World Health Organization (WHO) is integrating social determinants of health to address health equity through locating them in strategic and operational plans of country offices, regional offices, and headquater plans, also in programs and monitoring tools using the approach of addressing health in policies and across all sectors (61). This is embedded as part of the Sustainable Development Goals (SDGs) during the Health Assembly of 2014, leading to the adoption of Helsinki Statement and the resolution WHA67.12 endorsement. (61).

In 2010, it became apparent to world leaders that action across sectors was important, and hence, due consideration was given to health in cross-cutting policies as one of the ways to improve equity in health outcomes. This sectoral actions and health in policies was a fallout of the Health in All Policies (HiAP) in Adelaide (62) where there was a determined effort to advocate for policy responses to actively target social determinants of health aimed at reducing health inequity. The year 2012 heralded the approval of measures to support the five priority actions to address social determinants of health during which time the Rio declaration was endorsed by the 65th World Health Association (63). Subsequent to Rio declaration, there was the call for the acceleration of universal health coverage and implementation of large scale public health measures to address SDoH across all policies in all public and private sectors (64).

While all the milestones are essential to be taken into consideration and implemented, to monitor health equity and social determinants of health (SDOH), the system must be able to recognize the causal chain choke-points. Some of the rate-limiting steps are health service barriers, health determinants, and their outcomes. The role of SDOH and health inequities must be clearly understood, and carefully articulated measures put together for evidence-based action towards mitigating the impacts. This effort, however, will not be realized without reliance on concrete political efforts and strategic alignments of social and environment health determinants capped with regular skills development and capacity enhancements of the implementing people and partners providing sustainable development at all levels.

2.3 Deprivation and Equity issues

Health disparities is the differences in health status occurring among different population groups defined by specific characteristics (65). The differences in the health status mostly result from inequalities in the distribution of the underlying determinants of health across populations. In population health study, disease distribution and health inequalities caused by the underlying determinants can be explained using two main theoretical lenses, material and psychosocial interpretations. The *material interpretation*, emphasizes the graded relation between socioeconomic position and access to tangible material conditions such as food, shelter, and to other services and amenities (66). The *psychosocial interpretation* on the other hand focuses on the direct or indirect effects of stress stemming from where an individual belongs to on the socio-economic scale or living conditions (67).

While the interpretations above suffices to put some perspectives into the relationship between underlying determinants and the sequelae, the important factors associated with health disparities in Canada have been highlighted as geographic location, socio-economic status (SES), Aboriginal identity status which are embedded in colonization as determinant of health, and also gender, all of which are interrelated and interdependent factors (68). Some suggest that income status, educational status and occupational status are strongly interrelated and determine occurrence of ill-health or absence of it (69). The Health Disparities Task Force Group of the Federal/Provincial/Territorial Advisory Committee on Population Health and Health Security indicated that Canadians in the bottom SES quintile are five times more likely to rate their health as fair or poor as people in the highest (65) and it is also indicated that Canada's northern remote community dwellers have the lowest disability-free life-expectancy (DFLE) within the country. The quality of health services including the distribution and accessibility of it, are also associated with health disparities (65).

The lack of financial resources may be sufficient explanation for poor health outcomes. Low socio-economic deprivation levels have been associated with inability to make healthy choices, living in poor physical structures with its attendant health risks with life skills decision at the lowest ebb. This cycle may linger on for generations to come. As a result of higher severity and level of illness sequelae, people in the lowest socio-economic positions utilize health services more than those in the highest quintiles. (70) It is also noted that the health disparity among this group of people persist despite the fact that there is higher recourse to health services usage. To bridge this gap, Canada ensures financing of health services to foster health services access to residents in the lower socio-economic deprivation quantile and others in the country in order to reduce health disparity.(70) However, it is not clear if these goals have been fully met and to what extent if already sustainably met. It has been consistently indicated that health disparity wherever it may exist and in whichever form, is inconsistent with Canadian value the impact of which is felt by every member of the society. This impact is felt directly or otherwise irrespective of what SES the individual belongs to and such situation may threaten the togetherness and collective responsibilities of the communities and impact the wheel of economic improvement and overall achievement.

2.4 Canadian Health Equity Effort

The 2003 Accord (71) which positions Canada health sector as a leader in the annals of reduction of health disparities through the myriads of health strategies implementation is a culmination of decades of policy development and monitoring, evaluation and modification. This health disparities reduction efforts agenda is being constantly promoted and deeply entrenched within all government structures. While inequity is a central concern in ecological perspective, interventions coming from this approach may sometimes reinforce inequity in some populations especially if there were unaddressed social determinants of health. This is exemplified in an ecological approach to health promotion in remote Australian Aboriginal communities which could not improve with the meso-level interventions unless the underlying issues of social determinants are also addressed (72).

Canada has lot of auspicious initiatives in place, some of which are inter-sectoral collaborations, facilitation of the public, private and voluntary sectors disparities reduction initiatives, continued research into the socio determinants of health (SDOH) within the academic environment and even among the government parastatals. There is the targeted community programing and responsible reporting with support to all government instruments to make health disparity reduction an on-going public policy and a regularly addressed endeavor in all spheres of engagements. While there is political commitment at all levels of governance, federal, provincial and regional authorities, there also is the commitment and support to the Public Health Agency of Canada and the Federal Ministry of Health. The PHAC also had developed Health Inequalities Data Tool (73) and also released a 2018 report on health inequality in Canada (74) In addition to the above efforts, Canadian Institute for Health Information (CIHI) in collaboration with experts developed equity stratifiers that could help with health inequality measurements (75). With all these efforts in place, all is not perfect and there is the need for improvement in frameworks, and collection of the required data to test and improve them.

2.4.1 Canada effort to improve immunization uptake

Preventive efforts of communicable diseases continue to take the lead in the approach of the Canadian government towards achieving all-encompassing health care delivery. As part of the government effort to improve acceptance of vaccine and hence boosting coverage within all the communities in Canada, Canadian Immunization Resource Centre project was created in July

2017 facilitated by PHAC and funded by the Immunization Partnership Fund (76). The Resource Center project makes available resources and tools from the Canadian Vaccination Evidence Resource and Exchange Centre referred to as CANVax (https://www.canvax.ca). The CANVax is being promoted as partly a do it yourself as well as managed platform for immunization information, outbreak alert through interactive maps as well as access to provincial vaccination schedules.

Evaluation and feedback are great ways to check whether or not a program is on track to achieve its set objectives and targets. The Canadian government through support to the Public Health Agency of Canada compiles weekly report on the various vaccine-preventable diseases while such information is publicly available for planning purposes. Also, in the area of prevention of communicable disease through immunization service provision, several scholarly works have reported the approach of targeting immunization service to the geographical pocket based on scanning for evidence of inequity (54, 77-80) and addressing those for evidence-based and improved population health interventions. This study looks at variation in vaccine coverage by small area geography with a socio-economic lens in Saskatchewan so that the evidence uncovered may contribute to policy and practice.

2.5 Measles Epidemiology

2.5.1 Measles disease

Measles is a highly contagious viral illness which was described as far back as the 7th century (81-84). It caused an almost universal childhood infection in the pre-vaccination era (85, 86) with infection being commoner in the developing countries where it is often fatal (81, 87, 88). It is estimated that from a single measles case, about 12 to 18 people are at risk of being infected (89); the probability of transmission being influenced by the level of herd immunity, the concentration of people within a geographical location and the absolute population size. The infectivity is also affected by mobility of people and the attendant social interactions. The measles virus is a highly contagious type that lives in the nose and throat mucus of an infected person (90). The infective measles virus carried in droplet form is easily transferred by coughing or projected through sneezing. It may remain in airspace for an upward of two hours in fine droplet form after the release from the diseased person or the offending source without losing its infectivity (26, 44).

Measles is a human disease that does not infect any other animal species. Infected humans are able to spread the virus from four days before and four days after the appearance of the characteristic rash (44) thus enabling possible infection among the susceptible population, sometimes before identification, diagnosis and index case isolation. The typical disease episode cause intense debilitations, morbidity and mortality (25, 26) characterized by fever, runny nose, cough and reddened eyes followed by maculopapular rash around the face that spreads to the chest, arms, and legs within a few days. The rash occurs approximately 14 days following infection and two to four days following onset of prodromal symptoms.

The most common complications of measles include otitis media and pneumonia; however, a more severe complication like subacute sclerosing pan encephalitis (SSPE), a brain inflammation from persistent measles infection can occur in about 1 in 10,000 cases (91). The SSPE, as a complication of measles is a fatal condition which currently has no treatment (26, 35). Death has also been documented as a possible complication among 1 in 1,000 cases, however this ratio varies with the country's health systems and the infected pre-existing conditions (27, 92) Infection with measles may complicate other physiological conditions and states like pregnancy for example, contracting measles during pregnancy can result in spontaneous abortion, or premature labor and/or underweight newborns (93, 94). In immunocompromised persons, there has been reported prolonged severe infections especially those suffering from human immunodeficiency virus (HIV), lymphomas and certain leukemias (95). It is noted that measles may present in these conditions with an atypical rash masking the diagnosis, and shedding of the virus may occur for longer than usual (95, 96).

2.5.2 Measles Case Definition

The case definition for measles is important to be explained to give a better understanding to the reader so that we are able to distinguish between suspected measles and confirmed cases of measles. There are currently two methods to confirm measles cases, laboratory and clinically. Measles confirmed cases were defined by the British Columbia Centre of Disease Control (BCCDC) as 'either laboratory-confirmed or clinically confirmed in the absence of recent measles-containing vaccination (<28 days)' (97).

Laboratory confirmed cases were characterized by either isolation of measles virus from an appropriate clinical specimen, detection of measles virus RNA, seroconversion or a

significant (4-fold or greater) rise in measles-specific antibody titer between acute and convalescent sera, or positive serologic test for measles immunoglobulin (IgM) antibody using a recommended assay in a person who is either linked epidemiologically to a laboratory confirmed case or who is in or recently travelled to an area of known measles activity (97).

Clinically confirmed cases were defined by fever (≥38.3°C), a generalized maculopapular rash for at least 3 days, and either cough, coryza, or conjunctivitis and must be epidemiologically linked to a laboratory-confirmed case (97). Potential cases with recent immunization with a measles-containing vaccine (MCV) were excluded.

2.5.3 Mode of Transmission

The transmission of measles occurs through person-to-person contact or from coughing and sneezing as airborne spread. The virus of measles is known to survive for up to 2 hours suspended in the airspace in aerosolized form and infectious to individuals who come in contact with that contaminated space (90). It can also be transmitted by fomite from an infected surface if individuals come into contact with such surfaces and touched their faces, nostrils or eyes after contact with such contaminated surfaces (90). The severity of illness if it happens and when it happens of an infective agent in an at-risk population is measured by the attack rate. For measles, an attack rate of up to 90% has been reported with easy transmission occurring in overcrowded areas like airports, schools, densely populated communities etc. (90)

2.5.4 Understanding Herd Immunity and Reproduction number

Herd immunity is described as a form of immunity that occurs when there is a measure of protection of individuals who have not developed immunity in a given geographical location as a result of the vaccination of a significant proportion of the given population, also referred to as the herd. It is said to be present when a sizable or significant population percentage is protected through vaccination against infection from a virus or bacteria which makes it difficult for disease to spread to others because the susceptible people left to infect are few (86, 98, 99). It enables the protection of vulnerable people such newborn babies, older adults, or individuals who are too sick to be vaccinated and the immunocompromised (e.g. HIV infected with compromised immunity or those on anticancer or cytotoxic medications). It is particularly crucial for protecting

people who cannot be vaccinated because it can effectively stop the spread or propagation of an existing disease in the given community.

The term "herd immunity" appears to have been used first in 1923 in a paper titled "The spread of bacterial infection: the problem of herd immunity" published by Topley and Wilson (100, 101). In this paper, the researchers suggested, after their experiments, that infections spread occurred with difficulty among a population where each individual has been actively immunized and that in a given population where there's a sizable number of people who have not been actively immunized, the resultant immunity conferred do not stand against epidemic as the spread of the disease will occur. It therefore follows that the degree of immunity, which may save possible individual hosts when existing among equally resistant companions, may be reduced to no effect when they are co-existing with highly susceptible individuals. Subsequently, Black (1982) and Schlenker et al. (1992) both referred to this phenomenon as "the particular threshold proportion of immune individuals that should lead to a decline in incidence of infection" (86, 102).

To have a better understanding of the herd immunity threshold, the concept of reproduction number needs to also be explained. The average number of other persons that an infectious person will or can infect with an agent in a new susceptible population is termed the basic reproduction number (R_0) (98) which also may be summarized as a measure of the transmission potential of a particular disease. This basic reproduction number differs between infectious agents and depends on and it is a function of the infectiousness and the virulence of the offending agent. This infectiousness is affected by factors such as the infectious dose, survival in the environment, the duration of infection in the host (98, 102). R_0 may differ between population groups depending on the population density, which may affect the number of effective contacts a person has while he/she is infectious. Seasonal variations have also been reported to affect the R_0 in some environments. Two terms may seem similar, but they mean different things and are not interchangeable. These two terms are basic reproduction number and effective reproduction number. The basic reproduction number was defined in this section earlier. The effective reproductive number (R) on the other hand is the average number of secondary infections per one infectious case present in a population made up of susceptible and non-susceptible hosts (103). However, for herd immunity threshold calculations, basic reproduction number is used.

The proportion of a population that needs to be immune to lead to stability of an infectious disease in a community is herd immunity threshold (41, 103); if as a result of immunization this level is reached, it therefore follows that each infectious case will produce one new case leading to the stability of the infection within the population. This translates to R being equal to 1 in a state of equilibrium. When the $R_0 > 1$, there is a high tendency for epidemic while $R_0 < 1$ translates to the disease dying out over time.

$$HIT = \frac{R_0 - 1}{R_0} \quad \text{or} \quad 1 - \frac{1}{R_0}$$

The herd immunity threshold is an important and significant measure used in the control of infectious diseases, in immunisation interventions and also programmes targeting eradications. For measles, the R_0 is between 12 and 18. This translates to the fact that between 92% and 95% of a population needs to be vaccinated to offer protection against possible measles transmission and subsequent epidemic. It is to be noted that different diseases have different R_0 and that the required herd immunity for such disease will depend on the virulence of the agent of the disease or the infective pathogen.

2.5.5 Arguments for and against Herd Immunity Threshold (HIT)

The herd immunity threshold concept provides an important epidemiologic attribute with which to characterize and understand any particular infection. Health-care professionals indicate that a community needs at least 95% of its population (using measles as the point of reference) to be immunized in order to ensure “herd immunity”, or the idea that people who are not vaccinated, or cannot be vaccinated for a variety of other medical issues, will be protected when surrounded by a highly vaccinated population. (41) However, the safety of everyone, even those who are vaccinated, relies on the vaccination coverage rates of the community.

There had been different perspectives as to whether or not herd immunity is important in population prevention. In a recent work by Bester (2017), he argued that herd immunity achievement is inferior to actual vaccination. (104) This may be true in part, because in any society, getting every child vaccinated ultimately will offer the best outcome in terms of immunity for the entire population, however, in a community where the push for increased uptake of measles containing vaccination is a challenge, the achievement of herd immunity is a

desirable and good outcome. Holland and Zachary, (2014) also suggested that parents should be allowed to voluntarily determine what is good for their children based on information availability and provision backed by state-imposed higher level of information demand by parents to achieve herd effect rather than on compulsory immunization to achieve herd immunity requirements in the United States. (105) Also, whatever desire we have in terms of absolute and total vaccination, this may not be feasible because for as long as there is the vulnerable group of people, there will also be desire for looking into a target herd immunity threshold rather than total vaccination of the population group. It is to be noted that there have been more advocates of herd immunity achievement (55, 106-110) than the sporadic arguments which challenge the need for the concept.

2.5.6 At Risk population

Measles, a highly contagious disease is more common among the un-vaccinated children who are said to be at highest risk of the disease complications such as brain damage and death. Pregnant women without vaccination against measles are also at risk, and so are people who did not sero-convert after measles vaccination (111). There is a higher incidence of measles in many developing regions, Asia, Africa especially where weak health systems and infrastructures play a major role in grave measles consequences. Some other factors may increase the risk of a population to measles such as overcrowding, natural disasters and conflict.

2.5.7 Global Burden of Measles disease

Measles occurs worldwide, however, control efforts have substantially changed the global distribution of the disease and its incidence has decreased substantially in regions where vaccination has been instituted, and as a result, measles occurs largely in areas with low vaccination coverage rates, especially in the developing world. During the pre-vaccine era, more than 90 percent of children acquired measles by the age of 15 months (112, 113). Measles is the fifth most common cause of death in children <5 years of age (114). Before the introduction of measles vaccine, over two million deaths occurred annually, the majority being in children <5 years of age. Availability of measles vaccination beginning in the 1960s immediately impacted disease incidence and mortality rates. Despite the advancement in the field, measles continues to be a significant cause of morbidity and mortality. Precise incidence estimates are challenging to

obtain because of non-harmonized surveillance systems and probable under-reporting in some quarters.

Worldwide, there is huge variations in vaccination rates. This variation is reflected in the measles cases reported. There were an estimated 145,700 deaths in 2013 which was reported predominantly in the developing world.(115) This reduced to 134,200 deaths at about 367 deaths every day in 2015, with deaths being mostly among children under the age of 5 years (115). Consistent and aggressive immunization activities have reduced measles deaths by about 79% from an estimated 651,600 in year 2000 to the estimated figure of 134,200 in 2015; and the public health interventions world-wide prevented an estimated 20.3 million deaths between 2000 and 2015 (115)

The statistics from the World Health Organization which is compiled from case-based or aggregate surveillance system from member states report reflected that measles cases reported annually between 2000 – 2014 decreased by 69% from 853,479 to 267,482. Measles incidence also experienced 73% reduction from 146 to 46 cases per million (116) This, however, did not spread evenly as there was a drop from 65% in 2013 (113 of 175) to 58% in 2014 (98 of 169) in the number of member states reporting <5 cases per million. In the periods 2000 and predating 2014, the region of the Americas maintained measles incidence at <5 cases per million, but in 2014, there was an increase in the number of cases as a result of outbreaks which happened in Brazil and United States with 727 and 667 cases respectively (116) This had a spill-over effect to Canada with reported outbreaks in some major cities like Toronto and Quebec city.(16) In a recent data from WHO, 110,000 cases of measles death were recorded in 2017 (111), the deaths occurred mostly in children, despite the availability of prevention with effective vaccine. While we had up and downward swings and trends in the number of cases in the world over, the advancement in prevention efforts and upscaling of efforts continue throughout the world; and in 2018, WHO puts the measles death prevented with vaccination between 2000 and 2017 at 21.1 million worldwide (117).

2.5.8 Canada Measles burden

During late 1950s in North America and before the measles vaccine was introduced, there was a very noticeable reduction in measles-related deaths and case fatality rates in the United

States, which was thought to be as a result of health care improvement and better nutrition (118). From 1956 to 1960, an average of 450 measles-related deaths were reported in the United States each year compared with an average of 5,300 measles-related deaths during 1912–1916 (118). Nevertheless, in the late 1950s, serious complications due to measles remained frequent and costly. As a result of measles virus infections, an average of 150,000 patients had respiratory complications and 4,000 patients had encephalitis each year (118). These complications and other forms of debilitation resulted in an estimated 48,000 persons with measles being hospitalized every year (118).

In Canada, measles has been a reportable disease since 1924. (119). However, it was noted by Canadian government that the reporting was not done between 1958 and 1969.(120) In the pre-vaccine era, measles occurred in 2 to 3-year epidemic cycles. 1935 saw the highest incidence of measles with 183,000 cases (770 per 100,000 population). Measles complications which resulted in deaths were very common in the early 1900s while the highest ever reported number was 892 cases which was recorded in 1926. (119).

The trend of measles cases as compiled by the Public Health Agency of Canada and represented in figure 2.1 depicts that of an increasing trend from 1998 to 2018, if we visualize the linear trend line. However, in absolute figures, measles cases had been reducing between year 2002 to 2007 with an increase in cases being observed from 2008, an upsurge in all cases reported between that period happened in 2011 where a total of 748 cases were observed. There was however a reduction in cases since then to the most recent figure of 29 at the end of year 2018.

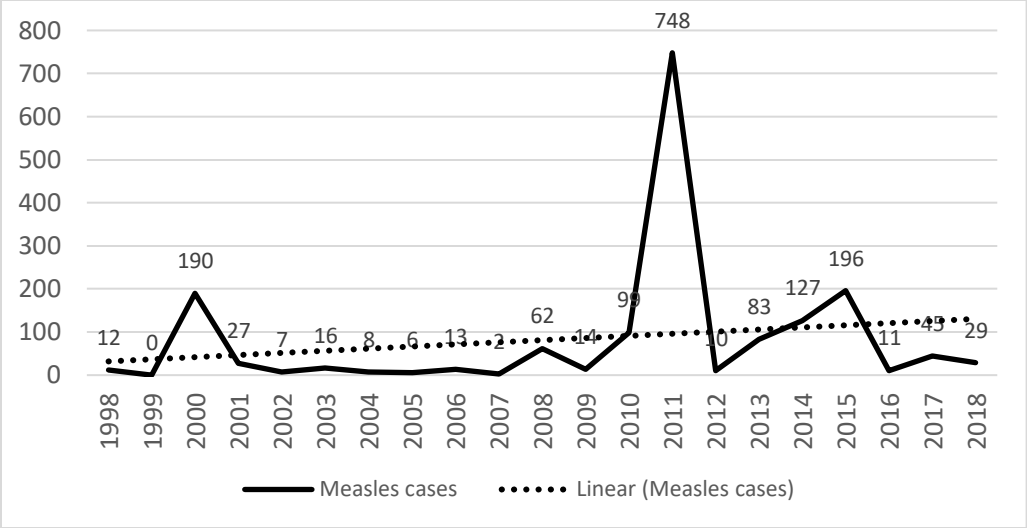


Figure 2-1: Canada Measles Cases by year (1998 - 2018)

In the first quarter of 2019, there is a clear indication that measles is still a potential public health problem in Canada as a total of 28 cases (figure 2.2) were reported (average 2.3 cases per week). These 28 cases have been reported by 5 out of the 13 provinces and territories in Canada. These jurisdictions are Québec, British Columbia, the Northwest Territories, Ontario, and Alberta. It is to be noted that two of these, namely Alberta and North West Territories border Saskatchewan directly in the West and North respectively.

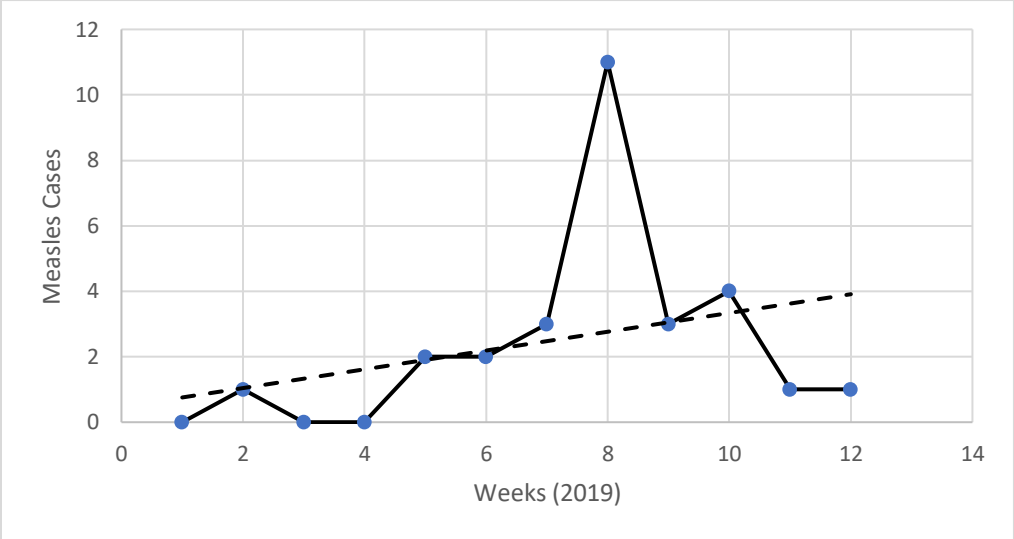


Figure 2-2: Canada Measles Cases by Week (2019) (source – PHAC (April 2019)

Measles is presently not endemic in Canada; however, cases continue to be brought into Canada by infected persons coming into Canada or by susceptible individuals exposed when going to areas where measles is still a threat to human existence or experiencing measles outbreaks. This can lead to potential spread into Canada, particularly in unvaccinated or under-vaccinated populations from travels, tourism and immigration.

2.5.9 Canadian Measles Elimination Efforts

In Canada, measles elimination was a recommended national objective. The National Advisory Committee on Immunization in 1980, emphasized the importance of the elimination of indigenous measles (119, 120). This objective was also reinforced by the Canadian Paediatric Association (121) The initial measles immunization programs implemented in Canada was for a dose of the MMR vaccine. While this one dose approach was in place, there was measles outbreaks in the provinces of Quebec and Ontario in the late 1980s and early 1990s which served as a pointer to the fact that the one-dose program may be inadequate. The National Advisory Committee on Immunization advocated the two-dose vaccine containing measles, mumps and rubella (MMR) schedule in 1992 as informed by research (122), an effort to rid the country of endemic transmission and infection with measles, mumps and rubella endemic viruses.

In 1994, Health Canada joined other Pan American Ministries of Health to set a target of measles elimination in the Western Hemisphere by 2000 (119, 123, 124) Measles elimination was however achieved in 1998 when Canada was declared free of endemic measles infection with subsequent epidemiological and virologic evidence suggesting that endemic transmission of measles has been mostly interrupted since then (119, 124). From that period onwards, the two-dose strategy has proved to be the most cost-effective for measles diseases prevention. Even though these efforts were on-going with a new paradigm shift from one to two dose regimen for measles elimination in Canada, an equitable access was sought to enable every potential beneficiary to have unhindered access to immunization, and therefore there was on-going efforts by the leading health body, the WHO, to achieve that. During the Global Vaccine Action Plan (GVAP), the World Health Organization recommended strategy for a more equitable access to vaccinations and a framework to prevent millions of deaths by 2020.

Two doses of Measles vaccine as MMR or MMRV are currently recommended to ensure good population immunity and for the prevention of outbreaks (125) (126), as evidenced by

studies which showed that about 15% of vaccinated children with only first dose fail to develop immunity against the infection (115). In like manner, a Canada-based research by Ratnan in 1995 found a significant drop in the immunity to sub-optimal level one year following administration of first dose of measles vaccine (127). The research provided evidence that administration of the second MMR vaccine at the 18 month age as being more beneficial, offering a higher level of protection to children at an earlier age (127). Despite this research evidence, about half the provinces in Canada still administer the second dose of measles containing vaccine later than 24 months of age as depicted in table 2-1. All provinces have since operated on the strategy of two-dose MMR vaccination, however, the age at which administration is done varies widely between provinces (128). Since measles transmission is dependent on several factors including population vaccination coverage rates, a high vaccine coverage is needed to sustain measles elimination. This recommended spaced 2-dose schedule infers high levels of individual immunity by reducing the likelihood of vaccination failure.

The federal, provincial, local and public health jurisdictions in Canada are responsible for the prevention and control of measles (129). The National Advisory Committee on Immunization make recommendations for the use of vaccines that are published in the Canadian Immunization Guide and administration is conducted according to provincial and territorial schedules (76) including guidance on the use of currently available vaccines and the new ones which have been approved for use on humans. It also provides direction on targeting vaccination to groups identified to be at risk for vaccine-preventable diseases for vaccination. For primary immunization against measles, the National Advisory Committee on Immunization (NACI) recommends that the first dose of MMRV (measles, mumps, rubella and varicella viruses) be administered at 12 to 15 months of age, and the second at 18 months or at 4 to 6 years of age (preschool) (128).

NACI gives recommendations based on which vaccines are shown to be effective. Despite the presence of NACI as a federal body in Canada, decisions on how and when to act on NACI recommendations are arrived at through budget discussions at the provincial level, since health is a provincial responsibility. Public Health branches at the provincial level put forward their recommendations as to any enhancements to the existing vaccine schedule for the province based on new NACI recommendations, together with information about costs of implementing

the recommendations in their province, and the local/regional epidemiology of the disease in question. Even though NACI gives recommendations based on which vaccines are shown to be effective, a lot of weight on costs of implementing its recommendations has not had adequate emphasis. However, this is slowly changing, as NACI is now starting to factor in cost effectiveness calculations into their recommendations and discussions around vaccine equity are now being included (130). The information on which this is based are who contracts the disease, age of contraction, prevalence of the disease and the severity of illness from it. It is to be noted that location may affect these factors which makes for differences on start of vaccination across Canada. While provinces of New Brunswick, Newfoundland and Labrador, Nova Scotia, Nunavut, Prince Edward Island, Quebec, Saskatchewan and Yukon Territories provide the MMR vaccine with first dose at 12 months and 2nd dose at 18 months of age, the remaining six Canada provinces administer the first dose of the measles containing vaccine at 12 months and the 2nd dose between 4 and 6 years of age (table 2-1). Among the jurisdictions that start later, it is worth noting that Northwest Territories start the administration of the second dose from 3 years of age, about a year earlier than the rest (130)

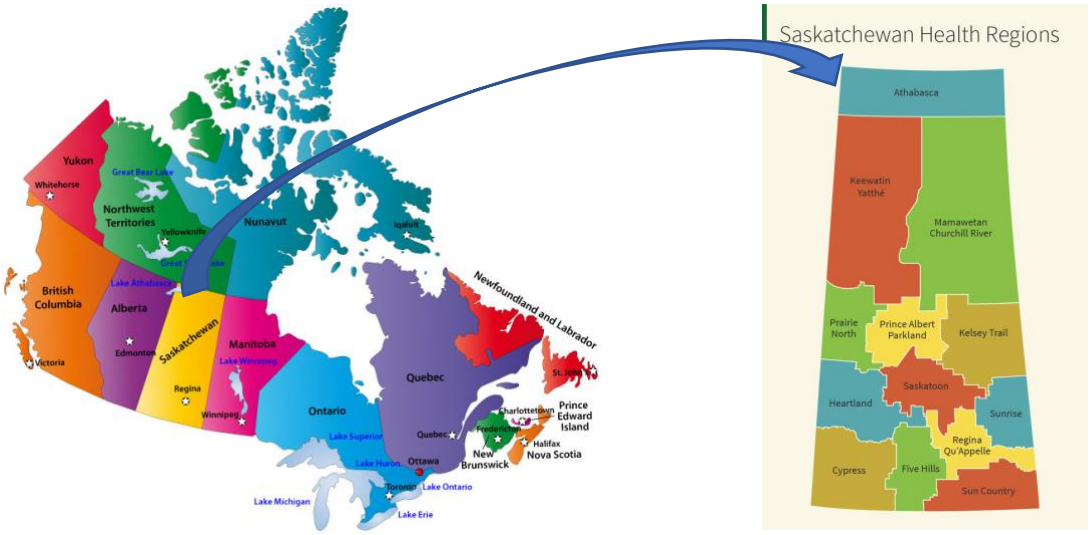
Table 2-1: Canadian Provinces and Age of Measles dose 1 and 2 vaccination.

PROVINCE	**Dose 1**	**Dose 2**	
	From 12 mths	From 18 mths	From 4 - 6 years
Alberta	X		X
British Columbia	X		X
Manitoba	X		X
New Brunswick	X	X	
Newfoundland & Labrador	X	X	
Northwest Territories	X		X (stat at yr. 3)
Nova Scotia	X	X	
Nunavut	X	X	
Ontario	X		X
Prince Edward Island	X	X	
Quebec	X	X	
Saskatchewan	X	X	
Yukon	X		X

While routine immunization is an important service rendered by the primary health care system in Canada, there could be need for catch-up measles immunization, a minimum of six weeks apart is required for MMRV administration which may also be done for the up to 12 years of age group for those not previously immunized with MMRV who are susceptible to these vaccine-preventable diseases. Booster doses are not recommended after the primary series of two doses have been completed. However, for those who have been exposed to measles, post-exposure prophylaxis with MMR vaccine within 72 hours of exposure is recommended from age of 6 months in the absence of any medical contraindications (128, 131). It is to be noted that apart from those 6months and above, the vulnerable groups like under 6 months, pregnant or immunocompromised are also considered for post-exposure prophylaxis with MMR vaccine at a dose of 0.5mL/kg up to 15mL intramuscular immunoglobulins (IMIg) using multiple injection sites for the administration provided injection volume is not a concern (131) (Appendix O)

2.5.10 Saskatchewan Context

Saskatchewan belong to a group of prairie provinces of Canada which is geographically located in the West of Canada. It occupies a large expanse of land of about 651,036 square kilometers and composed of many water bodies. It is bounded by Alberta on the west, Manitoba on the east, Northwest Territories on the north, Nunavut to the north-east and on the south by North Dakota and Montana of USA, with a population figure of 1,163,925 (2017) (132) (Figure 3-2). The weather condition in the province ranges between -45 degrees (-49 degrees Fahrenheit) and 45 degrees centigrade (113 degrees Fahrenheit), in the two extremes.



Map of Canada[1] Map of the province of Saskatchewan[2]

Figure 2-3: Canada map indicating the provinces and the territories and Saskatchewan map indicating the health regions before collapse into one health authority

The economy is driven mostly by agriculture, mining and energy. Saskatchewan is a diverse and rapidly growing province in Canada. There is influx of immigrants, students, business investors and refugees, who are relocating to the province to explore the booming economy (133).

The province of Saskatchewan currently operates through one health authority administratively. Until the collapse of the regional health authorities into one Saskatchewan Health Authority in 2017, the health administration was carried out through Athabasca health authority and twelve other health regions. Under the Saskatchewan Public Health Act of 1994, as amended by Saskatchewan Regulations 88/2003, 69/2014 and 47/2017 (134), health care providers in the province are required to report cases of measles. In line with the National Advisory Committee on Immunization (NACI) recommendations, the Saskatchewan routine measles immunization schedule for infants, children and adolescents are two doses of measles containing vaccine as part of the routine childhood vaccination schedule. The first dose is recommended at one year of age (12 months) with a follow up second dose commencing at 18 months.

[1] map of Canada – www.map-of-canada.org
[2] Province of Saskatchewan map – government of Saskatchewan (available at https://www.saskatchewan.ca/~/media/images/health/healthy%20living/health%20regions/rha.jpg?la=en)

Immunization service provision is fully functional in Saskatchewan and is publicly funded throughout the province. While effort is made to ensure that the public is protected from the occurrence of infection from vaccine preventable diseases, there are sporadic small outbreak of measles cases. Measles vaccination coverage has been progressively increasing in Saskatchewan and high in some jurisdictions but not uniformly high to prevent outbreaks. An observation of Saskatchewan measles cases between year 2011 and 2018 as depicted in figure 2-4 revealed an overall trend of a reduction in measles cases in Saskatchewan as no confirmed cases have been witnessed in Saskatchewan between the period of 2015 and 2018. However, if we look at what was observed in the 2011 to 2015 periods, one could see the picture of a rising pattern the one that could be likened to what existed in Canada (figure 2-1) where Saskatchewan is one of the 10 provinces and 3 territories. However, with the presence of measles in Canada coupled with the fact that the province of Saskatchewan is not meeting the herd immunity threshold to protect against spread of measles, if there is an outbreak, the possibility of spread of cases should a sentinel case be brought into the province may not be precluded.

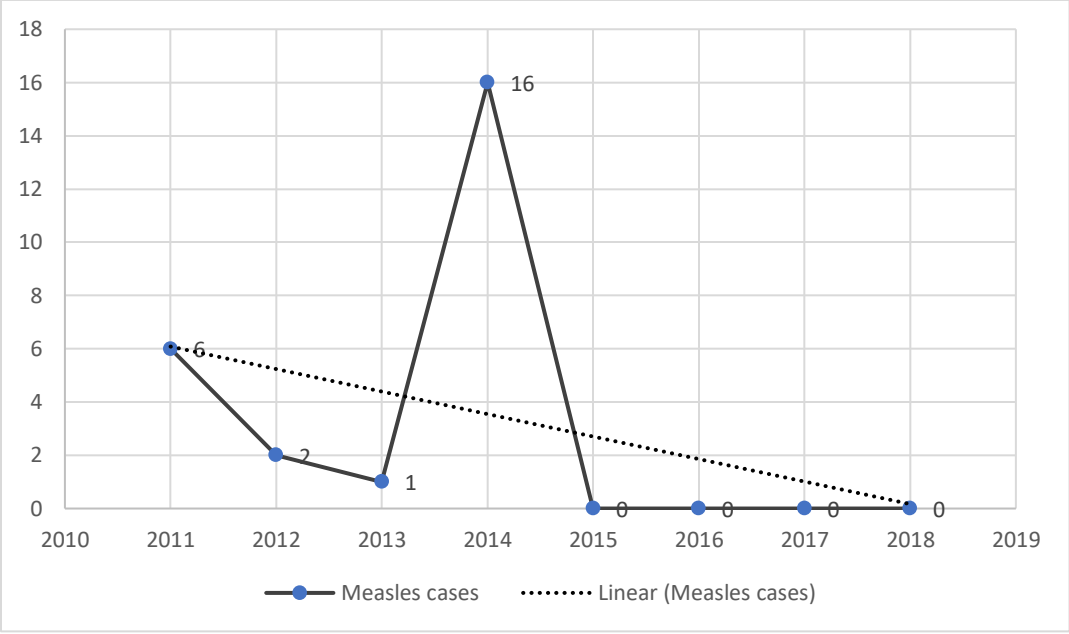


Figure 2-4: Province of Saskatchewan Measles Cases (2011 - 2018)

2.5.11 Vaccine Storage and the concept of Cold Chain in Immunization programs

Vaccines are biological products that require storage in a narrow temperature range to maintain effectiveness. Exceeding these narrow temperature range in either direction can

compromise quality (135). Extremes of temperature can range between excessive heat and freezing temperatures. Some vaccines have extreme sensitivity to freezing while some are sensitive to heat, some to light. In any of these instances, exposure of vaccines to the extremes of these condition causes them to lose their potency. The loss of vaccine potency will result in lack of protection from the disease the vaccine is supposed to protect the population from, even in the presence of a possible high vaccine coverage figures. If vaccines will lose potency when exposed to extremes of temperatures, then what temperature is right for vaccine storage. The loss of potency possibility for a vaccine led to concept of cold chain. A cold-chain is defined as a temperature-controlled supply chain. It is a set of processes and procedures put in place to maintain vaccines in optimal conditions from production, transportation, storage and to the final administration to the prospective recipient (136). Vaccines are either stored refrigerated or frozen with each vaccine having recommended temperatures for such storage. Optimum temperatures for refrigerated vaccine are between +2°C and +8°C (+35°F and +46°F) and for frozen vaccines at –15°C (+5°F) or below. Vaccines are also light-sensitive and should not be exposed to light for an undue long period of time (136).

Currently, three types of measles antigen-containing vaccine are used in Canada, which are MMRII containing measles, mumps and rubella), Priorix (measles, mumps and rubella) and Priorix Tetra (measles, mumps, rubella and varicella) (122). Wherever vaccine is used, and for it to remain potent until administered, there should be an effective cold chain system management in place. In Saskatchewan, to implement effective cold chain management and ensure that no vaccine with a broken cold chain goes unreported, a form titled Cold Chain Break Report (appendix O) has been created for that purpose which is filled by the reporting officer who isolates and quarantines such vaccines away from use while waiting for further directives from Saskatchewan Ministry of Health. Measles vaccines are to be stored between +2 and +8 degrees Celcius.

2.5.12 Measles vaccine and vaccination schedules

The measles vaccine is currently administered as Measles, Mumps, Rubella and Varicella (MMRV) or Measles, Mumps and Rubella (MMR) vaccine as we could see in the current immunization schedule in table 2-2. The schedule was in effect in 2015 when the data collection for this study started. The two-dose regimen that was studied in this research is hence based on

the schedule, so that the results could add to the current knowledge base on the coverage and level of vaccine prevention. The schedule is still current as at the time of this writeup.

Table 2-2: Saskatchewan Child Immunization Schedule

Routine Childhood Immunization Schedule	
Age/Grade	**Vaccines**
2 months	DTaP-IPV-Hib (Diphtheria, Tetatnus, acellular Pertusis, inactivated Polio and Haemophilus influenza type b) Pneumococcal conjugate 13 Rotavirus
4 months	DTaP-IPV-Hib (Diphtheria, Tetatnus, acellular Pertusis, inactivated Polio and Haemophilus influenza type b) Pneumococcal conjugate 13 Rotavirus
6 months	DTaP-IPV-Hib (Diphtheria, Tetatnus, acellular Pertusis, inactivated Polio and Haemophilus influenza type b)
12 months	MMRV (Measles, Mumps, Rubella, Varicella) Meningococcal conjugate C Pneumococcal conjugate 13
18 months	DTaP-IPV-Hib (Diphtheria, Tetatnus, acellular Pertusis, inactivated Polio and Haemophilus influenza type b) MMRV (Measles, Mumps, Rubella, Varicella)
4 – 6 years	DTaP-IPV (Diphtheria, Tetatnus, acellular Pertusis, inactivated Polio)
Grade 6	Hepatitis B Meningococcal conjugate ACYW-135, Varicella HPV (Human Papillomavirus) (girls only until 2017 and boys were included from 2017)
Grade 8	Tdap (Tetanus, Diphtheria, acellular Pertusis)
6 months to 17 years	Influenza (yearly)

(Source: Saskatchewan Ministry of Health, 2012, still in effect as of February 2019 apart from that boys were included in HPV administration from 2017)

2.5.12.1 Adverse Events/Reactions following measles vaccination

An adverse event following immunization is an untoward occurrence associated in time with vaccine administration, and further investigation determines whether there is a likely causal association or not. (137). The adverse event that occurred may or may not be causally associated, and investigation tries to determine this in order to give advice for further immunization and to do surveillance for possible emerging rare side effects or problems with a given vaccine lot.

Canada monitors adverse events following immunization and publishes the results on a regular basis through the Canadian Adverse Events Following Immunization Surveillance System (CAEFISS). The system maintains a structured public health reporting pathway for adverse events following immunization to CAEFISS from the vaccine recipient through the immunization provider, local public health units, the territorial, provincial and federal immunization authorities to the CAEFISS database housed by the Public Health Agency of Canada. (137)

Besides the pathway of surveillance and reporting, the public and the vaccine manufacturer are also closely involved in the monitoring (138). The immunization provider initiates the adverse events reporting and determines the investigations to be done, while further public health action to be carried out would either be at the level of the reporting unit or at the next level, the public health unit. The data from AEFI is shared with Health Products and Foods Branch of Health Canada, which is the Canadian vaccines national regulatory authority, a procedure that enables formal vaccine-related action to be taken if need be (137).

Adverse events are classified into two types depending on the severity, serious or non-serious. Vaccination site reactions, allergic or allergic-like events and rash are the common non-serious cases of adverse events while neurologic events which are often fever-triggered seizures and systemic events are the serious cases reported. Vaccine safety concerns can contribute to under-immunization (139) as a study in the US demonstrated that concerns are very high among the parents and caregiver with under-immunized children. The link between autism and MMR in a publication by Wakefield and twelve other co-authors (140), have contributed to caregivers expressing concerns on the safety of vaccines for their children and that publication contributed to some caregivers to believe that there was a causal link. This publication was subsequently retracted due to concerns about its veracity and quality. In a review of the literature study conducted by Canadian scholars, Doja A & Roberts W., (2006), they demonstrated that very few studies were found to support this theory, while the vast majority of studies showed that MMR vaccine and autism had no causal association (141). Despite the debunking of the findings of the Wakefield study, even with high quality studies like Hviid et al., 2019 that demonstrated with over 5 million person-years of follow-up and proved that the link was spurious (142), and other studies like Jain et al., 2015 that proved that autism risk was not even triggered by MMR vaccination and also that there's no harmful association between Autism Spectrum Disease

(ASD) and the receipt of MMR vaccine even among children with existing risk for ASD (143); the damage done by this one Wakefield article had wide reaching and long-lasting negative effects on people's trust in measles vaccine safety and hence the coverage figures more than thirty years after.

2.5.13 Coverage Disparity

Immunization coverage rates measure the numbers of individuals who have received the appropriate doses by a specific date or age and are a reliable indicator of the preventative measures to control the spread of disease. Differences in immunization coverage within and between health regions or geographical areas have been documented in the literature (54, 144, 145) and differences in health arising from social determinants of health between different groups make it challenging for some individuals and groups to integrate fully in the society.

Several factors influence the rate of immunization including poor access, low education, limited family support and poverty, among others. Saskatchewan also experiences immunization coverage disparities. Evidence from the Saskatoon Health Region (SHR) suggests that incomplete immunization is primarily associated with low income, single parenthood, cultural status, and differences in beliefs (146). According to a SHR 2012 annual report, immunization disparities within SHR exist between rural and urban areas and from neighborhood to neighborhood. The identified core neighborhoods of Saskatoon represent areas with relatively low immunization coverage and have been identified as priority areas for a scaled-up intervention (146). However, with such scaling up, much as it is desirable in the face of limited resources, it may affect coverage in other parts of the health region that currently had good coverage if resources have to be moved around.

In relation to measles coverage, disparity exists across various geographical boundaries and regions in the province. Several factors related to social determinants of health such as income, education, and culture have been attributed to the disparity rates between and within groups in Saskatchewan and also religious beliefs and colony formation have been documented to contribute to the disparity (78, 147)**.** Multiple chains of transmission have been documented among religious communities that actively oppose or resist immunization efforts (119, 148-150).

Although disparities in immunization coverage rates in Saskatoon were of great concern in and of themselves, most areas of the city do not have sufficient coverage rates to offer herd immunity. Coverage rates leading to herd immunity vary by disease, infectious rate and the basic reproduction number; for example, measles is highly contagious with a reproduction number in the range of 12 – 18, thus it is estimated that measles vaccination rates must be in the range of 92 – 95% for herd immunity to occur. These factors differ at an individual or regional level (151). Income inequality also affects the accessibility to the vaccination centers as low income can limit the choices people have or make which inadvertently militate against desirable positive changes of behavior. For example, in 2007, the absolute difference between rural Saskatoon Health Region (SHR) immunization coverage and Saskatoon core neighborhood coverage was between 23% and 28%, depending on the antigen. All the above pieces of evidence in the literature go to say that measles coverage disparity still exists in the province of Saskatchewan, the existence of which could negatively affect the health and well-being of the population should an outbreak take place.

2.5.14 SIMS and Panorama immunization registry

For coverage tracking and keeping the records of immunization activities, every province and territory in Canada maintains its own immunization registry. These registries allow for the identification of each child's immunization status, helps to identify populations that are behind in immunization for follow up activities for vaccine uptake improvement. In Saskatchewan, prior to 2015, the Saskatchewan Immunization Management System (SIMS) has been used, however, this registry was upgraded to Panorama in 2015.

The Saskatchewan Immunization Management System is a client-based registry recording vaccine delivered by Regional Public Health services. This registry system does not include vaccines delivered out of province or by First Nations communities that declined to use SIMS. (152) The Panorama immunization registry of the province of Saskatchewan is part of the pan-Canadian Panorama initiative which is funded through Canada Health Infoway. The system offers a series of enhancements enabling each person who receives public health services in the province of Saskatchewan to have a single, confidential client record, no matter where they receive those services in the province. This leads to improved productivity and effectiveness of public health workers and improved accuracy and cost-effectiveness of the public health system

(153). While SIMS allowed for fragmented reporting, Panorama, on the other hand, incorporates enhanced collaborative reporting among all health regions.

Panorama also has the added advantage that it enables easy abstraction of immunization records by health workers for use in decision-making and also gives the parents or caregivers the peace of mind of easy access to the records of their children. Automatic invalidation alerts on compromised vaccines and adverse events records are also managed through the system.(153) Panorama is currently used for about 75% of the Canadian population. The data on immunization in the province of Saskatchewan is recorded as soon as immunization services is rendered in all designated health facilities into the Panorama. This approach enhances a real-time availability of data to the permitted audience for planning and service delivery purposes. It also reduces the possibility of recorded data not making its way into the data management gateway.

2.5.15 Statistics Canada Health Regions Peer Grouping

To make reporting easy after analysis of health regions data, parameters for comparison to detect important differences is necessary to be developed. Statistics Canada came up with an algorithm of peer grouping for comparing all the health regions in Canada. This algorithm was called the health region peer grouping system. This is an algorithm to assemble Canada's health regions into peer groups based on similar characteristics using the data from Population Census figures and it is updated regularly (2). The first release was in 2002, with updates in 2003, 2007, 2011 and 2018. Health regions were categorized into 10 peer groups identified by alphabets A to J. In Saskatchewan, the 13 health regions fell under four of the thirteen (A, D, F and H) peer grouping. However, only A, D and H health region peer groups were included in this study. The peer grouping algorithm as it affects the grouping of the health regions in Saskatchewan is summarized in table 2-3, the percentage of the population in each of the peer groups are also indicated.

Table 2-3: Saskatchewan Health Regions Peer Grouping

Peer Group	Number of Health Regions	Health Region by name	% of Saskatchewan Population	Principal Characteristics
A	2	Regina Qu'Appelle, Saskatoon	55.5%	Urban-Rural Mix Av. Percentage of Aboriginal Pop Av. Percentage of immigrant pop
D	6	Cypress, Five Hills, Heartland, Kelsey Trail, Sun Country and Sunrise	26.62%	Mainly rural regions Av. Percentage of Aboriginal pop High employment rate
F	3	Athabasca, Keewatin Yatthé and Mamawetan Churchill River	03.41%	Northern and remote regions Very high proportion of Aboriginal people Very low employment rate Low proportion of immigrants
H	2	Prince Albert Parkland, Prairie North	14.30%	Rural Northern regions High proportion of aboriginal population Low proportion of immigrants

(Source: Statistics Canada)

2.5.16 Theoretical perspectives and measles immunization coverage

Much less prominent in the coverage issue, is research that focuses on herd immunity threshold and the literature and theory around measles vaccine uptake leading to attainment of herd immunity. Theories such as Anti-vaccine conspiracy theory (154) , Evolutionary game theory (155, 156), Vaccine-autism theory (140, 157, 158), Web 2.0 anti-vaccine theory (159-162), Social theory of risk (163, 164) and cultural theory(165) are competing and overlapping theories at the crux of vaccine uptake that may provide some insight to shape the Saskatchewan context.

2.5.16.1 Anti-vaccine conspiracy theory

Conspiracy theories are endeavors to postulate explanations and events as the secret acts of powerful, malicious damaging beliefs we found that individuals were more likely to endorse (166, 167). When such conspiracy is about vaccination and it focusses on negative effects, it can drive the tardiness of some believers in such controversial and damaging beliefs to not be vaccinated; with a potential for propagation of such belief. Conspiracy theories most times produce hypotheses that oppose the existing understanding of history or simple facts. Believers

of one conspiracy theory were more apt to agree in totality in others (168) Anti-vaccine conspiracy theories, therefore, reflect mistrust and suspicion of scientific research exploring the efficacy of vaccines and also its safety (169). Even though a downward trend in vaccination rates are clearly a product of myriads of contributing factors, thought must be made of the possible conspiracy theories impact on vaccination intentions. Taylor et al. argue that some peoples' mind processes negative information in a different way to others but depending upon the extensiveness and inescapability of that negative information to the receptor. In so doing, some people passively make use of the negative feedback while preserving their positive self-conceptions(170). Anti-vaccine conspiracy theory may help to explain why different people behave differently to negative and damaging information which may affect the perception of the risk they thought could be with vaccine uptake and hence the negative effect on the achievement of herd immunity in a lot of settings.

Those in the anti-vaccine movement exist in a spectrum, ranging from the science uneducated ones, those who have difficulty utilizing science-informed breakthroughs in their perception of risks, to people with reasonably high level of education attainment but who because of their repulsion and dislike for the use of vaccines use data and misconceptions to propagate fears and concerns in others (171, 172) The reasoning of the ideals of these individuals are weak and imperfect and with a habit of substituting personal anecdotes for empirical data (171, 173). Capurro et al., 2018, looked at the role the media play in shaping the effect of the anti-vaxxers on the outbreak of measles from Disneyland and how anti-vaxxer groups represent a threat to public health and moral order (174). This is still re-lived until now with anti-vaxxers developing different methods to propagate their campaign including the use of direct attacks on social media sites.

2.5.16.2 Evolutionary game theory

The history of vaccine uptake is laden with periods of policy resistance (175-177) often related to fear of the "unknown being injected into oneself or ones' ward". In deciding to vaccinate a child, there is consideration on whether without the vaccination there would be occurrence of the disease in question, whether the vaccine will cause the illness it is meant to prevent (177), whether the child would probably get sick with the disease as a result of the vaccine, and what the possible effects of the sickness might be (178).

Every prospective recipient of vaccine is presented with the merits of taking the vaccine and also the list of adverse effects that may arise from taking it. Each individual decision-making process is indirectly influenced by those of the others of which resultant effect will determine the uptake within a geographical space. Game theory, hence, helps to explain the prediction of individual behavior in a setting where the choice of one individual depends on the prevailing strategies adopted by others within that environment (179, 180). This may help to explain the magnitude of the reduced uptake with every increase in level of vaccine scare.

2.5.16.3 Web 2.0 anti-vaccine theory

Web 2.0 describes user-generated content, usability and interoperability of websites and not necessarily an update to existing websites. It is a phenomenon first mentioned by DiNucci in 1997 (181, 182) and popularized by the use of social media sites, as being more of user interactions besides information dissemination (181) In spite of vaccination being perceived as the most successful public health measure of all times, vaccines are still being promoted by some as unsafe. While public health communications actively take place on the internet, there is also the social media use for information sharing with involvement of active and influential anti-vaccination groups (161) propagating that vaccines and products are unsafe. This may help explain vaccine hesitancy and decreasing vaccine coverage with the attendant risk of persistence of vaccine-preventable diseases in some places and outbreaks in others (183).

Many studies (159, 184, 185) have demonstrated the negative connection between vaccine hesitancy and decreasing vaccine uptake, coverage and economic implications (56) Perceived risk protection from vaccine is at crossroads with potential protection thereof, as parents seek vaccination information from uncensored channels such as internet and social networking sites (186) which provide ready access, interactivity and anonymity. This moderated and intertwined within a web of other factors, information encountered by individuals have either positive or negative effect on them (187)

2.5.16.4 Social theory of risk

This theory explains how community social linkages influence and play important roles in risk perception individually and collectively. It is this community of social linkage that self-generate like-minded people that build into a contagion to influence behaviors and attitudes (188, 189). It is expected that some people may be more affected by the development, growth and

distribution of risks which may engender winners and losers. Power and access to and control of knowledge thus becomes paramount in a risk society (190). It is at this level that the society rather than solving its own problem becomes the problem and contributes to the propagation of it (191). Dovetailing these concepts and perspectives on measles antigen-containing vaccines, there have been debates on the mumps, measles and rubella vaccine and its alleged, even though debunked, link to autism with its attendant generation of contested risk notions (163, 192).

While this is a potential barrier to improved uptake of vaccination, education from the health-care providers has been postulated as potential bed-rock to allay public anxiety to break cross-linkage of ideas surrounding risk perceptions. It is essential to understand how the vaccination handlers and providers handle the perceived public resistance and how it can affect the weight of the resistance in the Saskatchewan context.

2.5.16.5 Theory of colonization and public policy distrust

The negative effects of colonization, assimilation and discriminatory policies in vulnerable communities have been reported to be detrimental to their social participation in public programs including vaccination (193). Colonization is a form of assimilation, mental slavery or extinction even in these communities (193). For example, in Canada, the Aboriginal peoples suffer physically and mentally from the effects of residential schools and other forms of assimilation (194). Furthermore, the negative impact of colonization impact vaccine acceptance and the resultant low coverage may be linked to the damage in public trust against the government (195), towards program implementers especially when there is a power imbalance between vaccine recipients in the community and the program implementers. All these experiences create a silo around the uptake of vaccines even when it is presented as if it was for the common good of inhabitants of a particular geographical location.

2.5.16.6 Culture and vaccine uptake

The impact of culture in achieving sufficient immunization coverage rates for several vaccines including measles have been reported in the literature (196, 197). Furthermore, there is a strong association between co-existence and community bonding among ethnic group members that precipitates the rapid exchange of information at the societal level (198, 199). This relationship is underpinned with cultural beliefs and norms that may feed into behavioral pattern

of certain individuals or families, leading to resistance or hesitancy for childhood vaccination uptake. This trend is prominent in environments with strong religious beliefs (198). In addition, hesitancy or resistance to vaccination among ethnic groups may be due to strong beliefs in traditional methods to address disease models as opposed to orthodox approaches.

2.5.16.7 Access and coverage

Several ways to improve access to immunization services have been tried in the past and some of these have been evaluated for their effectiveness. Enhancing immunization service access in the form of cost-reduction, non-medical setting provision of immunization, health setting service provision enhancement and improvement, as well as home visits were evaluated in a systematic review and it was found out that these forms of interventions on their own did not bring about a large improvement in immunization uptake but a combination of them in multicomponent interventions.(200) Measles immunization provision is free in the province of Saskatchewan, Canada, and health care system efforts is on the rise. However, whether these efforts are summing up is yet to be seen reflecting in the coverage figures; and locational and social-determinants of health preventing access may not be unlikely.

2.5.16.8 Vaccine hesitancy, refusal and coverage

As of May 3, 2019, more than seven hundred and fifty (750) cases of measles have been reported in the U.S. in year 2019, the biggest measles epidemic in the past twenty-five years and since measles elimination was declared in the country. It is also to be noted that the figure is more than double the measles cases reported for the whole 2018 year (372 cases).(201) The 2014 measles outbreak in the United States was believed to originate from the Disneyland Resort in Anaheim, California. (202) It was estimated that about 125 people contracted the measles disease. (202) It is to be noted that immunization in most States in the United States and most provinces in Canada is not compulsory, caregivers have to agree or be convinced that there is a benefit in taking up the vaccination for their wards before doing so. It is also known to them that they are free to not take up immunization if they have reasons not to, even on philosophical grounds. This creates a situation where given the opportunity, a caregiver may refuse immunization. However proof of measles vaccination is required for school entry in Ontario and New Brunswick.(38, 203)

Immunization success is dependent on high acceptance of the product and refusal will affect the protection of the vulnerable population. Omer et al., (2009) revealed that refusal of vaccines is on the rise in the Americas.(204) Some of these refusals are hinged on parental concerns of vaccine safety, religious or philosophical grounds. Antivaccination movement dates back to 1882 with formation of league of anti-compulsory vaccination in the US.(159). The challenge of vaccine refusal and anti-vaccination is still on the rise. Dubé et al., (2015) examined studies and categorized parental vaccination uptake determinants as media, religious values, communication and social norms under the broad umbrella, access and vaccination programs under organizational factors and knowledge, attitude and belief in individual factors.(159) Even though there are several other channels of health and immunization information, health care providers are still centrally placed to address parental concerns as they are cited as the most authentic information source to parents for immunization uptake decisions.(204)

2.5.17 Socio-economic factors, Deprivation and Equity issues

Inequities in the implementation of vaccine programs and services across several jurisdictions may contribute to significant gaps in achieving sufficient vaccine coverage (205). In some health jurisdictions, barriers to accessing vaccine services and programs are less when compared to some neighboring communities which are remotely located or impacted by other social determinants of health that restrict their participation in these programs (205).

In summary, there seems to be an interplay between all these theories, their trajectories and a host of other factors help to explain the determinants of measles vaccine uptake and achievement of herd immunity threshold in the province of Saskatchewan in Canada.

2.6 Summary of Chapter Two

Chapter two addressed the various levels at which health equity had been addressed. The chapter examined the concept of herd immunity threshold and its importance in populations. The epidemiology of measles as a vaccine-preventable condition was discussed while factors that impact measles immunization uptake were explored. The various theories at play that shaped the discussion of measles immunization were also described and the chapter concluded by examining social determinants of health and deprivation issues as an integral part of the guiding map in the design and conduct of the research.

Chapter 3: Methodology

3.1 Introduction and overview

In this methodology chapter, the study design, study population, inclusion and exclusion criteria for the selection of participants is discussed. Explanations are provided for the use of mixed methods in the study, the conceptual frameworks involved, and the philosophical underpinning of the study. The various methods used to answer the research questions are detailed, the resulting information and outcome measures from the methods employed, as well as explanation of the research team roles. The three-phased approach of the research is explained and elucidation of what data collection strategy and analysis methods used in each phase is done. The chapter concludes with the detailed explanation of each method for both the quantitative and qualitative strands as well as the intervention phases.

3.2 Conceptual Frameworks for health interventions to address social determinants of health.

In light of the literature review conducted, the evidence-based conceptual framework described below reveals a consideration of multiple determinants of vaccination across a number of theoretical models of health behavior as highlighted under chapter 2. While it affords an understanding of a useful framework for the examination of the impact of organizational, interpersonal and personal factors, it also provides opportunity to inspect and consider broader community and societal factors as they affect vaccination. The health behavior model has been used in understanding uptake of immunization programs and also in public health interventions (206, 207). Jake Epp, a former Minister of Health and Welfare in Canada in 1986 argues that ‘the causal relationships between behavior and health are not nearly as clear-cut as they are between "germs" and disease’ (208). This goes to explain further that there are so many interactions, contextual factors and complex issues at the crux of understanding how a preventive program would be laid out to achieve its set objectives.

The Health Behavior Framework integrates constructs from theoretical models such as Social Cognitive Theory as it relates to self-regulation (209) and also of group behavior (210), the interrelationship of Social Learning theory and Health Belief Model (211, 212) which has been demonstrated in understanding, predicting and influencing behaviors and also the Theory of Planned Behavior which provides context to actions as a reaction to intentions, even though not

all intended plans are carried out (213). Numerous factors at various levels, the individual, provider or health care system; also, at a broader geographic, social-economic and political environment interact in many complex ways to influence health. To achieve order in this complexity, a wide-ranging conceptual framework is needed to provide a critical roadmap for systematically addressing the multiple determinants of the health problem in which change is desired (207). To guide the development of data collection instruments, the Health Behavior Framework (figure 3.1) was used. This framework has been adapted from the works of Bastani, et al. (2010) and modified to fit and address the demands of this research.

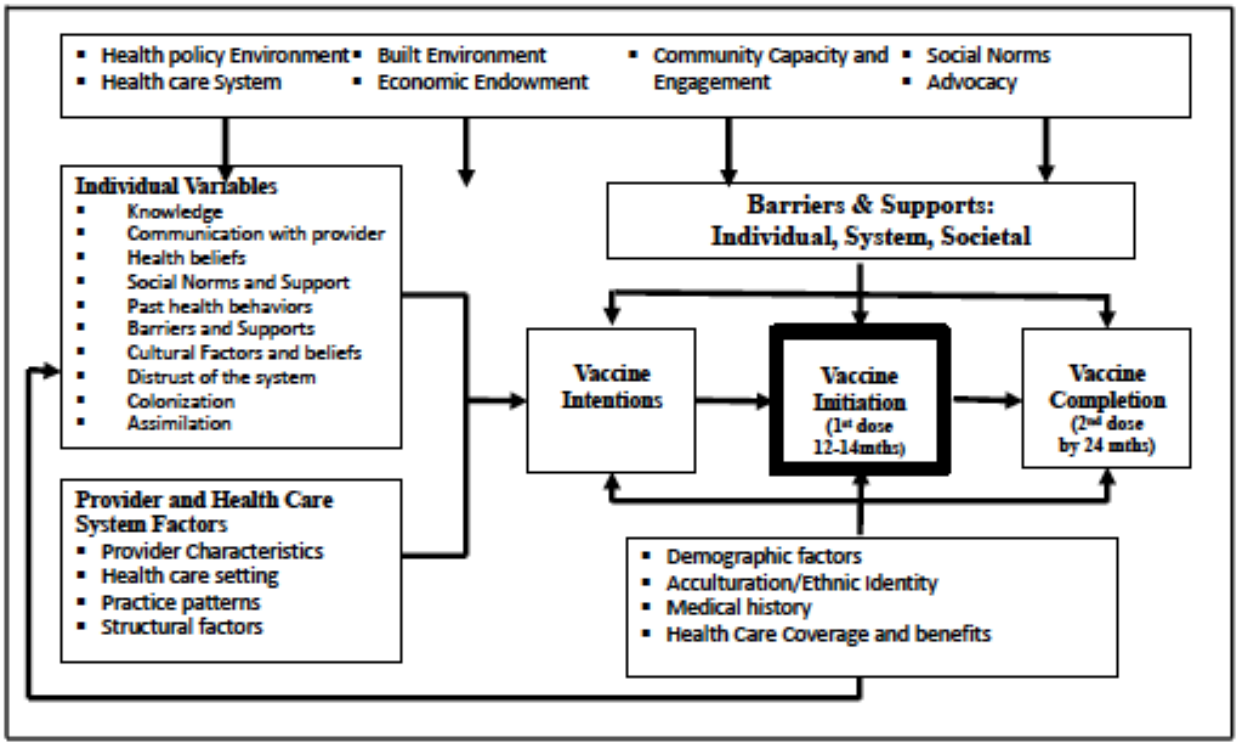


Figure 3-1: Health Behavior Framework

(adapted from Bastani et al., 2011 (206))

3.3 Relevance of mixed methods for the research

In any good research, it is important that researchers get concrete evidence out of the experience, hence methods may need to be integrated to get the breadth and depth of the inquiry. The use of mixed methods research hence refers to particular lines of inquiry or studies that utilize and integrate one or more qualitative and quantitative techniques for data collection, analysis or result assemblage. Mixing methods have been present for many years, from the time it was used

for complementarity and the richness of study results in 1959 (214) and for convergent validation by Jick in1979 (215). Whereas quantitative methods may help to isolate association and correlates among variables, qualitative data collection provides opportunity to gain more insight into events, factors and processes that could have resulted in the variation observed.

Mixed methods research involves the combination of both quantitative and qualitative research techniques in a single study to understand a research problem (216). It is described by Johnson, Onwuegbuzie & Turner (2007) as the type of research in which one researcher or a research team combine qualitative and quantitative elements of research approaches (e.g., the use of qualitative and quantitative philosophical viewpoints, data collection techniques, analytical methods and interpretation techniques) for purposes of enriching the breadth and depth of a research project (217). It has been argued that mixed methods research contributes to better understanding of complex social phenomena by utilizing multiple ways of knowing intentionally and valuing while respectfully engaging with their inherent differences (218). While quantitative and qualitative methods embrace two distinct paradigms considered mainstream methods, mixed methods has emerged as a third method in research undertakings and a medium for bridging gaps associated with quantitative and qualitative methods of inquiry (219, 220).

Population health is an interdisciplinary field, with complex issues to be addressed to arrive at workable policies and solutions. Mixed methods study is useful for addressing the complexity of contemporary social research problems (221), including population health depending on whether the research questions call for its use. A mixed method approach is meaningful and useful to population health research since multiple meanings and realities are elicited, which is important when diverse perspectives are being integrated for better health decision-making (217, 222). Some Population health challenges require multiple methodological lenses to unravel. Creswell et al., (2011) argue that such problems include “disparities among populations, ethnicities, and cultures, poor adherence to treatment thought to be effective; behavioral factors contributing to disability and health; and translational needs for health research”. (223) Such issues require a cross-disciplinary approach to draw evidence from various disciplinary methodologies, theories and traditions. Combining both quantitative and qualitative in mixed methods research thus offers a broad spectrum of resources to address the complexities of some public and population health problems (224)

In mixed methods research, both qualitative and quantitative data are collected, analyzed, merged, and linked or integrated to achieve the required rigor. This mixing can be done concurrently (embedded) or built one off of the other (sequentially). Depending on the research question, priority is given to one or both forms of strands. Good practice also suggests that the procedures are framed within a philosophical worldview and theoretical lens and integrated into one or more phases of a program of research (225). While health research continues to see merits in a mixed method approach, several challenges in designing, implementing and/or operationalizing the approach have been reported. This research explores these challenges from a population health context, drawing on its epistemological, analytical and practical angles, and provide some thoughts on how rigor can be achieved for better uptake of mixed methods techniques in the field.

Borkan, (2004) examined in a greater detail what primary health care research entails and provided the merits of the use of mixed methods in primary care research (226). He stated that greater details need to be known as to why particular variations are noticed in quantitative correlates. Sale, (2002) asserts that combining qualitative and quantitative methods in a single study is widely practiced and acknowledged in lots of health care research areas (227), even though the two paradigms do not study the same phenomena and he mentions that quantitative and qualitative methods cannot be combined for cross-validation or triangulation purposes. However, Sale agrees that they can be combined for complementary purposes (227). In this research, which looked at trends in measles immunization coverage between 2002 and 2013 and with consideration on how different variables of interest play out, changes that could have taken place in the period under consideration will need to be identified as well as the context under which such occurred. Such study will be better done using a mixed methods approach. Specifically, in this research, two phases of qualitative interviews have been carried out, one with the quantitative data analysis and the second after full data analysis (both quantitative and qualitative) and debriefing (integrated knowledge translation).

In the recent past, some studies have used mixed methods approach to answer immunization uptake in primary health care. Albright et al., (2014) used a mixed methods approach to examine provider attitudes towards immunization recall and reminder system to improve immunization coverage (228), Hawk and colleagues, (2017) examined practice characteristics associated with implementation of adult immunization using mixed methods(229),

and Closser and colleagues, (2012) looked at the impact of vertical polio eradication programs on the routine immunization programs (230). These studies which seek to understand the barriers and enablers to measles immunization uptake and also exploring perspectives among providers of the services as it affects the uptake of the measles antigen-containing vaccines, used a similar but modified mixed methods approach.

3.4 Philosophical underpinnings

Creswell and Plano Clark (2007) argue that when research questions are such that they cannot be answered by either quantitative or qualitative methods alone, then mixed methods could be employed (216). Sale et al. (2002) agree that mixed methods research helps when a range of phenomena and perspectives are required to be understood in a complex nature (227). While one is open to the advantages of both methods to answer research questions, researchers are admonished to locate their research study in a selected paradigm which is supposed to represent the worldviews and the beliefs of the researcher. Marti & Mertens, (2014) argue that in order to explore the potential of mixed methods to contribute to social change, the researcher has responsibility to add to scientific knowledge but not to only diagnose social problems but also to inform policies or actions aimed at improving them (231). "The researcher also needs to involve the people who are being ''researched'' in the studies to ultimately make sure that the knowledge produced, in its conceptual and applied dimensions, is more accurate and useful to that civil society. This represents progress in reference to moving from research ''on them'' to ''with them'' (231) p208

Plano Clarke et al., (2008) argue that researchers bring their set of beliefs and assumptions to the research being conducted, which ultimately guides the research they conduct (232). Morgan (2007) agrees that the questions posed by researchers and the methods they employed to answer them are paradigmatically influenced (233). Thus, the world view of the researcher is greatly influenced by the paradigm to which they align; for example, quantitative researchers on positivist paradigm and the qualitative researcher, naturalistic or constructivist tradition. However, traditionalists portend that the two paradigms should and cannot be combined as they are incompatible (227, 234). To liberate researchers from this paradigmatic divide, came the philosophy of pragmatism which postulated that a value-oriented research product can be achieved by using insights and procedures from both methods hence eclecticism

was advocated resulting in a ‘needs-based or contingency approach to research method and concept selection’(219) p17

The researcher identifies with the sentiments of Tashakkori and Teddlie (220), to study in whatever ways that seem appropriate and of value, with the ultimate goal of bringing about positive results. The resolve is hence on leaning on the worldview of pragmatism as the foundation of mixed methods (235) as a guiding philosophy in this study which would enable the author to avoid and go beyond the controversy of not mixing quantitative and qualitative research (220).

3.5 Research Location

The research setting is the province of Saskatchewan, one of the ten provinces and three territories that make up Canada. At the time of this study, the province was made up of twelve health regions plus Athabasca health authority as the thirteenth jurisdiction.

3.6 The Multi-jurisdictional Ethical considerations

Ethics approval for this study was sought at the University Behavioral Research Ethics Board where the researcher is affiliated and consent for participation sought and received from each of the 10 regional health authorities which participated (Appendix A). This was because all the health regions operated as autonomous regional authorities at the time the study commenced, and each jurisdiction needed to give permission for the researcher to work with their data and also interview participants who were members of those health regions. However, since 2018, one approval each at the level of the Saskatchewan Health Authority and Athabasca health authority is needed for this type of study to take place because of the amalgamation of the previous twelve health jurisdictions into one health authority.

3.7 Preliminary and Preparatory Phase:

The study was collaborative in nature, and it took place in three phases. All the health regions were recruited through a formal process and a buy-in for the research was achieved through employment of a collaborative approach. There was a formal meeting to brief the prospective participating health regions’ representatives and stakeholders about the intentions of the study targeting the Medical Health Officers (MHOs), the front-line immunization officers and/or the immunization coordinators. The proposal for the study was fully developed and fully

discussed and the main concepts presented with the intended beneficiaries during a scheduled Medical Health Officers Council of Saskatchewan (MHOCOS) quarterly meeting in Saskatoon.

The contact with the stakeholders in their scheduled meeting was made possible through the researcher's supervisor. After the initial contact and the concept narration in the stakeholders meeting, the researcher and the researched (i.e. the RHAs) worked collaboratively from the conception and proposal stage through the knowledge exchange phase before the final result synthesis. During the proposal presentation, the RHAs had the opportunity to raise concerns which were addressed, and corrections made before finally securing a buy-in for the research to take place.

3.8 Study Design

The study used a mixed-methods approach with explanatory sequential design (216, 225, 236) as depicted in figure 3-2. The research employed a multiphase design, with a total of three phases. The first phase consisted of quantitative data collection and analysis which was closely followed with qualitative interviews as the first qualitative interview strand, the second phase consist of a debriefing of the quantitative as well as the first set of qualitative results with the regional health authorities which doubles as the intervention, while the third phase consisted of the second stage of interviews as follow up to the initial two phases. The qualitative strand is included to provide richer explanations and context to the findings in the quantitative strand. This approach opens up opportunities to understand and attempt to explain contradictions between the findings of the two methods used (236-238). Interview respondents in this research were key informants.

The quantitative and the qualitative methods in this study had an almost equal priority with concurrent and sequential timing of data collection employed while integration took place at the level of analysis and discussion. The qualitative component was employed to provide explanations to the quantitative findings. The strength of this design was in the fact that the two phases built upon each other. The methodical process involved is represented diagrammatically in figure 3-2.

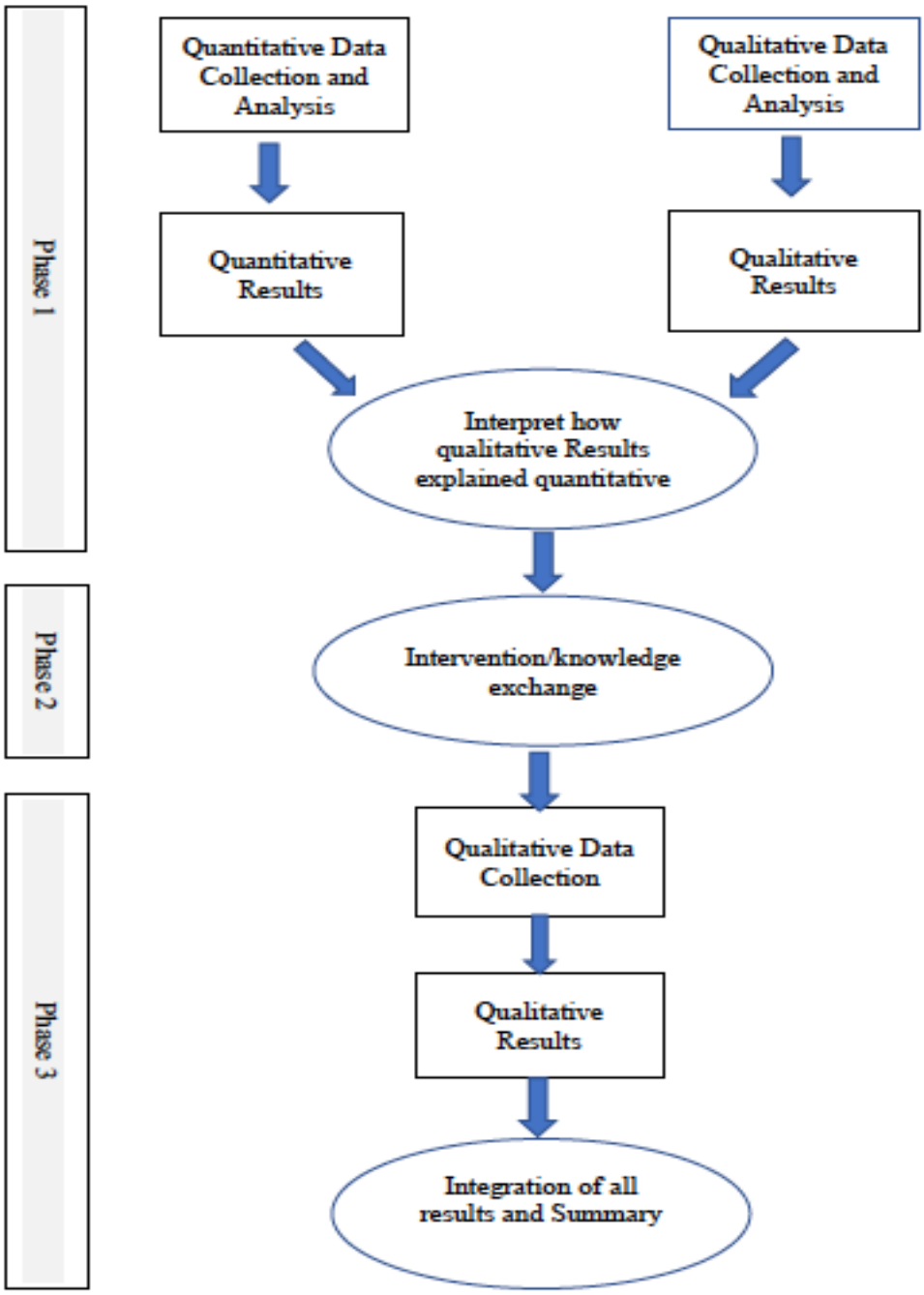


Figure 3-2: Diagrammatic Representation of the Research Design

3.9 Study Population

The quantitative portion of the study used data from two population groups, the up-to-date at 1year for the first dose of MMR/MMRV vaccination which comprised of all MMR or MMRV vaccinations given at age 12 – 14 months age and the up-to-date at 2 years for the second dose of

MMR or MMRV vaccine at age 18 – 24 months. The two groups were chosen to conform to the Saskatchewan immunization schedules. The quantitative data were those of children on the Saskatchewan immunization database abstracted in a special format to ensure that the data remained de-identified throughout the research process. The second set of data which was qualitative in nature came from interviewees who were the frontline officers and policy maker/adapters/implementers in their respective regional health authorities. These group of interviewees are key informants and their inclusion served to provide context to the findings while entrenching the study results with the experiences of the participants (222, 223). The selection of the key informants from the ten participating health regions and the selection criteria is summarized in figure 3-3 below

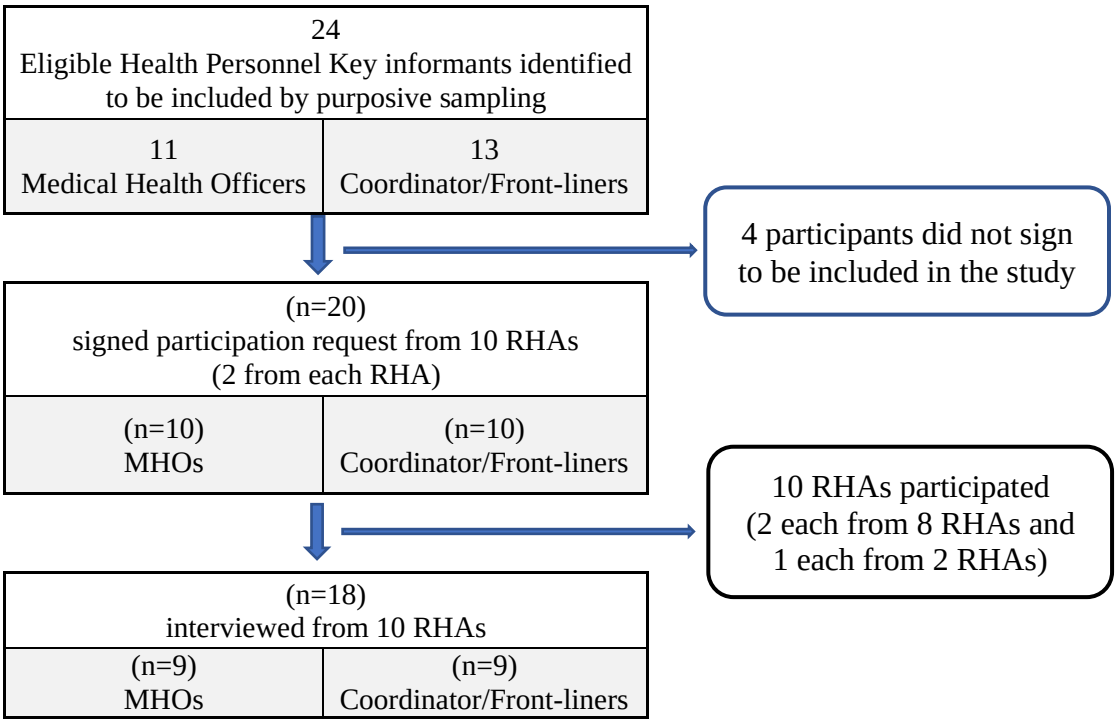


Figure 3-3: Participants included in the Qualitative Strand of the Study.

3.10 Introducing the Research Questions handling and reporting

The following section provides a quick overview of the research questions, methods employed, tools used and resulting information obtained.

The research questions one and two which used the quantitative data were to determine the available demographic information in the data that were associated with measles immunization coverage in Saskatchewan and also assess if there are differences between the health regions in terms of coverage figures looking at area of residence and socio-economic quintiles of deprivation. The purpose was to also look within each health region to assess how the two variables, area of residence and deprivation quintiles, affected the distribution of the coverage figures. The Panorama gateway[3] data was used which consisted of the following information – the year immunization was carried out, the covered population, the count of children immunized, the calculated coverage figure in percentages, the age of the children, area of residence and the socio-economic deprivation quintiles.

Research question three asks about the barriers and also the facilitators to achievement of measles herd immunity threshold of between 92 – 95% in Saskatchewan health regions. This was answered by interviewing the immunization providers in the various health regions using the first phase qualitative interview guide developed (Appendix B). The questions included in the interview guide explored participants' thoughts and experiences as they related to the coverage of measles vaccination in their respective health regions of practice.

Research question four asks about the perspectives of the providers on what policy interventions they felt were required to move the coverage figures of the measles immunization higher. It was also to seek their perspectives on the innovations they felt were necessary to improve equitable access to measles immunization in their health regions and Saskatchewan. This second stage interview was done after the initial results of the analysis of both the quantitative and the first qualitative interviews had been presented to the respective health regions. It was to check with the participants, what more they would like to consider as important innovative interventions to improve the coverage figures and also to explore from them what they felt should be the inputs of their employers. An interview guide (Appendix C) was also used to facilitate these discussions. For the purpose of clarity, the information above is summarized in table 3-1.

[3] The data registry used in province of Saskatchewan

Table 3-1: Research Questions, Methods, Tools and Information Elicited

Research Questions	Methods	Tools	Resulting Information
What demographic characteristics (age, socio-economic characteristics and area of residence) are associated with measles immunization coverage in Saskatchewan?	1. Syntax Generation for data abstraction 2. Data Cleaning and Verifications	1. MS Excel 2016 2. Joinpoint Regression Software 3. STATA data Analysis 15.1 4. IBM SPSS Software 25	1. Socio-Demographic Characteristics percentage figures 2. Line graphs showing percent coverage over study period for all RHAs 3. Coverage by locations over study period
What are the differences between and within Saskatchewan health regions measles immunization coverage among children aged 12 and 24 months between year 2002 and 2013?	1. Correlations 2. Regressions 3. Analysis of Variance (ANOVA)	1. MS Excel 2016 2. Joinpoint Regression Software 3. STATA Data Analysis 15.1 4. IBM SPSS Software version 25 5. Graphing Calculator	1. Comparison of location as a factor in measles immunization coverage figures 2. Demonstration of relative gap in socio-economic deprivation quintiles and effect on coverage figures 3. Demonstration of change in line of equity between 2002 and 2013 in all Saskatchewan RHAs
What are the facilitators and barriers to achievement of herd immunity threshold (92 – 95% coverage) for measles immunization coverage in Saskatchewan health regions?	1. Interview Guide Development 2. Pre-knowledge translation Key Informant interviews 3. Inductive and Deductive Analysis	Interviewer Review Nvivo version 11	Interview responses from key informants on barriers and enablers to measles immunization coverage rates
From healthcare provider's perspective, what policy interventions and innovations are required to improve equitable measles immunization coverage rates in Saskatchewan?	1. Interview Guide Development 2. Pre-testing of Interview Guide 3. Post-knowledge translation interviews 4. Inductive and Deductive Analysis	SSRL transcription Nvivo version 12	1. Feedback from key informants on their perspective on the knowledge translation 2. Interview responses from key informants on suggested policy interventions needed to improve coverage figures 3. Response from participants on innovative ways to improve measles immunization coverage rates

3.11 Roles played by the Research Team

For the execution of this research, there were the researchers, the research advisory committee members, the Public Health Observatory of Saskatoon personnel, the participating health regions and the Saskatchewan eHealth. The research advisory committee members performed varying roles throughout the research phases. Their roles sometime were cross-cutting; however, the simplest representation is depicted in table 3-2.

Table 3-2: Roles and Responsibilities of Research Team Members

Roles of the research team members	
Primary Researcher	1. Developed the research protocol and the research questions 2. Concept Narration to health region representatives for buy-in 3. Responsibility for interview guide development, data collection, analysis and impression formation
Thesis Supervisor	1 Facilitated the meeting with the health region representatives 2. Coordinated the whole research process 3. Performed the role of principal investigator throughout the research
Research Advisory Committee	1. Shaped the content of the concept and the research questions 2. Provided critical feedback for the conduct of the research 3. Reviewed themes in the qualitative data analysis process
Saskatoon Public Health Observatory (PHO)	1. Worked with the primary researcher for the syntax development for quantitative data abstraction 2. Liaise with the health regions for the collection of the de-identified quantitative data used in the analysis
Participating Health Regions	1. Release of the quantitative data and ensuring they were de-identified 2. Approved the research ethics and provided venues and other logistics for integrated knowledge translation 3. Reviewed the interview scripts and member checking procedures
Saskatchewan eHealth	1. Ran the generated syntax on the Panorama data before the release to the health regions for onward transmission to the Saskatoon PHO

3.12 Strategies for data collection

3.12.1 Quantitative Data

At the beginning of the study, all health regions in the province were approached in a stakeholders' meeting to be involved in the research, however, ten out of the existing thirteen health regions eventually participated and these were the health regions that also made data available through eHealth for analysis. The ten (10) health regions that signed up to participate in the study make up about 97% of the covered population of Saskatchewan.

The required quantitative data was procured through the eHealth with a syntax generated for the purpose of the study. The syntax was generated using the facility of the Public Health Observatory of Saskatoon Health Region with assistance of PHO Data Manager because of his understanding of the types of data captured and recorded on the Saskatchewan data management platform, Panorama. There was an agreement between the PHO personnel and the researcher on the elements to be included in the syntax to achieve the objectives of the research. The collation point for the received data from all the health regions was through the Saskatoon Public Health Observatory. Saskatoon health region PHO to serve as the data collation point was made possible through the existing data sharing agreement between all the health regions. As the data was received through eHealth in the Public Health Observatory of the Saskatoon Health Region, folders were created for each regional health authority. For quality control, the Saskatoon Health Region data which was received from eHealth was compared with what Saskatoon Health Region had within PHO. This was to serve as a proxy for the initial confirmation of what could be prevailing in other participating health regions.

Also, before the data were received through the eHealth, all data abstracted with the generated syntax have been sent by eHealth to all the RHAs, the data owners, to ascertain that the data was representative of what they expected. All other health regions apart from two sent information back to the researcher that the data which had been sent to them from the eHealth was representative of what they had expected. While the data validation was being done, it was noticed that there was a mix-up in the data for socio-economic deprivation quintiles of two health regions. This data mix-up was resolved by comparing the new information from eHealth with the existing data, a process which involved the two health regions in the data comparison. The data procurement process involved is diagrammatically represented in figure 3-4.

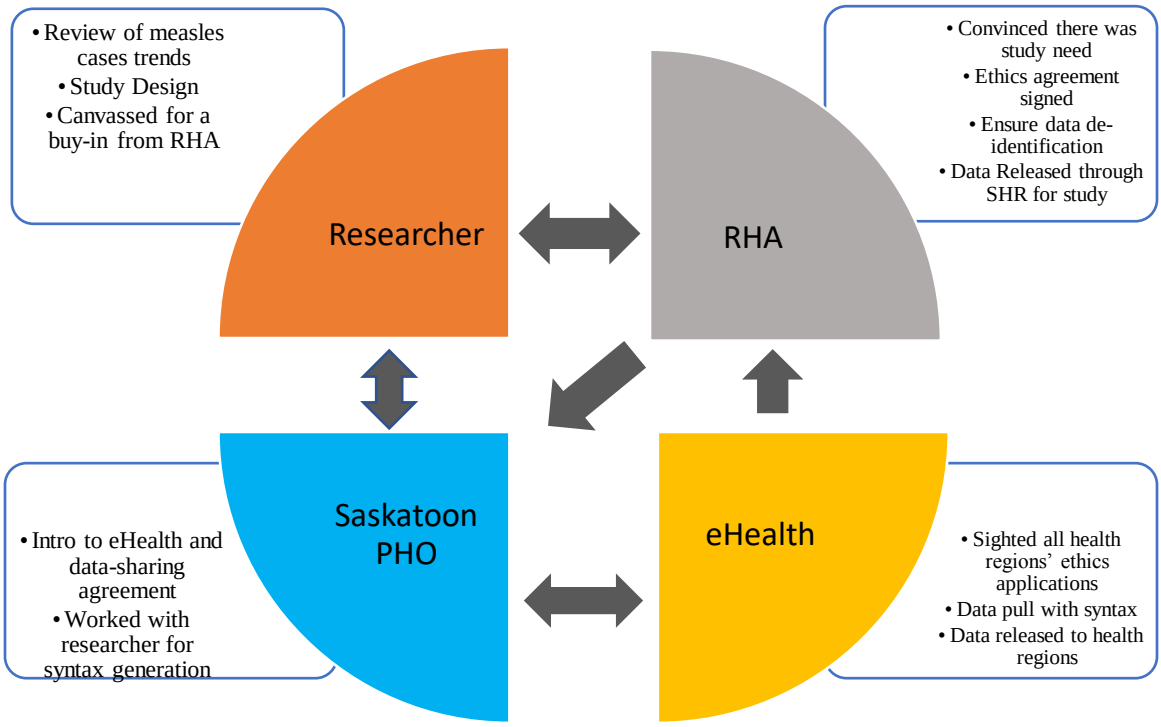


Figure 3-4: Quantitative data procurement pathway

3.12.2 Approach to Syntax Generation for data abstraction

The first stage involved defining which antigens are of interest. Since the researcher was interested in measles, the vaccines and vaccination of interest comprised of Measles, Mumps and Rubella (MMR) or Measles, Mumps, Rubella and Varicella (MMRV) vaccines. This is because measles vaccine is administered in combination with the two or three other antigens. The unit of analysis was all health regions within the Province of Saskatchewan. The syntax was hence developed to pull data regarding the coverage rates, on-time for first and second doses of measles antigen-containing vaccine uptake, age, socio-economic status depicted by the socio-economic deprivation quintiles and geographical locations of the covered population.

The standard definitions of the parameters to be considered in the analysis for coverage purposes was determined and defined appropriately as informed by available literature and Saskatchewan immunization schedule documents and guidelines. Data availability from the health regions was expected to have relatively insignificant variations as all health regions use a central immunization management registry called Panorama to which there has been a recent migration of the old platform named Saskatchewan Immunization Management (SIMS) program

in 2015. Therefore, the data used in this study was obtained from the late phases of the SIMS platform just before the migration to the Panorama platform.

The quantitative data employed a total sample of all children ages 12–14 months (on-time for first dose of measles vaccination) and 18 – 24 months (on-time for second dose of measles vaccination) as the two cohorts of children immunized with measles-containing antigen in the participating health regions in the province of Saskatchewan. The Saskatchewan government requires administration of two doses of measles containing vaccine as part of its routine childhood immunization schedule; the first dose being recommended at 12 months and a second dose from 18 months until 24 months. This preventive measure stems from the recommendation of the World Health Organization as adopted by the Pan American Health Organization and also the Canadian government and hence the province of Saskatchewan government as an entity for preventive care. De Serres et al., (2012) assessed the effectiveness of first dose before 15 months being able to offer adequate protection against measles and found out that delaying first dose till 15 months of age reduces the risk of measles for a 2-dose regimen.(239)

While there are variations in the time the various provinces in Canada typically give 2nd dose of measles containing vaccine, however, it is preferable to confer this extra protection as early as possible since complications of measles are higher in younger children, and there is a desire to have high herd immunity as soon as possible in order to maximize the size of the total population cohort with high levels of immunity. Despite the variations, Saskatchewan routine immunization schedule prescribes 2nd dose of MMR/MMRV between 18 months and 24 months. For the purposes of this study and for comparability purposes, the schedule is adhered to and it forms the basis of the two groups of children included in the study as described in the inclusion and the exclusion criteria below.

Up to date at 14 months: – the child must have received 1 valid dose of MMR or MMRV vaccine between 365 and 425 days of age. All children with one dose of MMR/MMRV vaccine outside this range are not considered to be on-time and up-to-date and hence not included in the analysis.
Up to date at 24 months: – the child must have received 2 valid doses of MMR/MMRV between 365 and 731 days of age. Any child who receive a second dose of MMR/MMRV vaccination outside of 731 days is not considered on-time for 2nd dose of measles immunization. This

delineation formed the basis of the syntax generated for data abstraction. All children with a Panorama status of "active" are included, health card type was not taken into account.

3.12.3 Qualitative Data

The qualitative data collection took place in two different predetermined phases, the pre-intervention (phase 1) and post-intervention (phase 2) periods, with each interview phase answering different questions of the research. Both of the interviews were carried out with immunization administrators and front-line immunization providers and coordinators as key informants. The interviews in the first phase of the research was to help the researcher answer the third research question on the barriers and enablers to measles immunization in Saskatchewan. It was administered through an interview guide (Appendix B) of which content was influenced by the theories and the frameworks described in chapter 2 of this document. It was also enriched with grey literature, meeting notes and other existing policy documents from the government of the province of Saskatchewan, Public Health Agency of Canada, and World Health Organization (WHO). Besides helping the researcher to answer the researcher question on the barriers and enablers to measles immunization, the interview also explored factors and help to explain findings in the quantitative data. The first qualitative data acquisitions took place at almost the same period as the quantitative data, even though the qualitative data collection procedures were a bit delayed for logistical reasons. This delay however, allowed the researcher to carry out a preliminary analysis of the quantitative data and allowed some questions generated from the quantitative findings to be included in the interview instruments of the qualitative strand.

The second part of the qualitative data collection, which took place as the third phase of the research, came from the same set of interviewees as in the first phase. This phase of the interviews took place after the intervention/knowledge exchange phase (phase 2) with the data custodians, the interviewees at the RHAs. The interview was also administered with an interview guide (Appendix C) enabling the researcher to answer the fourth research question which states *from healthcare provider's perspective, what policy interventions and innovations are required to improve equitable measles immunization coverage rates in Saskatchewan*.

The interview phases will be discussed in fuller detail in the next topics.

3.12.3.1 Why the use of key informants?

This source of qualitative data collection was preferred because the goal of the research is to obtain qualitative description of perceptions and experiences of which the identified interviewees have a first-hand knowledge. Two key informants from each RHA were identified for interview which could provide opportunities for comparison and enrichment of the received information. The information obtained was to help explain some observations in the trend and patterns of the quantitative data. The two key informants have been selected by expert purposive strategy from each health region at different authority levels that are directly related to immunization policy administration and implementation. They are also taken as the best group for their direct role in immunization concept development, immunization administration, its provision and management. The target key informants were Medical Health Officers (MHOs) and frontline immunization coordinators for each health region who by virtue of the positions they occupy are able to provide the required information from the perspectives of immunization service providers. While the physicians (MHOs) provide directions on policy administration, the front-line immunization officers and coordinators are directly involved in the implementation of the immunization strategies.

Physicians play a significant role in rapidly changing primary health care delivery and public health systems. Their inclusion in surveys and interviews to elicit their perspective is hence important. Survey of physicians are important tools in policy research as well as in practice (240), and provide effective sources of information on their attitudes, knowledge, and practices as it relates to care delivery. Studies have found low response rates among physicians, raising concerns on the generalizability and validity of the outcome of research involving them (241, 242). Previous research has looked into health workers, especially doctor's participation rates and factors that could influence these rates (243). Gunn WJ et al. (1981) found that passing through the directorate and letting the participants know beforehand that reports will be available to them has enhanced participation. (243). A systematic review of methodologies of improving response rates of physicians found that incentive and design-based approaches were critical (240). In terms of the design strategies, postal and telephone strategies were found to be generally more successful than fax or Web-based approaches. There was also evidence to

support the use of mixed-mode surveys[4] in this group of health care population (240). This phase of the interviews leveraged on the design-based approach (240) to ensure improved participation in the following ways described here .

The researcher looked for the opportunity of a forum where the physicians had a meeting to make a proposal presentation to them. The researcher made a PowerPoint presentation of the summary proposal to the attendees. In that forum, there was opportunity for firsthand information to be provided and questions were asked concerning the need for them to participate. There was exchange of ideas on what the participants would expect as deliverables of the research at the forum, and therefore, a possible working relationship was already established culminating in buy-in. All phases of the research were highlighted to the participants who were already sensitized about the relevance in their work. This approach probably contributed to a high participation rate of 88% during the telephone interviews of the first phase of the research. Even though the other members of the RHA team, the front-line immunization personnel and coordinators of immunization services were not in the meeting where the sensitization of the Medical Health Officers took place, the MHOs took the message back to the rest of the unit members regarding the upcoming research.

Information from contextual sources are also needed to understand fully patterns that are not clearly explained by the interviews obtained from the health regions informants or to buttress the points obtained therefrom. These sources are existing documents from the health regions, Saskatchewan government policy documents, research papers, Statistics Canada and Public Health Agency of Canada. Since this research in part aimed to get to the root of the difficulty in achieving herd immunity threshold hence added information from these sources was necessary to add a contextual component to the information obtained

3.12.3.2 Study Phase 1 Interviews

This portion of the research was required to answer the third research question "What are the facilitators and barriers to achievement of herd immunity threshold (92 – 95% coverage) for measles immunization coverage in Saskatchewan health regions?" In terms of the whole study

[4] Mixed mode survey is a way of using more than one mode to carry out a survey. This could be the use of e-mail, fax, telephone or postage letters etc.

design, it is the Pre-Intervention/integrated knowledge translation interviews. Interviews were used to acquire the relevant information required to answer the question.

Dörnyei (2007) argues that interviewing is 'a natural and socially acceptable' method of data collection which can be used in several ways and situation and for a variety of topical issues (244). Interviews serve to direct respondents or participants to respond to the questions posed. There are three main types of qualitative research interviews e.g. structured, semi-structured and narrative/unstructured interviews. (245, 246) This study used semi-structured type. However, this particular phase used telephone interview (Appendix B). A written consent for participation was received from each of the participants ahead of the proposed date of interviews.

3.12.3.3 Interview Guide Development

The researcher designed the interview guides (Appendices B & C) and the design took into consideration and incorporated elements of the theories and the framework discussed in the literature review. Policy documents of Saskatchewan government and the Public Health Agency of Canada were also reviewed to enrich the interview guide. Because of the controversy, confusion and the panic that currently wraps around measles in recent times, it became expedient to touch on as many theories as possible that underpin the research and to come up with an interview guide that could better address the various factors that needed exploring. Specific questions to follow up on important findings on patterns and variability in the quantitatively analyzed data was introduced for each health region to elicit reasons and explanations for the observed trends, patterns and changes. The interview guide was reviewed by the thesis advisory committee before use.

3.12.3.4 Pre-testing of the interview guide.

Before final use, interview guide for the first phase interview was pre-tested on two respondents with similar responsibilities as the prospective interviewees so as to ensure that the instrument would be administered free of technical and logistic issues and to be sure it will capture the relevant information required for the research. The researcher reviewed and modified the content of the interview guide based on the outcome of the pre-testing carried out. It was again reviewed by the research team and another experienced qualitative researcher outside of the thesis advisory committee.

3.12.3.5 Conduct of the Interviews

Telephone was favored for the conduct of the first phase interviews for feasibility purposes as the study covers a wide geographical area as well as time being a constraint. Although found to be used less than face-to-face interview method in qualitative research, the telephone interview method is argued to be a "versatile data collection tool" (247)p393. Besides the fact that both interviewers and interviewees are both within their comfort zone, respondents are also very relaxed and may be willing to freely release information adjudged to be detailed and of high quality (248) and can also be rich (249, 250) Telephone method also ensures that the interviewers have access to geographically sparsely located respondents at a reduced cost (251). It gives some respondents some level of assumed privacy with decreased interviewer-interviewee pressure (248).

This research took place in the province of Saskatchewan, which covers a wide geographical area. The cost and travel time for face to face interviews for both phases one and three of the research could be a major constraint. The first set of the interview required 18 contacts while the second set required 10 contacts. The first phase with a larger number of contacts was hence carried out by telephone. The second set of interviews in phase three of the study utilized the face-to-face approach because of the fewer number and also because it took place shortly after the debriefing exercise which required the presence of the researcher in the participating health regions facilities.

The telephone interviews were conducted from a designated quiet room within the department of Community Health and Epidemiology and all interview related telephone calls made through the department telephone for confidential purposes. Before each interview took place, there was also a verbal consent from the interview participants confirming their participation and also their agreement for audiotaping. All interviews were audiotaped for ease of transcription and accuracy. Besides the audiotaping, the researcher complemented the audiotaping with field notes.

3.12.3.6 Transcription of the Interviews Tapes

The researcher listened to the recorded interview tapes and carried out the transcription of the responses from all the recipients. A verbatim transcription of the recorded interviews and responses was done. The transcription was typed out in Microsoft Word document for easy

uploading into the Nvivo analysis software. Transcribing the interview responses by the researcher enabled the opportunity of a good familiarization with the contents even before coding commenced. To ensure that transcripts captured participants expressed thoughts and reflected the information given, all interview transcripts was e-mailed back to the interviewees for them to double-check the final copy of the transcript for agreement, conformity and confirmation of the included information before being used in the analysis. Where errors existed, this was corrected, and the information put straight by the respondents and sent back to the researcher. The interviewees also had the instruction from the researcher that where participants felt no need for correction, the respondent still needed to correspond back to the researcher that the information was as discussed during the interview sessions, a way to affirm that the information as contained in the transcript was a correct capture of the interaction, and all the participants complied.

3.12.4 Research Phase 2: Intervention Phase – Integrated Knowledge Translation

This phase is a bridging phase between phases 1 and 3 of the research. In this phase, the preliminary results from the analyzed quantitative and qualitative data of the first phase was presented to the participating RHAs members including the interview respondents in form of de-briefing. While the researcher deemed it fit to conduct the first phases of the quantitative and the qualitative phases of the research and bring up preliminary evidences that needed to be addressed with the aim of using information derivable from previous practices and uptake trends to influence positive changes in the future of measles vaccine delivery and immunization programs, it was also pertinent to understand the perspectives of the health care providers about a more robust measles immunization uptake. This procedure was introduced to foster some interaction with the regional health authorities' staff and the interviewees. It also gave an opportunity to validate the findings of the initial phases of the research.

This phase enabled an opportunity to offer a feedback to the health regions in line with the initial request of the health regions during the proposal presentation and buy-in meeting. It was also an opportunity to put a face to the various individuals that participated in telephone interviews in the first interview phase and to kick-start the next phase of the interview while the RHAs participants had a concrete information to discuss. This phase also enabled the researcher and the interviewed participants to discuss on other intervention methods used in all the health

regions the researcher had interacted with, as well as what the reported outcomes were in order to see how such can be adapted where this intervention may be new to.

The preparations for this exercise which spanned over 2 months involved letters of information on the phase, how it will be executed, what period it is being planned for and what to expect. A letter of information was drafted and approved by the supervisor. The letter was accompanied by a detailed graphical report of the measles coverage rates in all the cities and communities in the individual health regions and the trends in the period under study and by a short summary result of prominent themes from the first qualitative interview phase. In communities where data were suppressed (i.e. where there were less than six children living in the community), analysis was omitted. This initial analyzed result was aimed at giving the RHA an opportunity to see the preliminary results as it pertained to their health region data for their understanding and to pave way for a richer discussion. The letter was sent to the participating health regions at least one month before the actual debrief visit was carried out. The advance information provision was done to enable the RHAs to study the preliminary results as they relate to their regional health authority situation and also to deliberate ahead of time what is needed to be done differently going forward. On the day of individual RHA appointment, the researcher presented a slide deck tailor-made to the individual RHAs during the face-to-face interaction and knowledge exchange.

3.12.4.1 Negotiating for Intervention/Debriefing date

The province of Saskatchewan is wide geographically. With this in mind, the researcher sought an opportunity to cluster the health regions by geographical location to make the reach easy with fewer travel days. However, this arrangement did not work because every health region followed their separate programs. After a failed negotiation for a systematic and cost-effective travel with health regions for suitable dates to accommodate a 2-hour interaction time, the research moved ahead to visit each individual health region at a time convenient for the health region. The researcher adjusted his availability to suit those of the health regions.

3.12.4.2 Debriefing Audience

The participating audience for the knowledge translation and intervention phase was determined by each health region. The data analyzed belonged to the whole health region and it

was designed to let health regions know what the quantitative data revealed, what the interview participants felt which had been tied together to inform possible future actions.
Some health region made the intervention phase open to health workers in their health region, some included the administrative staff while in some others, the discussion was limited to the interviewed participants only.

3.12.4.3 Impressions from the exercise

The travel afforded the researcher to put context to the diverse nature of Saskatchewan and participant discussions. The communities were well dispersed over large portion of land and perspectives on access and the reach in those places could be imagined. On the part of the interview participants and some health workers in attendance, it was a period of surprise, intrigue, 'yes, I said it', affirmative nods, curious and quizzical responses from expressions and gestures. While some health regions said it was a very useful exercise and would be nice if it took place on regular basis, others had a demand for a follow up session with a larger audience for overall information dissemination.

3.12.5 Study Phase three: Post-intervention phase interviews

This phase is the third and the last phase of the three phases of the research. The phase was included in the study design to elicit the measles immunization providers' thoughts and possible actions to improve measles immunization coverage after seeing the results of the analyzed quantitative and qualitative data from first phase as presented in the second phase of the study. This portion of the research was required to help the researcher to answer the third research question "*From healthcare provider's perspective, what policy interventions and innovations are required to improve equitable measles immunization coverage rates in Saskatchewan*?

A reminder letter was sent two weeks before the agreed date for the event to be sure the health region has prepared for the event including venue arrangements. Like the first phase, the data gathering was carried out with face-to-face interviews. Even though it took place a short while after the debriefing exercise, it was designed to be held with the interviewees that participated in the first set of interviews. Unlike the first interviews which took place with the individual key informants within each health region, this phase of the interview departs from the

first one in that it brought the two interviewees of the individual RHAs together in one room while a prepared interview guide (Appendix C) was used to administer the interview. It also departs from the first set of interviews in that it was a face-to-face interview unlike the telephone administered-format of the first phase.

The researcher planned according to the initial study design to interview the previously interviewed participants in the first interview totaling 18 participants; however, 16 of the previous 18 participants were available to be interviewed as one of the previous participants had retired from the Saskatchewan government service and the second participant was on vacation during the interview period. Before the interview took place, the RHA already had a replacement in post for the retired respondent and the replacement personnel was interviewed instead. In this interview phase, the participants were interviewed together as a unit representing the participating RHAs.

3.12.5.1 Interview Guide Development

The researcher designed the interview guide as a follow up of what was known from the analyzed previous first phase interview data and the preliminary results from the quantitative data, as well as reports and other grey literature from Saskatchewan. The interview guide was shorter for this phase, but the question was the type that enabled long response from the participants to express opinions on what they thought could be more innovative to improve the current immunization figures and also what they felt could be done at the level of the government to boost their efforts. The interview guide was again reviewed by the thesis advisory committee before use.

Before the proposed use, interview guide was again pre-tested on a respondent with similar responsibilities as the prospective interviewees and the researcher reviewed and modified the content of the interview guide based on the outcome of the pre-testing carried out. It was again reviewed by the supervisor and the research advisory committee.

3.12.5.2 Conduct of the second set of interviews

This interview phase took place at the level of the health region with the previous participants of the first phase coming together to be interviewed at the same time and in one room. This meant that a total of ten interviews corresponding to the ten participating health

regions were conducted over the period of two months. The interview was conducted in a face-to-face format in designated quiet room decided by the respective RHAs. Before each interview took place, there was also a verbal consent from the interview participants for their participation and audiotaping. All the conducted interviews were audiotaped for ease of transcription and accuracy of information captured. Besides the audiotaping, there was also field notes taken to complement the interviews and also as a backup. The face-to-face method was used here because it was feasible and deemed most appropriate because the debriefing/knowledge exchange exercise had just been completed while the interview was to take place after that exercise. It was observed that the respondents were more relaxed and ready to talk for longer periods of time and the interaction enabled visual cues, observations, body languages and useful gestures to be captured. (252)

3.12.5.3 Transcription of the phase three interview data

The audio recording of the interviews was transcribed by the Social Sciences Research Laboratories (SSRL), a research support unit within the University of Saskatchewan. Transcripts were made available in Microsoft Word format and was imported in that format by the researcher into NVivo qualitative analysis software version 12 for data reduction, organization, and coding into the relevant nodes. The researcher ensured to read through all the transcript received from SSRL while listening to the audio to ensure it represented the correct information he had heard from the field. This process was also supported with the field notes the researcher took during the interview sessions.

3.12.6 The Analysis procedures – Quantitative Data Analysis

3.12.6.1 Describing Changes in Coverage Trends – Joinpoint regression models:

The model, which is composed of continuous linear phases, is often useful to describe changes in trend data (4, 253). The goal of the trend analysis in coverage rates change is to determine whether there is an increase or decrease over time and to assess the rate of change. Joinpoint Trend Analysis regression software can be used to test whether an apparent change in trend over a time period is statistically significant or not (254). This research is evaluating time trends in measles immunization coverage by geographical location and socio-economic

deprivation quintile characteristics. Joinpoint is useful to look at the behavior of a response variable separately in characteristics of groups in the different periods of the explanatory variable. (4, 253) The research will be applying Annual Percent Change (APC) and Average Annual Percent Change (AAPC) to compare the rates of changes that are not constant over a given time period for the measles immunization coverage data. The confidence intervals is said to give an indication of an increase or decrease depending on whether it is positive or negative of the Annual Percentage Change. (4) When the lower confidence limit has a positive value, the rate of change over the time period is depicted to be an increase and a decrease if the upper confidence limit is negative.

Ratio statistic = $(\mu_1 + 1) / (\mu_2 + 1)$ where APC of the two groups are represented by μ_1 and μ_2 respectively. (4)

Relating the rate of change for the two groups to put an explanation to how the two groups relate to each other over the time period under observation, annual change for group 1 is higher than for 2 if $\mu_1>1$ and lower if $\mu_1<1$. (253)

The data used in this research had the outcome variable provided in form of percent coverage rate. To use such data for Joinpoint regression, the percentages were converted to proportions. This translates to percentages divided by 100 to get the proportion, p. The standard error (SE) of the proportion was calculated using the formula below as this value was also necessary in the Joinpoint regression analysis:

Standard Error (SE) for large sample sizes = sqrt [p x (1 – p) / n]

(where p is the proportion, n is the total population of the observed)

We used the percent coverage data calculated for all the birth year (2002 – 2013) from each health region peer group. The response variable for the analysis of coverage was the natural logarithm of the percent coverage, and the independent variable was the year from 2002 to 2013. We fitted the simplest Joinpoint model that the data allowed. A statistically significant Joinpoint was set at $p<0.05$.

3.12.6.2 Measuring disparities in immunization coverage

An important aim of this study was to use disaggregated data at the level of geographical locations, socio-economic quintiles of deprivation of the two groups of children on-time for their measles vaccination over 2002 – 2013 to understand inequalities in immunization coverage among the participating regional health authorities in Saskatchewan, hence it was expedient to

make sure that the data to use remain comparable over the period of study. The data on measles immunization used in this study consisted of coverage rates of on-time for first dose at one year of age for measles vaccine uptake among children 12 – 14 months and also on-time for second dose of measles vaccine at 18 – 24 months among children aged 18–24 months.

All the data used were comparable. The data was abstracted from the Panorama gateway with generated syntax disaggregated by geographical locations as well as socio-economic deprivation quintiles. The socio-economic quintiles of deprivation used was the deprivation index determined at area-level by using the deprivation index which was developed by the Institut National de Sante Publique du Quebec (INSPQ). (3)

The Saskatchewan government produces results of data on coverage rates for all vaccinations carried out in the province through the production of Vaccine Preventable Disease Monitoring Reports (255) and quarterly childhood immunization coverage statistics document (48), however, for the purpose of this study, we are interested in the analysis of children who are on-time for their first and second doses of measles vaccination with measles vaccines (MMR and MMRV) by looking at the stipulated or recommended ages at which such vaccines should be taken according to the Saskatchewan Immunization schedule chart. (256) The researcher ensured that variables and the categories to be analyzed were consistent over the study period and time for all the health regions.

In terms of categorization by geographies and quintiles of socio-economic deprivation, the researcher found out that some participants data were recorded as unclassified. This unclassified group ranged between 1.5% and 9% of the RHAs data. This group of children were excluded in the final analysis.

3.12.6.3 Measuring coverage disparity using the Area Level Concentration Index

The distribution of immunization coverage rates for ranked groups of people can be measured using the Area Level Concentration index. (51) This is done by measuring the cumulative immunization distribution on the vertical axis while the horizontal axis will have children ranked according to household wealth from the poorest to the richest. (51) In a condition of exact equality, the proportion of immunized children should increase at equal rate with children ranked according to wealth of the household, with a resultant straight-line plot and a slope of 1 with an angle of 45 degrees. In situations where the poorer children's uptake of immunization is less than they should take, the resultant line will be a curve below the 45

degrees line (the line representing exact equity). (51) If on the other hand, children from lower income household uptake of immunization is more than their presumed share, then there will be a curve in the line above the 45-degree line of equity. (51)

In this study, the Lorenz curve is used which measures equality with variation between -1 and +1 to show the change and extent of inequality in 2002 and 2013. The far away from the line of equality the Lorenz curve is, the more the disparity. For more specific measure of equality or inequality, a mathematical formula/tool called the Gini coefficient is used and this involves looking at the two areas under the 45 degrees line which is subtended by the Lorenz curve. The Gini coefficient is represented by the formula of area subtended by the curve just below the line of equality divided by the total area under the line of equality, for example: Gini Coefficient = A/A+B

When A is 0, then A/A+B = 0 which depicts line of equality.

When A = 1, then A = A+B,

therefore, A/A+B = 1 (this depicts a perfect unequal distribution which does not exist).

The difference between the Lorenz curve and the Gini coefficient is that the Lorenz curve depicting the Concentration index varies between -1 and +1 while Gini coefficient varies from 0 representing full equality to 1, full inequality.(51, 257)

In this research, we are combining two variables which are overall immunization coverage and the relative immunization gap to come up with a 2 x 2 classification based on the average results and calculated relative gap as used by Delamonica et al., (2005).(51) (table 3.3)

Table 3-3: Quadrants of possible Relationship between Measles Immunization Coverage Rates and changes in Relative Gap between the least deprived and the most deprived quintiles

		Relative Immunization Gap	
		Narrowing	Widening
Overall immunization coverage Rate	Improving	Best Outcome	Improvement for those better off but with inequality
	Worsening	Worsening with some protection of the worse off	Worst Outcome

(adapted from Delamonica E, Minujin A, & Jama Gulaid (2005))

We could see improvement in measles immunization uptake (coverage increase) with increases in the relative gap or increase in immunization uptake going with reduction in relative gap. There can also be a situation where there's reduction in measles immunization uptake (lower coverage) going with an increase in relative gap or reduction in immunization coverage rate going with reduction in relative gap. These possible permutations and possibilities are represented in table 3.3.

The research used the measure of inequality in immunization coverage as the ratio between the lowest and the highest figures of coverage corresponding to the lowest and the highest deprivation quintile, depicting the relative gap.(51) To visualize the relationship between the variables of immunization coverage rates and relative gap and the distribution on the four quadrants with respect to each health region, a graphing calculator was employed to plot the variables on both sides of 'y' and 'x' axes.

3.12.6.4 Assessing for differences within and between the health regions

The assessment of the differences within and between the health regions looking at the places of residence as well as the socio-economic deprivation quintiles was done at two different

levels. The researcher looked at the differences at the level of the health region peer groups and also at the level of the individual health regions. IBM SPSS statistical software version 25 was used for this analysis.

Health Region Level – Places of Residence

To compare the immunization coverage rates in the places of residence across the ten participating health regions, all variables of CITY and NOT CITY were cross-checked for assumptions of t-test. Variables which met the assumptions were analyzed using the t-test and the variables which violated the assumptions for t-test were assessed for assumptions of a lower order statistical tests (non-parametric tests) and analyzed accordingly.

Health Region Level – Socio-economic deprivation quintile

To understand whether there were differences in measles immunization coverage rates within the different health regions with reference to the deprivation quintiles, one-way ANOVA test was run for the variables in health regions that met its assumptions. The variables which violated the one-way ANOVA test were checked for assumptions of a lower order statistical test (non-parametric tests) and analyzed accordingly.
The detailed description of these analytical methods is reported under the results section in chapter four.

3.12.7 The Analysis procedures – Qualitative Data Analysis

This section discusses the analysis procedures that have been used for the two qualitative data collected in this study. The qualitative data in form of interviews were collected in phases one and three of the research.

3.12.7.1 Phase 1 Qualitative Interview Data Analysis procedure

To ensure good familiarization with the interview transcripts, the researcher repeatedly read the interview data to search for recurring words and patterns, similarities and relationships to point to the main idea communicated by each respondent. Ideas that developed while the data familiarization took place were documented to inform possible nodes generation. Analysis commenced with inductive generation of themes before exploring areas of alignment with

underlying theories and the research questions. This was to prevent restriction of the data without opportunity of exploring other frames that could be important for consideration. To ensure the protection of the identity of the respondents, each interview transcript was coded using a number and alphabet coding system to represent each health region and its participants.

Interview responses were analyzed qualitatively using NVIVO software version 11 for data organization while taking into account the theories identified in the literature review. The qualitative data went through a hybrid inductive and deductive thematic analysis using the strategy described by Fereday & Muir-Cochrane (258). Ideas in the interviews were first coded into nodes and nodes grouped into meaningful themes which then informed the compilation into bigger ideas. The researcher identified passages in the transcribed texts data, with respect to the concept being addressed by respondents, looked for relationship between the concepts and categorized the codes based on their similarities and relative differences. The coded sections were then organized to subthemes and then themes. It was found that some sections or passages of some interview response fitted more than one theme and hence were coded in multiple ways depending on how many themes that they fit into. The researcher ensured that identified subthemes met recurrence and repetition criteria by ensuring a full understanding of the data which helped to reduce biases and preconceived notions (259).

The coded data assisted in describing and explaining social phenomena and the results were incorporated into consensus and agreements in phase 3 of the research. The final analysis and reporting were influenced by the themes and contextual descriptions and based on the health region peer grouping algorithm developed by Statistics Canada (annex) which was adopted for this study. The intervention information acquired was carried forward to inform the development of phase 3 portion of the research.

3.12.7.2 Phase 3 Qualitative Interview Data Analysis procedure

In this phase of the interview, the researcher read the transcribed data for familiarization and to inductively search for recurring words and patterns, similarities and relationships to point to the main idea communicated by each respondent. Ideas that developed while the data familiarization took place were documented to inform possible nodes generation. Categories that lacked adequate support and reasonable links in the data were dropped or collapsed into others

with adequate support. Like the previous qualitative data in the first phase, the hybrid inductive and deductive thematic analysis strategy described by Fereday & Muir-Cochrane was used (258).

Nvivo version 12 was used for the data analysis. Ideas in the interviews were first coded into nodes and nodes grouped into meaningful themes which then informed the compilation into bigger ideas. The researcher identified passages in the transcribed text data, with respect to the concept being addressed by respondents, looked for relationships between the concepts and categorized the codes based on their similarities and relative differences. The coded sections were then organized to subthemes and then themes.

3.12.7.3 Finalizing the themes and merging phase 1 and 3 qualitative analysis

With the assistance of the research advisory committee, the themes were scrutinized to be sure they met the need of the research questions and theories that guided the study. The themes arrived at in this interview analysis phase was then compared with the themes that arose from the first phase of interviews to see areas of alignment.

3.13 Quality and Rigor in the Research

Rigor was demonstrated in both strands of the study design and methods used. The desire to expand the breadth, accuracy and granularity of population/public health research is growing (238). Research ethics and researchers' integrity are central to this concern, especially with a mixed-method approach that is often expected to be collaborative and integrative. The procedure for attaining method-specific and integrative rigor requires continual checks on credibility, reliability, and trustworthiness in the entire research process (260).

For the quantitative strand, the internal and external validity as well as the reliability must be checked at all stages, while for the qualitative strand, adequate attention must be paid to ensure trustworthiness through credibility, confirmability, dependability and transferability tests. These qualitative rigor aspects require reflexivity, deep data description, member checking, and peer debriefing.

3.13.1 Validity and the Reliability of Quantitative phase of the Study

For the quantitative part for which validity and reliability would be a test of the rigor, the data was extracted from eHealth (Saskatchewan electronic health records management) by generating a query to reduce redundancy in the data. This process was followed by a data

cleaning process. The sample is the population of all children 0-24 months in each of the years under study (2002–2013). The inclusion and exclusion criteria which were set for the research was strictly adhered to. After the data release from the eHealth, the custodian of the data, it was then sent to each of the participating health regions to cross-check with the previous coverage outputs to ascertain that the data was theirs and in conformity with available RHAs information and data before being released to the researcher for use in the study.

3.13.2 Rigor and Trustworthiness of the Study Qualitative phases

Researchers refer to the rigor or trustworthiness in a study as the level of confidence that can be reposed in the data acquisition, the ensuing interpretation, and other methods employed to ensure the study quality (261). For the qualitative aspect, data were obtained through key informant interviews selected via purposive sampling technique. In this sampling technique, what is to be known is decided by the researcher as well as the people who are able to provide the required information as their responsibility and experience dictates (262). The key informants in this research were key to information provision as it related to the questions to be answered in the research and majority of them had been in the service of their RHAs for an appreciable period of time with 83% (n=15) having at least 11 years' experience on the job.

Two interviews at pre and post-interventions phases were carried out via telephone and face-to-face respectively. During each interview phase, interview guides (appendices D and E) developed by the researcher with the assistance of two senior qualitative researchers were used. The instruments were pilot-tested with two groups with similar responsibilities to the intended participants to validate the instruments. Probing questions were included in the interview guide to help with eliciting as much information as the participant had on the main question stem. Even though two key informants had been selected by purposive strategy from each health region at different authority levels, the participants were interviewed separately during the first interview phase and together in the second interview. Lincoln argues that credibility of a research can be attained and strengthened through triangulation, member checking and peer-debriefing (263). Interview script went through verbatim transcription and sent back for transcript review before commencement of analysis to ensure trust-worthiness of the data. For transparency, knowledge translation was integrated into the design in the form of peer-debriefing with the analyzed data. This also increases the dependability of the research process and hence the results.

The qualitative results section was written with substantive quotes for illustration purposes and for the readership to have own opinions while cross-checking the researcher's understanding of the data, his insight and intuition (264, 265). It also allows the readership and other researchers to assess transferability of the research into other settings and/or contexts (266). Finally, reproducibility and fidelity were ensured through careful and detailed documentation of the research process while the necessary materials and instruments were included either in the result section of the research document or as an appendix.

3.14 Summary of Chapter Three

Under chapter three, the philosophical underpinning and conceptual frameworks were examined, the study design, location, population were described. The researcher explained the research process, tools involved in data collection, the methods employed, and procedures utilized were elucidated. The different phases of the research were clearly laid out and so also were the procedures for both the quantitative and qualitative methods and the analysis. The chapter rounded up by examining the rigor and quality demonstrated in the research.

Chapter 4: Results

4.1 Introduction and Overview

In this chapter, the results from the analyzed data have been presented following the study phases while answering the research questions. The results of the quantitative strands and those of the two qualitative strands have been presented separately; and so also was the outcome and experience from the intervention phase. The quantitative results are presented for each variable at three distinct levels, the provincial level, the health region peer groups and at the level of the individual participating regional health authorities. The two qualitative strands on the other hand have been presented separately with the specifics addressed by each highlighted diagrammatically to provide clarity to the results.

4.2 Participation Rates

The quantitative analysis utilized the total available data of the covered population of children in SIMS between 2002 and 2013 (pulled out of Panorama at the early phases of data migration) (n= 169,582) while the qualitative strands used interview data obtained from eighteen (n=18) participants and seventeen (n=17) participants of the first and the second interview phases respectively.

4.3 Findings from Research Questions One and Two

The findings from the first two research questions are discussed together under this subtopic.

From Table 4-1, which used the 24 months of age covered population figure, it is observed that there has been a progressive increase of the study population figures from 2002 to 2013. The total under 2 years covered population reached its highest figure of 15,189 in 2009 and decreased gradually until 2013 but without reaching the baseline figure of 2002.

For changes in geographical location population, a progressive increase was observed in terms of proportion of people living in the CITY areas from 2002 to 2013 while there was a gradual reduction of population living in the NOT CITY locations over the same study period. This may not be unconnected with rural-urban migration in the province.

Among the health regions, Regina and Saskatoon RHAs enjoyed progressive increase in population figures throughout the period under study, with Saskatoon RHA seeing a higher level

of increase than Regina RHA. The other health regions in the province observed a reduction in population figures as depicted by their reducing proportional figures between 2002 and 2013.

Table 4-1: Characteristics of the Study Population

Characteristics of the Study Population													
Variable		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Geographical Location													
	CITY	62.59	63.60	64.25	64.21	64.81	64.85	65.78	65.81	66.60	66.25	67.78	68.80
	NOT CITY	33.81	33.03	32.05	32.27	31.73	31.78	31.16	31.02	30.26	30.59	29.53	28.56
Regional Health Authority													
Peer Group A	Regina Qu'	23.99	24.94	24.93	25.06	25.65	25.49	26.08	26.05	25.95	26.24	26.78	25.70
	Saskatoon	30.84	31.41	30.65	31.25	30.97	31.30	31.93	32.00	31.83	32.71	32.96	33.51
Peer Group D	Cypress	4.16	3.85	4.12	3.83	3.64	3.72	3.46	3.63	3.33	3.53	3.32	3.37
	Five Hills	4.83	4.41	4.82	4.56	4.57	4.87	4.61	4.74	4.75	4.95	4.84	4.65
	Heartland	4.22	4.03	3.86	4.04	4.08	3.98	3.93	3.77	3.80	3.87	3.97	3.57
	Kelsey Trail	3.47	3.48	3.42	3.59	3.38	3.10	3.23	3.10	3.44	3.24	2.99	3.06
	Sun Country	5.45	5.66	5.57	5.59	5.69	5.59	5.24	5.52	4.98	5.29	4.88	5.34
	Sunrise	4.96	4.70	4.90	4.57	4.62	4.68	4.83	4.58	4.81	4.43	4.37	4.30
Peer Group H	Prairie North	7.46	7.04	7.05	6.68	7.16	7.33	6.99	6.47	6.76	5.79	6.21	6.83
	Prince Alb Park	10.58	10.52	10.71	10.53	10.19	10.19	10.42	10.79	10.28	10.12	9.78	10.00
Socio-Economic Deprivation Quintile													
	Q1	19.60	19.63	19.54	19.71	19.62	19.46	19.28	19.03	18.95	18.84	17.53	17.41
	Q2	19.87	20.08	19.37	19.91	20.05	19.94	19.27	19.64	19.51	20.09	19.93	20.28
	Q3	16.76	16.76	16.47	16.16	16.45	16.93	16.87	16.72	16.87	17.36	17.72	17.51
	Q4	14.83	14.35	14.00	14.45	14.52	14.88	14.86	14.41	14.12	13.77	14.49	14.43
	Q5	16.66	17.46	16.98	17.59	17.65	18.06	18.19	18.54	18.75	18.65	19.54	19.51
	n	13273	13656	13724	13580	13756	14607	14627	15189	14580	14193	14291	14106

(All figures are shown in percentages apart from the values of n)

From Figure 4-1, in the overall total population figure analyzed, an average of about one third lived in the NOT CITY locations while about two-third lived in the CITY locations in the study period. It should be noted that 3% was unclassified into either CITY or NOT CITY location.

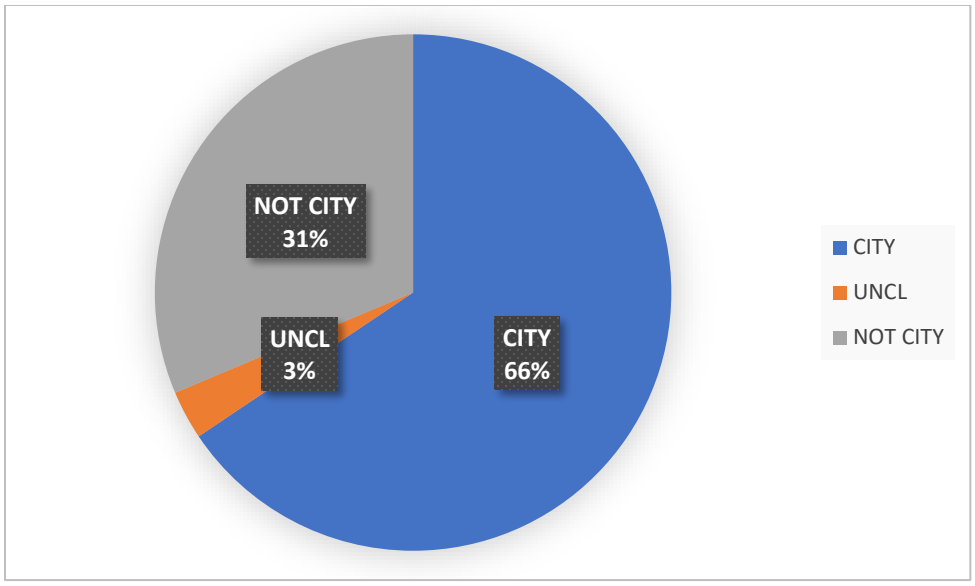


Figure 4-1: Study population by geographical location

The analysis to characterize the participants in terms of socio-economic positions used the Socio-Economic Deprivation Quintiles (S-EDQ) as defined by Statistics Canada. According to the classification, S-EDQ1 is the least deprived while S-EDQ5 is the most deprived category. The definition of S-EDQ can be found in the glossary of this document. Figure 4-2 presents the proportion of study participants in the 10 participating health regions in terms of the deprivation quintile they belong to. About 20% of the total participants belong to the S-E DQ2, followed by S-EDQ1 at 19.4% and then S-EDQ5 (18.51%).

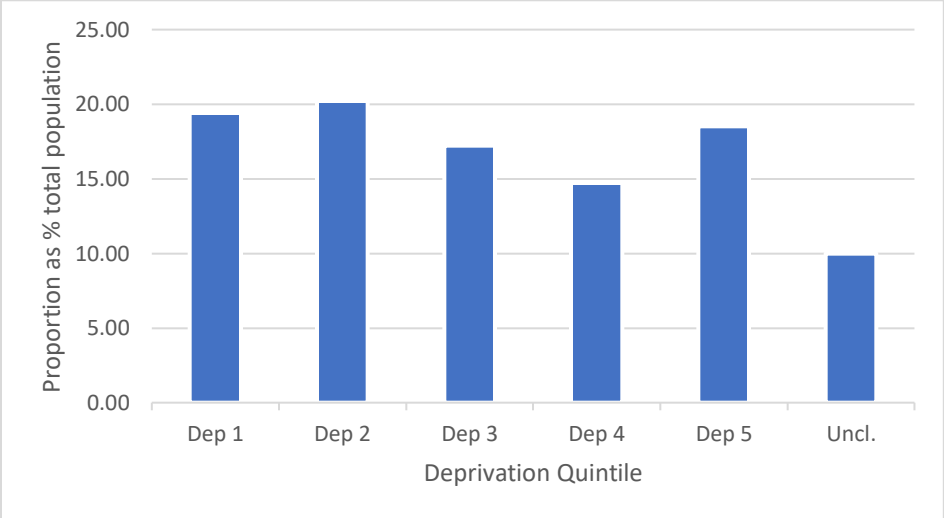


Figure 4-2: Distribution by deprivation quintiles of the study population

4.4 Health Region Peer Groups

The peer groups have been described in chapter four as a method of classification of regional health authorities in Canadian provinces and territories into ten distinct groups based on a cluster of principal characteristics. These principal characteristics are rurality vs urbanization, proportion of Aboriginal or immigrants' populations and employment rate. In terms of this classification, Saskatchewan RHAs were classified under four of the ten groups which are A, D, F and H (table 4-2). Saskatoon and Regina are in group A with both urban-rural mix, and average proportions of Aboriginal and immigrants' population. The A peer group makes up about 55.67% of Saskatchewan total population. Six RHAs (Cypress, Five Hills, Heartland, Kelsey Trail, Sun Country and Sunrise) belong to group D and are mainly rural regions with average percentage of Aboriginal population but high employment rate, and in total makes up 26.62% of Saskatchewan population figure. In group F are two health regions (Keewatin Yatthé and Mamawetan Churchill River) and one health authority (Athabasca), which is composed of the northern but remote regions, low proportion of Aboriginal peoples and immigrants as well as low level of employment. The F group constituted 3.41% of Saskatchewan population. Two RHAs are grouped under H which is the last of the Saskatchewan RHAs peer groups, these are Prince Albert Parkland and Prairie North health regions. This H health region peer group constituted about 14.30% of the total Saskatchewan population with also rural northern regions, low proportion of immigrants like the F peer group but higher proportion of Aboriginals unlike the F RHAs peer group.

It is to be noted that the data for F peer group were not analyzed in this research because the two health regions Mamawetan Churchill River and Keewatin Yatthé and Athabasca health authority which made up this group did not sign up to participate and hence their data were not reported on. The F peer group health region accounts for a total covered population of about 3.41% of the province of Saskatchewan. The rest of the Saskatchewan health regions covered population constituting ten health regions and 96.59% of the total population was included in the study, analyzed and reported on. The RHA peer groups present in the province of Saskatchewan are the A, D, F and H as highlighted in table 4-2.

Table 4-2: RHAs in Saskatchewan by Peer Groups showing proportion and principal characteristics

RHA Peer Group	Number of RHAs	RHA by name	% of Saskatchewan population	Principal Characteristics
A	2	Regina Qu'Appelle Saskatoon	55.70%	Urban-Rural mix Av. Percentage of Aboriginal pop Av. Percentage of immigrant population
D	6	Cypress Five Hills Heartland Kelsey Trail Sun Country Sunrise	26.62%	Mainly rural regions Av. Percentage of Aboriginal pop. High employment rate
F	3	Athabasca Keewatin Yatthé Mamawetan Churchill River	03.41%	Northern and remote regions Very high proportion of Aboriginal pop. Low proportion of immigrants Very low employment rate
H	2	Prince Albert Parkland Prairie North	14.20%	Rural Norther regions High proportion of Aboriginal pop. Low proportion of immigrants

Figure 4-3 displays the coverage rates for the on-time for 2nd measles vaccine dose for the individual participating health regions between 2002 and 2013. In year 2002, the study start period, Sun Country health region had the highest coverage of 67.22% while Prairie North health region had the lowest of 49.15%. In 2013, the end of the study period, Sun Country attained the highest coverage figure of 84.2% while Prince Albert Parkland had the lowest coverage figure at 60.58% as compared with other RHAs. It should be noted, however, that there were varying coverage rates for each of the health regions during the years 2002 – 2013. It is observed that Sun Country RHA performed fairly better than all the other RHAs in the study period.

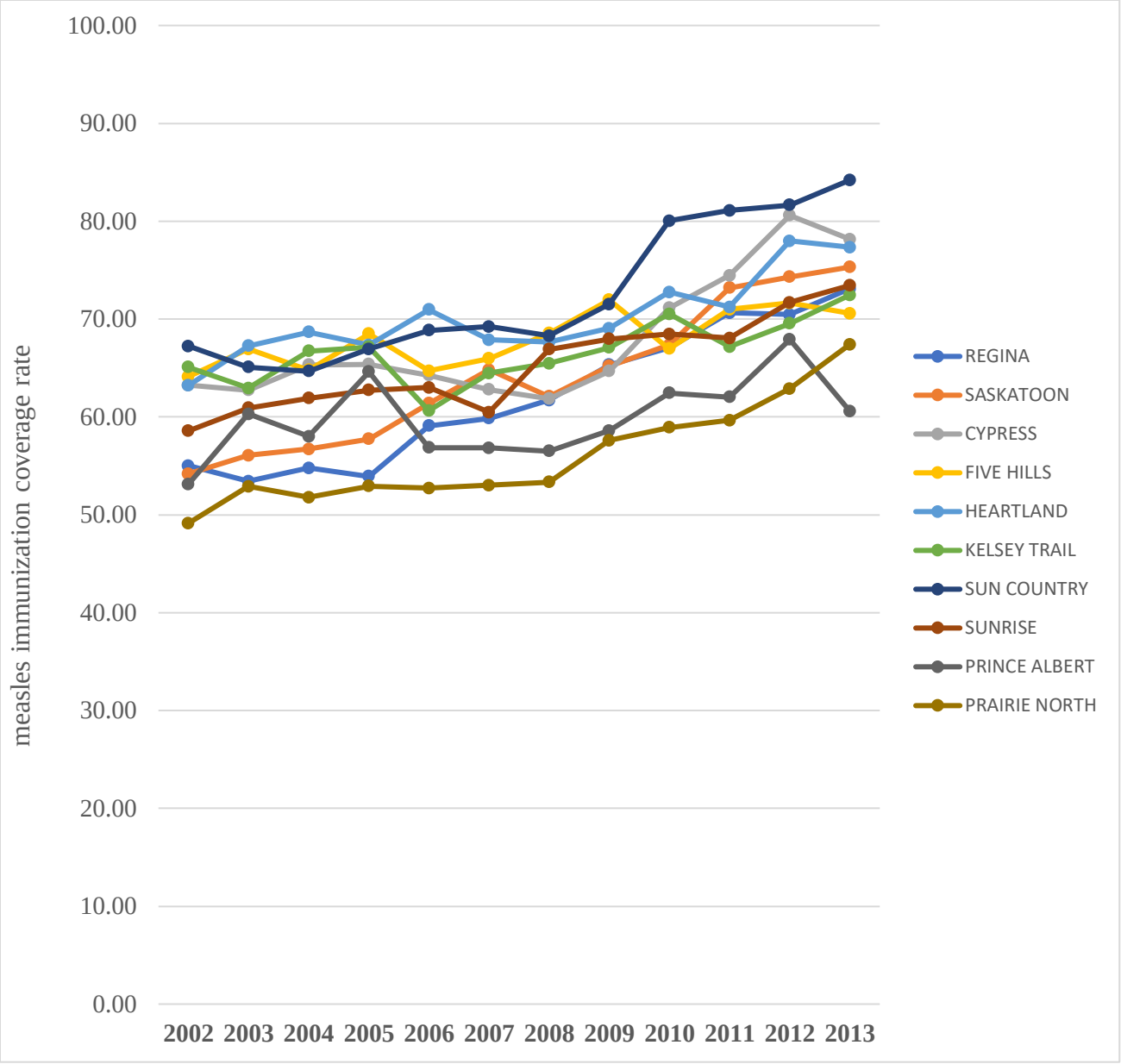


Figure 4-3: Saskatchewan on-time for 2nd dose at 2yr Measles Coverage by individual RHA (2002 - 2013)

Figure 4-4 shows the average coverage rate for the ten participating health regions during the period, from 56.32% in 2002 to 73.21% in 2013. There was a progressive increase in coverage over this time period with an AAPC of 2.4 (C.I. 2.0 – 2.9, $P < .005$). And if we look at the segments, the three segments represented by the APC were all significantly different from zero at 1.68, 4.09 and 2.14 for the periods 2002 – 2008, 2008 – 2011 and 2011 – 2013 respectively.

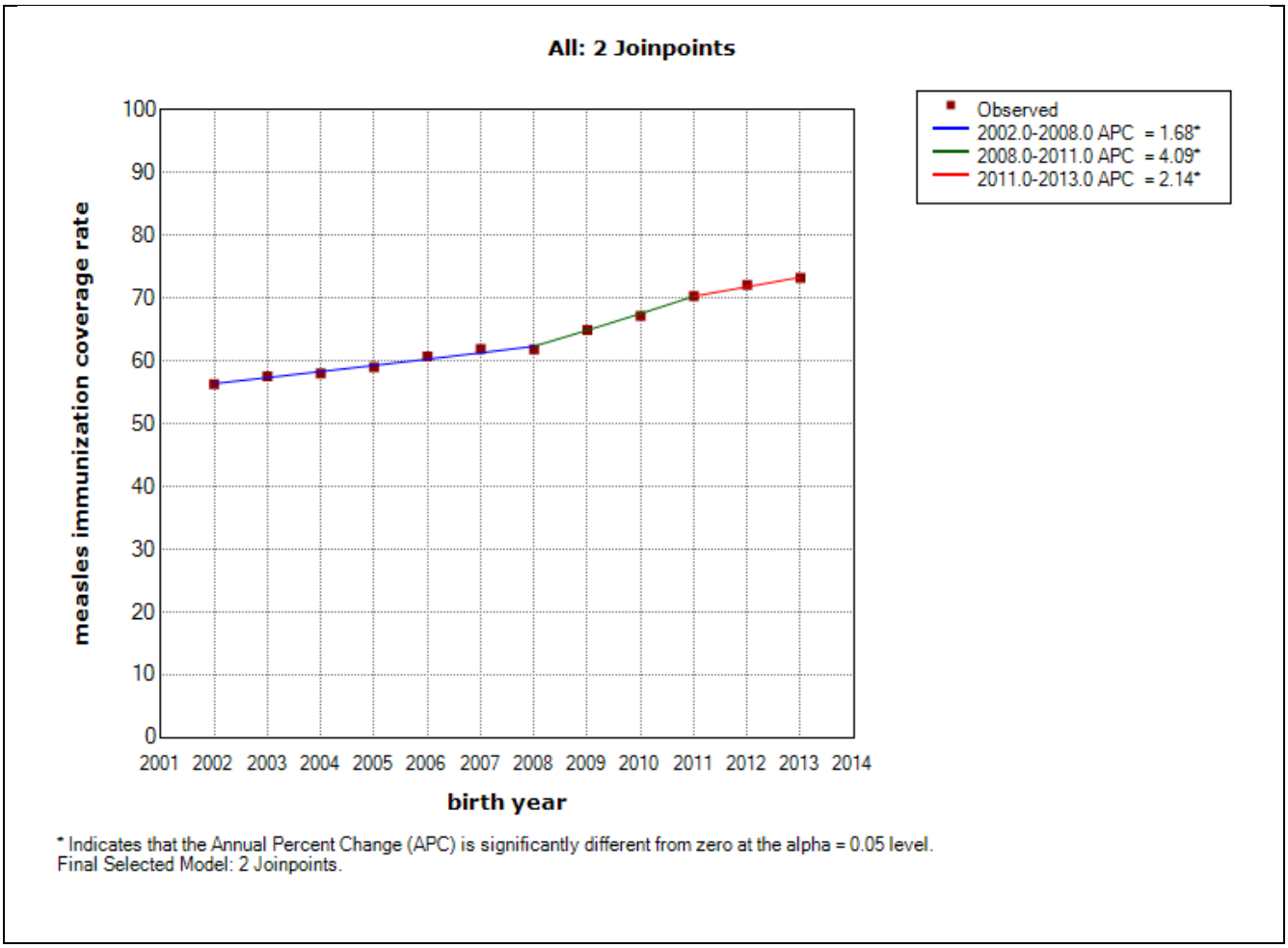


Figure 4-4: Saskatchewan 10 RHAs average on-time at 2yr for measles coverage (2002 - 2013)

4.4.1 Assessment of effect of socio-demographic characteristics on measles immunization coverage

In this section, the effect of geographical location and socio-economic deprivation on measles immunization coverage at the level of individual health regions and at the level of health region peer groups were assessed. The research also looked at what the level of disparity among the least socio-economic deprivation quintile and most deprived quintile was in 2002 as compared with end of the study period in 2013. The study used Gini coefficient and Area level concentration curve and coefficient at the level of the individual health regions. The last part of the results section brought together the relationship between coverage rate changes and relative gap between the ‘most’ and ‘least’ socio-economic deprivation quintiles.

To understand the effect of geographic location and socio-economic deprivation on measles immunization coverage figures in the province of Saskatchewan, we employed the use of Joinpoint regression software to fit the best possible model on the trend over the period of study (procedure description under section 3.12.6.1). The Joinpoint regression had capacity to make comparison between two lines. For visualization purposes, this was appropriate to show the relationship between the geographical locations. However, we needed to show the relationship between more than two variables in the deprivation quintile relationships, hence a syntax was generated on STATA to bring this idea into graphic effect resulting in figures 4-5 to 4-8 below.

The last part of the results section that brought together the relationship between coverage rate changes and relative gap between the 'most' and 'least' socio-economic deprivation quintiles plotted the variables of interest (relative gap and coverage rate change) on graphing calculator. The display was on four quadrants to characterize relative gap and coverage difference between 2002 and 2013 in terms of four possible combinations to assess whether there is improvement or worsening of those variables. The quadrants of possible relationship between measles immunization coverage rates and changes in relative gap between the least deprived and the most deprived quintiles has been described in section 3.12.6.3 and table 3-3.

4.4.1.1 Effect of Geographic Location on Measles Immunization Coverage

To assess if geographic location had any effect on measles immunization coverage, the assessment was done at the level of the pooled data of all the ten participating health regions and also at the level of the health region peer groups.

4.4.1.1.1 Provincial level

First, the researcher assessed the effect of geographical location at the level of all the ten participating health regions and among the two groups of children who qualified for measles immunization. Figure 4-5 displays the result of the assessment at the level of the pooled coverage among the ten participating health regions.

In the on-time for first dose at 1-year age group, there was increase in coverage rates from 2002-2004, followed by a decrease between 2004 and 2007 after which there was a progressive increase from 2007 till 2013 for the NOT CITY geographical location. The Annual

Percentage Change (APC) increase for the 2007 – 2013 period was 2.9 which was significantly different from zero at the alpha of 0.05 (Confidence interval 1.4 – 2.2). The coverage rates for the CITY location increased from 2002 – 2009 at an APC of 0.8 which was not significant but from 2009 – 2013 there was a higher and progressive increase with an APC of 2.0 which was significant (CI 1.7 – 4.1). The two trend lines in this Joinpoint were tested for parallelism to see whether they were different, and parallelism was rejected (p value < 0.027). A rejection of the test of parallelism indicates that the trends on coverage were different in both geographical locations (see table 4-3)

Among the on-time for second dose at 2-year age group using the ten RHA pooled data, there was increase in coverage rates between 2002 and 2008 (APC 0.8), after which there was a higher progressive increase from 2008 till 2013 (APC 3.0) for the NOT CITY geographical location. Both of the APC were significantly different from zero at the alpha of < 0.05 (CI of 0.1 – 1.6 and 2.1 – 3.8 respectively). The CITY location coverage rates with a three-section Joinpoints displayed an increase from 2002 – 2008 at an APC of 2.3, a further increase of APC of 4.5 from 2008 – 2011. In both of those APCs, the rate of change was significant with CIs of 1.7 – 3.0 and 1.6 – 7.5 respectively. The third Joinpoint for the CITY location even though it had an increase from 2011 – 2013 with an APC of 2.0, this was not significant (CI -0.4 – 4.6). The two coverage rate trends for the on-time for second dose at 2-year age group in the CITY and NOT CITY locations were tested for parallelism to check whether there was any difference between the two trend lines, and Parallelism was rejected (p value = 0.027) (table 4-3), which also indicates that there was a significant difference between the trend lines of the two geographical locations.

There was increase in the coverage trends in the two geographical locations under study as well as among the two age groups studied. The trends of coverage rates were higher in the rural than in the urban locations for the on-time for measles vaccination of the two groups. Also, in the two set of comparisons, the rejection of parallelism suggested that the trends were significantly different for the two geographical locations coverages.

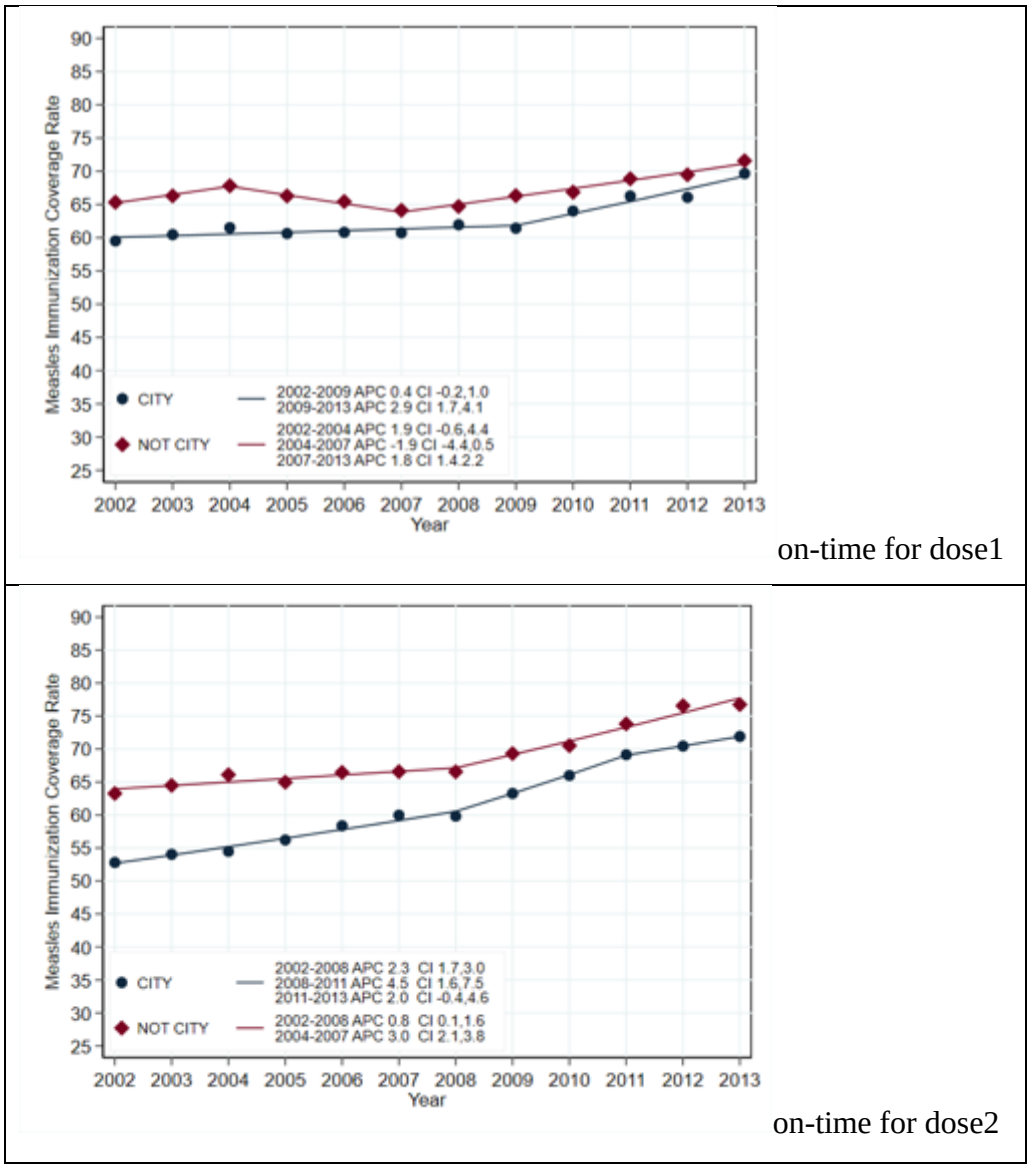


Figure 4-5: Trends of measles immunization coverage rates among the on-time for 1st and 2nd dose in 10 Saskatchewan RHAs by CITY and NOT CITY geographical locations (2002–2013)

4.4.1.1.2 Health Region Peer Group Level

To assess if geographical location is associated with measles immunization coverage at the level of health region peer groups, the researcher looked at this effect among the on-time for first dose at 1-year and on-time for second dose at 2 years. The results for this assessment are displayed in figure 4-6 where the resulting result depicted by six graphs have been arranged in two columns, the on-time for first dose on left column and on-time for the second dose on the right column. Each of the columns are crossed by three peer groups in rows.

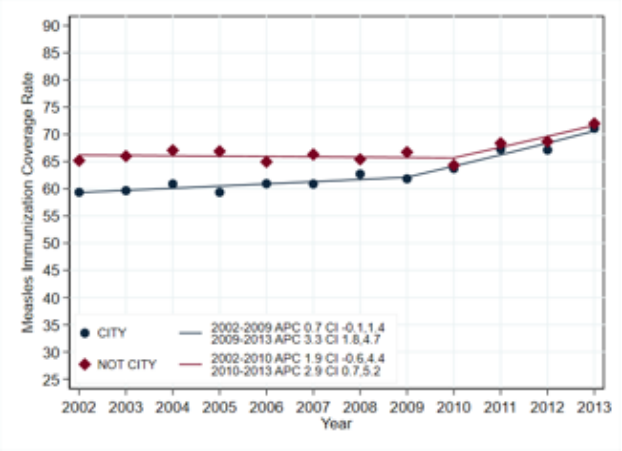
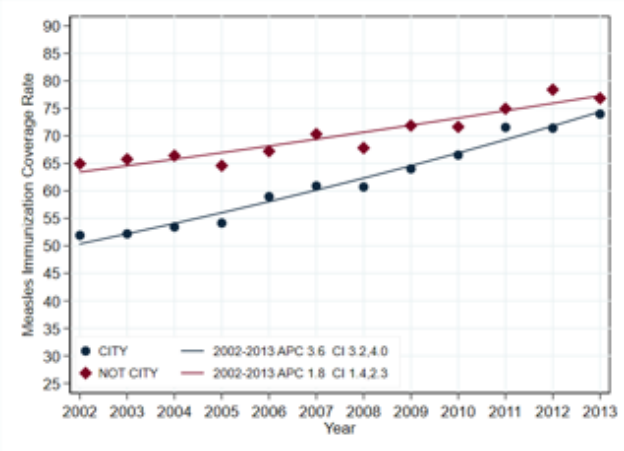
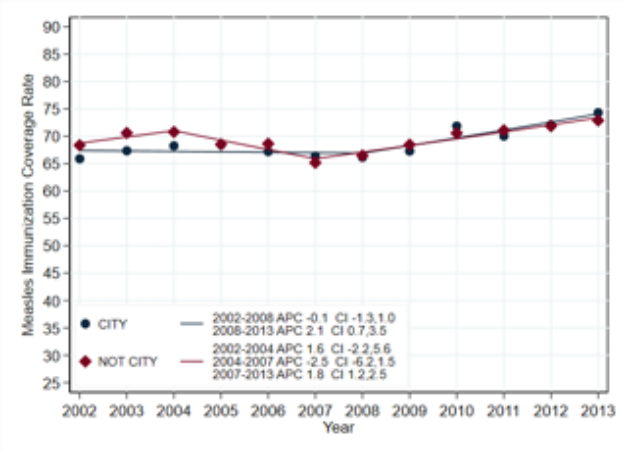
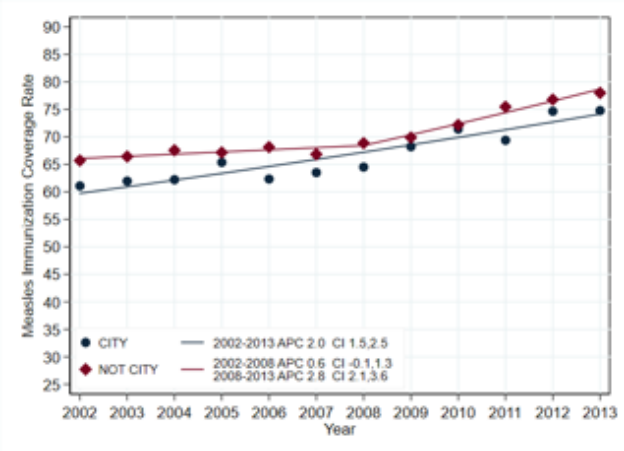
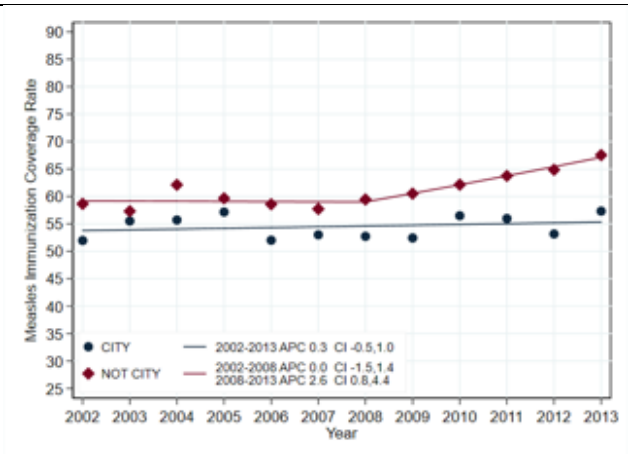
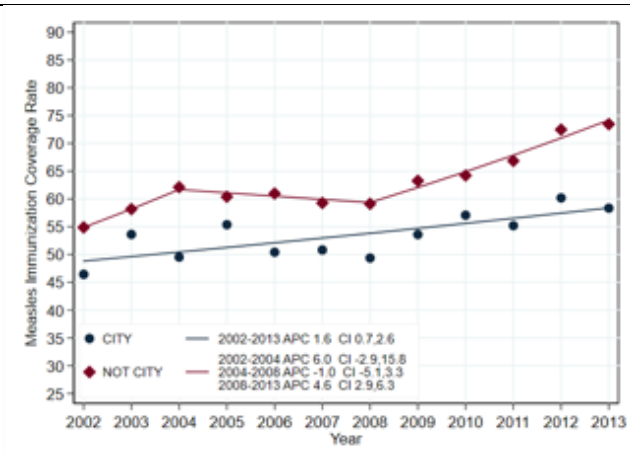
	On-time for 1st measles vaccination	On-time for 2nd measles vaccination
Peer Group A		
Peer Group D		
Peer Group H		

Figure 4-6: Trends of measles immunization coverage rates among the on-time for 1st and 2nd dose in Saskatchewan RHAs Peer Groups by CITY and NOT CITY locations (2002–2013)

The coverage rate data which was disaggregated at the level of health region peer groups was used for the assessment. Multiple Joinpoint regressions were run and fitted with the result shown in figure 4-6. From the trend lines of the two age groups (on-time for 1st and 2nd doses), it was observed that coverage trends were higher for the NOT CITY locations than in the CITY locations for the period under study.

Table 4-3: Summary of AAPC value and test for parallelism for CITY and NOT CITY locations for on-time for age at measles immunization in Saskatchewan.

		Observation		CITY		NOT CITY		Parallelism		
RHA Peer Grp	On-Time for Dose	Start	End	AAPC	*P*-value	AAPC	*P*-value	Rejected	Failed to Reject	*P*-value
All 10 RHAs	1	2002	2013	1.3	0	0.8	0	Y		0.0027
	2	2002	2013	2.9	0	1.8	0	Y		0.0027
A	1	2002	2013	1.6	0	0.7	0	Y		0.0017
	2	2002	2013	3.6	0	1.8	0	Y		0.0004
D	1	2002	2013	0.9	0	0.6	0.2	Y		0.044
	2	2002	2013	2	0	1.6	0		Y	0.2593
H	1	2002	2013	-0.5	0.4	0.2	0		Y	0.05
	2	2002	2013	1.6	0	2.8	0		Y	0.6694

It is noted that some of the trend lines ranged from one to three-line segments depending on the number of Annual Percentage Change Joinpoint models fitted. The summary measure of the trend over a specified interval is the AAPC which is computed as a weighted average of Joinpoint model APCs. (267) While it allowed for the reporting of average APCs over multiple years, the validity of the resulting value is not affected by an indication of Joinpoint models even if the years had trend changes.

It is represented by the formula AAPC =

$$(\exp[\Sigma w_i b_i/\Sigma w_i]-1) \times 100 \text{ (267)}$$

For the purpose of reporting the results in figure 4-6, the Average Annual Percentage Change (AAPC) summarized in table 4-3 was used in combination with figure 4-6.

On-time for 1st Dose at 1-year

Peer Group A

The Average Annual Percentage Change (AAPC) for the CITY location between 2002 and 2013 was 1.6, which was a significant change (*P*<.001) while the AAPC for the NOT City location was 0.7 which also was significant (*P*<.001). The CITY and NOT CITY location trends were assessed for Parallelism which was rejected (*P*=.002). The two trend lines of the CITY and NOT CITY geographical locations demonstrated progressive convergence from 2002 to 2013, however, the degree of convergence increased from about year 2010 till 2013.

Peer Group D

For RHA peer group D, the AAPC for the CITY location between 2002 and 2013 was 0.9, which was a significant change (*P*<.001) while the AAPC for the NOT City location was 0.6 which was not a significant change (*P*=.200). The CITY and NOT CITY location trends were assessed for Parallelism which was rejected (*P*=.044). The two lines representing the CITY and NOT CITY geographical locations demonstrated an initial divergence from 2002 to 2004, then convergence from 2004 until 2006 after which there was more or less a merge until 2013.

Peer Group H

The AAPC for the CITY location between 2002 and 2013 was –0.5, which was a not a significant change (*P*=.4) while the AAPC for the NOT City location was 0.2 but was significant (*P*<.001). The CITY and NOT CITY location trends were assessed for Parallelism which was failed to be rejected (*P*=.05). The two lines representing the CITY and NOT CITY geographical locations demonstrated almost an equal rate of change until 2008 after which there was divergence that went on to the end of the study period. There was a marginal decrease in trend coverage rates in the CITY location for the RHA peer group H from 2002 – 2013.

On-time for second dose at 2 years:

Peer Group A

The Average Annual Percentage Change (AAPC) for the CITY location between 2002 and 2013 was 3.6, which was a significant change (*P*<.001) while the AAPC for the NOT City location was 1.8 also significant (*P*<.001). The CITY and NOT CITY location trends were assessed for

Parallelism which was rejected (*P*<.001). The two lines representing geographical locations demonstrated a progressive convergence from 2002 to 2013.

Peer Group D

In this group, the AAPC for the CITY location between 2002 and 2013 was 2.0, which was a significant change (*P*<.001) while the AAPC for the NOT City location was 1.6 which also was significant (*P*<.001). However, The CITY and NOT CITY location trends were assessed for Parallelism and failed to be rejected (*P*= .259). The two lines representing the CITY and NOT CITY geographical locations demonstrated convergence until 2008 after which there was divergence in the coverage rate till 2013. The compared coverage trend lines for the two geographical locations was not statistically different.

Peer Group H

The AAPC for the CITY location between 2002 and 2013 was 1.6, which was a significant change (*P*<.001) while the AAPC for the NOT City location was 2.8 which was also significant (*P*<.001). However, like in RHA Peer Group D of the on-time for second dose at 2 years, the CITY and NOT CITY location trends were assessed for Parallelism and also failed to be rejected (*P*= .669). The two lines representing the CITY and NOT CITY geographical locations demonstrated divergence from 2002 to 2004, then convergence until 2008 after which there was divergence in the coverage rate till 2013, the end of the study period. It should be noted that the trend line for the NOT CITY location showed a decrease between 2004 – 2008.

In terms of the visualization of the trend lines for all the RHA Peer Groups, it was observed that apart from the trendlines of CITY and NOT CITY for RHA Peer Group D of the on-time for first measles immunization dose at one year where the trend line was almost intertwined., the coverage trends was higher in the NOT CITY than in the CITY locations for all the groups data analyzed.

Summarizing these findings, it is observed that though the coverage rates in the NOT CITY locations were higher in almost all the peer groups, the rate of increase in coverage as reflected by the AAPC was lower in the NOT CITY locations apart from among the peer group H where it was higher. It is also noted that apart from peer group A health regions where there was convergence of lines in both the age groups studied, there was divergence in peer group H

health regions which commenced from 2008 for both age groups studied. The peer group D health region age groups did not demonstrate a uniformity in rate of change of the fitted lines. While the on-time for first dose demonstrated a convergence up till 2007, the two lines remained almost equal till 2013, while for the on-time for second dose group, it was an initial convergence with a divergence after 2008. It is evident from the pooled data of the health regions in figure 4-5 that there was an overall convergence in the lines representing the geographical locations.

Parallelism test of slopes in Joinpoint regression gives an indication of whether the two slopes being compared are either different or not (267). Parallelism is rejected when they are different and failed to reject when they are not different. In this instance, the geographical location slopes compared for the pooled data analyzed for all the health regions in both age groups were different, likewise for peer group A geographical location comparison for both age groups and for 1-year age group of peer group D. In contrast to the others, the CITY and NOT CITY locations coverage slopes were not different for the year two age group of peer group D health regions as well as both age groups for the peer group H health regions.

4.4.1.2 Effect of socio-economic deprivation on measles immunization coverage

To assess if socio-economic status is associated with measles coverage rates in the province of Saskatchewan, Joinpoint regression was used to model the coverage trends and the summary results presented in table 4-4. For visualization of the trend lines, STATA statistical software was used to plot the graphs.

Though all the five socio-economic deprivation quintiles were illustrated in the Joinpoint fitted models, however, for the purpose of this research, only S-E DQ1 and 5 only are compared in the RHA pooled data and the RHA Peer Groups for the on-time for first dose at 1-year and on-time for second dose at 2-year age groups.

Changes in trend of measles immunization coverage rates among the on-time for 1st and 2nd dose in 10 Saskatchewan RHAs by Socio-economic Deprivation Quintiles (2002–2013) are presented in figure 4-7 while the results for the RHA Peer Groups are in figure 4-8. The AAPC for both figures 4-7 and 4-8 are summarized in table 4-4.

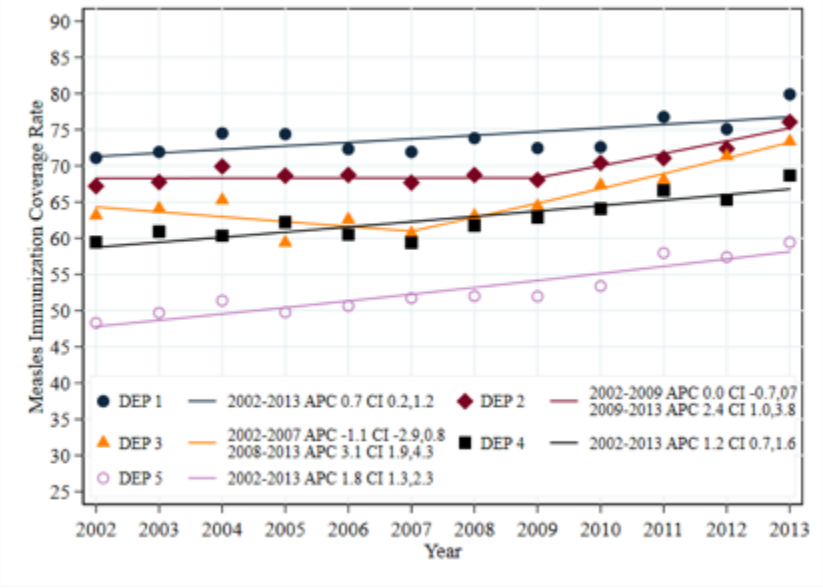
4.4.1.2.1 Provincial level

First, we assess the effect of socio-economic deprivation characteristics at the level of all the ten participating health regions. From figure 4-7 which summarized an assessment at the level of the pooled coverage data among the ten participating health regions.

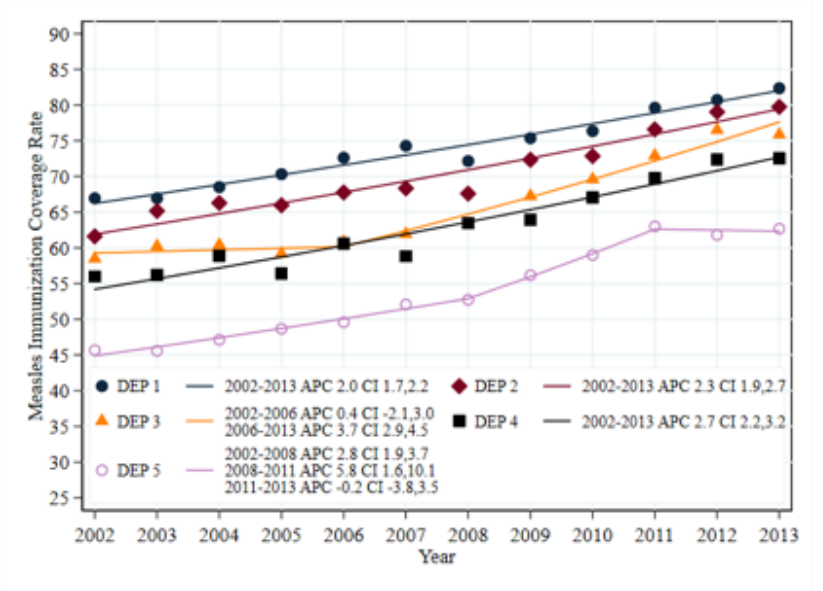
Among the on-time for first dose at 1-year age group, there was gentle but progressive increase in coverage rates between 2002-2013 in the S-EDQ1 with an Annual Percentage Change (APC) 0.7 which was significantly different from zero at the alpha of=0.05 (CI 0.2 – 1.2). The S-EDQ5 coverage rates increased also through the period with an APC of 1.8 which was also significant (CI 1.3 – 2.3). The two trend lines in these Joinpoints models were tested for parallelism to see whether they were different, and parallelism was rejected ($P<.001$), meaning the trends on coverage were different among both socio-economic deprivation quintiles (see table 4-4)

In the on-time for second dose at 2-year age group, there was increase in coverage rates from 2002-2013 (APC 2.0) in the S-EDQ1, an increase that was significantly different from zero (CI of 1.7 – 2.2). The S-EDQ5 coverage rates with a three-section Joinpoints displayed an increase from 2002 – 2008 with APC of 2.8, a further increase to 5.8 from 2008 – 2011. In both of those APCs (2002-2008 and 2008-2011), the rate of change was significant with CIs of 1.9 – 3.7 and 1.6 – 10.1 respectively. The third Joinpoint for the S-EDQ5 showed a decrease from 2011 – 2013 with an APC of -0.2, which was not significant (CI -3.8 – 3.5). The two coverage rate trends for the on-time for second dose at 2-year age group in the S-EDQ1 and 5 were tested for parallelism (whether there was any difference between the two trend lines), and Parallelism was rejected ($P<.001$) (table 4-4). For the S-EDQ5 which had three Joinpoint segments, the model was checked for AAPC to create one value for the change in trend in the period under study (2002 – 2013), a value of 3.0 which was significant at an alpha of 0.05 ($P<.001$)

Summarizing, there was progressive increase in the coverage rates for both S-EDQ 1 and 5 for both age groups studied, the increase in coverage as depicted by the AAPC showed that the change was significantly different from zero in both groups. The coverage rates were higher in the S-EDQ1 than S-EDQ5 for both on-time for first dose at 1-year and on-time for second dose at 2-year age groups all through 2002 – 2013.



On-time for first dose at 1year



On-time for second dose at 2years

Figure 4-7: Changes in trend of measles immunization coverage rates among the on-time for 1st and 2nd dose in 10 Saskatchewan RHAs by Socio-economic Deprivation Quintiles (2002–2013)

4.4.1.2.2 Health Region Peer Group Level

The coverage rate data disaggregated at the level of health region peer groups was also assessed for whether there was as association between socio-economic deprivation and coverage rates of measles immunization. Multiple Joinpoint regressions were run (figure 4-8). In the figure, the six graphs have been arranged in two columns, the on-time for first dose at age of 1-year measles vaccination on the left column and the on-time for the second dose at 2-year on the right column and the peer groups are arranged in rows.

On-time for 1st dose at one year:

Peer Group A

The Average Annual Percentage Change (AAPC) for the Socio-economic Deprivation Quintile 1 (S-EDQ1) between 2002 and 2013 was 0.9, which was a significant change ($P<.001$) while the AAPC for the S-EDQ5 was 2.6 which also was significant ($P<.001$). The S-EDQ1 and 5 trends were assessed for Parallelism which was rejected ($P<.001$)

Peer Group D

The Average Annual Percentage Change (AAPC) for the Socio-economic Deprivation Quintile 1 (S-EDQ1) between 2002 and 2013 was 0.6, which was a significant change ($P<.001$) while the AAPC for the S-EDQ5 was 1.3 which was not significant ($P= .20$). The S-EDQ 1 and 5 trends were assessed for Parallelism which was rejected ($P= .048$)

Peer Group H

The Average Annual Percentage Change (AAPC) for the Socio-economic Deprivation Quintile 1 (S-EDQ1) between 2002 and 2013 was 0.3, which was not significant ($P= .40$) while the AAPC for S-EDQ5 was 1.0 which was significant ($P<.001$). The S-EDQ 1 and 5 trends were assessed for Parallelism which failed to be rejected ($P= .180$)

On-time for second dose at 2 years:

Peer Group A -

The Average Annual Percentage Change (AAPC) for the Socio-economic Deprivation Quintile 1 (S-EDQ1) between 2002 and 2013 was 2.0, which was a significant change ($P<.001$) while the

AAPC for the S-EDQ5 was 4.4 which also was significant (P<.001). The S-EDQ 1 and 5 trends were assessed for Parallelism which was rejected (P<.001)

Peer Group D

For RHA Peer Group D, the Average Annual Percentage Change (AAPC) for the S-EDQ1 between 2002 and 2013 was 2.0, which was a significant change (P<.001) while the AAPC for the S-EDQ5 was 3.4 which also was significant (P<.001). The assessment for Parallelism of S-EDQs 1 and 5 trends was rejected (P<.001)

Peer Group H

Finally, the Average Annual Percentage Change (AAPC) for the Socio-economic Deprivation Quintile 1 (S-EDQ1) between 2002 and 2013 was 1.7, which was a significant change (P<.001) while the AAPC for the S-EDQ5 was 2.2 which also was significant (P<.001). The S-EDQs 1 and 5 trends were assessed for Parallelism and failed to be rejected (P= .002)

From figure 4-8, it was observed that all the trend lines for S-EDQ5 was persistently lower than those of the S-EDQ1 for all the RHA Peer Groups and for both groups of children studied.

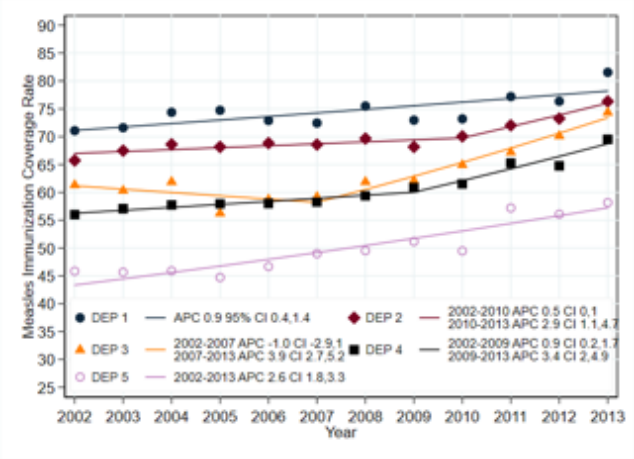
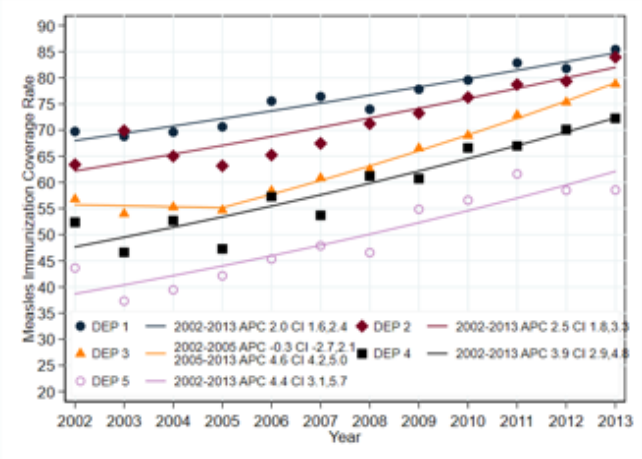
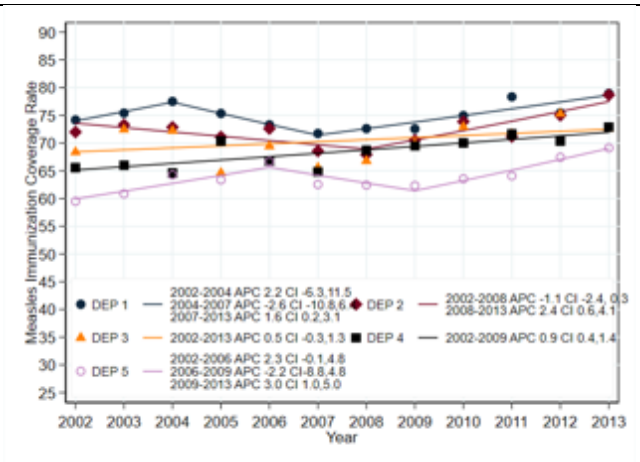
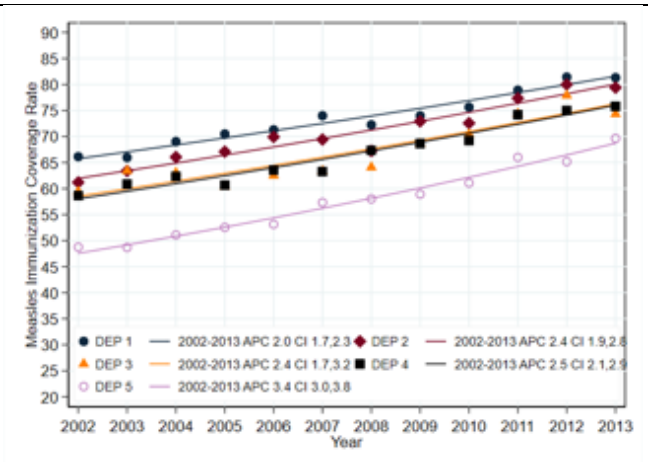
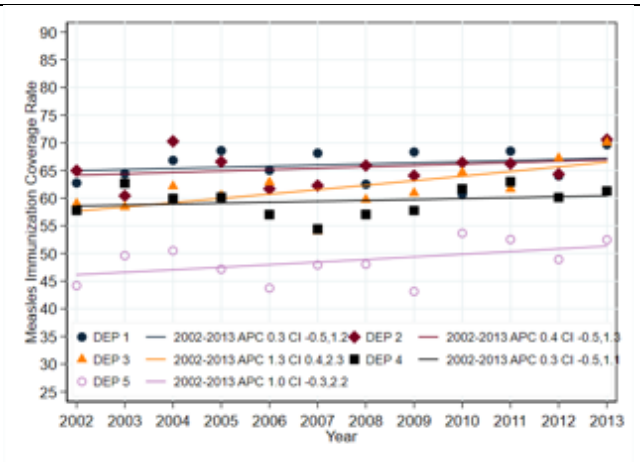
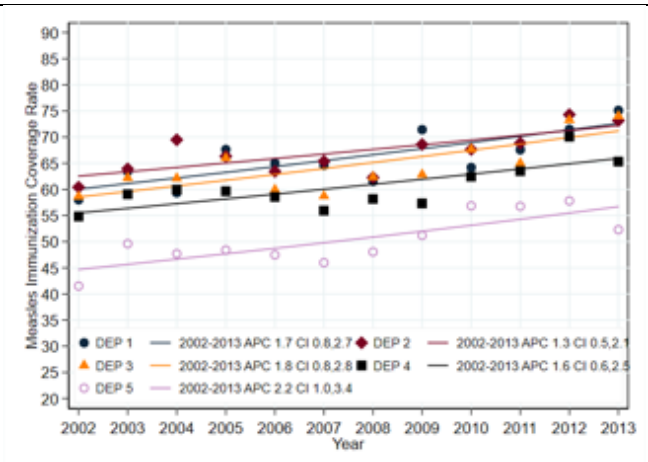
	On-time for 1st measles vaccination	On-time for 2nd measles vaccination
Peer Group A		
Peer Group D		
Peer Group H		

Figure 4-8: Changes in trend of measles immunization coverage rates among on-time for 1st and 2 dose measles vaccine among Saskatchewan RHA Peer Groups by Socio-economic Deprivation Quintiles (2002–2013)

Table 4-4: Summary of AAPC values and test of parallelism for S-E DQ1 and Q5 and effect on measles immunization coverage (2002 – 2013)

		Observation		S-E DEP Q1		S-E DEP Q5		Test of Parallelism		
RHA Peer Grp	On-Time for Dose	Start	End	AAPC	*P*-value	AAPC	*P*-value	Rejected	Failed to Reject	*P*-value
All 10 RHAs	1	2002	2013	0.7	0	1.8	0	Y		<.001
	2	2002	2013	2	0	3	0	Y		<.001
A	1	2002	2013	0.9	0	2.6	0	Y		<.001
	2	2002	2013	2	0	4.4	0	Y		<.001
D	1	2002	2013	0.6	0	1.3	0.2	Y		0.048
	2	2002	2013	2	0	3.4	0	Y		<.001
H	1	2002	2013	0.3	0.4	1	0		Y	0.180
	2	2002	2013	1.7	0	2.2	0		Y	0.536

Summarizing the findings of socio-economic deprivation quintile and relationship to measles immunization coverage, the coverage rates for S-EDQ 1 and 5 increased progressively between 2002 and 2013 in the province and among the RHA peer groups. However, the coverage rate for all the period analyzed was higher among the S-EDQ 1 than S-EDQ 5 at the level of the province as well as among the health region peer groups. Generally, the AAPC for S-EDQ 5 had higher values both at the level of the province as well as among the RHA peer groups (table 4-4), an indication of progressive reduction of disparity from 2002 -2013, between the two S-EDQs. Finally, apart from RHA peer group H where the test of parallelism failed to be rejected in the comparison of S-EDQ 1 and 5 for both age groups, depicting that the trends were not statistically different, however, there was statistically significant difference between the coverage trends of S-EDQ 1 and 5 among the other two RHA peer groups (A and D) as well as at the level of the province.

4.4.2 Assessing Changes in Relative Gap between S-E quintiles of deprivation

To compare trends in the relative gap between RHAs in terms of immunization coverage rates in the province of Saskatchewan, we plotted percentage change in immunization coverage between 2002 and 2013 against the relative gap in coverage. The research compared the least deprived and the most deprived S-E quintile for both on-time for first dose at 12-14 months (figure 4-9) and on-time for second dose at 24 months (18 – 24 months) group (figure 4-10).

The absolute figures of the relative gaps and the coverage rates by the socio-economic quintiles of deprivation for the start and end of observation periods are summarized in tables 4-5 and 4-6.

Table 4-5: Coverage rates and relative gaps of on-time for first dose of measles vaccine among children aged 12–14 months by socio-economic deprivation quintile

RHA	Year	Coverage Rates					Total Coverage (All Quintiles)	Relative Gap
		Deprivation Quintile						
		1	2	3	4	5		
Regina Qu'Appelle	2002	71.19	66.18	59.86	49.48	42.97	58.51	1.66
	2013	83.14	79.29	75.07	65.10	53.05	70.23	1.57
Saskatoon	2002	70.97	65.54	62.66	62.53	48.36	62.13	1.47
	2013	80.09	75.02	73.64	73.74	62.83	72.08	1.27
Cypress	2002	81.43	72.67	64.71	55.36	61.43	66.67	1.33
	2013	88.06	71.17	65.05	73.58	78.95	73.74	1.12
Five Hills	2002	71.86	81.67	70.31	81.97	64.93	69.27	1.11
	2013	74.36	76.09	72.31	74.19	70.12	71.34	1.06
Heartland	2002	68.35	70.76	73.60	75.63	76.92	70.18	0.89
	2013	76.92	81.34	75.50	75.64	62.50	75.94	1.23
Kelsey Trail	2002	71.43	58.33	64.71	58.70	65.58	65.29	1.09
	2013	53.33	64.52	60.44	60.87	67.52	64.12	0.79
Sun Country	2002	78.21	73.37	67.24	72.07	55.56	71.65	1.41
	2013	79.65	89.01	79.14	79.59	71.59	80.48	1.11
Sunrise	2002	69.23	66.23	66.96	56.88	54.26	59.48	1.28
	2013	84.62	73.08	80.73	68.78	66.13	71.45	1.28
Prairie North	2002	65.44	64.73	55.73	62.79	40.99	59.33	1.60
	2013	70.86	74.88	71.74	65.43	54.21	65.98	1.31
Prince Albert Parkland	2002	57.89	65.24	61.84	52.11	46.53	53.84	1.24
	2013	67.14	65.32	68.10	55.62	51.60	57.68	1.30

Among the on-time for first measles vaccination at one year, all study participating health regions in the province of Saskatchewan showed improving coverage and improving relative gap apart from Kelsey Trail which showed worsening coverage but improving (reducing) relative gap, and Sunrise, Prince Albert Parkland and Heartland with improving coverage but increasing (widening) relative gap (figure 4-9)

For the on-time for second measles immunization at two-year age group, all the ten participating health regions in Saskatchewan demonstrated improving coverage and improving (reducing) relative gap apart from Sunrise and Heartland with improving coverage but worsening (widening) relative gap (figure 4-10)

Table 4-6: Coverage Rates and Relative Gaps of on-time for second dose of measles vaccine among children aged 18–24 months by socio-economic deprivation quintile

RHA	Year	Coverage Rates					Total Coverage (All Quintiles)	Relative Gap
		Deprivation Quintile						
		1	2	3	4	5		
Regina Qu'Appelle	2002	67.57	63.03	55.02	48.85	42.02	55.03	1.61
	2013	85.79	82.12	78.15	69.61	55.84	73.10	1.54
Saskatoon	2002	65.28	58.14	53.37	56.00	40.66	54.19	1.61
	2013	82.49	78.86	74.30	78.78	69.01	75.31	1.20
Cypress	2002	62.86	71.51	60.29	62.50	50.00	63.22	1.26
	2013	86.57	80.98	66.02	79.25	80.70	78.15	1.07
Five Hills	2002	70.35	78.33	67.19	63.93	57.46	64.12	1.22
	2013	75.90	76.09	70.77	72.58	64.02	70.58	1.19
Heartland	2002	64.56	66.08	71.20	61.34	69.23	63.21	0.93
	2013	76.92	79.85	83.44	74.36	75.00	77.34	1.03
Kelsey Trail	2002	64.29	54.17	63.87	67.39	66.88	65.08	0.96
	2013	60.00	87.10	68.13	60.87	75.80	72.45	0.79
Sun Country	2002	80.45	64.50	65.52	67.57	57.14	67.22	1.41
	2013	83.72	89.56	81.60	86.73	81.82	84.20	1.02
Sunrise	2002	70.77	59.74	65.22	58.72	55.81	58.57	1.27
	2013	86.54	83.33	78.90	71.43	67.74	73.43	1.28
Prairie North	2002	55.88	57.00	53.44	58.14	34.23	49.15	1.63
	2013	79.47	74.41	73.19	72.02	52.11	67.40	1.53
Prince Albert Parkland	2002	61.84	64.17	63.16	51.05	46.86	53.13	1.32
	2013	65.71	71.68	75.00	56.18	52.39	60.58	1.25

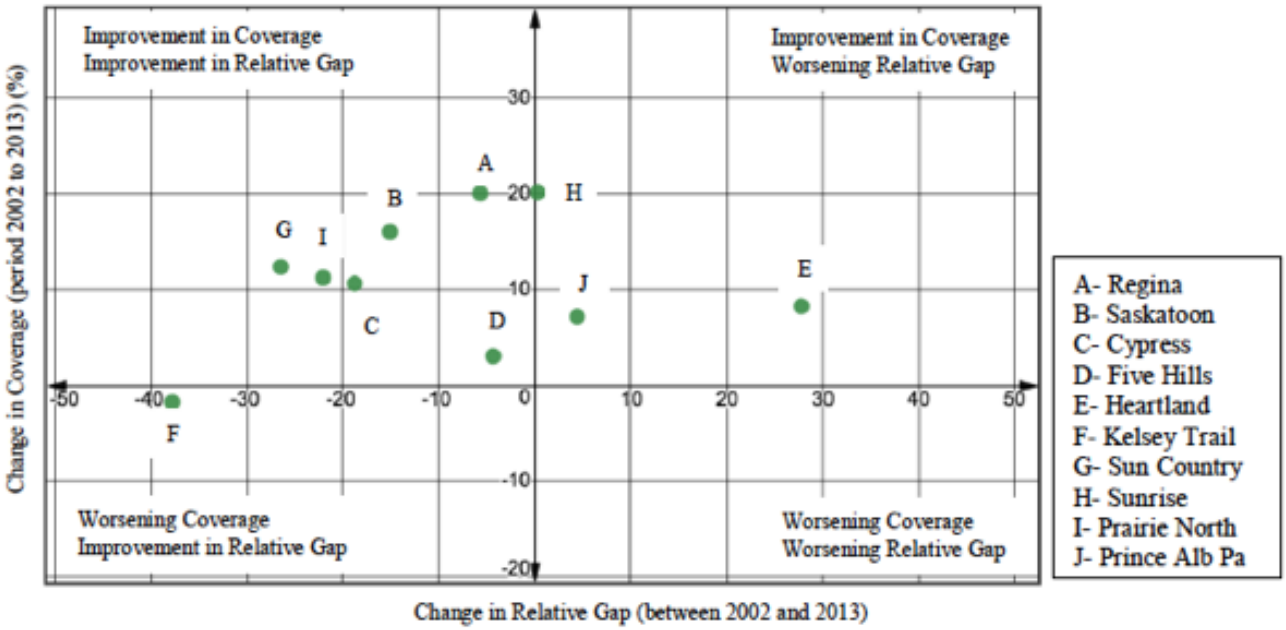


Figure 4-9: Relationship between changes in the Saskatchewan Measles Immunization Coverage and Relative Gap of on-time for first dose at 1year among participating RHAs

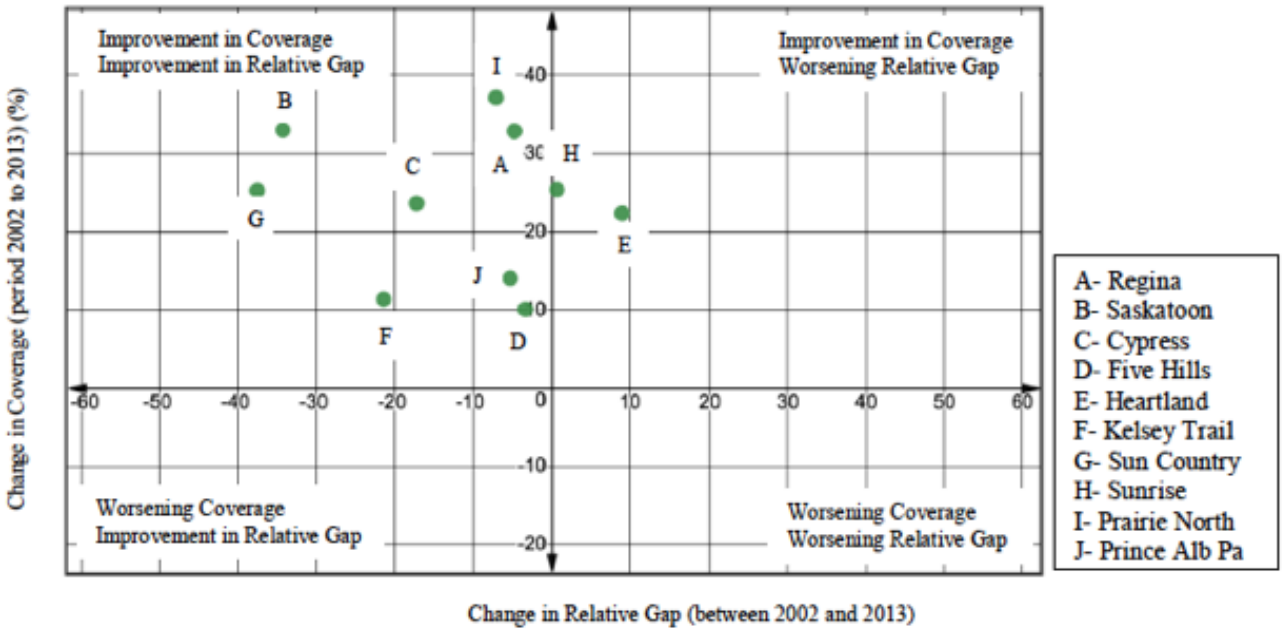


Figure 4-10: Relationship between changes in Saskatchewan Measles Immunization Coverage and Relative Gap of on-time for second dose at 2years among participating RHAs

4.4.3 Assessing Changes in Equality between 2002 – 2013 among RHAs

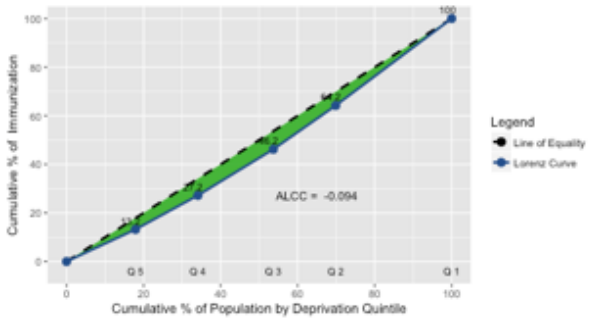
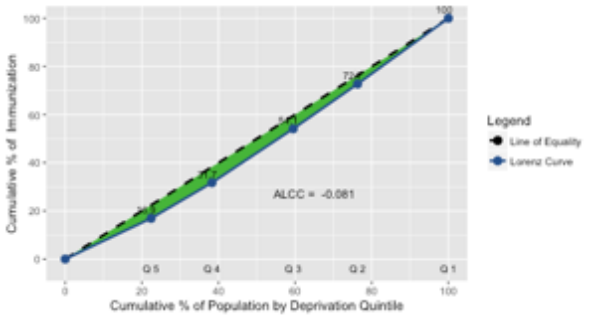
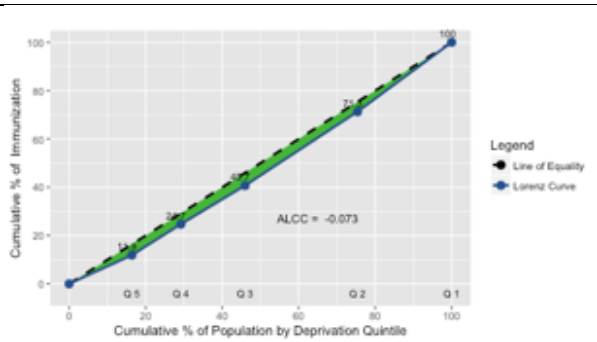
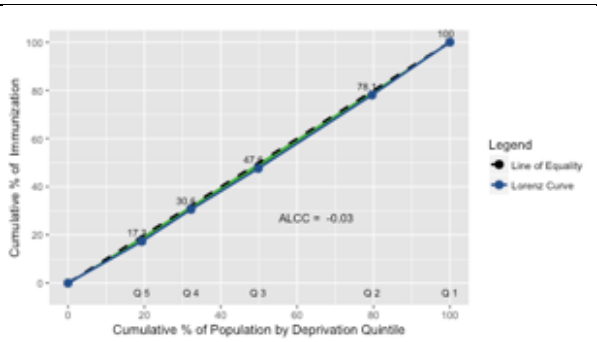
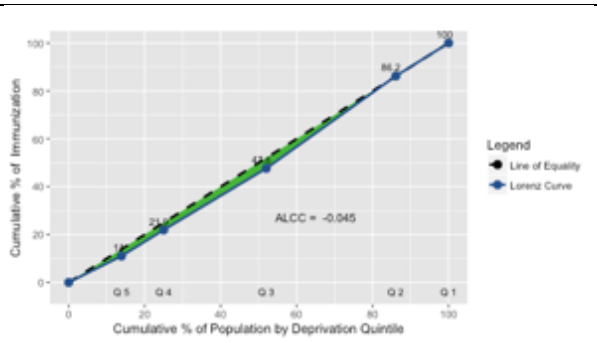
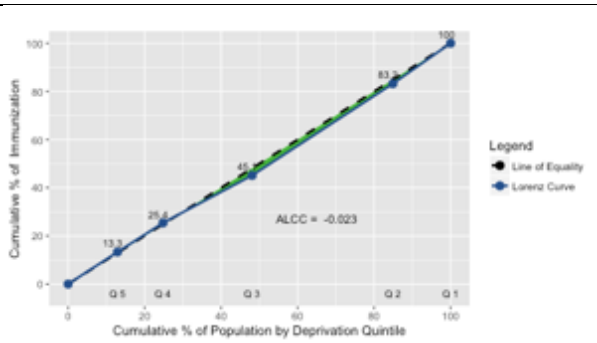
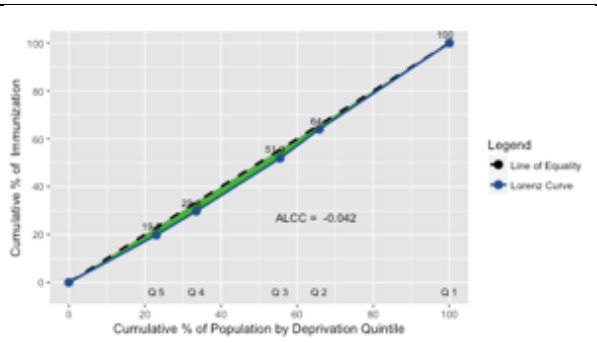
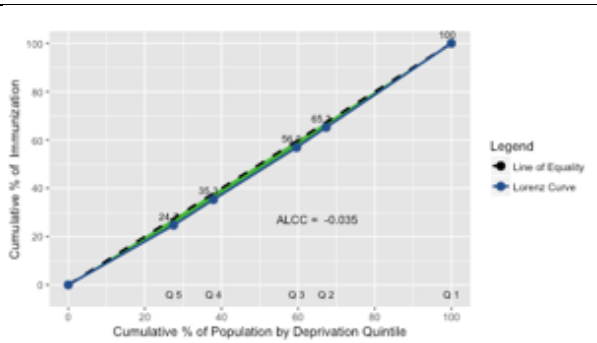
To assess if there are any changes in the level of equality between the least and the most deprived socio-economic quintiles between 2002 and 2013 in the RHAs, we used the on-time for second measles vaccination dose at 24 months to calculate and generate the area level concentration curves and coefficient. This was done for each of the health regions for both 2002 and 2013 to see how the level of equality had changed within those two points of the study period.

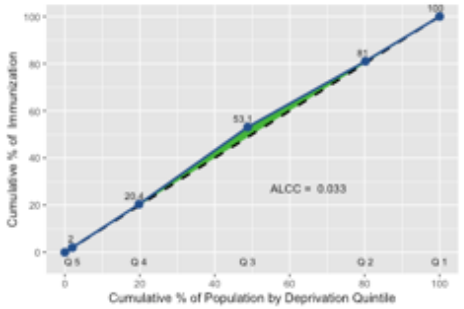
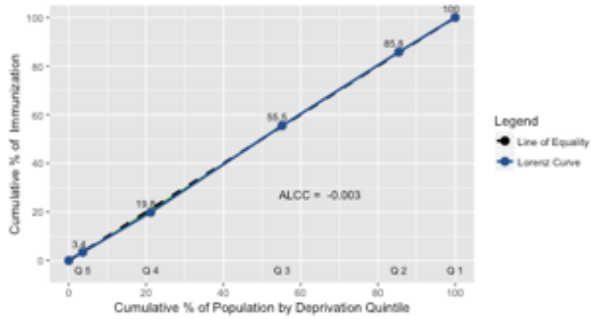
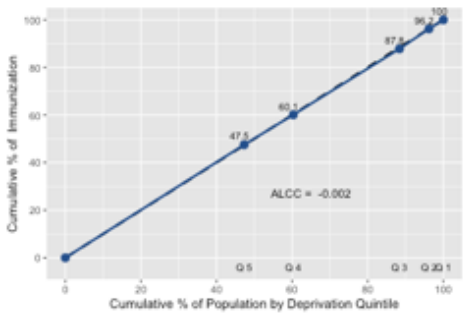
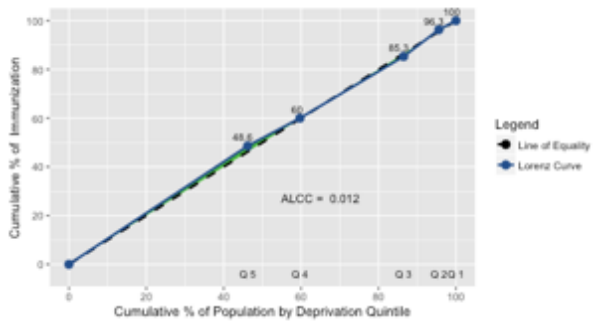
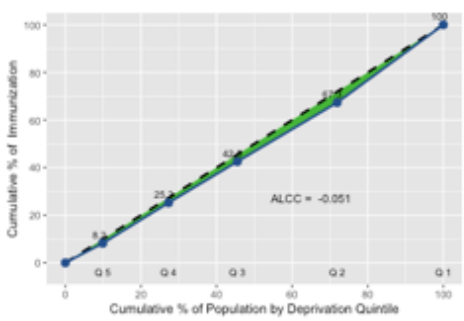
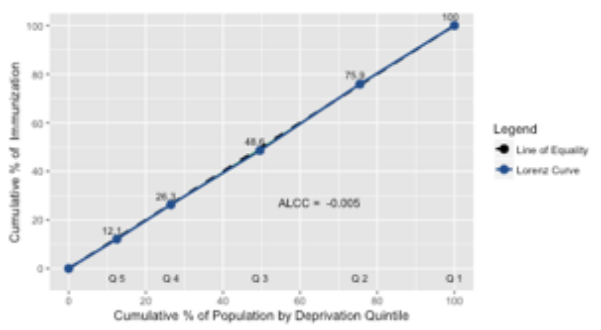
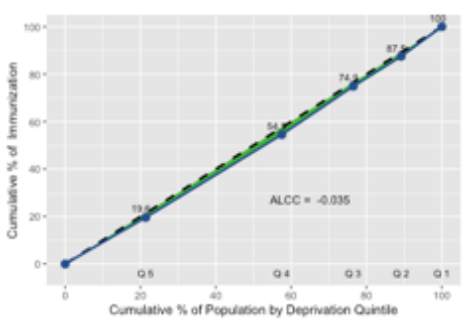
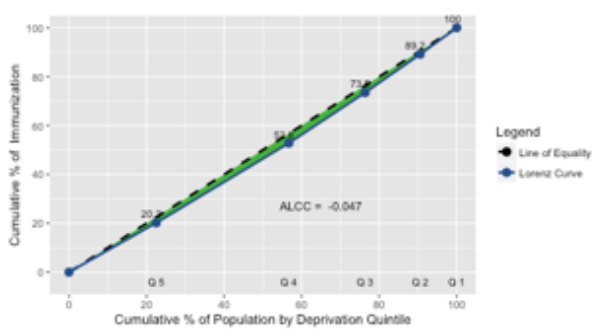
The on-time for second dose data was used to assess this effect because the on-time for the second valid measles vaccination is taken as the 'up-to-date for measles coverage' in the province of Saskatchewan and hence in this study and also because the ultimate adequate coverage for measles prevention is the spaced 2-dose regimen. From figure 4-11, apart from Heartland and Sunrise Health Regions where disparity widened between 2002 and 2013, and Prince Albert where it remained almost unchanged, there was a reduction in level of disparity in all the other RHAs. This observation is also summarized in table 4-7.

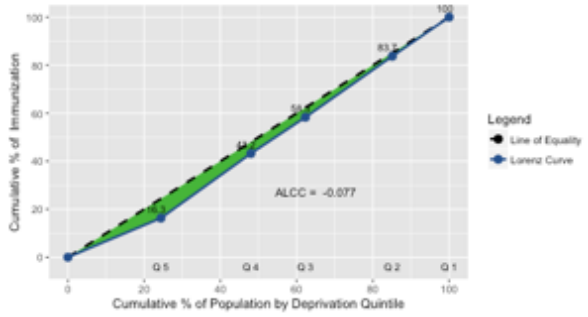
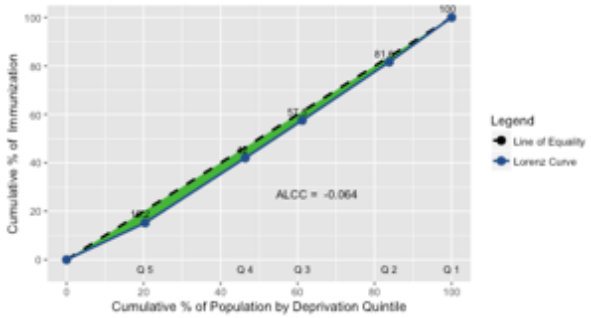
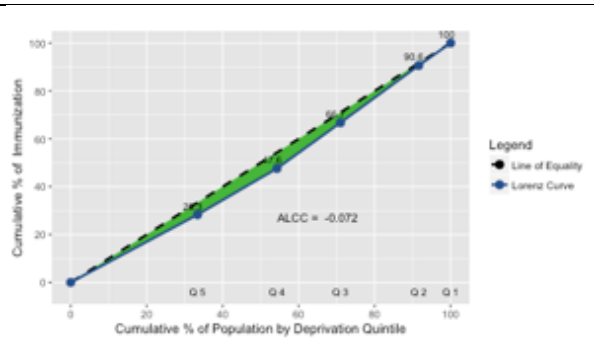
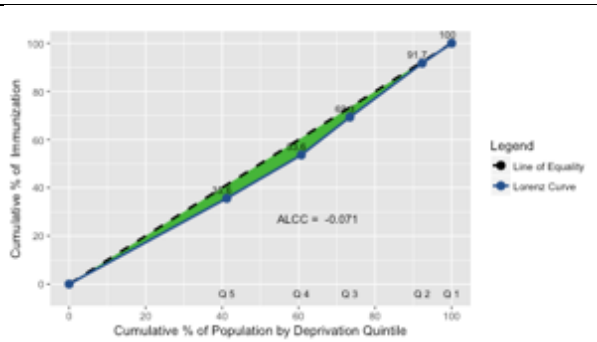
Table 4-7: Summary Change of level of Equality between 2002 and 2013 in ten Saskatchewan Health Regions

Peer Group	RHAs	2002	2013	Remark
Grp A	Regina Qu'Appelle	-0.094	-0.081	Reduced
	Saskatoon	-0.073	-0.030	Reduced
Grp D	Cypress	-0.045	-0.025	Reduced
	Five Hills	-0.042	-0.035	Reduced
	Kelsey Trail	-0.002	0.012	Reduced
Grp H	Sun Country	-0.051	-0.005	Reduced
	Prairie North	-0.077	-0.064	Reduced
Grp H	Prince Albert Parkland	-0.072	-0.071	Borderline
Grp D	Heartland	0.033	-0.003	Widened
	Sunrise	-0.035	-0.071	Widened

Figure 4-11: Summary figures comparing change of level of equality between 2002 and 2013 in ten Health Regions

RHAs	Area Level Concentration Curve and Coefficient for on-time for second dose at 2 years	
	2002	2013
Regina Qu'Appelle		
Saskatoon		
Cypress		
Five Hills		

RHAs	Area Level Concentration Curve and Coefficient for on-time for second dose at 2 years	
	2002	2013
Heartland		
Kelsey Trail		
Sun Country		
Sunrise		

RHA	Area Level Concentration Curve and Coefficient	
	2002	2013
Prairie North		
Prince Albert		

4.4.4 Summary Findings from Research Question 1

The quantitative analysis utilized the total available data of the covered population of children in SIMS between 2002 and 2013 (pulled out of Panorama at the early phases of data migration) (n= 169,582). About one third of this population lived in the NOT CITY locations while about two-third lived in the CITY locations. A progressive increase was observed in terms of proportion of people who lived in the CITY areas from 2002 to 2013 while there was a gradual reduction of population living in the NOT CITY locations. This may not be unconnected with rural-urban migration in the province.

In 2002, the coverage rate ranged between 49.15% (lowest figure for RHA) and 67.22% (highest attained by an RHA) which increased to between 60.58% and 84.2% (being the lowest and highest rates attained by RHAs) in 2013. Provincially, the average coverage rate for the ten participating health regions during the period was 56.32% (2002) with a progressive increase to 73.21% (2013).

There was increase in the coverage trends in the two geographical locations under study as well as among the two age groups. The trends of coverage rates were higher in the rural than in the urban locations for the measles vaccination among the two groups. Also, in the two set of comparisons, the rejection of parallelism suggested that the trends were significantly different for the two geographical locations coverages. For the peer groups, it is observed that though the coverage rates in the NOT CITY locations were higher in almost all the peer groups, the rate of increase in coverage as reflected by the AAPC was lower in the NOT CITY locations apart from among the RHA peer group H where it was higher. It is also noted that apart from RHA peer group A where there was convergence of trend lines in both the age groups studied, there was divergence in peer group H health regions from year 2008 for both age groups studied. The peer group D health region age groups did not demonstrate a uniformity in rate of change of the fitted lines. While the on-time for first dose demonstrated a convergence up till 2007, the two lines remained almost equal till 2013, and for the on-time for second dose group, it was an initial convergence with a divergence after year 2008.

There was a progressive increase in the coverage rates for both S-EDQ 1 and 5 for both age groups studied at the provincial level and among the RHA peer groups, the increase in coverage as depicted by the AAPC showed that the change was significantly different from zero in both groups. The coverage rates were higher in the S-EDQ1 than S-EDQ5 for both on-time for first dose at 1-year and on-time for second dose at 2-year age groups all through 2002 – 2013. Even though the coverage rate for the period analyzed was higher among the S-EDQ 1 than S-EDQ 5 at the level of the province as well as among the health region peer groups, the AAPC for S-EDQ 5 had higher values both at the level of the province as well as among the RHA peer groups (table 4-4), an indication of progressive reduction of disparity from 2002 -2013 between the two S-EDQs (1 and 5) compared.

Looking at the individual RHAs, in the on-time for first measles vaccination at one year, there was an improving (increasing) coverage and improving (reducing) relative gap apart from Kelsey Trail which showed worsening coverage but improving (reducing) relative gap, and Sunrise, Prince Albert Parkland and Heartland with improving coverage but increasing (widening) relative gap (figure 4-9). And for the on-time for second measles immunization at two-year age group, all the ten participating health regions in the province of Saskatchewan

demonstrated improving (increasing) coverage and improving (reducing) relative gap apart from Sunrise and Heartland with improving coverage but worsening (widening) relative gap.

Finally, looking at how the level of disparity has changed between 2002 and 2013 for the individual health regions, there was a reduction in all the RHAs in Saskatchewan apart from Heartland and Sunrise Health Regions where disparity widened and in Prince Albert where it remained unchanged (table 4-7).

4.5 Findings from Research Question 2

This research question analyzed for the differences between and within Saskatchewan RHAs measles immunization coverage among children aged 12 and 24 months between year 2002 and 2013. Assessing differences within the health regions and the health region peer groups will be addressed using the data of the two groups under study (i.e. on-time for measles vaccination at 1-year and at 2-year age groups).

To answer this research question and ensure a clear understanding of the procedures involved and hence the results presentation in a logical manner, the researcher presented the results of the two different year groups, one after the other. It also examined the differences at two levels, the individual RHAs and RHA peer groups levels.

4.5.1 On-time for first measles dose at 1 year

4.5.1.1 Individual Health Regions Level Results

To compare the immunization coverage rates in the places of residence across the ten participating health regions, all variables of CITY and NOT CITY were cross-checked for assumptions of *t*-test. Apart from variables in Heartland, Sun Country and Prince Albert, variables in all the remaining health regions met all the assumptions for *t*-test statistic; dependent variables were not markedly skewed and Levene's test was not statistically significant (see Appendix G). Variables which violated the assumptions for *t*-test were assessed for assumptions of Mann-Whitney statistical test and they all met the assumptions (data were independent, there was an underlying continuity from low to high in the CITY and NOT CITY immunization coverage rates).

Results of *t*-test statistic in table 4-8, indicate that there were statistically significant differences on immunization coverage rates in CITY and NOT CITY locations in all the

participating health regions apart from Kelsey Trail, Sun Country and Sunrise. Inspection of the mean coverage rates for CITY and NOT CITY in the regions that showed statistically significant differences, apart from Cypress, immunization coverage rates were higher in NOT CITY compared to the CITY. The effect sizes for all these differences in measles immunization coverage rates were all much larger than typical according to Cohen.(268)

Table 4-8: Comparison of Measles Immunization Coverage among the on-time for first dose at 1year in City and Not City across the ten health regions

Variables	*M*	*Mean Rank*	*SD*	*t*	*U*	*df*	*P*	*d/r*
Regina Qu'Ap				-3.324		22	.003	1.38
City	61.39		4.53					
Not City	66.57		2.94					
Saskatoon				-2.441		22	.023	1.01
City	64.06		3.46					
Not City	67.08		2.53					
Cypress				2.219		22	.037	0.92
City	70.16		5.01					
Not City	66.23		3.56					
Five Hills				-7.011		22	< .001	2.97
City	67.19		1.54					
Not City	73.53		2.73					
Heartland					1	22	< .001	0.84
City		6.58	8.51					
Not City		18.42	2.51					
Kelsey Trail				0.267		22	0.792	
City	66.19		5.04					
Not City	65.75		2.84					
Sun Country					56	22	0.356	
City		13.83	6.31					
Not City		11.17	3.48					
Sunrise				0.447		22	0.659	
City	66.33		3.03					
Not City	65.69		3.94					
Prairie North				-5.501		22	< .001	2.25
City	55.18		2.82					
Not City	61.77		3.05					
Prince Albert					22	22	0.004	0.59
City		8.33	2.74					
No City		16.67	5.81					

Effect sizes (d) for t-test statistics were calculated using the formula $d = (M_1 - M_2)/SD_{pooled}$*; M_1 is mean for the first Group and M_2 for the second Group, SD_{pooled} is average standard deviation for the two groups.*
Effect sizes (r) for Mann-Whitney statistics were calculated using the formula $r = Z/\sqrt{N}$.

Results for Mann-Whitney statistical test indicate that there were statistically significant differences on immunization coverage rates in the CITY and NOT CITY in Heartland and Prince Albert but not in Sun Country. Inspection of the mean rank measles immunization coverage rates for Heartland and Prince Albert showed that the NOT CITY had higher coverage rates than the CITY location. These differences are much larger than typical in both health regions according to Cohen (268)

To understand whether there were differences in measles immunization coverage rates within the different health regions with reference to the deprivation quintiles, one-way ANOVA test was run for the variables in seven health regions that met its assumptions. The deprivation quintiles (DepQ1-Q5) were the independent variables, and the immunization coverage rates in theses quintile were the dependent variables. In the assumptions for ANOVA test for these seven health regions, the data were independent, variances for the dependent variables in the deprivation quintiles were equal, and the dependent variables were not markedly skewed (Appendix G). Results for the ANOVA tests indicate that, apart from Kelsey Trail, the remaining six health regions have statistically significant differences among the five deprivation quintiles within each of the health regions (see table 4-9).

Table 4-9: One-way Analysis of Variance comparing Socio-economic Deprivation Quintiles across the Ten Health Regions for on-time for measles first dose.

Source	*df*	*Sum of Squares*	*Mean Square*	*F*	*P*
Regina	4			54.68	< .001
Between groups		5474.32	1368.58		
Within groups		1376.60	25.03		
Total		6850.92			
Saskatoon	4			56.78	< .001
Between groups		3349.63	837.41		
Within groups		811.09	14.75		
Total		4160.73			
Cypress	4			11.39	< .001
Between groups		2004.27	501.07		
Within groups		2420.08	44.00		
Total		4424.35			
Five Hills	4			11.64	< .001
Between groups		760.28	190.07		
Within groups		898.47	16.34		
Total		1658.75			
Heartland					
Between groups					
Within groups					
Total					
Kelsey Trail	4			1.84	.137
Between groups		319.37	79.84		
Within groups		2175.70	43.51		
Total		2495.07			
Sun Country					
Between groups					
Within groups					
Total					
Sunrise	4			21.842	< .001
Between groups		2717.69	679.42		
Within groups		1710.84	31.11		
Total		4428.53			
Prairie North	4			36.35	< .001
Between groups		2975.82	743.96		
Within groups		1125.52	20.46		
Total		4101.35			
Prince Albert					
Between groups					
Within groups					
Total					

NOTE: Assumptions for the one-way ANOVA were violated in the shaded sections. Therefore, the variables in these sections were all analyzed using Kruskal-Wallis test (K-W) because all the K-W test assumptions were assessed and met.

To understand which exact pairs of deprivation quintiles were different, Games-Howell was conducted for Sunrise HR while Tukey ANOVA post-hoc tests were conducted for the deprivation quintiles in the remaining five health regions. Tukey post hoc tests were done because all the Levene's statistical tests for homogeneity of variances were not statistically significant, while the one which was statistically significant, Games-Howell was used. (269) All the post hoc test results are summarized in Appendix H.

In Regina Qu'Appelle RHA, apart from Q1 and Q2, the rest of the deprivation quintiles were statistically significantly different when compared with each other. In Saskatoon health region, apart from the pairs Q1 and Q2, Q1 and Q3 and Q1 and Q4, the rest of the deprivation quintile pairs were statistically significantly different. In Cypress RHA, six pairs of deprivation quintiles were statistically not different (Q1 and Q2, Q2 and Q3, Q2 and Q4, Q3 and Q4, Q3 and Q5, Q4 and Q5), the rest of the pairs were statistically significantly different. In Five hills health region, apart from the pairs of Q1 and Q5, Q2 and Q5, Q3 and Q5, Q4 and Q5 which were statistically significantly different, the rest of the pairs were not. In Sunrise RHA, apart from Q1 and Q2, Q1 and Q3, Q2 and Q3, Q3 and Q1, the rest of the pairs were statistically significantly different. Lastly, for Prairie North RHA, apart from the pairs Q1 and Q5, Q2 and Q5, Q3 and Q5, Q4 and Q5 which were statistically different, the rest of the pairs were not. (Appendix H).

To understand whether there were differences on measles immunization coverage rates with reference to the deprivation quintiles within the three health regions (Heartland, Sun Country and Prince Albert Parkland) which never met the assumptions for ANOVA test, Kruskal-Wallis (K-W) test was conducted. Kruskal-Wallis test assumptions were tested and met (*data were independent, and there was underlying continuity from low to high in the dependent variables*). Results of K-W test, in table 4-10 indicate that there were statistically significant differences in the deprivation quintiles within each of these three health regions. To understand which exact pairs differed, Mann-Whitney (M-W) post hoc tests were conducted. In the M-W post hoc tests, the level of significance was adjusted by dividing 0.05 by 5 (Bonferroni correction) so that the M-W significance required to be statistically significant was less than 0.01. (269) It should be noted that when conducting multiple analyses on the same dependent variable, the chance of committing a Type I error increases, thus increasing the likelihood of

coming about a significant result by pure chance. To correct for this, or protect from Type I error, a Bonferroni correction is conducted (270-272)

Table 4-10: A Kruskal-Wallis (K-W) test summary comparing Socio-economic Deprivation Quintiles across three Health Regions.

Variables	***N***	***Mean Rank***	***X2***	***P***
Heartland			15.26	.004
DEP Q1	12	26.58		
DEP Q2	12	15.92		
DEP Q3	12	41.17		
DEP Q4	12	33.75		
DEP Q5	9	27.11		
Sun Country			17.61	.002
DEP Q1	12	43.17		
DEP Q2	12	40.33		
DEP Q3	12	23.58		
DEP Q4	12	24.92		
DEP Q5	12	20.50		
Prince Albert				< .001
DEP Q1	12	45.54	40.62	
DEP Q2	12	42.00		
DEP Q3	12	37.79		
DEP Q4	12	18.50		
DEP Q5	12	8.67		

The tests could go on to test the differences within all the 5 deprivation quintiles. However, to limit the number of tables generated and save time on further analysis, the researcher limited further analysis to the differences between the least deprived socio-economic deprivation quintile (Q1) and the most deprived quintile (Q5) and this is shown in table 4-11.

Results for M-W post hoc tests for Q1 and Q5 indicate that, apart from within Heartland health region, deprivation quintiles Q1 and Q5 are statistically different within Sun Country and Prince Albert Parkland health regions. Inspection of the means for Sun Country and Prince Albert Parkland deprivation Q1 and Q5 which were statistically significant, showed that there are higher measles immunization coverage rates in deprivation Q1 as compared to Q5. These differences are much larger than typical ($r = 0.849$) for Prince Albert Parkland and larger than typical ($r = 0.672$) for Sun Country according to Cohen (268)

Table 4-11: Mann-Whitney post hoc tests summary comparing Socio-economic Deprivation Quintiles across three Health Regions.

Variables	*N*	*Mean Rank*	*U*	*z*	*P*	*r*
Heartland			53.50	-.036	.972	
DEP Q1	12	11.04				
DEP Q2						
DEP Q3						
DEP Q4						
DEP Q5	9	10.94				
TOTAL	21					
Sun Country			15.00	-3.292	.001	0.672
DEP Q1	12	17.25				
DEP Q2						
DEP Q3						
DEP Q4						
DEP Q5	12	7.75				
TOTAL	24					
Prince Albert			0.00	-4.157	< .001	0.849
DEP Q1	12	18.50				
DEP Q2						
DEP Q3						
DEP Q4						
DEP Q5	12	6.50				
TOTAL	24					

4.5.1.2 Health Region Peer Groups Level Results

To find out whether there was a statistically significant difference among the three RHA peer groups of A, D, and H on immunization coverage rates in relation to place of residence and socio-economic deprivation quintiles, ANOVA tests were conducted. City, Not City, and deprivation quintiles (Q1, 2, 3, 4, 5) were the independent variables. Immunization coverage values of the deprivation quintiles were the dependent variables. Assumptions for ANOVA test were all tested and met by all the dependent variables. These assumptions are: (i) observations were independent, (ii) variances on the dependent variables were equal across groups, and (iii) the dependent variables were not markedly skewed for each group (skewness for CITY= .012, for NOT CITY= -.419, for DEP Q1= -.473, for DEP Q2= .013, for DEP Q3= .140, for DEP Q4= .370, for DEP Q5= .365) (Appendix I). The results of ANOVA test indicate that all the three peer groups were statistically significantly different on the immunization coverage rates and

deprivation quintiles across the three RHA peer groups as indicated by their mean comparisons in table 4-12.

To find out which exact pairs of RHA peer groups were different, ANOVA post hoc tests were conducted. Tukey post hoc tests were run to compare the different categories across the three RHA peer groups because all the Levene's statistic values were not statistically significant (269) as indicated in Appendix I. Results of these post hoc tests indicate that peer groups A, D, and H were statistically significantly different on immunization coverage rates. The post hoc test results also indicate that apart from peer groups A and D for DEP Q1 and Q2, A and H for DEP Q3, Q4 and Q5, which were statistically not different, all the other peer group comparisons were statistically significantly different. These post hoc test results are shown in table 4-13. All the statistically significant differences among the three RHA peer groups had much larger than typical effect sizes (see table 4-13) according to Cohen (268)

Table 4-12: One-way Analysis of Variance Summary table comparing RHA peer groups Socio-economic Deprivation Quintiles among the on-time for first dose at 1 year.

Variables		Sum of Squares	df	Mean Square	F	Sig.
CITY	Between Groups	1244.822	2	622.411	72.79	< .001
	Within Groups	282.176	33	8.551		
	Total	1526.999	35			
NOT CITY	Between Groups	446.715	2	223.357	34.84	< .001
	Within Groups	211.563	33	6.411		
	Total	658.277	35			
Deprivation Q1	Between Groups	646.027	2	323.014	43.21	< .001
	Within Groups	246.704	33	7.476		
	Total	892.732	35			
Deprivation Q2	Between Groups	301.015	2	150.508	17.34	< .001
	Within Groups	286.483	33	8.681		
	Total	587.498	35			
Deprivation Q3	Between Groups	482.356	2	241.178	13.18	< .001
	Within Groups	603.751	33	18.295		
	Total	1086.107	35			
Deprivation Q4	Between Groups	580.781	2	290.391	27.94	< .001
	Within Groups	342.94	33	10.392		
	Total	923.721	35			
Deprivation Q5	Between Groups	1723.781	2	861.89	60.61	< .001
	Within Groups	469.309	33	14.221		
	Total	2193.09	35			

Table 4-13: Tukey post-hoc test for ANOVA comparing RHA Peer Groups S-E Dep Quintiles for on-time for first dose

Dependent Variable	Peer groups	Peer groups	Mean Difference	Std. Error	Sig.	*d*	95% Confidence Interval	
							Lower Bound	Upper Bound
CITY	Peer A	Peer D	-5.87640*	1.19379	< .001	1.82	-8.8057	-2.9471
	Peer D	Peer H	14.32695*	1.19379	< .001	5.98	11.3976	17.2563
	Peer H	Peer A	-8.45055*	1.19379	< .001	2.9	-11.3799	-5.5212
NOT CITY	Peer A	Peer D	-2.62646*	1.03368	0.041	1.23	-5.1629	-0.09
	Peer D	Peer H	8.43121*	1.03368	< .001	3.13	5.8948	10.9677
	Peer H	Peer A	-5.80475*	1.03368	< .001	2.22	-8.3412	-3.2683
Deprivation Q1	Peer A	Peer D	-0.5355	1.11624	0.881		-3.2745	2.2035
	Peer D	Peer H	9.24207*	1.11624	< .001	3.51	6.5031	11.9811
	Peer H	Peer A	-8.70656*	1.11624	< .001	2.98	-11.4456	-5.9675
Deprivation Q2	Peer A	Peer D	-2.55985	1.20286	0.100		-5.5114	0.3917
	Peer D	Peer H	6.99939*	1.20286	< .001	2.35	4.0478	9.951
	Peer H	Peer A	-4.43955*	1.20286	0.002	1.49	-7.3911	-1.488
Deprivation Q3	Peer A	Peer D	-6.95708*	1.74621	0.001	1.65	-11.2419	-2.6722
	Peer D	Peer H	8.37688*	1.74621	< .001	2.24	4.092	12.6617
	Peer H	Peer A	-1.41981	1.74621	0.698		-5.7046	2.865
Deprivation Q4	Peer A	Peer D	-7.90218*	1.31606	< .001	2.57	-11.1315	-4.6728
	Peer D	Peer H	9.02695*	1.31606	< .001	3.85	5.7976	12.2563
	Peer H	Peer A	-1.12477	1.31606	0.672		-4.3541	2.1046
Deprivation Q5	Peer A	Peer D	-13.88629*	1.53956	< .001	3.7	-17.6641	-10.1085
	Peer D	Peer H	15.36043*	1.53956	< .001	4.9	11.5827	19.1382
	Peer H	Peer A	-1.47414	1.53956	0.608		-5.2519	2.3036

4.5.2 On-time for second measles dose at 24 months

4.5.2.1 Individual Health Region Level Results

To understand whether there was a difference or not in the immunization coverages in City and Not City geographical locations with regard to on-time for measles vaccination at 24 months

coverage rates, either a *t*-test or Mann-Whitney (M-W) statistical test was conducted on the health region data. Apart from variables in Regina Qu'Appelle, Heartland, Kelsey Trail, and Prince Albert Parkland, variables in the rest of the regions that were checked met the assumptions of *t*-test (data were independent, dependent variables were not markedly skewed and Levene's test of homogeneity of variance was not statistically significant (Appendix K). The variables which violated the *t*-test assumptions were checked and met the assumptions of the *M-W* test (Appendix K) (assumptions listed in previous section, 4.4.1.1). The summary results is presented in table 4-14.

Results of the *t*-test statistics in table 4-14 indicate that there was a statistically significant difference on measles immunization coverage between City and Not City in the health regions of Saskatoon (*t=-2.83,P= .01*), Five Hills (*t=-4.42,P<.001*), and Prairie North (*t=-5.574, P<.001*). Inspection of the means of the variables in these regions shows that in all of them, Not City had a higher measles immunization coverage compared to that in the City (see table 4-14). According to Cohen (1988), these differences are much larger than typical effect differences (Saskatoon *d*=1.18, Five Hills *d*=1.81, Prairie North *d*=2.29,) hence could not have happened by chance. (268)

Results of the M-W tests in table 4-14, indicate that there was a statistically significant difference on measles immunization coverage between City and Not City in the health regions of Regina (*U=26.00, p=.01*), Heartland (*U=0.00, P<.001*), and Prince Albert (*U=24.00, p=.01*). Inspection of the mean ranks of the variables in these regions shows that there was a higher measles immunization coverage rate in Not City compared to City in the three health regions (see table 4-14). According to Cohen (1988), these differences are larger than typical for Heartland (*r*= 0.85) and much larger than typical for both Regina (*r*= 0.54) and Prince Albert (*r*= 0.57); hence, couldn't have happened by chance. (268)

Table 4-14: Comparison of Measles immunization coverage rates among on-time for 2nd dose at 24 months in City and Not City locations across the ten health regions.

Variables	*Mean*	*Mean Rank*	*SD*	*t*	*U*	*df*	*P*	*d/r*
Regina Qu'Ap					26.00	22	0.01	0.54
CITY		8.67	7.98					
NOT CITY		16.33	4.77					
Saskatoon				-2.83		22	0.01	1.18
CITY	62.76		8.01					
NOT CITY	70.47		5.01					
Cypress				-0.02		22	0.98	
CITY	67.92		7.85					
NOT CITY	67.98		5.85					
Five Hills				-4.42		22	< .001	1.81
CITY	66.28		3.02					
NOT CITY	71.94		3.24					
Heartland					0.00	22	< .001	0.85
CITY		6.5	8.20					
NOT CITY		18.5	4.30					
Kelsey Trail					71.00	22	0.95	
CITY		12.58	6.05					
NOT CITY		12.42	3.15					
Sun Country				-0.175		22	0.86	
CITY	72.27		8.26					
NOT CITY	72.8		6.54					
Sunrise				-1.562		22	0.13	
CITY	63.88		5.04					
NOT CITY	67.18		5.31					
Prairie North				-5.574		22	< .001	2.29
CITY	48.2		6.61					
NOT CITY	61.85		5.31					
Prince Albert					24.00	22	0.01	0.57
CITY		8.5	3.88					
NOT CITY		16.5	7.20					

***Note**: variables in the shaded health regions were analyzed with Mann-Whitney statistical test, and statistical tests were significant at the level of 0.05.*

To understand if there was a statistically significant difference in the measles immunization coverage in the different deprivation quintiles within each health region, one-way ANOVA was conducted for the variables in all the health regions apart from Kelsey Trail. The variables for these nine health regions were checked and met the assumptions for one-way ANOVA (see Appendix K) for skewness and Levene's test) (assumptions mentioned above).

Assumptions for the one-way ANOVA were violated for the variables in Kelsey Trail. Therefore, the variables in Kelsey Trail RHA were analyzed using Kruskal-Wallis test (K-W) because all the K-W test assumptions were assessed and met (assumptions mentioned earlier in the document). Results of the K-W test indicate that there was no statistically significant difference in the measles immunization coverage rates among the deprivation quantiles of Kelsey Trail ($X_2=8.351$, $p= .08$).

Results of the one-way ANOVA test in table 4-15 indicate that there was statistically significant difference between the different deprivation quintiles in each of the nine health regions. To find out which exact pairs of deprivation quintiles in each health region was different, Tukey post-hoc tests were conducted for variables whose homogeneity of variances were not statistically significant and Games-Howell for those which were statistically significant (as shown in Appendix L). ANOVA results were taken to be valid even when homogeneity of variances was violated because one-way ANOVA is robust to this violation given the existing F (ANOVA) statistical significance. (269)

Table 4-15: One-way Analysis of Variance Summary Table comparing deprivation quintiles across the ten Health Regions for on-time for second dose at 2 years.

Source	*df*	*Sum of Squares*	*Mean Square*	*F*	*P*
Regina	4			24.03	< .001
Between groups		5911.50	1477.88		
Within groups		3382.92	61.51		
Total		9494.43			
Saskatoon	4			11.68	< .001
Between groups		2968.04	742.01		
Within groups		3492.98	63.51		
Total		6461.01			
Cypress	4			5.81	.001
Between groups		1785.29	446.32		
Within groups		4227.78	76.87		
Total		6013.07			
Five Hills	4			5.83	.001
Between groups		639.86	159.97		
Within groups		1508.04	27.42		
Total		2147.91			
Heartland	4			7.56	< .001
Between groups		903.31	225.83		
Within groups		1553.86	29.88		
Total		2457.17			
Kelsey Trail					
Between groups					
Within groups					
Total					
Sun Country	4			2.88	.031
Between groups		827.10	206.78		
Within groups		3953.76	71.89		
Total		4780.86			
Sunrise	4			18.12	< .001
Between groups		2691.89	647.97		
Within groups		1967.04	35.76		
Total		4558.93			
Prairie North	4			22.16	< .001
Between groups		3703.01	925.75		
Within groups		2297.50	41.77		
Total		6000.51			
Prince Albert	4			23.19	< .001
Between groups		2342.05	585.51		
Within groups		1388.51	25.25		
Total		3730.56			

Results of Tukey post-hoc tests indicate that: In Regina, the pairs of Q1Q3, Q1Q4, Q1Q5, Q2Q4, Q2Q5, and Q3Q5 had statistically significant differences on measles immunization coverage rates; in Saskatoon, pairs of Q1Q3, Q1Q5, Q2Q5, Q3Q5, and Q4Q5 had statistically significant differences on measles immunization coverage rates; in Cypress, pairs of Q1Q5, and Q2Q5 had statistically significant differences on measles immunization coverage rates; in Heartland, pairs of Q2Q3, Q2Q5, Q3Q4, and Q4Q5 had statistically significant differences on measles immunization coverage rates; in Sun Country, pairs of Q1Q3 had statistically significant differences on measles immunization coverage rates; in Sunrise, apart from the pairs of Q1Q2, Q1Q3, Q2Q3, and Q4Q5, the rest had statistically significant differences on measles immunization coverage rates; in Prairie North, pairs of Q1Q5, Q2Q5, Q3Q5, and Q4Q5 had statistically significant differences on measles immunization coverage rates; in Prince Albert Parkland, pairs of Q1Q4, Q1Q5, Q2Q4, Q2Q5, Q3Q4, and Q3Q5 had statistically significant differences on measles immunization coverage rates (Appendix L). Results for Games-Howell post-hoc test indicates that only pairs of Q1Q5, Q2Q5, and Q3Q5 were statistically significantly different on measles immunization coverage rates in Five Hills health region. (Appendix L)

4.5.2.2 Health Region Peer Groups Level Results

To understand whether there was a statistically significant difference in the immunization coverages rates across the three peer groups, one-way ANOVA and Kruskal Wallis (K-W) statistical tests were conducted. All observations were independent, and the dependent variables were not markedly skewed for each group (skewness for CITY= .200, for NOT CITY= -.031, for DEP Q1= .037, for DEP Q2= .591, for DEP Q3= .433, for DEP Q4= -.018, for DEP Q5= .174) (Appendix M). Dependent variables that had equal variance across groups were analyzed with one-way ANOVA test (these met one-way ANOVA test assumptions) and those with different variances were analyzed with K-W test (because they violated one-way ANOVA test assumptions but met K-W test assumptions).

Results of one-way ANOVA test (table 4-16) indicate that apart from deprivation quintiles Q2 and Q3, the rest of the variables were statistically significantly different across the three peer groups. To understand which exact pairs of these peer groups were different, Tukey ANOVA post hoc tests were conducted. Results of these post hoc tests (table 4-18) indicate that measles immunization coverage rates were statistically significantly different for peer groups A and H, D and H in NOT CITY, A and H, D and H in deprivation quintile Q1, A and D, D and H

in deprivation quintile Q5. All these differences were much larger than typical(268) as shown in table 4-18.

Results of the K-W tests (table 4-17) indicate that measles immunization coverage rates were statistically significantly different in CITY but not in the NOT CITY locations; and deprivation quintile Q4 only out of the five DEPQs across the three peer groups. To understand which exact pair of these peer groups were different, Mann-Whitney post hoc tests were conducted. Results of these post-hoc tests show that for measles immunization coverage rate, peer groups A and H (*U=27.00, P= 0.008, d= 1.38*), D and H (*U= 0.00, P <.001, d= 2.93*)were statistically significantly different, and for deprivation quintile Q4, peer groups D and H (*U= 27.00, P= 0.008, d=1.22*), A and D (*U=35.00, P= 0.033, d=1.04*) were statistically significantly different. According to Cohen (268), these differences are of large effect sizes, hence, and could not be by chance.

Table 4-16: One-way Analysis of Variance summary table comparing deprivation quintiles and residence across the RHA peer groups for on-time for 2 dose at 24mths age group

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
NOT CITY coverage rate	Between Groups	417.236	2	208.618	8.646	.001
	Within Groups	796.285	33	24.130		
	Total	1213.521	35			
Deprivation QI	Between Groups	676.494	2	338.247	11.857	< .001
	Within Groups	941.387	33	28.527		
	Total	1617.881	35			
Deprivation Q2	Between Groups	131.684	2	65.842	1.920	.163
	Within Groups	1131.697	33	34.294		
	Total	1263.381	35			
Deprivation Q3	Between Groups	63.557	2	31.778	0.693	.507
	Within Groups	1513.625	33	45.867		
	Total	1577.182	35			
Deprivation Q5	Between Groups	479.523	2	239.762	5.096	.012
	Within Groups	1552.493	33	47.045		
	Total	2032.016	35			

Table 4-17: A Kruskal-Wallis (K-W) test summary table comparing Deprivation Quintiles across three Health Regions peer groups for on-time for 2nd dose at 24mths age group

Variables	*N*	*Mean Rank*	*X2*	*P*
City	12		18.39	< .001
Peer A		19.67		
Peer D		27.08		
Peer H		8.75		
DEP Q4	12		7.60	.022
Peer A		14.75		
Peer D		25.33		
Peer H		15.42		

Table 4-18: Post-hoc test for ANOVA table comparing deprivation quintiles and residence location across the RHA peer groups for on-time for 2nd measles dose at 24mths group

Dependent Variable	Peer groups	Peer groups	Mean Difference	Std. Error	Sig.	*d*	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD								
NOT CITY	Peer A	Peer D	-.19090	2.00540	.995		-5.1117	4.7299
		Peer H	7.12446*	2.00540	.003	1.377	2.2036	12.0453
	Peer D	Peer H	7.31536*	2.00540	.003	1.412	2.3945	12.2362
Deprivation QI	Peer A	Peer D	2.64283	2.18048	.455		-2.7076	7.9933
		Peer H	10.22778*	2.18048	.000	1.903	4.8773	15.5782
	Peer D	Peer H	7.58495*	2.18048	.004	1.462	2.2345	12.9354
Deprivation Q2	Peer A	Peer D	.85500	2.39074	.932		-5.0114	6.7214
		Peer H	4.41651	2.39074	.170		-1.4499	10.2829
	Peer D	Peer H	3.56151	2.39074	.309		-2.3049	9.4279
Deprivation Q3	Peer A	Peer D	-3.09281	2.76488	.510		-9.8773	3.6916
		Peer H	-.66865	2.76488	.968		-7.4531	6.1158
	Peer D	Peer H	2.42416	2.76488	.659		-4.3603	9.2086
Deprivation Q5	Peer A	Peer D	-8.17032*	2.80016	.017	1.071	-15.0413	-1.2993
		Peer H	-.94274	2.80016	.940		-7.8138	5.9283
	Peer D	Peer H	7.22758*	2.80016	.038	1.218	.3566	14.0986

4.5.3 Summary of findings from Research Question 2

On-time for measles vaccination first dose:

There were statistically significant differences on immunization coverage rates in CITY and NOT CITY locations in all the participating health regions apart from Kelsey Trail, Sunrise and Sun Country. Immunization coverage rates were higher in the NOT CITY compared to the CITY locations.

ANOVA was used to test if there were differences among the deprivation quintiles within each of the health regions, it was observed that there were statistically significant differences among the five deprivation quintiles. The study checked for which deprivation quintiles pair comparisons were different, and it was revealed that even though there were different pairs that were different within each health region, Q1 and Q5 were consistently statistically different within all the RHAs apart from within Heartland health region. There are also higher measles immunization coverage rates for deprivation Q1 compared to Q5.

In the urban RHAs, Regina Qu'Appelle and Saskatoon RHAs, Q1 and Q2 were common to both that were not statistically significantly different when compared with each other. This finding is observed in all other RHAs in the Saskatchewan rural areas too. However, other socio-economic quintile comparisons had varying constellations among the various RHAs.

Comparing the peer groups as well as socio-economic deprivation quintiles, all the peer group comparisons were statistically significantly different on measles immunization coverage rates apart from peer groups A and D for DEP Q1 and Q2, A and H for DEP Q3, Q4 and Q5, which were statistically not different.

On-time for measles vaccination second dose:

Apart from in Sun Country where only pair Q1Q3, and Cypress with pairs of Q1Q5, and Q2Q5 that had statistically significant differences on measles immunization coverage rates, all other RHAs results demonstrated at least three pairs that had statistically significant differences on measles immunization coverage rates.

In the RHAs peer group comparison, results of one-way ANOVA test indicate that apart from deprivation quintiles Q2 and Q3, the rest of the variables were statistically significantly different across the three peer groups. The results also indicated that measles immunization coverage rates were statistically significantly different for peer groups A and H, D and H in NOT CITY, A and

H, D and H in deprivation quintile Q1, A and D, D and H in deprivation quintile Q5. Results of analysis also indicates that measles immunization coverage rates were statistically significantly different in CITY but not in the NOT CITY locations; and in deprivation quintile Q4 only out of the five DEPQs across the three peer groups.

4.6 Findings from Research Question Three

This section helps the researcher to answer the third of four questions which asks what the facilitators and barriers are to achievement of herd immunity threshold (92 – 95% coverage) for measles immunization coverage in Saskatchewan health regions. To gather the information required to answer this question, an interview guide was used, and this section summarizes the responses from participants. Reporting the findings in this phase of the research utilized some quotes from the participants especially for illustration of some of the ideas, to illuminate the context and the experience (264), and to enable the reader to reflect more on the interpretations(265).

4.6.1 Participation

12 individual RHAs and Athabasca health authority in Saskatchewan before the current unified Saskatchewan Health Authority were approached for participation in the research. Even though there were 13 health jurisdictions, there were 11 administrative areas for the health regions. The 10 health regions in the south of the province were administered through one Medical Health Officer (MHO) each while the three Health Regions situated in the north had health administration through an MHO who works for the North Inter-tribal Health Authority (NITHA). Each of the regional health authorities administered by NITHA had individual immunization lead persons. If every health region administration had a buy-in to the research, and two from each health region were to be available to be interviewed, there would be 20 targeted key informant respondents from the RHAs not administered by NITHA and four (1 MHO and 3 Immunization Coordinators) participants from NITHA administered RHAs. Ten health regions not including any of NITHA RHAs signed on for participation in the research making a total of 20 anticipated interviewees. From the 20 enrolled and anticipated respondents, 18 were available to be interviewed in the first phase of interviews sessions, two each from each of eight RHAs, and one from each of the remaining two RHAs.

From figure 4-12, 83% (n=15) of the respondents had at least 11 years' experience, either in the present position or within the health region system serving in various capacities in the public health of the province of Saskatchewan. Disaggregating the interview respondents further into MHOs and Coordinators/Front-line Immunization Officers, there was an average of 13 and 20 experience years on the job respectively for the two groups.

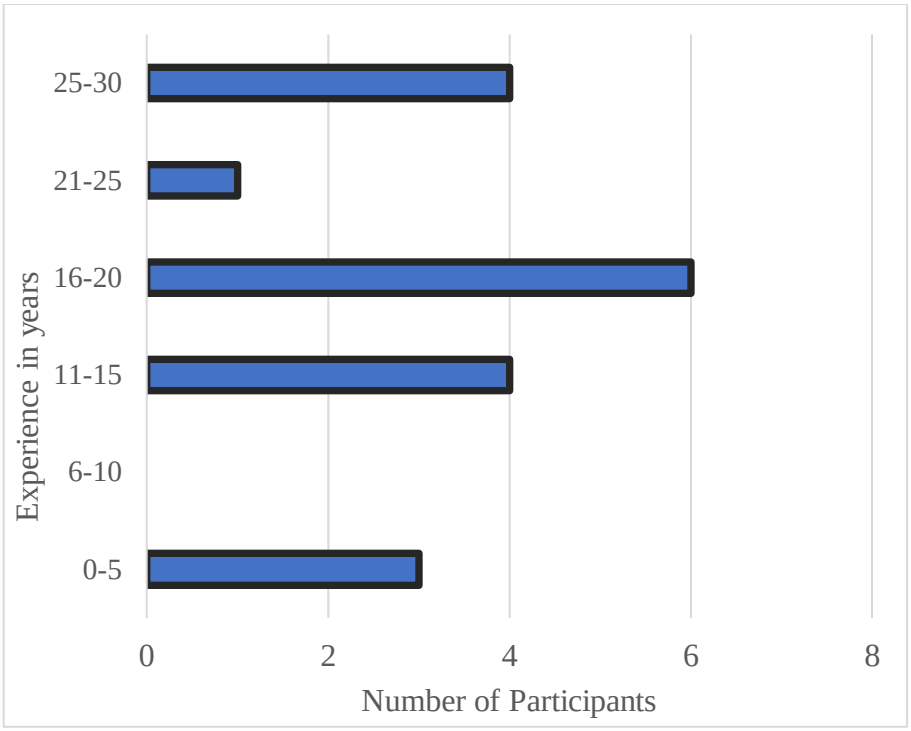


Figure 4-12: All Participants Total Experience in Years (in November 2016 study start)

4.6.2 Barriers to measles vaccination uptake:

The research participants responded to interview questions generated to provide answer to the research question three on the barriers to measles immunization uptake. The analysis of the data from the response produced four themes, namely Access-related issues, Fear/Hesitancy, Anti-vaccination (anti-vaxxers), and Limited Resources/System related issues. The results from the themes are discussed in this section and also the sub-themes to highlight the significant results while ensuring a richer experience for the reader.

Figure 4-13 represents the themes and the subthemes which came out from the first phase of the qualitative data and these are explained in this section of the document. Among the factors contributing as barriers to measles immunization uptake, anti-vaccination was mentioned more

regularly by the some of the participants, so also were resource limitation, database disconnect, transient population and vaccine hesitancy.

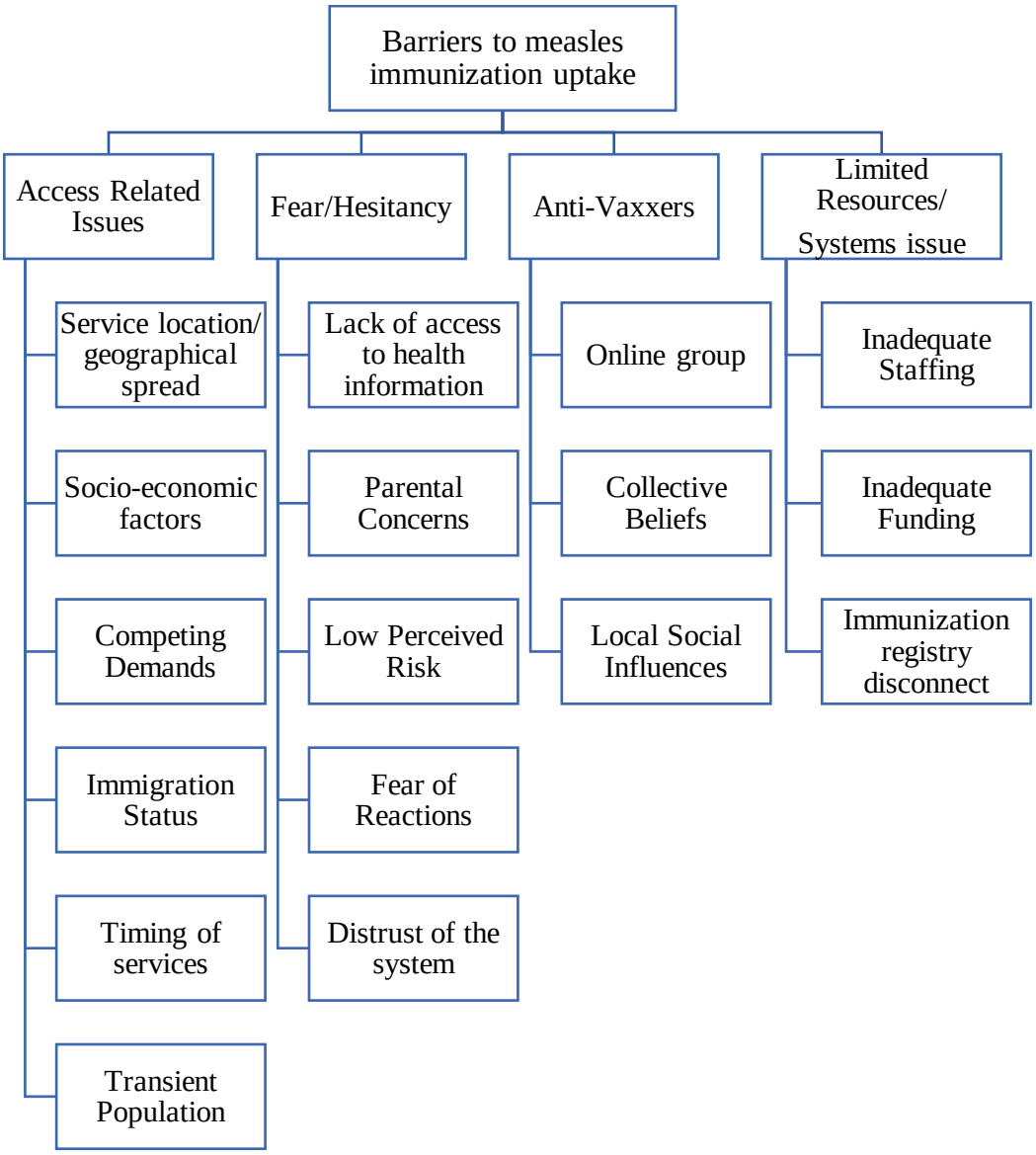


Figure 4-13: Barrier to improving measles immunization uptake - themes and sub-themes

4.6.2.1 Access Related Issues

Access related issues here refer to physical and perceived access barriers, personal circumstances of the caregivers including socio-economic circumstances, immigration status and residency type within the health regions.

4.6.2.1.1 Service Location/Geographic Spread

Location of health facilities with respect to the geographical spread of the localities the service is supposed to serve have been cited as some of the problems in some health regions. A participant commented thus:

> *we have some pockets of the population which are completely rural in our health region, so we have to be able to maintain going out to all of those sites…. So, its labor-intensive for us, which is possibly a barrier from work-force perspective*

Some other respondent believed that some of the health service locations have been sited to improve access to some group of people, but such locations become hidden to others and would need regular awareness campaigns to reach those other groups of people.

4.6.2.1.2 Socio-economic factors

The personal circumstances of the caregivers (parents and guardians of children) came up as one of the factors that may prevent them from accessing services irrespective of their location and availability. One respondent commented that:

> *immunization is just not their biggest priority, the biggest priority might be whether there is food tonight, or my husband lost a job, or I don't have a house to sleep in, so it's not that they don't believe in immunization, it's just that it's not top of the list for them*

The above comments may be because some of these caregivers sometimes have more than one child to care/cater for, if a mother has three children and one is due for immunization and she has no support to keep the rest with and there's no means of transportation because she is not financially capable to afford a vehicle, it becomes difficult for such caregivers to bring that only child that is due for immunization to the clinic to access service.

4.6.2.1.3 Immigration Status

The respondents mentioned the issue of immigration as a barrier, which in some instances they discussed that it may not be unconnected with a low level of awareness of health service provision for someone in a new environment or lack of understanding of the ways to navigate available health services. However, in this instance, they had mentioned and referred to the issue in relation to the 'new Canadians'. Participants highlighted that the 'New Canadians' come into the country through two major streams, the government stream and the private sponsorship. The private streams include churches and other sources that are not directly linked to the government.

Refugees have a streamlined path to access health care, mostly through the Open-Door Societies or through other government established channels. In the government channels, the refugees are provided with orientation of the existing government health care and other support services in their neighborhood. It gets more complicated when they are not refugees, or they are sponsored by the church or individuals, that is when health services navigation become a challenge:

> *…for the refugees that are privately sponsored; we don't really have a good way of connecting with those people. I suspect we have a number of privately sponsored refugees in our population that have never accessed us because there is no formal organization or process for these people.*

With the fairly large health regions and their linked communities, there could be a hope that some program might bring the new immigrants who did not come through the government to connect with the health facility, but this may be different in those health regions with smaller populations as this comment reveals:

> *In a smaller health region, we don't have those supports and so it's a little harder to get to that group, so I think that has made a difference in our immunization rates.*

It should be noted that if these categories of the new immigrants have had any contact with the health system within the province, they will be registered as part of the covered population, if however they could not navigate immunization services, they will still be in the denominator and not accounted for in the numerator since their inability to navigate immunization services prevented them from accessing vaccination. This will affect the coverage figures negatively.

4.6.2.1.4 Timing of Services

For some caregivers who are in active workforce, it becomes difficult to leave work for attending the clinic especially among some caregivers that do more than one job to make ends meet. Majority of the clinics are open for service when the caregivers are busy working to earn a living and hence finding the extra time to make a clinic appearance with the children may be impossible. This came up as a notable barrier from the point of view of the service providers:

> *Some clients have problems with location or time that the appointments are available to the general population, they are just not able to make it happen during the work hours*

4.6.2.1.5 Transient population

The transient population in the context of this interview have been described as those categories of clients who have a place of residence in the health regions and also live on-reserve which falls under federal jurisdiction for health service provision. Those who do not have a

permanent place of residence in the health regions have also been included in this description. Several respondents identified transience as a challenge to achieving higher coverage. First Nations people, for example, may move between jurisdictions when they move between on-reserve and off-reserve. They are registered in the provincial system within the health regions data management platform, have residence in both the on and off reserve. In both places, they are a part of the denominator for coverage calculation.

> *We do see some of our lower rates in rural areas that border with Federal Reserve. There is difficulty capturing immunization coverage with children that may be going back and forth between a reserve and our health region.*

The data captured by both federal and the province are not merged. Sometimes, these group of potential clients might receive a dose recorded in the provincial data and not come for the second dose or even other vaccine types when they become due for them. They may also receive a dose in the federal jurisdiction, but they can still appear not to be fully immunized as their complete record is not in any of the two systems. When the health regions make efforts to reach them, they cannot be found. The challenge would be to determine whether they are adequately immunized. Some health regions even have the 'transient population' come in for vaccination without a regular residential address and following up with them is a challenge

> *Well our transient population is the one that we're not able to catch because we don't have contact information with them, the only way we find out about them is when they actually present or when they hit school age and we find out about them that way*

It could be that the transient population may be behind in immunization status, but it may also be that they are not. Some respondents even opined that in some of the on-reserve communities, house-to-house immunization is practiced and if such a client had been more present in their on-reserve residence, they could even have adequate immunization:

> *there is a lot of movement between the city and reserves, with low rates on Panorama, because the First Nations jurisdictions … since they don't enter anything unto panorama...they might even be over-immunized**,** but we have no idea*

The challenge or difficulty to follow up with the immunization status of the transient population is a major barrier to improving on the measles immunization coverage rate in any of the health regions where the transient population exists.

4.6.2.2 Fear/Hesitancy

Fear was one aspect of barrier that the respondents talked about in different ways, but all the discussions led to the possibility of caregivers not bringing their wards for measles

immunization for myriads of reasons. They however were of the opinion that provided such anxieties can be allayed, there is some level of hope that such caregiver can bring their children to take up the immunization. Some fears discussed are just as simple as those of needles piercing their children:

"We definitely have some that just have fears and hesitancies of needles",

Other fears and anxiety that were expressed as creating barrier to measles immunization uptake included whether the measles vaccine actually causes autism or autism-related disorders, the possibility of reactions to the vaccine, etc. Other factors culminating in fear/hesitancy was distrust of the system. These factors are discussed in fuller details in the section below.

4.6.2.2.1 Lack of access to health information

While it is commonplace to believe that health information is readily available because of the level of technology that we have today, discerning the right information from the misleading ones may be a challenge for those who do not seek information from the right sources.
This factor was discussed more in regard to the transient population and of other people of low socio-economic status who do not make regular contact with the health service.

4.6.2.2.2 Low Perceived Risk

Some respondents think that a lot of the caregivers have never seen what measles looks like, never seen someone who was infected with it before and had always felt if their child is doing well, there is really no need for vaccination. Again, participants said some caregivers are of the opinion that if everyone around their child is free of any infection, their child should be safe. Respondents also spoke about the fact that the successes of the past years that rolled back infectious disease as a result of research, development, immunization efforts and virile preventive services, resulted in some communicable diseases to no longer be as common as they used to be and hence the challenges of this present age may not be unconnected to the successes of the past years.

> *…I would say a lot of it is that the public is no longer aware of these diseases, the impact that it can have if there is a low immunization rate. So, I think that we are the victim of our success from immunization success over the decades.*

And in a like manner, some caregivers do not know what the consequences of not getting the children vaccinated might be like, even though the comment below could also belong to the

limited access to health information that may be pervasive around some of the Saskatchewan communities.

> *I think it's the lack of knowledge around the vaccine and of the consequences for their children not being vaccinated.*

Still, in a similar vein, a lot of emphasis was placed on the fact that people are believing the disease is not there any longer and hence preventive efforts are becoming a scarier preposition than the thought of the possibility of the measles infection itself. The fact that the measles infection is no longer present in so many of our communities nowadays is good evidence that preventive efforts have paid off over time. While this is a welcome development, however, if the covered population becomes tacit in its efforts at sustaining this development, the gains of the past could be eroded.

4.6.2.2.3 Fear of Reactions

Even though the participants talked about the fear of reactions on the part of the caregiver as a potential source of barrier, they however, said that in the light of what they have experienced that most of their clients already know this possibility. They went further to substantiate that with the information which they give readily to the potential clients and in so many other fora where immunization are talked about. Whether information on measles specifically, MMR or MMRV or other vaccination programs, most of the clients know the caregivers who for the most part will take immunization know the reactions are mild and know how to deal with them. In all, the respondents say they are aware of those rare adverse events but never had any or experienced any child that had it since their period of practice:

> *We barely see any reactions. The reactions that we usually seen are those that are expected, like local reactions or fever, rash. But those are all the things we tell them that can happen and so (sic) the most part people are interested in immunizing their kids …. I feel like the fear of immunization reaction is heightened on social media and conversation that people have, not necessarily personal experiences.*

The type of fear which the respondents believed have a potential to affect the coverage is those fears of the unknown side effects, some of which some prospective immunization recipient had discussed critically about. Respondents were of the opinion that some of that information about potential major reactions circulate within some pockets of the communities and those are the type the providers believe could be a potential barrier especially if no knowledgeable personnel or a health worker is available to counter the notion. The negative activities directed to

measles vaccination on the social media is becoming more of the barrier towards improving the uptake of the vaccine, and this is an added layer to the concerns of the various communities where the health care workers operate. This development is compounded by the tactics of the anti-vaxxers who use the social platforms to propagate their wrong and misleading ideas.

4.6.2.2.4 Parental Concerns

This barrier bears similarities to the discussion under fear of reactions even though there was an extension of the fear to whether the children could even have the actual diseases from the means of its prevention. This was collapsed eventually as part of the subthemes under fear of reactions but was highlighted in this text to make it known that the respondents are aware that some of the caregivers worry about this also, hence a barrier to coverage improvement.

> *…I think that people, because the diseases are not as prevalent now as they used to be, they are not scared of the diseases because they don't see them, so they are more scared by the vaccine than the disease.*

Participants also discussed that some parents had wondered 'how many is enough or too much' among the crowded immunization schedules that children have to take at every milestone in their early years and wondered if cross-reactions that science had not caught up with could not be happening. Such thoughts, respondents think is a barrier to the uptake of measles immunization especially when measles is given in combination with other antigens in MMR and MMRV.

4.6.2.2.5 Distrust of the system

Distrust of the system was one of the factors identified as a barrier to improving the measles immunization uptake in Saskatchewan. A quote below summarizes some of the reasoning behind why coverage may be low in some areas and among some groups of community inhabitants.

> *…when you have people, who have an 'unnatural distrust' of authority, of government and you are a representative of the government, so whatever information – correct information in this instance, that is out there is going to be viewed through the biased lens of it being from the government.*

Trust is an important element for acceptance and uptake of measles immunization. This trust could be at various levels; established in the vaccine product itself, in the individual health care workers, the government and the system at the larger end. The previous interactions with the government and the system, the contexts in which those interactions have taken place, the result of such and the efforts at rebuilding such relationships may constitute either as an enabler or a

barrier depending on the level, and this may be locally specific. This is very important in the context of colonization in Canada or in regard to immigrants or refugees who come from countries with systems that they do not trust.

4.6.2.3 Anti-Vaccination Issues

4.6.2.3.1 Anti-Vaxxers – Online group

Some interview participants from seven of the ten health regions in the research mentioned in one way or the other about the challenge the anti-vaxxers pose to the measles immunization coverage in Saskatchewan. Social media interactions had been blamed by almost all the participants that talked about it even though a few also believed some local influences also contribute:

> *…we do have some religious group and then have people that just have philosophical objections for whatever reason, things they've read from the internet or the hype from people like Jenny McCarthy.*

Participants did not shy away from the possible presence of local groups in the various communities where they operate and discussed the challenges of reaching the anti-vaxxers:

> *…and of course, there are anti-vaxxers. They don't have any immunizations. They don't go into the system at all where their name could be, and they're home-schoolers. So, they're not going to go in the school system. They're not in the government systems…*

Participants believe it becomes more of labelling to go after people you suspect but could not confirm if they have philosophies that tag measles vaccination or other vaccines as not good for prevention of diseases, a challenge which is compounded by the fact since some of these people do not even enter the system, it becomes more difficult to track them for targeted response.

4.6.2.3.2 Collective Beliefs

Participants mentioned Hutterite communities in the context of refusing immunization on philosophical grounds, or religious grounds, or for lack of belief of any beneficial effect. Some participants said this may also be a location specific issue in their experience as there are some Hutterite communities supportive of immunization while others are against vaccination:

> *…we have the Hutterite communities and we have about (n=undisclosed) colonies in our region and most of them are good with immunization, but we do have 1 or 2 colonies that don't believe in immunization, so, that cohort you cannot really access for immunization.*

However, while this group of community members have existed for a long time and have been known to the health regions officials, the pockets that are completely not immunizing and that may influence other members have been the main barriers.

> *we have …(n=undisclosed) … Hutterites colonies right now, some of them with those enclosed populations are with small children and continue to choose not to immunize. We've been aware of that for years, but now we are starting to see other pockets…. So that's a barrier for us."*

Besides the Hutterite communities that are known to the health workers, the participants have identified a few other places where local social groups exist in pockets that are actively against vaccinations.

4.6.2.4 Systemic /Resource Limitations

This theme centered much on discussion on funding and staffing as the major barriers (discussed below) putting some context on the perspectives of the providers. A few quotes have been considered important to be shared to substantiate the researchers' report and allow for readers' reflection.

4.6.2.4.1 Funding, Staffing and Media access

Some participants spoke specifically on the barrier the reduced and shrinking financing of the health system in their health regions cause. This was discussed in terms of disposable funds to have more presence online to reach the clients that depend on that type of communication for knowledge acquisition. Some discussed funding reductions and the fact that the number of clients to follow up on in the face of population growth is increasing, but there has not been any significant increased staffing in some RHAs while there had been none at all in some others in over several years.

> *…one of the main challenges is budget deficit and also overworked public health nurses. I have not seen even a single added to PHN staff in the last decades while so many other vaccines have been added to the publicly funded program.*

Participants maintained that they still worked hard enough to overcome the many challenges that scenarios like inadequate manpower throw at them, but it is a major barrier to tackle every issue. Some of these issues of reaching the population that are underserved is worse for some health regions with large towns and those with widespread small geographical locations.

> *I think another barrier we have is reaching people, the amount of resources we have makes it difficult to reach the "hard to reach people*

Extending services to other new places could help with reaching the hard to reach people but some participants have been constrained with even creating drop-in clinics and even when such are created, it could not be sustained throughout the year as staff allocation becomes a challenge.

> *…sometimes it's hard to run a drop-in clinic if you don't have enough nurses…also things get pushed back and funding gets tighter…*

Media coverage for activities and for information dissemination was identified to be a great boost to reaching a large audience. However, the participants also discussed funding as a barrier to accessing the services of the media for the purpose of raising awareness.

4.6.2.4.2 Immunization Registry Disconnect

Immunization registry disconnect was also found to be a barrier to improving the measles immunization coverage figures let alone getting to the herd immunity threshold. In this context, and for the most part, the registry disconnect discussed was about the data gateway/storage which the province of Saskatchewan uses and what the federal level maintains which never had a link. The other database disconnect was between the health regions (RHA-RHA data disconnect) before the advent of the 'one health authority' which the Province of Saskatchewan currently operates. The federal data are still kept separately from the provincial data, but the issue of health regions keeping separate data that are not linked to those of other health regions has been resolved with the advent of the one Saskatchewan Health Authority created. The lack of harmonization between the federal and provincial data, however, remains a challenge:

> *…It's really not that the majority of kids are behind on immunization it's just that there is incomplete records on panorama so it shows that they are behind but really if the reserve records were on the platform, those kids could be up to date…*

4.6.3 Enablers for measles immunization uptake

The research question three to which the respondents had provided response to in this research had two parts to it – the barriers as well as enablers for measles immunization uptake in Saskatchewan. The barriers have been discussed under 4.6.2 above. This section highlights the enablers to measles immunization uptake as discussed by the providers interviewed in this research. Four major themes came out of the analyzed data, these were socio-economic divide reduction, engaging communication, flexibility and dynamism and the role of the media. The summary illustration of the themes and sub-themes is found in Figure 4-14. To illustrate the

information obtained, relevant quotes from the participants have been used where necessary to illuminate the main themes as well as the sub-themes.

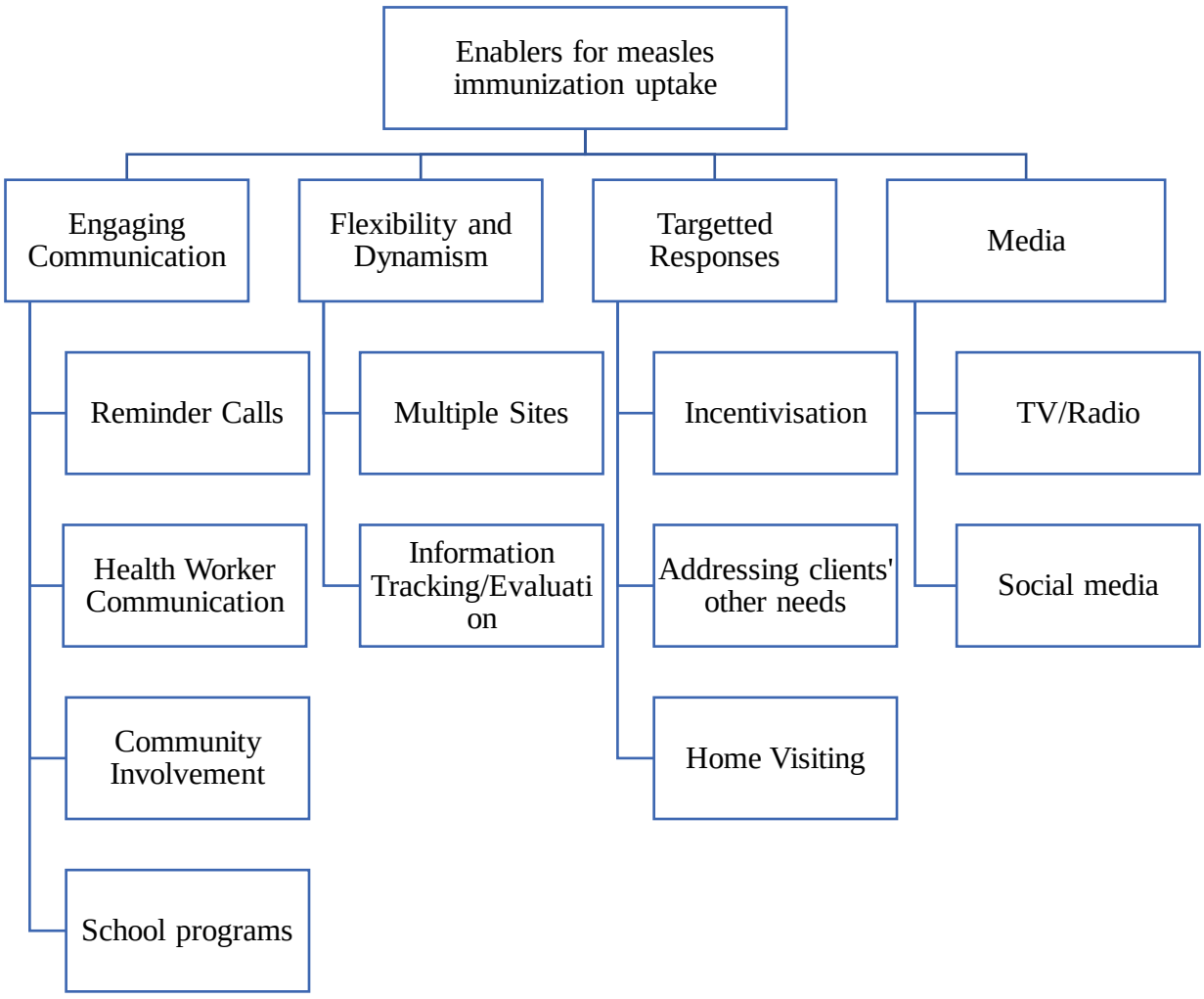


Figure 4-14: Enablers of measles immunization uptake in Saskatchewan - themes and sub-themes

Participants identified communication, health worker collaboration, flexibility and dynamism, multiple sites/extended hours, targeted response and use of media as important enablers for measles immunization uptake in Saskatchewan. Other mentioned enablers were database reconciliation, incentives provision, staff training and development, and school programs.

4.6.3.1 Engaging communication

Engaging communication was discussed extensively by the participants. However, the researcher grouped these conversations under three sub-themes discussed below. These are discussed in the following subsections with relevant quotes to illustrate. The more prominent ones were functioning reminder system, regular health worker communication and involvement in community engagements.

4.6.3.1.1 Reminder System

The participants emphasized how important an enabler the use of reminder methods are to measles immunization uptake in the various health regions. They use telephone, letter in the mail, little cards and promotion of the immuniza.ca app to remind their clients when they are due for immunization or when they are behind schedule:

> *"once the child was 13 months old and they hadn't received their 1-year immunization, they'd get a little card in the mail that reminded them they needed to book an appointment."*

Since the introduction of immunizer.ca app, the RHAs have promoted the use of the app, especially among the caregivers. The app is interactive, and it provides information about vaccines recommended by the NACI as well as answers to a lot of frequently asked questions. The clients can get their reminder for immunization uptake as well.

> *"We are promoting the use of the immunize.ca app, which also gives the schedule, in sense of reminders to clients"*

4.6.3.1.2 Health Worker Communication

The RHA health workers believe that one of the enablers to improving the uptake of measles vaccines in their various health regions is the regular communication they have among the staff members which serve to update their knowledge of particular issues, develop organizational ways to address clients' needs which make the clients to build confidence in their health care providers:

> *"We do a lot to educate the nurses, so they feel very confident in communication with the public about the immunization services that they are providing, and so they feel confident and well informed about different programs. I think that's really important, that clients feel that their health care provider is knowledgeable, and they are skilled in what they are doing"*

The training and manpower development is not limited to the staff of the health regions only. There was an extension of education and collaborations with other health care workers outside of the RHAs:

> *we do education with other health care providers too; we support our physicians and Nurse Practitioners.*

The last but an important component of the engaging communication for health workers which the participants also felt was great to improve coverage was a central point source for continuing education for staff to discuss best practices:

> *When I first started in public health, we used to be able to go for a week and be updated in all the best practice and everything that was new. So being able to have some education for our nurses around the anti-vaccine movement and how to deal with those parents, I think some of that would help us out considerably in this area.*

The participant has spoken about anti-vaxxer education in this quote, not because that was the only topic of interest but because it was one of the challenges to improving measles immunization uptake at the time of interview. There are so many issues out there to be discussed in such fora if constituted.

4.6.3.1.3 Community involvement/engagement

Even though participants from about half of the health regions interviewed talked about the use of community engagement to improve measles immunization coverage, several methods at doing this have been tried and participants commented that they were able to see benefit. Some commented that they made handouts and pamphlets which they gave out at maternity wards upon delivery of babies. The handouts were used as an anchor to engage the new caregivers on immunization conversation, especially to use the opportunity to clear those doubts about tough questions

> *We give handouts and discuss immunizations at the maternity visit program and home visit right after the baby is born.*

Participation in community programs has also been found out to be a strength to improving immunization uptake. Awareness has also been carried out during community fairs for which participants said such events helped to bring the conversation about measles immunization to the forefront especially in environments where they were beginning to see low attendance and uptake of immunization services generally:

> *We have gone to a couple of health fairs or promotional days where we actually take immunization displays with us and just talk about not just measles but other vaccines…*

4.6.3.1.4 School Programs

Participants have found out that when kids have missed the time for their measles immunization schedules, the next avenue to reach them were the schools. Assessments of the immunization status of the children attending schools were carried out with the use of school nurse, where there is one, or with visiting nurse from public health through an arrangement with the school division. Letters are sent home to the caregiver for consent to administer the vaccines that were due to the children. Participants pointed to the fact that this approach may seem to appear a bit late to add the required coverage value to measles immunization uptake at two years of age, but they found out it helped to remind the caregivers about other children in their homes that are yet to be behind schedule who may need to go for their routine vaccination.

> *so, as you know we immunize in schools and that is one way of making it more accessible. In kindergarten, for those kids that don't have a second dose may be, we also started with a project in daycares a few years back and in the initial project, we selected daycares in low-income neighborhoods"*

4.6.3.2 Flexibility and Dynamism

Participants commented that being flexible with timing for services has been very helpful to get more people to immunization which they believe is one of the efforts that worked well and hence a strength to the program. They found out that a lot of people that work are not able to take time off during the public health clinic hours as set by immunization services, hence drop-in clinics work pretty well. Besides the drop-in clinics, timing of services has been adjusted to start a bit later to end late so those who close work at about 4:30 could still access services.

> *…we've even initiated a few appointments on Fridays, and we are doing a lot of outreach clinics in rural and our vulnerable populations as well, like multicultural centers and those that are isolated and are not able to get to public health…*

Participants also commented on granting more access to the people in low socio-economic positions and they found out that the drop-in clinic seem to work better for them. Some of these LSE group of people do not own phones and hence reminder messages may not even reach them and also, they work several jobs to make ends meet and would only be available at their own time or convenience for immunization service uptake:

> *We find that the drop-in clinics work better for low SES and sometimes, you know you need to start later in the day not everyone is an early riser.*

4.6.3.2.1 Multiple Sites

One of the factors that some of the participants adduced their improving coverage to was making available multiple sites that clients can access, especially for places where transportation is an issue. In this instance, the availability of multiple sites is an enabler to improving uptake.

> *We have really worked on the placement of our clinics, areas where we know we have low immunization rates, where transportation is an issue, we've actually put immunization clinics there,*

Some participants affirmed that since they created multiple sites within some neighborhoods., they could see that coverage figures got better as a result of people having close access to services in those particular areas.

4.6.3.2.2 Information tracking/Evaluation

The respondents think it is a strength to run through overdue lists regularly, creating regular reports to inform themselves of where they are in terms of coverage. They also believe tracking the clients' records regularly lets them know where to direct resources in order to get the maximum results. Participants phone clients that have missed their appointments and re-book them to get people in for their vaccinations:

> *We did adjust all of our appointments and now we are electronically scheduling those, so it's easier, if we have another staff that couldn't be at that clinic that day, so we could send out a replacement in because we have the information on the clients, so we should be able to do that so we don't cancel the appointment which is better for coverage.*

Besides the information tracking, which the participants believe is a strength and having a positive impact on coverage figures, they also talk about internal evaluation of programs to align the results with the set objectives. This they say they do according to schedules that vary from health region to health region. They also go beyond looking at the coverage figures and follow up with phone calls and reminder cards to patient's residence address, they are also vigilant to geographical locational measles uptake changes and make efforts to pick up clients attitudes that point to vaccine hesitancy so that the challenge can be addressed pro-actively:

> *"we are analyzing which areas of the region have low coverage like we have done in the rural areas as well, as I mentioned before, the hesitancy group which are in …. So, these are some cases where we are trying to identify whether it has to do with the access or might be some hesitant group that we want to go after."*

4.6.3.3 Targeted Responses

4.6.3.3.1 Incentivization

Participants from three health regions discussed on provision of incentives as an enabler, however, two of the three health regions have tried it. In those two that have tried, the result was more clients were brought to measles immunization. The form of incentives used in these cases were provision of transportation when clients could not visit the clinic when due for immunization for lack of transport. In other instances, they provided bus passes. Rewards in the form of gift cards have also been tried with good results.

> *…we offer transportation if people don't have a way of getting to our clinics, we go and pick them up and drive them to the clinics.*

The participants however contextualize the use of incentives and commented that different forms of incentives work in different groups of people and this is where knowing your clientele characteristics become important, as the providers need to understand their clients to be able to know what works.

> *Incentives work actually better in lower socio-economic neighborhoods…We have incentives or rewards from time to time, we would buy books for kids, and we have gifts cards from Safeway or Co-op that we would give to the parents.*

4.6.3.3.2 Addressing client's other needs

Some other enablers that have been identified by participants is addressing the other needs of the clients. These needs are other social determinants of health without which the prospective client or caregiver may not prioritize immunization:

> *"Our inner-city population, unless we can address some of their other needs, the other determinants of well-being, we are not going to make a huge rise in terms of immunization. So, when you call them, it cannot only be about your kid is behind in immunization, you need to listen to the other needs they have and put them in contact with other groups that can support them enough."*

4.6.3.3.3 Home visiting

A participant from one health region talks about home visiting to boost immunization coverage, however, they think that may not be sustainable. The participant, however, believes it could work provided they are able to do it. This was also mentioned as being part of the practice on the federal side, among the on-reserve First Nations population.

there are definitely different ideas out there…. just like home immunization especially for those caregivers we identify that will need it to be up to date…

4.6.3.4 Media

The participants asserted that the media play a great role in enabling measles and all other forms of immunization uptake in the province of Saskatchewan.

I think the media does play a large role, the media really works, we used it some time for influenza and we had several people lined up to get flu vaccine, even though we weren't appropriately staffed to manage the turnout, but we were happy to have the people. I think it's a relationship we have to build with the media. But the media really does help.

4.6.3.4.1 TV/Radio

The participants agree that radio and TV have improved their coverage rates. Some of the interviewed participants develop press releases and send to media houses to encourage parents to immunize their children and reiterate the importance of not only getting vaccinated but the timeliness of the vaccination.

I think it would be great for the media to continue to supplement social media messages, but media does provide excellent service especially the radio stations provide excellent support for us

Because of the regularity, some of the health region participants in immunization services have contact with radio and television outlets, the media houses even use the opportunity to educate the public by partnering with the health workers to shed light on issues around vaccination that need clarifications.

…the media contacts me and asks me questions and I try to address their questions, in that way educating people and parents about vaccination.

4.6.3.4.2 Social Media

The health regions participants talked a lot about how great an enabler the radio and television outlets had been to their work on measles immunization coverage, but only a few talked about the place of social media as also an influencer that should not be neglected in this age of the use of the web and various form of social media. Some of the few that talked about social media has the quote below as illustrating that, and they were passionate about the impact of social media

… we have been doing some tweeting in the past and we have been putting information up on our website, we also have a baby-friendly or a website for baby connect…however, we have not explored the use to their full potentials

4.6.4 Summary of Question Three Results

This section helped provide answers to the third of four research questions, what are the facilitators and barriers to achievement of herd immunity threshold (92 – 95% coverage) for measles immunization coverage in Saskatchewan health regions? The findings under the section was a characterization of the participants experiences elicited with interview guide. The findings were reported utilizing some quotes from the participants to illustrate the ideas and illuminate the context and the experience.

The various barriers to improving measles immunization uptake in the province of Saskatchewan from the health care providers perspective were uncovered. The findings arranged according to themes were access related issues, caregivers fears and hesitancy, anti-vaccination challenges and system and resource limitations. The access related issues bother on social determinants of health, immigration with resultant health system navigation challenges; fears and hesitancy with attendant low perceived risk, parental/caregiver concerns and fears emanating from risk of reactions and hesitancy as a result of distrust of the system. It also uncovered antivaccination issues and the effect of collective beliefs. The section rounded up with the barriers resulting from resource limitations to fund media, inadequate staffing to cope with the growing population and system issues that bother on immunization registry disconnect and lack of harmonization.

Even though there were barriers identified as above, the research also elicited enablers to uptake of measles immunization in the province. These enablers range from the use of engaging communication through putting reminder systems in place and using them effectively, regular and effective health worker/provider communication and making awareness of the public a priority system to health providers flexibility and dynamism through the creation and running of multiple vaccination sites and periodic evaluation of the measles immunization records. A couple of targeted responses were reported by participants to have complemented the generally directed enablers, and these range from the use of incentives especially for the low socio-economic status clients, addressing caregivers' other needs to carrying out home visits to the clients who could benefit from such arrangements. On the last note, the participants established that the use of the media (TV, Radio and Social media) was a great enabler which majority of the participants have the experience of use of, with incredible results and which they alluded to have increasing potentials that they hope to still tap into in the future.

4.6.5 Intervention Phase Outcomes

The exercise which was specific to each health region took place in all the participating health regions with the use of Microsoft PowerPoint slide deck by the researcher. The information session started off with demographics of the analyzed immunization data, the total population breakdown by socioeconomic quintiles of deprivation. Socio-economic inequalities measurement tools were discussed as a basis for the development of the quintile of deprivation. The presentation touched on trend of coverage of the on-time for the first dose at 1 year and also on-time for the second dose at 2 years, the CITY and NOT CITY locations trend patterns, socio-economic deprivation quintile coverages while comparing S-EDQ1 and 5 for the two age groups in the study. The quantitative discussion ended up with a comparison of the levels of disparity in 2002 and 2013, the study start and end periods.

While the quantitative data discussion was completely specific to the health region, the qualitative portion was a summary of the analyzed experiences of all the health region participants. The discussion summarized the themes of the main findings on the barriers and enablers identified in the interviews conducted. The interaction offered the prospect of exchange of ideas and the opportunity to bring under one roof experiences from other places. A few of the participants quotes were used to elicit discussion on themes and sub-themes. The exercise which lasted from 60 – 70 minutes concluded with a presentation of the summary of findings and preliminary suggestions.

This phase afforded the researcher to contextualize the discussions better. Interactions were more cordial, and faces could be attached to the previous voice and numerous correspondences. There was opportunity to see what was obtainable in the various health regions in terms of interventions and the displayed evidence of such on visual program progress status walls. The researcher was also able to draw conclusions on what may be gaps in intervention and human resources challenge.

4.7 Findings from Research Question Four

The research question states *'From the healthcare provider's perspective, what policy interventions and innovations are required to improve equitable measles immunization coverage rates in Saskatchewan?* At this point in the research, the researcher had had a first set of

interviews from the same participants and had also presented the preliminary research outcomes both of the quantitative and the qualitative data. In this round of researcher-participants interactions, the interviews, also guided by an interview guide (Appendix B) were geared towards following up on the previous interaction and encounters. Ten interviews were conducted in this round with each lasting between 25 and 48 minutes.

There were two major questions on which the interview was centered, and which also guided the structuring of the used interview guide. Participants have been asked specifically about what more they would do in terms of innovations or changes to previous interventions to improve immunization coverage figures in their area of jurisdiction, given the presented research results and information made available to them by the researcher, and also what their expectations from the institution they represented would be, going forward. The interactions elicited the findings discussed in this section which also are reported with substantial but important participants' quotes where necessary to illustrate further on the interaction and responses, and for the readership to be able to form own opinions.

4.7.1 Access Improvement and Missed Opportunity Reduction

The participants touched on a lot of issues as regards access improvement and reducing missed opportunity. These possibilities were captured through the following sub-themes – the use of after-hours clinics, clinics in daycare sites, door-to-door immunization service and satellite or rural clinic availability. Some of the participants want to start extended clinics hours, while those who have started began to see a need to continue to keep them and even staff them better to catch on those children whose parents may not be able to find time during the regular opening hours to bring them in. A participant commented that;

> *… we have only one day of extended hour clinic. And we don't have any weekend clinics. So that's one thing (weekend clinic) we're trying to look at doing.*

Some other participants saw that the rural areas had almost the same population as the city areas through the demographics results presented and they felt they needed to pay attention to the rural areas as well as the city locations, as they felt making the distance covered to access essential service like immunization as short as possible is important.

> *I really want to ensure that we can keep our rural clinics. Because then I think that because – as your information is showing – our region is as much rural as it is city. And so, in order to ensure that we're not decreasing people's access because they have to*

come into … (a named city)… that we're still keeping those rural clinics so that people can still go close to where they live.

Some participants felt it was time to try the door-to-door immunizations in some areas where they have identified, like the inner cities, while some would want to make a case for satellite clinics in daycare centers where it wasn't existing yet.

4.7.2 Education and Awareness creation

Some participants saw a place for capacity building for members of staff to be able to handle emerging issues. Participants are aware that a lot has been happening in the domain of immunization provision in recent times that they felt the knowledge of staff members needed to be updated. Even though some participants said they have some internal evaluation and needs assessments culminating in tailor-made education for staff members, they felt the time has come to make this capacity building a province-wide one to learn best-practices. A quote below from a participant illustrates what public health was like in the past and what they think needed to be done differently looking into the future:

When I first started in public health, we used to be able to go for a week and be updated in all the best practice and everything that was new. So being able to have some education for our public health nurses around the anti-vaccine movement and how to deal with those parents. I think some of that would help us out considerably in this area.

Besides the education for the members of staff as presented in the above paragraph, some participants would want to start utilizing the same spaces the anti-vaxxers use to propagate their information by providing information in those places as well. The participants also feel the regular population especially the hesitant group need to be educated as well on what herd immunity really means so that they have a right interpretation of it for the common good of the population

I think education on herd immunity ……A lot of our people read about immunization and think well I won't immunize my child because all my neighbors are going to immunize their children and then they'll be protected.

Some participants would want more ministry presence and to continue with the central production of the immunization brochures.

4.7.3 Reminder Calls

Participants who work in RHA with an automated reminder call system would like to continue with that and would like a situation where they could combine that with in-person calls

so that the opportunity to attend to some of the hard questions and clarifications from difficult clients can be met. Some participants want to include texting as part of the reminder system because some of the caregivers work on farms and run tractors and equipment that may prevent them from hearing the phone ring let alone answer these calls. If the opportunity is there to text, some of those opportunities of being able to leave information behind will not be lost. Some would even want to agitate for the use of text because they identified that some of their potential clients' caregivers are on text-only plans even though participants expressed the challenges with the ethics and privacy procedures, which they hoped could be addressed in no time.

> *… we would like to get to the point where we could use text reminders, but up until now our privacy officer has not allowed us to use texting for our clients. So not all of our clients have phones, but some have text-only plans so if they don't get the reminder by phone voice mail, they might still be able to receive a text….*

Some participants even would like to do targeted telephone reminders especially if they know those areas where they have the least coverage.

4.7.4 Resource Mobilization

In response to what the participants expect the institution they represent to do for them going forward, some participants responded that they will need more staff members that could analyze data and disseminate the resulting information to inform their actions, even if they needed to share statisticians/epidemiologists:

> *We need some epidemiologist support, somebody who could dig in and say "You know what…. (name)? These are the postal codes that are the lowest." And I would say "Well, oh where is that?" And then we would look on the map and figure it out. And we would say "Why? What's going on in that postal code and that rural community of … (names of communities)?*

Some participants discoursed further that the presence of such categories of members of staff is long overdue, even though a few large health regions had them in place. A participant explained in a more specific way, addressing the needs of the rural areas where they have vast land to cover:

> *You know, we really need the epidemiologist support, or data analyst or research analyst, however you call it. So, we have lots of jobs for epidemiologist to do … My summary is that the rural area needs epidemiologist support.*

Participants affirm that tracking those figures, the coverage data, the location and localization where the figures they see come from will make a real difference.

4.7.5 Collaboration

Collaboration among all the health workers in the healthcare delivery sector is a way to get all the potential clients to be brought up to date on immunization and issues around it. Since the last interview in phase one, more participants have explored the area of collaborating with family physicians, pediatricians and bigger practice to either assist in immunization drives or ask, 'is your immunization up to date?' from their clients. Some are even helping with the difficult conversations with the hesitant group or anti-vaxxers to bring them to immunization:

> *... but I think also to help us – and you had mentioned it – other professionals, we've got, actually just recently, a really good group of doctors in the primary health center in ... (city mentioned) ... that talk with everybody about immunization. And so, we've had some anti-vaxxers that have come over and started their kids based on their encounter with the physicians.*

4.7.6 System Oriented Innovations

System-oriented approaches that the participants would like to pay more attention to henceforth include but are not limited to, are more familiarity with their data, providing accountability reports to all their field PHNs where possible so far as it does not invade privacy or breach of confidentiality. They also want to maintain more contact with the families and would like to start responding to birth rates and monitor wait times more than before. Since the last research interviews, some participants talked about their health region's commencement of accountability reports which was described as an action by the lead/coordinating officer to look for all children that are due for immunization, but that have not made contact with the public health, and pulling their contacts and names which are then sent to the PHNs working in those areas to get them immunized and record into the system. They sometimes have referred to this as Panorama auditing, which they say had had a huge impact on their coverage rates.

The respondents also would like to do more on monitoring the wait times to ensure that all clients get the measles immunization service they require at the right time reducing the backlogs. A participant explained:

> *We need to monitor the wait time for the immunization clinic by health units. Because if I'm a parent trying to get my child immunized and I call today, I'm told that, "you have to wait another three months to get an appointment" you know that can be discouraging...*

This effort at a reduction in backlog is thought to prevent loss to follow up.

4.7.7 Targeted Approaches

Still responding to the question of what more the health region representatives in this research will do to move the measles immunization effort, the discussion touched on vaccine hesitancy, anti-vaccination, distrust of the system and the transient population. Here, the participants would like to use more targeted approaches to address these issues in the coming intervention efforts. Participants would like more than before to focus their efforts on the vaccine refusal groups through the targeted approaches of identifying the pockets, the groups and/or the individuals involved, finding out the main reason behind such attitudes, doing motivational and regular communication, engaging with their leaders and other authorities that can help with ameliorating the situations:

> *… So, if it is a resistant population group, so those who are vaccine-hesitant or who are totally anti-vaxxers, that will hinge on communication, engagement, looking for opinion leaders in that community, wherever they may be.*

The targeted approaches, they explained further, will go alongside with the regular awareness campaigns and community engagements as described in the early sections of this document.

4.8 Summary of Results

The quantitative analysis utilized the total available data of the covered population of children in SIMS between 2002 and 2013 (pulled out of Panorama at the early phases of data migration) (n= 169,582). About one-third of this population lived in the NOT CITY locations while about two-thirds lived in the CITY locations. A progressive increase was observed in terms of the proportion of people who lived in the CITY areas from 2002 to 2013 while there was a gradual reduction of the population living in the NOT CITY locations.

In 2002, the coverage rate ranged between 49.15% (the lowest figure for RHA) and 67.22% (highest attained by an RHA) which increased to between 60.58% and 84.2% (being the lowest and highest rates attained by RHAs) in 2013. Provincially, the average coverage rate for the ten participating health regions during the period was 56.32% (2002) with a progressive increase to 73.21% (2013). This figure may be different if the data of the remaining 3 RHAs constituting about 3% of the province of Saskatchewan were added and analyzed with the available measles immunization data.

There was a progressive increase in measles immunization coverage in the two geographical locations under study as well as among the two age groups in the period under

study. For the geographical locations, the coverage rates were higher all through the period under study for the rural than in the urban locations among the two groups. Also, in the two set of comparisons, the rejection of parallelism suggested that the trends were significantly different for the two geographical locations coverages. In the peer groups, it is observed that though the coverage rates in the NOT CITY locations were higher in all the RHA peer groups, the rate of increase in coverage as reflected by the AAPC was lower in the NOT CITY locations apart from among the RHA peer group H where it was higher. It is also noted that apart from RHA peer group A where there was convergence of trend lines in both age groups (1-year and 2-year) studied, there was a divergence in trend lines in peer group H health regions from year 2008 for both age groups. The peer group D health region age groups did not demonstrate a uniformity in the rate of change of the fitted lines; while the on-time for the first dose demonstrated a convergence up till 2007, the two lines remained almost equal till 2013, and for the on-time for second dose group, it was an initial convergence with a divergence after the year 2008.

There was a progressive increase in the coverage rates for both S-EDQ 1 and 5 for both age groups studied at the provincial level and among the RHA peer groups. The increase in coverage as depicted by the AAPC showed that the change was significantly different from zero in both groups. The coverage rates were higher in the S-EDQ1 than S-EDQ5 for both on-time for the first dose at 1-year and on-time for the second dose at 2-year age groups between 2002 – 2013. Even though the coverage rate for the period analyzed was higher among the S-EDQ 1 than S-EDQ 5 at the level of the province as well as among the health region peer groups, the AAPC for S-EDQ 5 were higher both at the level of the province as well as among the RHA peer groups (table 4-4). This is an indication of progressive reduction of disparity from 2002 -2013 between the two S-EDQs (1 and 5) compared. Looking at the individual RHAs, in the on-time for first measles vaccination at one year, there was an improving (increasing) coverage and improving (reducing) relative gap apart from Kelsey Trail which showed worsening coverage but improving (reducing) relative gap, and Sunrise, Prince Albert Parkland and Heartland with improving coverage but increasing (widening) relative gap (figure 4-9). And for the on-time for second measles immunization at the two-year age group, all the ten participating health regions in the province of Saskatchewan demonstrated improving (increasing) coverage and improving (reducing) relative gap apart from Sunrise and Heartland with improving coverage but worsening (widening) relative gap.

Looking at how the level of disparity has changed between 2002 and 2013 for the individual health regions, there was measles uptake disparity reduction in all the RHAs in Saskatchewan apart from Heartland and Sunrise RHAs where disparity widened and in Prince Albert where it remained almost unchanged (table 4-7).

ANOVA was used to test if there were differences among the deprivation quintiles within each of the health regions, it was observed that there were statistically significant differences among the five deprivation quintiles. The study checked for which deprivation quintiles pair comparisons were different and found that even though there were different pairs in different constellations that were different within each health region, Q1 and Q5 were consistently statistically different within all the RHAs apart from within Heartland health region where the pair was not significantly different. There are also higher measles immunization coverage rates for deprivation Q1 compared to Q5.

The findings from the third of four research questions considered the facilitators and barriers to achievement of herd immunity threshold (92 – 95% coverage) for measles immunization coverage in Saskatchewan health regions. The participants' discussed and uncovered the various barriers to improving measles immunization uptake in the province of Saskatchewan. The findings as illustrated by the themes touched on access-related issues, caregivers fears and hesitancy, anti-vaccination challenges and system and resource limitations. The access related issues bother on social determinants of health, immigration resulting in health system navigation challenges; fears and hesitancy with attendant low perceived risk, parental/caregiver concerns and fears emanating from the risk of reactions and also hesitancy as a result distrust of the system. It also uncovered anti-vaccination issues and concerns from anti-vaccination behaviors and hesitancy effects as a result of collective beliefs. The section rounded with the barriers resulting from resource limitations to funding media, inadequate staffing to cope with the population growth and system issues that bother on immunization registry disconnect and lack of data harmonization.

Even though there were barriers identified, the research also elicited enablers to uptake of measles immunization in the province. These enablers range from the use of engaging communication through putting reminder systems in place and using them effectively, regular and effective health worker/provider communication and making awareness creation within the public a priority. There is also the health providers flexibility and dynamism through the creation

and running of multiple sites complimented with periodic evaluation of the measles immunization records. Some targeted responses were also uncovered and reported by the participants which range from the use of incentives especially for the low socio-economic status clients, addressing caregivers' other needs to carrying out home visits to the clients who could benefit from such arrangements. The participants established that the use of media (TV, Radio and Social media) was a great enabler which majority of the participants have the experience of use of with incredible results and which they allude to that it has increasing potentials that they would still want to benefit from.

While the participants had identified barriers and enablers to measles immunization, they also discussed a way forward to improve immunization coverage through intensification of efforts on strategies that are working while making efforts for new innovations. The intervention phase led to the exchange of innovative ideas from other health regions with the participants. In the next phases of implementation strategies, the RHAs would focus on both targeted and general approaches. The general strategies range from access improvement while reducing missed opportunities, increasing awareness among the population while providing education to the health care providers to the use of reminder calls with the possibility of using SMS/text messages to caregivers. They will also want to reinforce collaboration both within the RHA workforce as well as the involvement of the primary health care physicians for client reminders. For targeted approaches, they will increase community engagements and communications to address the issue of hesitancy and anti-vaccination movements where possible, and work on mitigating SDoH by providing increased access to the socio-economic groups that need help by incentivization, transportation provision and linking them with other support services in their environment.

Finally, while the above innovations and service improvement measures are part of the resolve and determinations of the participants as regional health authorities representatives in public and preventive health, they have discussed around what part they expect the government they represent to play, which were provision of the necessary resources, improved funding for activities and human resource availability.

Chapter 5: Discussion, Recommendation and Conclusion

5.1 Overview of the Chapter

This chapter consolidates all the key findings in the research and advances possible explanations for the findings in the light of available evidence and the context of the accessible body of knowledge. It also provides implications for important and notable findings. The geographical location terminology, 'CITY' and 'NOT CITY' were used interchangeably with 'Urban' and 'Rural' respectively throughout the remaining part of the document for a better audience understanding and comparability purposes with other existing body of knowledge.

5.2 Participation Rates

There were two levels of participation, the health region (for their available immunization coverage data of children 24 months and below) as well as the individual interviewees who were the key informants in the two phases of the qualitative data collection. Ten out of thirteen RHAs in the province of Saskatchewan participated in the research and provided access to the required data of the under 24 months age population covered by eHealth. The interviews had a 75% participation rate (n=18).

5.3 Trends in measles immunization

The trend in measles immunization coverage across the ten health regions increased steadily from 2002 – 2013, according to the analyzed data. This trend increase may be a response to all the various health region-specific innovations and program implementation practices that took place during the study period in the respective health regions. These innovations and practices have been demonstrated in the key informant qualitative findings of this study. During this period, many regional health authorities in Saskatchewan utilized reminder systems more effectively, increased the number of immunization service delivery points and became more flexible in terms of clinic opening hours to allow for caregivers who could not attend within the strict regular opening hours. The reminder call systems were initiated in 2008 more prominently in Saskatoon Health Region and later in other RHAs with significant impact. Some regional health authorities introduced some targeted approaches to improve immunization uptake by the initiation and maintenance of community program builders to reach out to the parents and clients in the inner-city core neighborhoods. In addition to these targeted implementation practices, it was also clearly stated in the qualitative portion of this research that addressing clients' other

needs like the determinants of the clients' well-being contributed to the successes recorded in the respective health regions over the period. What resonated among the participants was the fact that these interventions and implementation practices were not applied in the form of 'one size fits all'; rather, they were made culturally relevant and contextually appropriate. The above efforts are part of the strategies and interventions that made the difference and culminated in an increased uptake of measles immunization especially by bridging the gap in the socio-economic divide with a resultant improvement in the coverage rates over the period under study.

Immunization trends monitoring has been reliant on coverage rates for its estimation utilizing data which are routinely collected as a proportion of prescribed target populations (273-276). It is information from such coverage figures that are needed for required vaccine-needs projection, planning and implementation of vaccination programs, including the evaluation of progress toward both national and international goals. Such information is important to understand the extent to which the individuals are protected from possible measles infection. Subsequently, knowing this protection level will help to assess how close to the required herd immunity the various populations are. The herd immunity threshold for measles immunization to prevent outbreaks is between 92 and 95% (86, 102, 277). The coverage goal for childhood vaccines developed in 2017 was 95% for age 2 for all publicly funded vaccines in all the territories and the provinces (278). This goal is consistent with the WHO, and 2012 Global Vaccine Action Plans which provided a framework for more equitable access to vaccines currently in use for the full benefits derivable from them (279) while reflecting the Canadian context which has been adopted since 1996.

5.4 Measles Coverage Disparities in Saskatchewan

From the coverage figures depicted in figures 4-3 and 4-4, the ten Saskatchewan participating health regions appear to fall short in reaching this target in the period studied. During the 2002 to 2013 period, a maximum of 73.21% children were on-time for the complete 2 doses of measles vaccination missing the 95% target by about 22% in the year with the highest coverage for all the ten participating health regions. The highest figure of 73.21% was achieved in the year 2013. These findings are significant because of the clinical implication of not reaching the target. 73.21% is below the 95% target to prevent the spread of an outbreak (41, 280). Saskatchewan is one of the jurisdictions in Canada carrying out an independent periodic provincial coverage assessment. However, some of these assessment coverages are still at variance with the 2013

reported figures from the Childhood National Immunization Coverage Survey (281). It is to be noted that an outbreak of measles occurred in Saskatchewan between 2011 and 2013 in a decreasing number count of six, two and one respectively for those years. However, there was a worrisome surge of sixteen cases in the province in the year 2014. There had been no new cases since then in the province even though there had been outbreaks in some other Canadian provinces and territories (figure 2-2). Even though there was a steady increase in coverage figures between 2011 and 2013 (figure 4-4), the coverage rate was not high enough to prevent the outbreak experienced.

5.4.1 Indigenous peoples' context and the burden of history

The trend of events surrounding measles immunization coverage in each RHA showed that Sun Country had a higher level of coverage in the period considered than other RHAs. Prairie North had the lowest measles immunization coverage for the period analyzed among the ten participating health regions. These two health regions belong to different Health Region Peer Groups, where Sun Country is in Peer Group D, Prairie North belongs to group H. In general, the health regions in peer group D have overall better immunization coverage rates compared to A and H perhaps due to the differences in the peer group characteristics of the two health regions. While D peer group is comprised of mainly rural regions with an average percentage of the Aboriginal population but high employment rate, the H peer group is comprised of rural regions, low immigrant population but a high Aboriginal population. What distinguishes D and H groups is the proportion of the Aboriginal population. While D has an average proportion, there is a very high proportion of the Aboriginal population in H.

In Canada, Aboriginal peoples suffer physically and mentally from the effects of residential schools and other forms of assimilation (194). The negative effects of colonization, assimilation, and discriminatory policies in vulnerable communities have been reported to be detrimental to their social participation in public programs, including vaccination (193). Furthermore, the negative impacts of colonization affect vaccine acceptance with resultant low coverage, and consequently, the damage to public trust against the government (195), towards program implementers especially when there is a power imbalance between vaccine recipients in the community and the program implementers. All these experiences create a silo around the uptake of vaccines even when presented as a common public good. The Truth and Reconciliation

Call to Action (282), and the programs in place to address them could bridge this gap while healing the wounds of the past for trust and confidence in the system to return. It could build upon the statements established on January 7, 1998, and the on-going programs established by the working group looking into re-building between the Aboriginal and non-Aboriginal Canadians (283). The Truth and Reconciliation Commission Call to Action Number 23 (TRC #23) could help bridge the gap and boost trust in areas where confidence in the system is still at the lowest ebb. Bridging this gap can be by increasing the employment of qualified Aboriginal people in health care delivery, retaining them in Aboriginal communities and updating the cultural competencies of existing and new staff (282). Again, in the D peer group of health regions where Sun Country belonged, there is a higher level of employment which has been shown to have a direct relationship to the uptake of immunization generally and of the utilization of other health products. Low employment and hence lower household income were found to be associated with lower uptake of measles immunization services (284, 285). The high level of employment in the D group would explain part of the higher percentage of the inhabitants of Sun Country than those in Prairie North to utilize immunization services for communicable disease prevention.

5.4.2 Urban-rural context: the reverse difference

The trend of events in the rural and the urban geographical locations showed that the rural area has higher immunization coverage rates for both age group cohorts studied (figure 4-5). However, analysis of the measles immunization coverage rates between urban and rural areas across the ten individual health regions showed that this observation is not necessarily true for only Cypress RHA in the on-time for first measles antigen-containing vaccine at one-year dose. Cypress RHA had a higher immunization coverage in urban compared to rural locations. While this observation in Cypress RHA cannot be fully explained, the higher immunization coverage in rural compared to urban areas can be justified by several reasons/factors linked to the fact that the rural locations are more reliant on smaller clinics as public health facilities for the provision of health care and immunization services.(286) The 2013 Saskatoon RHA annual report also noted that rates in the rural locations were higher than in the urban locations.(287)

The use of public health facilities that are located in bigger buildings could be a challenge in the bigger cities especially because some potential clients could have difficulties locating the

public health unit where a building houses more than one public service unit. The research found out that the transient populations are more difficult to track in the urban than in the rural locations. There are also some categories of people in the urban locations that are not very conversant with navigating the public health system, for example, the new immigrants. Therefore, the research identified that more efforts have to be put into targeted strategies to bring immunization to transient populations and the new immigrants. Vaccine refusal on philosophical grounds has also been identified as being more common in urban locations than in the past. This does not preclude the presence of vaccine hesitancy in the rural areas, but the RHAs have had to deal with that factor more in the urban locations. All these factors contribute to lower uptake and hence lower coverage for measles immunization. The health regions are addressing the hesitancy issues by locating where it is happening, in what category of people and developing context-specific measures to deal with the situation. The media has also been identified as having a major role to play in this awareness campaign, as has a higher level of support from the Ministry of Health in supporting advertising at a provincial level.

Slifkin et al., (1997) (286) also found measles immunization coverage to be higher in rural locations than urban locations in 11 States in the United States. Another study in the United Kingdom found that a decline in MMR coverage was associated with a dense population which is characteristic of urban locations (288). This study also showed a correlation with the presence of inner cities where deprivation is a factor that affects coverage rates. A similar pattern was found in a study in Australia (289). It is to be noted that in contradistinction to the finding in this research that coverage rates were higher in the NOT CITY locations (rural locations) than in the urban locations, some studies have found the reverse of this observation in other parts of the world (290, 291). There was a higher coverage in the urban than in the rural locations in parts of Asia (291) and Africa (292). This reverse difference may point to the fact that the factors responsible for the differences are completely different in the developed and developing parts of the world. While health systems and low resources may be the primary drivers in developing countries, hesitancy and the socio-economic divide are more important drivers in the developed world, and this is true for Saskatchewan, a Canadian province as discussed earlier.

5.5 Progress in measles vaccination in the province

5.5.1 Closing equality gaps

For Peer Group A, there was a progressive narrowing in the differences in immunization coverages between the urban and rural locations for both age cohorts studied and from 2002 – 2013. Comparing Peer Groups D and H for measles immunization coverage for on-time for doses 1 and 2, there was a general narrowing of coverage differences between urban and rural locations between 2002 and 2008, whereas between 2008 and 2013, there was a general divergence in the immunization coverage rates. It was observed that even though the coverage rates were higher in the rural locations, the rate of change was lower than in the rural locations as reflected in the AAPC figures (table 4-3). This finding implies that more people are taking up measles immunization in the urban locations which may not be unconnected with innovative interventions to drive up coverage figures in the urban locations while not relenting on the on-going efforts in the rural locations as well.

In recent times, there had been more caregivers asking to know more about measles immunization and the public health programs in some health regions in Saskatchewan have responded by improving the capacity of their public health nurses to meet and surpass the confidence reposed in them. The study confirms high confidence in the ability of health care providers to communicate effectively as well as the knowledge of immunization requirements, policy and the demographic contexts of implementation. There is collaboration and training to other health workers in the health region as well so that wherever the caregivers get to, there was always the right information to enable them to make informed decisions regarding measles vaccination. While more efforts are required to reach immunization capacity across the regions, the research identifies continuing education, the regular conversation about the current challenges and collaboration with other health workers as a key factor towards addressing low uptake of measles immunization in urban locations in Saskatchewan.

Despite the fact that there were no rigorous studies carried out province-wide in Saskatchewan yet to point out reasons why coverage rates were better in the rural locations, some of the innovative efforts that came out clearly from the qualitative interviews conducted gave a pointer to the fact that access which was found to be a challenge in the inner-city neighborhoods was addressed using the community program builders. This effort is part of the

myriad efforts to improve coverage in urban locations. This finding agrees with the Saskatoon Health Region Report on the State of Immunization (287).

5.5.2 Socio-economic deprivation and the role of incentivization

In Saskatchewan, different sociao-economic factors grouped under deprivation quintiles have set a significant difference in the measles immunization coverage rates in both individual health regions and grouped health regions peers. For on-time for first dose, as seen in tables 4-9, and 4-10, Regina, Saskatoon, Cypress, Five Hills, Sunrise, Prairie North, Heartland, Sun Country, and Prince Albert Parkland had statistically significant differences in the effect of the deprivation quintiles on immunization coverage rates. This observation in the individual health regions was also true for peer group comparisons. There was a statistically significant difference between measles immunization coverage rates in all the deprivation quintiles between peer groups A, D, and H.

For on-time for measles second dose, as seen in table 4-15, all the health regions and peer groups had statistically significant differences on the effect of the deprivation quintiles on measles immunization coverage rates. Deprivation quintiles in all these health regions and peer groups are grouped into DEP Q1, Q2, Q3, Q4, and Q5; where Q1 is the least deprived group and Q5 is the most deprived quintile. Comparing the least (Q1) and the most (Q5) deprived quintiles showed statistically significant differences across all these health regions. Deprivation quintiles are determined by deprivation indices which are inclusive of both social and material (economic) factors (3, 293). The social factors include the proportion of individuals living alone, single marital status, and single-parent families. The material factors include income, education, and employment. The least (Q1) deprived quintile belongs to a high social-economic class and the most deprived quintile belongs to a low social-economic class (3) The level of deprivation of these quintiles increases from Q1 towards Q5 with a subsequent relational decline in measles immunization coverage rates in them. As such, the above observed statistical differences in the coverage rates in the health regions and peer groups were because of the big differences between the different deprivation quintiles.

The AAPC in measles immunization coverage rates were positively different across all the peer groups for on-time for doses one and two for both Q1 and Q5. However, these differences were not statistically significant for only peer groups D (Q5) and H (Q1) for on-time

for dose one (table 4-4). Even though the absolute coverage rates were higher for S-EDQ1 than the S-EDQ5, however, the AAPC was generally higher for S-EDQ5 than S-EDQ1 for all the peer groups and all the participating health regions. The improved coverage among the S-EDQ5 than S-EDQ1 is a positive finding in terms of reduction in disparity in immunization uptake in Saskatchewan. There were examples of efforts to bridge the gap in measles immunization uptake among the low socio-economic groups some of which are incentivization and taxi vouchers or transportation to public health facilities, where some families struggle to cope with other determinants of health. A careful study of health providers' clientele also reveals the challenges of the inner-city population and the special approach required to get them to immunization, include the importance of linking them to available public social safety programs, resources, and support groups. Brealey et al., (2013) and Marmot, et al., (2008) argue that equity in immunization will require reaching the underserved population which will involve special programming efforts, research, and development for their needs to be met (294, 295). Cocker-Buque et al. (2002) also emphasized the use of locally designed interventions as being effective in reducing disparities.(296) In Saskatchewan, interventions to reduce disparities have been specially designed, locally contextualized as evidenced by the participants responses and insights given. However, greater involvement of the government in the form of improved financing of the health sector would turn things around and increase the gains derivable from these efforts.

Despite the variations in the effect of the socio-economic factors on the measles immunization coverage rates in various parts of Saskatchewan, evidence shows that efforts are in place to narrow the relative gap of inequality in some regions as well as nationally and internationally. At the provincial level (Saskatchewan, Canada) this evidence is observed in figures 4-10 and 4-11. In eight out of the ten participating health regions, there was an increase in measles immunization coverage with a subsequent reduction in relative inequality gap. In the remaining two health regions, there was an improvement in coverage comparing 2002 and 2013 like in the other eight, but the size of the inequality gap between S-EDQ1 and S-EDQ5 was unchanged or increased. This improvement can reliably be attributed to the existing measles immunization enablers identified in this research. The enablers that emerged from the interaction with the key informants were categorized into four themes; socio-economic divide reduction, engaging communication, flexibility and dynamism, and media use.

5.5.3 Enablers of measles vaccination at individual scale

Across all these themes were the individual measles vaccination enablers which almost every key informant at each health region considered important. Enablers that were frequently mentioned were communication, health-workers collaboration, flexibility and dynamism, multiple sites, having a media source, availability of information tracking and evaluation, and community program involvement. These enablers are discussed in detail below.

5.5.3.1 Effective communication

Effective and engaging communication has been advanced as an important condition to improving the uptake of measles vaccination in this time of complacency and apathy towards immunization services. Communication was elicited at three levels, at the caregiver and provider level, the provider-provider level within the public health institution and at the level of immunization provider and other health workers outside of the public health institution. The reminder call or mail system and information giving as well as addressing questions from caregivers happens at the caregiver – provider level, while health worker to health worker communication involves communications within the public health unit and also with other health workers outside the health unit who would be involved in information dissemination. The importance of engaging communication has been emphasized by WHO (297) and also other studies (298). Communication has also been found in a review of published reviews to be a useful tool to address uptake, especially on-time uptake of vaccination where reminder and client recall systems were found to be good drivers of immunization uptake (299). Although the review failed to show evidence that such communication helped vaccine-hesitant caregivers.

5.5.3.2 Health-workers collaboration

Collaboration among the various health workers was seen in Saskatchewan as another enabler that was instrumental in contributing to measles vaccination uptake. This collaboration was extended beyond the immediate public health facility and to other primary health care settings and family physicians as evidenced in the interview results. The form of collaboration in this instance included that the family physician could help with reminder opportunities when their patients are consulting them. They could do that with as simple a question as *…is your immunization up to date?*

The inclusion of immunization data in the e-Health viewer also helps physicians look up the immunization status of their patients so they can target their questions to those who are behind. However, this capability is not being used optimally so far, and family physicians and other doctors need to be encouraged to use this routinely. Also, increasing the number of health care staff that are providing immunization could help improve coverage rates, as long as good data capture occurs so people don't have more vaccine errors. This form of collaboration helps to address health system issues (300) Even though collaboration among the health workers have been discussed by the participants as an enabler, collaboration should be encouraged to be extended beyond the health sector to the level of inter-sectoral collaboration which has been found to be very key in reducing health disparities.(301) Daycare centers will be one of those places to which such collaboration should be extended. It is happening in some health regions already, but it would be more effective if the scope was expanded.

5.5.3.3 Flexibility and dynamism

Flexibility and dynamism have been introduced in the delivery of measles and other immunization services in the public health system to reduce disparity. This combined with having multiple sites is one of the ways to ensure that everybody has unhindered access to the publicly available immunizations in Saskatchewan including measles immunization. These factors which increase access and availability have been found to be a great enabler for the uptake of measles immunization (296) especially for those who because of the nature of their jobs could not access immunization during the regular opening hours of public health clinics.

5.5.3.4 Having multiple sites for vaccination

Having multiple sites for vaccination purposes is about increasing and servicing more sites to ensure that irrespective of where caregivers or potential immunization beneficiaries reside, there is an available site to get immunized. In the face of limited resources, multiple sites may be a challenge to staff on a regular basis. Saskatoon has increased the number of sites, but not all of them are open every day due to the increased cost and the possibility that they would not all be busy enough if they were open every day.

5.5.3.5 Media sources

The availability of media sources and use has been found to be a good facilitator of measles immunization awareness campaigns and public education. The media sources in Saskatchewan include television, radio and newspaper outlets. While some health regions have access to both TV and radio stations, the services from these were not regularly available in some health regions while some had local access to only a radio station. In all the media outlets, health regions needed to pay for their news to be aired. As a way to mitigate this, requests can be made to be interviewed during immunization catch up campaigns or at the start of a new season by sending out a media release and then booking interviews if there is interest. Also, using social media can be a way to get free media coverage. Much as these media outlets have been found by the participants as valued enablers, the available resources in the health region could be a challenge to their utilization especially with the growing importance of social media. The news media is an indispensable source of information, especially health information (302). They can be employed to create awareness for immunization and promote vaccine importance as well as raise concerns about safety issues (303). While the media can promote vaccine uptake, it could also fan the embers of hesitancy and anti-vaccination as evidenced in the negative impact of a newspaper called South Wales Evening Post on MMR uptake (304). In the case of Saskatchewan, no health region reported any negative journalism in measles vaccination during the interview. Be that as it may, the potential for negative journalism exists and effective collaboration for accurate information reporting has opportunities to continually impact measles vaccination (e.g. MMR and MMRV) positively.

5.5.3.6 Information tracking and evaluation

Availability of information tracking and evaluation is seen as a very useful enabler by some of the participants, but not all health regions are adequately staffed to be able to provide that service hence the over-reliance on the Ministry of Health to supply periodic coverage figures. The opportunity to ameliorate this challenge has come with the creation of a single health authority for the province; which could allow the shared resources of epidemiologists and other staff of the Public Health Observatory to give immunization providers across the province a similar set of information as Saskatoon RHA has been getting.

5.5.3.7 Community program involvement

Participation in community programs has also been found to be a strength in improving immunization uptake. This can be that health workers interact directly with community members by attending community organized programs and events or having community members be a part of the public health team. Community members integrated as part of the public health team has been used in Saskatoon Health Region with demonstrable success. Community program builders help to build linkages with the community members and work by collaborating with the marginalized community members (287). Being a part of community programs enabled the participating public health nurses an opportunity to interact with care givers, opinion leaders and stakeholders to kick-start measles immunization communication and be able to respond to some of the deep questions outside of the health care facility. Some RHAs used the 'ask approach' to provide information to caregivers in a way that you might get more positive resolve. This approach has been found to help to address communities' challenges around hesitancy where it exists.

5.5.3.8 Incentive Provision

Although the subtheme of incentives provision was less reported to qualify to be among the most important enablers, the participants who discussed the factor put a lot of emphasis on its relevance in reducing the challenge of some groups of clients because of the effects of the social determinants of health. The available report on vaccine uptake inequality reduction interventions indicates that it is very vital to the reduction of disparity and improving uptake (296). The impact of the social determinants of health and inequalities it causes is well documented in literature and vaccines are not spared (305).

5.6 Observable issues in current immunization trends

At the international level, the United Nations has advocated for policy responses to target social determinants of health aimed at reducing health inequity (62). Canada had put in place reforms dating back to the time of Lalonde (306). These reforms consisted of the Ottawa Charter gathering for health promotion (307) which detailed the interrelationships between social determinants of health, a fallout of which Jake Epp in 1986 expanded on to provide the health promotion framework (208).

To advance these efforts, the federal, provincial and territorial Ministers of Health reached agreement in a report entitled Strategies for Population Health: Investing in the Health of Canadians to provide yet a more robust framework to guide policy development to address social determinants of health and by extension health disparities. All these efforts culminated in the 2003 Accord (71) which positions Canada's health sector as a leader in the annals of reduction of health disparities through myriads of health strategies implementation and monitoring, evaluation and modification. The pronouncements exist at the higher level, bringing it to bear at the small area geographies is important.

In spite of the existing facilitators and enablers to measles immunization uptake in Saskatchewan, more involvement is needed to overcome the identified barriers. Understanding the involvement needed at the local health region level is key to tackling the measles immunization challenge in Saskatchewan and Canada as a whole.

5.6.1 Equitable measles immunization coverage rates

Efforts at improving equity in measles immunization coverage rates in Saskatchewan is a dominant finding of the research and is closely linked to access as a determinant of coverage rate. Progress in measles immunization rates, and consequently, reducing the rate of missed opportunity, must consider the contextual realities of the various demographics including the aspects of Indigenousness, immigration status, socio-economic issues, and locational characteristics. Findings show that the use of after-hours clinics, clinics in daycares, door-to-door immunization service and satellite or rural clinic availability are helping to increase access, especially among populations and groups who have exibited hesitancy to measles immunization. These context-specific approaches include an understanding of the attitudes and perceptions of measles immunization uptake among parents in such populations, creating effective measles immunization strategies, and engaging the leaders in those groups.

Rural and urban measles immunization disparity in the context of the reverse difference has been discussed; however, the observation that herd immunity has not been achieved in both groups shows that more effort that align with and are sensitive to locational characteristics should be part of the equitable access discourse in immunization literature. This is equally linked to data availability, accessibility, and usability, particularly to track coverage efficiency and manage lags in program implementation. Currently, the quarterly Ministry of Health average

coverage rates releases do not indicate the level of coverage within different geographical quintiles and locations of the health region, thus flagging the need for epidemidiologists to work with other health professionals to develop tracking tools that can facilitate data exploration beyond population level statistics to a more granular level that captures equity variables in different parts of the respective health regions.

5.6.2 Staff effectiveness and best practices guideline

The importance of public awareness and engagement has been discussed, so also is the need for more human resources in rural areas. The reported shortage of resources could be an indirect factor affecting the staffing levels at different health regions where it is indicated. While more education will be helpful to parents and guardians of minors to better understand the relevance of immunization after measles had been uncommon in their midst, it must be the role of the health workers, which has been described as inadequate, to create widespread measles vaccine knowledge for an increasing demand for vaccine uptake. A gap in the data is also the non-availability of good practice guidance in the area of vaccine penetration strategies that health care providers can rely on to enhance equitable measles immunization coverage rates in the province. Part of such guidelines would examine health worker**:**population ratios in various contexts (i.e. rural-urban and needs-based) and communication, implementation, monitoring, and evaluation, with an overall architecture for continuous improvement towards achieving herd immunity threshold.

5.7 Impact of the research on future coverage reporting and use of data

This research is the first to cover a wider geographical area of the province of Saskatchewan and the first set of data pulled out at the interphase of SIMS and Panorama data management. Findings from this research may hence be useful as a baseline for future research on measles immunization uptake in Saskatchewan and as a pilot for assessing the level of coverage for other communicable and vaccine-preventable diseases in the province.

5.8 Population Health, Policy, and Practice Implications

5.8.1 Research Significance and Contributions to Population Health

There is a great potential that this research could improve practical application for measles uptake strategies as it brought together different perspectives to address the low coverage issues. It offers added knowledge on high-yield interventions to improve immunization uptake in low-coverage areas. The assumption is that more information in the factors determining higher coverage strategies may lead to possible vaccine uptake decisions among the populations that are behind in their immunizations and ultimately reduce inequality. It was evident from this research that the province of Saskatchewan is yet to meet the herd immunity threshold for measles necessary to prevent the spread of an outbreak.

Revisiting the conceptual framework, the Health Behavior Framework (figure 3-1) and the theories discussed in this document helped in the development and the implementation of the research journey. The health behavior framework used in this research (pg 39) was a modified and adapted version from the original works of Bastani and colleagues. The original framework as presented by the scholars (206) was very encompassing and a handy tool that provided a guiding map in this study, however, it required modification and adaptation to the contexts of Saskatchewan. Distrust of the system and assimilation are important factors in Saskatchewan as well as the Canadian context that needed to be considered in the study of measles immunization barriers. These variables which were not part of the original framework were incorporated into the final framework used by the author of this study.

The modified HBF identified knowledge as an important individual variable in the decision for measles immunization uptake. It was apparent in this study that knowledge played a key role in a caregiver's acceptance of measles vaccination. Having adequate knowledge about the measles vaccines can help influence individual perception about its usefulness and safety (171). Interaction with the participants of this research elicited the various ways by which the healthcare providers make the concrete and accurate information available to the population, including the use of community engagements for information dissemination. The framework identifies social norms, advocacy, and community capacity building and engagement to deliver the right information. These enabling environment factors were also discussed by the key informants as elicited by the interview instruments.

Further, on this research experience, the importance of public health staff capacity building was emphasized. This was cited as necessary for clients of measles immunization to repose confidence in the providers. It also enables the staff to be more confident with up to date knowledge to face the current challenges of vaccine hesitancy and in some cases, vaccine refusals. However, the staff capacity building content is currently developed at the level of individual health regions, inclusion of national and international best practices is envisaged to be easier if the province can leverage on the existence of the one health authority to develop the training modules centrally. Also operating at the individual variables level were the social determinants of health. The SDoH were found to have important influence on measles immunization uptake. In this framework, the SDoH factors can be clustered under barriers and supports. The framework could hence be enhanced by listing some of the important SDoH that are notable influencers for measles immunization uptake.

The effects of structural factors influencing measles immunization uptake emerged in the study. Some of these factors were related to accessibility and built environment. The structural factors in the framework operated at two different levels, at the health provider level as well as at a higher level of influence for vaccine intentions, initiation, and completion. The location of the factors enabled a broad-based and holistic opportunity to elicit all the structural factors that influence measles coverage rates. These factors were addressed with universal and targeted approaches where flexibility and dynamism as well as institution locational arrangements are universal approaches and incentive provision, a targeted approach. These two approaches can be used for their complimentary benefits (298).

The framework also provided an opportunity to elicit and understand the factors that operate at organizational domains of influence, some of which are health policy environment, demographic factors, healthcare coverage and benefits. Healthcare benefit as an influencing factor of measles immunization does not apply in the case of Saskatchewan. This is because measles immunization is provided free province-wide in Saskatchewan.

Canada receives a high number of immigrants and refugees. Some of these group of new Canadians come with their inherent values and cultures regarding immunization uptake. Without proper orientation in place, some of these group of people find navigating the health system challenging (308). An integrated primary health care has been used in some settings to address such challenges of timely access to health related services (309), although this practice is

province specific. While a similar approach is currently operational in Saskatoon and Regina, it is yet to take effect in the smaller communities of the province. The country needs to harmonize the orientation and linkage to public services for such groups and communities.

Database disconnect was prominently discussed by participants. Before the advent of the use of the data management system called Panorama in the province of Saskatchewan, there was no connection between individual health regions in terms of access to immunization data. This non-communication of RHA data registries has been solved with Panorama. Among the First Nations communities, however, database non-harmonization is still a challenge because the First Nations communities who live on-reserve use the federal system and are vaccinated by the federal system while the recording take place in the federal system. Saskatchewan provincial data has no communication with the federal data. Even though vaccination is also open to the First Nations members while in the province, the recording of such services is only documented in the provincial database. Because of their movement between the two jurisdictions, it becomes challenging to capture their data accurately with an attendant impact on the coverage figures of the province. The Canadian government should work towards a harmonized national registry for immunization data to ensure a more accurate reporting of national immunization coverages.

Looking back on the research journey, I can conclude that the mixed methods provided an overall useful and unique way to answer the closely linked yet distinct research questions of this study. The analysis of the quantitative data presented different patterns of change in measles coverages within and between the participating health regions in the province of Saskatchewan. It also showed that there were unequal coverage and uptake among the different socio-economic groups as well as a clear urban-rural difference. These distribution patterns and differences in the different groups, communities and small geographies could only be understood further by the interaction the researcher had with the providers of the immunization service, hence the need for the qualitative portion of the research. It has been argued that mixed methods research contributes to a better understanding of complex social phenomena by utilizing multiple ways of knowing (218). Without using the lenses of the health care providers, it would have been a difficult task to understand and contextualize the relevant factors at play that also have direct or indirect influence on achieving the herd immunity threshold for measles prevention. Finally, it would also have been daunting to identify the best approaches to tackle the impeding factors to improved coverage as well as the enablers that have proved useful in the various contexts.

5.8.2 Programmatic implications/Guidance for Practice

There is increased awareness, and enriched knowledge on progress in terms of measles immunization coverage in the province and the results obtained could help determine the level of inequality in immunization coverage using measles vaccination as a proxy while pointing programmers in the right direction for reducing other strategic programming gaps in Saskatchewan. Frequent data updates are also needed to guide program delivery and evaluate effectiveness at a more granular level. The quarterly or annual data at a broad geographic level as it is currently done is only useful to give a general picture, but these are not actionable and may not encourage regular progress.

The temporal factors associated with immunization uptake that is uncovered will provide vital information for collaboration, policy, and program improvement with ultimately improved measles immunization delivery efficiency in the province towards reducing coverage challenges. The study results and outcome may assist in building a framework or providing a platform and opportunities to update existing frameworks for health promotion action in Saskatchewan and influence other provinces in Canada. Going forward, the study highlights the need for a more cohesive stakeholder engagement towards improved health action in the province, with measles immunization serving as a pivot for improved uptake of other antigens towards a reduction in immunization-preventable morbidity and mortality.

In the most recent World Health Organization's ten global health threats identified for 2019, numbers 7 and 8 respectively are weak primary health care and vaccine hesitancy. Routine immunization and a functional primary health care system are intertwined, pointing to the need for a more coordinated approach to vaccination and overall reduction in missed opportunities as much as possible. When the primary health system is weak, those functions of meeting up with adequate coverage of the population for vaccine-preventable diseases becomes a challenge. This could only be made worse in the face of vaccine hesitancy and especially to vaccines like MMR and MMRV. Therefore, government and policymakers need to be more proactive to improve primary health care delivery for it to perform its role adequately.

In context, coverage figures are used to track achievement towards disease elimination; these figures, however, do not usually tell the complete story and its ramifications. Thus, inputs from health providers and researchers have proven to yield better insights. Efforts are on, commitments are high, but challenges are different and myriad, even though there are some

similarities in contiguous RHAs. The use of coverage figures needs to be complemented with some level of disaggregation to see coverage in various groups and strata, geographical locations, and socio-economic quintiles of deprivation similar to what this research attempted to do.

Adapting the research from 10 RHAs to one RHA could be a challenge; however, with some level of understanding of the most up to date administrative structure, results can be retro-fitted for adaptation. The research has been conducted at the level of RHAs, and where the communities that made up the RHAs remained as they were originally, its adaptation is feasible.

Elementary school checks could be used to identify and correct the missing immunity at school entry. This would be used as a catch-up phase depending on if the province put a standing policy in place to ensure it happens. This effort will require the cooperation of the provincial government and school boards, the teachers, social workers, parents, and caregivers.

The eHealth in Saskatchewan also captures data on the 7-year old population, and that could also be a point where we get to know what the position of immunity is, even though checking at that point is a delayed measure, but it could assure the program planners and implementers of the state of immunization coverage and hence protection from vaccine-preventable diseases.

5.8.3 Implications for Research

Since the province migrated from the Saskatchewan Immunization Management System (SIMS) to Panorama Public Health Information gateway in February 2015 for management of immunization data, this study may well be the first to conduct a comprehensive analysis of immunization coverage on the platform interphase. Apart from informing the province on progress in terms of immunization coverage and what the trend had been, it may be useful as a baseline for future reference to measure immunization coverage progress. Overall, the research contributes new conceptual and analytical insights to the international scholarship on health equity and measles vaccines and immunization policy.

5.9 Study Strengths

The study utilized the total sample of the covered population of the 1-year old and 2-year-old populations from 2002 – 2013 in the quantitative analysis hence giving a complete picture of the coverage for the antigen under study. For the qualitative data, the study included the

perspectives and views of the key personnel in charge of primary health care and preventive services including immunization for children and had a reasonably high (75%) participation rate from the proposed interview participants. The consent from the particpants for the interviews were both in written form and repeated with a verbal consent just before the actual interviews.

The province is yet to meet the threshold for measles immunization for the on-time for measles vaccination as a result of some of the barriers identified. It is not unlikely that this trend affects other vaccine-preventable communicable diseases as well. This study hence could be a pivot to carry an in-depth study on the other vaccines in order to assess the performance of the province in meeting national immunization coverage goals with an equity lens.

5.10 Study Limitations

The study commenced when the province operated through 12 RHAs plus the Athabasca Health Authority. While the study was still underway, the province commenced with the consolidation of all its health regions into one Saskatchewan Health Authority (SHA). However, while the consolidation had taken place, and administration pulled into a central place, the primary health care delivery operations remained with the previous health regions, and the land demarcation and the previous cities, towns, and villages that made up the previous health regions remained the same. The potential impact the study would have will most probably remain reasonably unaffected by this organizational change. However, in terms of programmatic implications, the study has to be adapted to fit into the current nomenclatures. Consolidation brought to bear; the challenge had to do with making the study relevant in terms of dissemination of information from the study to an audience of a different constellation.

Secondly, while the research went on, there were a few changes such as retirements among the interview respondents, which made the second set of interview participants incomplete. However, a representative number of interview respondents were available to respond to interview questions in each of the RHAs. Moreover, also, where retirement took place, a replacement was available to complete the interviews. The effect of retirement was minimized because the second phase of the interviews was done with health region participants interviewed together as a team of health region key informants.

Ethics approval turn-around time was problematic. The ethics application took the researcher 362 days to be fully received from all the participating institutions and participants. This was because every health region operated as a separate autonomous entity and the

researcher needed to get ethics approval from all of the participating health regions, each with varying ethics approval processes and procedures in place as well as from the University of Saskatchewan as the institution where the researcher was housed. If this research were to have been started after the province collapsed to one health authority, this would have saved much time on ethics approval and documentation, and hence gained more time for other research processes and procedures. Also, in some instances, it took a long time to get appointments for the interviews in both the first and second phases of the qualitative data collection. Travel time could have been an issue, especially if the study were done in some seasons of the year, especially in the peak of winter. This was not a problem in this research as the first phase of the interviewing that took place during the fall period was by telephone.

In this research, we have looked at enablers and barriers for uptake of immunization, coverage disparities and inequity issues in uptake from the extensive literature search, healthcare providers' perspective and through the various levels of analysis. What we have not done is to look at the consumer/caregiver perspective. It should be noted that whatever the providers may have said, identified or responded to, either for barriers or strengths to inform the next steps healthcare providers would want to take, it could either be from what the caregivers or measles immunization program clients have told them, what they have studied, from their own experience or just assumptions that have been made by them. However, it is envisaged that the output of this research would shape policy and planning.

This was the first time eHealth through the agreement of the participating health regions shared immunization data with a graduate student; hence, data abstraction syntax was generated to ensure the de-identification of the data. However, this limited the extent of the research questions this study could have answered as the data utilized in the analysis was de-identified low-level aggregate data. The study had looked at the on-time for measles doses coverage in the two cohorts that receive measles vaccination used as a proxy for the level of immunity conferred as well as a proportion of the herd immunity threshold. The proportion of the province of Saskatchewan under 2-year olds who were on-time for measles immunization was established in this research. However, to what extent the delay was could not assessed as the data did not permit that; hence the effect of this delay on other immunization schedules could not be determined.

The data utilized contained an unclassified group regarding the area of geographical location and S-EDQ participants belonged to, hence some level of misclassification could exist as a result. The S-EDQ data contained about 10% unclassified data while the geographical location data contained about 3% unclassified data. The researcher is not sure what the implication of this limitation could be as the distribution of these individuals is not known. However, because of the way the data was abstracted, the researcher could not carry out any cleaning procedures. The data management unit of the health regional authority should put effort into data cleaning to resolve this issue for future research.

5.11 Study Delimitations

The researcher was set to understand the barriers and enablers of measles immunization uptake from the perspective of the direct providers of measles antigen-containing vaccination in the province of Saskatchewan. Information seeking through interviews were limited to the key informants selected based on their level of closeness to the management of immunization and program development, Saskatchewan and NACI immunization policy interpretation, vaccine administration, implementation and evaluation of immunization activities. These groups of key informants were the MHOs and the Immunization coordinators and/or front-line immunization providers in the participating regional health authorities. The research limited its scope to those key informants not because it was not important to understand from the perspective of the caregivers and other users of measles immunization, but for time limitation, this was not done. It also would have been useful to interview eHealth staff on data management and the Manager of the central cold chain store where vaccines are received for distribution purposes, but the research scope could not do that within the ambit of time available to the student researcher.

The eHealth released three-age cohort (on-time for measles vaccination dose at age 1-year, 2-year and 7-year) data, as were available on the data management platform and in response to the data abstraction syntax generated by the researcher. However, the research team limited the analysis and reporting of the research to the first two age groups (1-year and 2-years) which were the ages of the first dose and second dose of MMR and MMRV according to the schedule of immunization for the province of Saskatchewan (table 2-2 in section 2.5.12)

There was also the availability of data on all the five deprivation quintiles (S-EDQ 1, 2, 3, 4 and 5), while effort was made to see what happened among the other S-EDQs, most concentration of the analysis and comparison of deprivation was done for S-EDQ 1 and 5 which

were the least deprived and the most deprived quintiles respectively. The analysis was done to understand and report whether there was inequality between those two groups and if there were, whether the degree of inequality that existed between those selected two groups changed over the period of study and how it changed (was it that of an increase or a reduction).

5.12 Generalizability and Transferability

This refers to the extent to which the findings of the research enquiry and results are applicable outside the context and the specifics of the situation under which it was studied (310, 311). This research took place in Saskatchewan with data which was a total population of children under 24 months old in the 10 participating health regions. The population of the ten health regions that participated in the research makes up about 97% of the total population of the province. The remaining three jurisdictions in the north of Saskatchewan did not participate, Even though a substantially larger proportion of the province of Saskatchewan has been studied, the results may not be generalizable as two regional health authorities (Mamawetan Churchill River and Keewatin Yathé) and Athabasca Health Authority did not participate in the study. The context, circumstances, and conditions of these three jurisdictions may not make the results and the conclusions drawn applicable to them. Also, the quantitative portion of the data utilized data from 2002 – 2013, the characteristics of the immunization uptake could have changed in recent times hence a more recent data may be needed to determine if any changes are found.

The researcher made effort to provide a rich and deep description of the research process. The researcher ensured that the voice of the interview participants and clear detailing of their perceptions was done in the study. This was done to enable readers to make own possible transferability decisions to other settings with due considerations of their contexts and characteristics.

5.13 Recommendations

The examination of measles immunization uptake and on-time coverage is fundamentally important to gauge the feasibility and potential for measles outbreaks. It is also important to note that surveillance platforms are vital to monitoring the trends of coverage in all jurisdictions. Elimination of a vaccine-preventable disease exists in a dynamism, and it can be achieved as well as lost if the coverage rate goes too low and population immunity is compromised (124). Canada currently has measles elimination status as it had had no endemic measles transmission

since 1998. The country should, however, strive to maintain that status by keeping levels of coverage high enough at all times and this effort will be a contribution of the independent program efficiencies in all the provinces and territories.

Reminder systems in the form of a reminder call and mail in program is a great innovation, and it works incredibly well. In complementing the effect of the reminder calls and mail-in programs, some health regions have started the use of text or short message system (SMS) as a form of reminder system. The reminder call is automated in some health regions while it is by human communication in others. It will be more effective and require less staff time if it can be automated across the whole province. However, some health regions have expressed a desire to be able to call in-person sometimes especially if potential clients have questions and clarifications, hence combining the automation with the human interface should be pilot-tested.

While there was concern on the inability to use the SMS/text messaging system for reminders because of privacy regulations especially when the regional health authorities operated as different autonomous entities; it is recommended that the Saskatchewan health authority being one entity explore the use of SMS/text messaging as one of the ways to reach the audience, especially because of clients who are on SMS contracts.

5.13.1 One Health Authority advantage

The amalgamation of the previous regional health regions to one health authority, Saskatchewan Health Authority (https://www.saskhealthauthority.ca/) is a significant development; it abolishes the bureaucracies of data access as there is harmonization of the available client information at all public health units and to its workers through the Panorama info gateway managed by eHealth Saskatchewan. The Panorama gateway platform shortens client wait time and also improves monitoring of vaccine supply and utilization. It will be desirable, however, to have access to Panorama every time of the day, especially when public health unit's flexibility allows evening clinics to take place for clients' improved access to immunization services. The one health authority also has greater possibility of faster adoption of best practices across the province.

5.13.2 Immunization Coordinator/Provider Education

The public health and immunization providers play a key role in population, community, and individual parent's decision-making for uptake of measles immunization services. By training, knowledge and experience, they are the source of factual information as regard to vaccines and immunizations. Their role is central to planning, promoting, implementing and evaluating immunization services. This role promises to improve public trust, improved user-focused program planning with eventual user satisfaction. The providers need to be kept abreast with the most updated information on the best practices in the current world of public health. The research found out that the previous health regions were autonomous in the way things were done. However, while the old RHAs operated, participants had the opportunity to attend seminars on best practices, which ceased after some time. The new one Saskatchewan health authority had ushered in a new way of doing things. Bringing back such a laudable program of continuing education for immunization providers will go a long way to making new concepts and best practices available for them to tap into while contextualization takes place in their respective jurisdictions.

5.13.3 Community Engagement with Education

Public health should have periodic educational interventions and engaging communications with parents and caregivers on the efficacy of measles vaccination and the low level of adverse events risk. These educational communications should be extended to day-care centers and to upcoming mothers where feasible. Also, that measles antigen vaccine can be administered with mumps and rubella in MMR or with mumps, rubella, and varicella in MMRV and that the risk of combo administration is not higher than could potentially result from any one of the three or four antigens. Providing educational information in as many common languages as are available will be the best, however focus can be placed on the languages spoken by a large cluster of community inhabitants

5.13.4 Is Legislation an option?

Some countries and governments have advocated legislation to help improve coverage while reducing refusals based on flimsy philosophical reasons and on some religious grounds (312). However, only medical exceptions are entertained for example in California after the measles

outbreak in Disneyland. They are joining Mississippi and West Virginia in the United States as major States putting this legislation in place. In Korea, measles vaccination certificates have been required for registration in elementary school to drive the rate of uptake of measles vaccination up (313). Some other countries are in the process of passing a law in that regard. Davies, et al., (1982) made a recommendation in the paper titled "Canada needs a compulsory measles vaccination program" (314). Presently, only Manitoba and Ontario require evidence of measles vaccination before entry to elementary school in Canada. However, the impact of this effort has not been convincing and the implications of the introduction of it in Saskatchewan needs to be carefully studied.

5.14 Summary of Discussion and Recommendations

This chapter provided insights into the trends in the Saskatchewan measles immunization coverage between over a 12-year period. The study highlighted the relationship of socio-economic deprivation and geographical locations of residence on coverage and the impact on the vaccine uptake. Some of the underlying cultural and contextual factors influencing measles immunization delivery and uptake were elicited and discussed. The on-going efforts to mitigate and reduce inequity in the province as well as at the granular levels for measles vaccine uptake was discussed. While efforts was made to discuss the universal approaches to improve uptake, targeted approaches to mitigate social determinants of health and to increase community engagement and communications to address the issue of hesitancy and anti-vaccination movements were also discussed.

The chapter also touched on research participants perspectives on the future of measles immunization delivery and the role expected of the provincial authorities. A review of the strengths, limitations as well as the delimitation was done. The chapter concluded by assessing the generalizability and transferability of the of the research findings, an option on legalization and implications for population health and practice as well as the research significance.

5.15 Conclusions

Health Services policies, with a great emphasis on how the implementation is carried out, can bring about either an increase or reduction in health disparities. The interventions deployed in the province of Saskatchewan in the various health regions (now Saskatchewan Health Authority) to improve uptake and the attendant impact on the coverage rate has yielded

improvement progressively over the period under study. For children vaccinated in public health clinics, the proportion with on-time vaccine uptake increased from 2002 to 2013. While only 61.72% (n=8,188) of the 12 – 14 months old were on-time for Measles Vaccine in 2002, this increased to 70.35% (n=9,957) in 2013. In like manner, 56.32 percent (n=7472) of the 18 – 24 month olds were on-time for measles vaccination in 2002 as compared to 73.21% (n=10,361) in 2013.

The reminder or recall interventions sent by vaccine providers are effective to increase the likelihood of being vaccinated and to reduce the number of under-immunized but potential beneficiaries (315-317)

Evidence in this study supported the fact that even though improvement may be slow, disparity and inequality among the socio-economic deprivation quintiles as well as in geographical locations as regards measles immunization uptake is reducing in almost all parts of Saskatchewan; though the rates differ for jurisdictions. Targeted primary health care innovations geared towards accessibility have great potential to bring the required impact among the lowest socio-economic quintiles and populations that are relatively disadvantaged, while universal health promotion strategies tend to be more effective in higher SES groups.

Determination of the pattern of measles immunization trend by geographical location and socio-economic deprivation quintile among the two age groups can help to track the coverage patterns with opportunity to modify interventions aimed at improving immunization uptake towards achieving the herd immunity threshold.

Vaccination advocacy and communications should aim at building and maintaining trust in the public health professional, in the health system as well as in the measles vaccines. Since measles is no longer regularly seen, stories about cases and people who were affected or impacted by vaccine-preventable conditions should be discussed while Ministry of Health or Saskatchewan Health Authority advertising and awareness campaigns should complement. It is also recommended that the Saskatchewan Health Authority produce vaccine brochures centrally for public health units' use.

5.16 Suggested Further Research

The study utilized 2002 – 2013 data and worked on the platform of the SIMS. The research could be dated and some of the reported data may not apply to the present issues surrounding

measles immunization. Research on the platform of Panorama info gateway from 2014 to 2018 is recommended to see what has changed since the last data of 2013.

While we provide services to a defined population, we need to also check with the user of the service for their level of satisfaction. A research to check user satisfaction could be appropriate at this point.

This research had focused on the health-care providers for their perspectives, a research study looking at the perspectives of the caregivers may complement the findings in the current study.

The proportion of the province of Saskatchewan who were on-time for measles immunization was established in this research. However, to what extent the delay could have been and if there was any effect on other vaccines was not assessed as the data did not permit that. This limited assessment of the real extent of the problem and impact of delay in uptake of measles immunization. This effect needs further investigating.

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Appendices

7.1 Appendix A: Consent certificate from each of 10 RHAs participating in research

Department of Community Health & Epidemiology

University of Saskatchewan
Health Science Building, 107 Wiggins Road
Saskatoon SK CAN S7N 5E5
16 January, 2016

The Medical Officer of Health,

…….

…….

Dear Sir/Ma

IMMUNISATION COVERAGE IN SASKATCHEWAN STUDY

As a follow up on the presentation at the meeting of the Medical Officers of Health for all Health Regions in Saskatchewan which was held at Saskatoon on June 17, 2015, I am requesting your participation in the immunisation coverage study province-wide in Saskatchewan.

The study will highlight Measles coverage within the various health regions overall and between deprivation quintiles. Information obtained from this study will help to discern ways to improve coverage in our various settings and geographical areas where there may be low coverage.

I therefore want to solicit your participation in this study. Hope you will be willing to participate?

Data management procedure:

Using the Saskatoon Health Region (SHR) Panorama data extracts, Public Health Observatory (PHO) staff will develop the syntax required to calculate measles coverage rates for the various sub-groups (e.g., health region level, quintiles of deprivation, dissemination areas, etc.). The PHO then shares the syntax with e-Health who in turn runs the syntax on the RHA-specific data extracts. The e-Health would then release the RHA-specific aggregate data tables to the individual RHAs to certify that tables generated from data is de-identified and releasable for the analysis.

If you are interested, please fill the certificate of consent part of this request, scan and send back to the following addresses to begin the project.

<supervisor's e-mail address provided>

Cc: *<student's e-mail address provided>*

Part II: Certificate of Consent

I have read the foregoing information, I hereby indicate my willingness to have e-Health run this syntax run on my health region's data, and have e-health send the output to me for review, and then released for the proposed analysis.

Name_____

Signature _____

Date _____

I look forward to working with you on this project.

Yours truly,

Marcus Ilesanmi

(MSc Student in Community Health & Epidemiology)

Supervisor: Dr. Cordell Neudorf, CMHO, Saskatoon Health Region, and

Assoc. Prof. Dept. of CH&E, Univ. of Saskatchewan

SNo	RHA Name	Ethics/ RHA Consent to participate and data Release Received
1	Cypress RHA	Yes
2	Five Hills RHA	Yes
3	Heartland RHA	Yes
4	Kelsey Trail RHA	Yes
5	Prairie North RHA	Yes
6	Prince Albert Parkland RHA	Yes
7	Regina Qu'Appelle	Yes
8	Saskatoon RHA	Yes
9	Sun Country RHA	Yes
10	Sunrise RHA	Yes

7.2 Appendix B: Pre-Intervention/First phase Qualitative Strand Interview Guide

Introduction:

- How long have you been at your position?

Questions

- What is your role in the measles immunization program in your health region?
- What has measles immunization coverage been for your health region in the past?
- What is the current level of priority for improving measles immunization coverage among 0 – 2-year-old children in your RHA?
- What targets for immunization coverage would you propose for your RHA for the next two years?
    - What do you think are the barriers to achieving a higher coverage rate in your RHA?

In your RHA;

- What strategies have you used to increase the uptake of measles immunizations?
- Did this work equally well with all populations (groups)?
    - Were there populations that you feel were not responsive to these strategies?
    - What might work better?
- What can you sustain personally or as a health region?
    - Provide reasons for challenges with sustainability.
- What are the strengths you think you can build on?
    - What initiatives are needed in your RHA to ensure continued improvement in coverage rates
- How have you engaged patients/families, providers, the media, the public on awareness of the need for immunization or the barriers to immunization? What role does the media play?
    - What are some of the challenges encountered?

7.3 Appendix C: Post-Intervention/Second phase Qualitative Strand Interview Guide

Introduction and Interview recording consent

My name is Marcus Ilesanmi, a graduate student in the Department of Community Health and Epidemiology, University of Saskatchewan under the supervision of Dr. Cordell Neudorf.

This is a follow up interview of the project titled - Measles immunization in Saskatchewan – coverage disparities and challenges to the achievement of herd immunity threshold is intended to last about 25-30minutes

The conversation will be recorded for transcription accuracy purposes, but your comments will be held confidential. The information obtained will be used only in aggregates when compiling and documenting the research findings.

Do I have your consent for participation and voice recording?

Thank you

We are now going into the interview questions.

Questions/Interview Guide

- Has your role in the measles immunization program in your health region changed since the last interview?

- Now that we have seen the analyzed results, from your perspective as a healthcare provider, what more would you like to do to improve immunization coverage figures in your area?

- What innovations in the interventions will you carry out to improve equitable measles immunization coverage rates in your health region/area?
    - Is this intervention universal or targeted?
    - Did you make adjustments for some sub-groups?

- What do you expect the institution you represent to do differently, going forward?

7.4 Appendix D: Canada Health Regions Peer Group with principal characteristics

Peer group	Number of health regions	Percent of Canadian population (2006 Census)	Principal characteristics
A	34	33.85%	Urban-rural mix from coast to coast Average percentage of Aboriginal population Average percentage of immigrant population
B	8	16.66%	Mainly urban centers in Ontario and Alberta with moderately high population density Low percentage of Aboriginal population Very High employment rate Higher than average percentage of immigrant population
C	20	10.06%	Sparsely populated urban-rural mix in Eastern and Central provinces Average percentage of Aboriginal population Average employment rate Low percentage of immigrant population
D	15	4.83%	Mainly rural regions from Quebec to British Columbia Average percentage of Aboriginal population High employment rate
E	6	3.32%	Mainly rural and remote regions in the Western provinces and the Territories High proportion of Aboriginal population Average percentage of immigrant population
F	5	0.49%	Northern and remote regions Very high proportion of Aboriginal population Very low employment rate Low proportion of immigrants
G	3	15.65%	Largest metro centers with an average population density of 4,065 people per square kilometer Very low proportion of Aboriginal population Average employment rate Very high proportion of immigrant population
H	8	1.83%	Rural northern regions from coast to coast High proportion of Aboriginal population Low proportion of immigrants
I	7	1.73%	Mainly rural Eastern regions Average percentage of Aboriginal population Low employment rate Very low percentage of immigrant population
J	6	11.58%	Mainly urban centers in Ontario and British Columbia with high population density Low proportion of Aboriginal population High proportion of immigrants

(Source: Statistics Canada)

7.5 Appendix E: Permission to modify and use Health Behavior Framework

Subject: RE: Permit to use and modify Health Behaviour Framework
Date: Friday, 1 March 2019 at 00:24:41 Central Standard Time
From: Roshan Bastani, Ph.D
To: Ilesanmi, Marcus
CC: Guerra, Michelle

Dear Marcus,

You are most welcome to use the framework. We have updated the framework a little and renamed it the Multilevel Health Outcomes Framework. If you would to see the updated version, Michelle Guerra from my office can send you the information.

Best,

Roshan Bastani

From: Ilesanmi, Marcus [mailto:[redacted]
Sent: Monday, February 4, 2019 9:08 AM
To: Roshan Bastani, Ph.D <[redacted]>
Subject: Permit to use and modify Health Behaviour Framework

Dear Roshan Bastani,

Trust this e-mail finds you well.
I am a PhD student in the Department of Community Health and Epidemiology, University of Saskatchewan, Canada.
I am working on barriers and enablers to measles immunization uptake in Saskatchewan and interested in adapting the Health Behavior Framework which you have used in your research on "Integrating Theory into Community Interventions to Reduce Liver Cancer Disparities: The Health Behavior Framework" to explain the effect of the factors of interest.
I hereby ask for permission to use the framework in my thesis.
Thank you and best regards,

Marcus Ilesanmi
Department of Community Health and Epidemiology
University of Saskatchewan
105 Wiggins Avenue
SK S7N 5E5
Canada.

7.6 Appendix F: Sample Codebook (Using Analysis Data from phase 3 interviews)

Nodes

Name	Description	Files	References
Access improvement and Missed Opportunity reduction	Includes ways by which the health regions make access to immunisation services possible and ensuring that when not feasible for clients, other opportunities are provided	0	0
Access	ability to utilise or procure immunization services	3	3
After hours clinics	improving access	8	11
Clinics in daycare, door to door, home, CHC, and mobile clinic	flexibility around access	5	11
Nurses visiting schools	Improving access through taking vaccination to outreaches	1	1
Satellite and rural clinics	Flexibility to improve access and uptake/utilization	3	3
Transportation to clinics	Improving access especially for the socio-economically challenged	5	6
Education and Awareness	Ways to ensure that immunization knowledge is made available to the potential clients	0	0
Education	expanding avenues to disseminate information to the public	4	8
Idea		0	0
Immunization brochures	targeted information	1	1
Reminder Interventions	This involved ways to ensure clients do not forget their appointments and responsibilities as care-givers	0	0
Reminder recall process	Reminder system	8	20
Resource Mobilisation	This involves resources fund, human, community or social capital tapped	0	0
Collaboration	Increasing ways to disseminate information	3	4
Resources	Fund, human resources (PHN and data managers)	8	23
System Oriented	These are initiatives and interventions that are done at the health system level	0	0
Accountability report	A document put together by health regions at the instance of ministry to follow up on improvement of coverage figures	2	3

Name	Description	Files	References
Maintaining contact with families	Lost to follow up clients	2	5
Monitoring wait times	Wait times are constantly monitored to ensure client have quick access and do not have to wait too long to be lost to follow up	1	1
Responding to birth rate	Responsiveness to prenatal and postnatal data for planning purposes	1	1
Systems and data	Data disconnect as a result of transient population and needing data manager for data clean-up	10	21
Targeted Approaches	These are approaches targeted to some specific groups of clients and potential clients	0	0
Distrust of the system	public policy distrust	1	1
Transcient population follow-up		1	2
Vaccine hesitancy and anti-vaxxers	Those refusing immunisation for reasons and those propagating false immunisation preventing others as well for immunizing	6	15

7.7 Appendix G: Skewness and Levene's tests for Residence and Deprivation coverages for first measles dose at 1 year in ten Saskatchewan Health Regions

Residence percentages (City & Not City)	**Skewness**	**Levene's test(F)**	***p***
Regina	-0.217	4.232	0.052
Saskatoon	0.384	1.300	0.266
Cypress	0.366	1.390	0.251
Five Hills	0.384	3.962	0.059
Heartland	-0.549	10.188	0.004
Kelsey Trail	0.029	1.765	0.198
Sun Country	0.987	8.133	0.009
Sunrise	-0.453	2.451	0.132
Prairie North	0.081	0.415	0.526
Prince Albert P	1.154	5.237	0.032
Deprivation Quintiles (Q1, Q2, Q3, Q4, Q5)	**Skewness**	**Levene's test(F)**	***p***
Regina	-0.204	1.506	0.213
Saskatoon	-0.592	1.579	0.193
Cypress	-0.170	1.788	0.144
Five Hills	-0.151	2.088	0.095
Heartland	-0.455	6.760	0.00
Kelsey Trail	0.845	2.150	0.088
Sun Country	-0.244	2.757	0.037
Sunrise	-0.019	3.647	0.010
Prairie North	-0.936	1.160	0.338
Prince Albert P	0.033	2.684	0.041

7.8 Appendix H: On-time for first Measles vaccination at year one - Multiple Comparisons (Post-hoc tests) for six regions

Deprivation Quantiles	Deprivation Quantiles	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
REGINA	**Tukey HSD**					
DEPQ1	DEPQ2	5.54361	2.04243	0.065	-0.2167	11.3039
	DEPQ3	12.50385*	2.04243	< .001	6.7435	18.2642
	DEPQ4	18.64157*	2.04243	< .001	12.8813	24.4019
	DEPQ5	27.13500*	2.04243	< .001	21.3747	32.8953
DEPQ2	DEPQ3	6.96025*	2.04243	0.01	1.1999	12.7206
	DEPQ4	13.09797*	2.04243	< .001	7.3376	18.8583
	DEPQ5	21.59139*	2.04243	< .001	15.8311	27.3517
DEPQ3	DEPQ4	6.13772*	2.04243	0.031	0.3774	11.898
	DEPQ5	14.63115*	2.04243	< .001	8.8708	20.3915
DEPQ4	DEPQ5	8.49343*	2.04243	0.001	2.7331	14.2537
SASKATOON	**Tukey HSD**					
DEP Q1	DEP Q2	4.05728	1.56776	0.087	-0.3643	8.4789
	DEP Q3	10.17915*	1.56776	< .001	5.7576	14.6007
	DEP Q4	9.36337*	1.56776	< .001	4.9418	13.785
	DEP Q5	22.12588*	1.56776	< .001	17.7043	26.5475
DEP Q2						
	DEP Q3	6.12187*	1.56776	0.002	1.7003	10.5435
	DEP Q4	5.30609*	1.56776	0.011	0.8845	9.7277
	DEP Q5	18.06860*	1.56776	< .001	13.647	22.4902
DEP Q3						
	DEP Q4	-0.81579	1.56776	0.985	-5.2374	3.6058
	DEP Q5	11.94672*	1.56776	< .001	7.5251	16.3683
DEP Q4						
	DEP Q5	12.76251*	1.56776	< .001	8.3409	17.1841
CYPRESS	**Tukey HSD**					
DEP Q1	DEP Q2	3.87237	2.70806	0.611	-3.7652	11.51
	DEP Q3	10.99976*	2.70806	0.001	3.3622	18.6374
	DEP Q4	11.17954*	2.70806	0.001	3.5419	18.8171
	DEP Q5	16.24190*	2.70806	< .001	8.6043	23.8795
DEP Q2						

	DEP Q3	7.12739	2.70806	0.078	-0.5102	14.765
	DEP Q4	7.30717	2.70806	0.067	-0.3304	14.9448
	DEP Q5	12.36953*	2.70806	< .001	4.7319	20.0071
DEP Q3						
	DEP Q4	0.17978	2.70806	1	-7.4578	7.8174
	DEP Q5	5.24214	2.70806	0.311	-2.3955	12.8798
DEP Q4						
	DEP Q5	5.06237	2.70806	0.346	-2.5752	12.7
	DEP Q4	-5.06237	2.70806	0.346	-12.7	2.5752
FIVE HILLS	**Tukey HSD**					
DEP Q1	DEP Q2	1.06781	1.65005	0.966	-3.5859	5.7215
	DEP Q3	2.43726	1.65005	0.581	-2.2164	7.0909
	DEP Q4	0.73394	1.65005	0.992	-3.9197	5.3876
	DEP Q5	9.73657*	1.65005	< .001	5.0829	14.3902
DEP Q2						
	DEP Q3	1.36945	1.65005	0.92	-3.2842	6.0231
	DEP Q4	-0.33387	1.65005	1	-4.9875	4.3198
	DEP Q5	8.66876*	1.65005	< .001	4.0151	13.3224
DEP Q3						
	DEP Q4	-1.70332	1.65005	0.839	-6.357	2.9503
	DEP Q5	7.29931*	1.65005	< .001	2.6456	11.953
DEP Q4	DEP Q5	9.00263*	1.65005	< .001	4.349	13.6563
SUNRISE	**Games-Howell**					
DEP Q1	DEP Q2	3.00417	2.246735	0.672	-3.662628	9.670963
	DEP Q3	4.66578	2.858846	0.496	-3.936023	13.267575
	DEP Q4	11.89634*	1.818727	< .001	6.397722	17.394956
	DEP Q5	18.57856*	1.929633	< .001	12.807682	24.349443
DEP Q2	DEP Q3	1.66161	2.891373	0.977	-7.01987	10.343088
	DEP Q4	8.89217*	1.86944	0.001	3.226926	14.557418
	DEP Q5	15.57440*	1.977504	< .001	9.64954	21.499251
DEP Q3	DEP Q4	7.230563	2.572933	0.085	-0.764922	15.226048
	DEP Q5	13.91279*	2.65249	0.001	5.768979	22.056595
DEP Q4	DEP Q5	6.68222*	1.473251	0.001	2.297441	11.067007
PRAIRIE NORTH	**Tukey HSD**					

DEP Q1	DEP Q2	-1.38511	1.8468	0.944	-6.5937	3.8235
	DEP Q3	3.97654	1.8468	0.213	-1.232	9.1851
	DEP Q4	2.72798	1.8468	0.581	-2.4806	7.9366
	DEP Q5	18.28147*	1.8468	< .001	13.0729	23.4901
DEP Q2	DEP Q3	5.36166*	1.8468	0.041	0.1531	10.5702
	DEP Q4	4.11309	1.8468	0.185	-1.0955	9.3217
	DEP Q5	19.66659*	1.8468	< .001	14.458	24.8752
DEP Q3	DEP Q4	-1.24856	1.8468	0.961	-6.4571	3.96
	DEP Q5	14.30493*	1.8468	< .001	9.0963	19.5135
DEP Q4	DEP Q5	15.55349*	1.8468	< .001	10.3449	20.7621

*. The mean difference is significant at the 0.05 level.

7.9 Appendix I: Test of Homogeneity of Variances for within differences of RHAs Peer Group Location and S-E deprivation quintile among on-time for first dose at 1 year

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
City	1.438	2	33	.252
No City percentage	1.760	2	33	.188
Deprivation Q1	.746	2	33	.482
Deprivation Q2	.074	2	33	.929
Deprivation Q3	.784	2	33	.465
Deprivation Q4	1.272	2	33	.294
Deprivation Q5	1.985	2	33	.154

7.10 Appendix J: Means and Standard Deviations Comparison across RHA Peer Groups in relation to Deprivation Quintiles and Place of Residence for on-time for 1st dose

	Peer A *n* *M* *SD*	**Peer D** *n* *M* *SD*	**Peer H** *n* *M* *SD*
City	12 62.90 3.74	12 68.78 2.71	12 54.45 2.08
Not City	12 66.83 2.09	12 69.46 2.25	12 61.03 3.13
DEP Q1	12 74.49 2.90	12 75.03 2.33	12 65.79 2.94
DEP Q2	12 69.75 2.87	12 72.31 2.87	12 65.31 3.09
DEP Q3	12 63.18 5.15	12 70.14 3.28	12 61.76 4.19
DEP Q4	12 60.53 4.06	12 68.43 2.80	12 59.41 2.61
DEP Q5	12 49.96 4.76	12 63.85 2.75	12 48.49 3.52

7.11 Appendix K: Skewness and Levene's tests for residence and deprivation percentages for all the health regions for on-time for 2nd dose at year 2yrs

Residence percentages (City & Not City)	**Skewness**	**Levene's test(F)**	***P***
Regina	-0.473	4.608	0.043
Saskatoon	-0.318	2.559	0.124
Cypress	0.841	1.910	0.181
Five Hills	0.155	0.253	0.620
Heartland	-0.168	4.642	0.042
Kelsey Trail	-0.336	5.342	0.031
Sun Country	0.465	1.685	0.208
Sunrise	0.138	0.010	0.922
Prairie North	-0.024	1.343	0.259
Prince Albert P	1.190	4.714	0.041
Deprivation Quintiles (Q1, Q2, Q3, Q4, Q5)	**Skewness**	**Levene's test(F)**	***P***
Regina	-0.237	1.184	0.328
Saskatoon	-0.512	1.448	0.231
Cypress	-0.374	2.472	0.055
Five Hills	0.115	3.012	0.026
Heartland	0.114	2.491	0.054
Kelsey Trail	0.622	3.834	0.008
Sun Country	-0.011	1.859	0.131
Sunrise	0.063	1.251	0.300
Prairie North	-0.726	0.947	0444
Prince Albert P	0.064	0.489	0.743

7.12 Appendix L: Multiple Comparisons (post-hoc tests) for six Health Regions Deprivation Quintiles for on-time for 2nd dose measles immunization at 2 years

Dependent Variable: Percentage of Deprivation Quantiles

Variables	Deprivation Quantiles	Mean Difference	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
REGINA	**Tukey HSD**					
DEP Q1	DEP Q2	5.28482	3.20176	.472	-3.7452	14.3148
	DEP Q3	12.82538*	3.20176	.002	3.7954	21.8554
	DEP Q4	19.29011*	3.20176	< .001	10.2601	28.3201
	DEP Q5	27.98449*	3.20176	< .001	18.9545	37.0145
DEP Q2	DEP Q3	7.54056	3.20176	.143	-1.4895	16.5706
	DEP Q4	14.00529*	3.20176	.001	4.9753	23.0353
	DEP Q5	22.69967*	3.20176	< .001	13.6696	31.7297
DEP Q3	DEP Q4	6.46473	3.20176	.271	-2.5653	15.4948
	DEP Q5	15.15911*	3.20176	< .001	6.1291	24.1891
DEP Q4	DEP Q5	8.69437	3.20176	.064	-.3356	17.7244
SASKATOON	**Tukey HSD**					
DEP Q1	DEP Q2	3.33694	3.25343	.842	-5.8388	12.5127
	DEP Q3	10.04921*	3.25343	.025	.8735	19.2249
	DEP Q4	7.16874	3.25343	.194	-2.0070	16.3445
	DEP Q5	20.52742*	3.25343	< .001	11.3517	29.7031
DEP Q2	DEP Q3	6.71226	3.25343	.251	-2.4635	15.8880
	DEP Q4	3.83180	3.25343	.764	-5.3439	13.0075
	DEP Q5	17.19047*	3.25343	< .001	8.0147	26.3662
DEP Q3	DEP Q4	-2.88046	3.25343	.901	-12.0562	6.2953
	DEP Q5	10.47821*	3.25343	.018	1.3025	19.6539
DEP Q4	DEP Q5	13.35867*	3.25343	.001	4.1829	22.5344
CYPRESS	**Tukey HSD**					
DEP Q1	DEP Q2	-.13678	3.57931	1.000	-10.2316	9.9580
	DEP Q3	7.91086	3.57931	.191	-2.1840	18.0057
	DEP Q4	6.44525	3.57931	.384	-3.6496	16.5401
	DEP Q5	14.46240*	3.57931	.002	4.3676	24.5572
DEP Q2	DEP Q3	8.04764	3.57931	.178	-2.0472	18.1425
	DEP Q4	6.58202	3.57931	.362	-3.5128	16.6768
	DEP Q5	14.59918*	3.57931	.001	4.5044	24.6940
DEP Q3	DEP Q4	-1.46561	3.57931	.994	-11.5604	8.6292
	DEP Q5	6.55154	3.57931	.367	-3.5433	16.6464

DEP Q4	DEP Q5	8.01716	3.57931	.181	-2.0777	18.1120
FIVE HILLS	**Games-Howell**					
DEP Q1	DEP Q2	-.72147	2.23057	.997	-7.5181	6.0752
	DEP Q3	1.10952	1.78761	.970	-4.2385	6.4576
	DEP Q4	3.82441	2.10061	.393	-2.5436	10.1924
	DEP Q5	8.24516*	1.46219	.000	3.9066	12.5837
DEP Q2	DEP Q3	1.83099	2.44397	.942	-5.4753	9.1373
	DEP Q4	4.54588	2.68142	.457	-3.4140	12.5058
	DEP Q5	8.96663*	2.21708	.007	2.1985	15.7347
DEP Q3	DEP Q4	2.71489	2.32597	.769	-4.2160	9.6458
	DEP Q5	7.13564*	1.77075	.005	1.8307	12.4406
DEP Q4	DEP Q5	4.42075	2.08628	.256	-1.9153	10.7568
HEARTLAND	**Tukey HSD**					
DEP Q1	DEP Q2	4.91883	2.23166	.194	-1.3874	11.2250
	DEP Q3	-4.28756	2.23166	.319	-10.5938	2.0187
	DEP Q4	3.38542	2.23166	.556	-2.9208	9.6916
	DEP Q5	-5.32126	2.41047	.193	-12.1327	1.4902
DEP Q2	DEP Q3	-9.20639*	2.23166	.001	-15.5126	-2.9002
	DEP Q4	-1.53341	2.23166	.958	-7.8396	4.7728
	DEP Q5	-10.24009*	2.41047	.001	-17.0516	-3.4286
DEP Q3	DEP Q4	7.67298*	2.23166	.010	1.3668	13.9792
	DEP Q5	-1.03371	2.41047	.993	-7.8452	5.7778
DEP Q4	DEP Q5	-8.70668*	2.41047	.006	-15.5182	-1.8952
SUN COUNTRY	**Tukey HSD**					
DEP Q1	DEP Q2	3.28337	3.46137	.876	-6.4788	13.0456
	DEP Q3	9.92658*	3.46137	.044	.1644	19.6888
	DEP Q4	7.65622	3.46137	.191	-2.1060	17.4184
	DEP Q5	8.72347	3.46137	.101	-1.0387	18.4857
DEP Q2	DEP Q3	6.64321	3.46137	.320	-3.1190	16.4054
	DEP Q4	4.37285	3.46137	.714	-5.3894	14.1351
	DEP Q5	5.44010	3.46137	.522	-4.3221	15.2023
DEP Q3	DEP Q4	-2.27036	3.46137	.965	-12.0326	7.4918
	DEP Q5	-1.20311	3.46137	.997	-10.9653	8.5591
DEP Q4	DEP Q5	1.06725	3.46137	.998	-8.6950	10.8295
SUNRISE	**Tukey HSD**					
DEP Q1	DEP Q2	2.45504	2.44146	.852	-4.4307	9.3407
	DEP Q3	3.32193	2.44146	.655	-3.5638	10.2076

	DEP Q4	10.97802*	2.44146	< .001	4.0923	17.8637
	DEP Q5	17.81749*	2.44146	< .001	10.9318	24.7032
DEP Q2	DEP Q3	.86690	2.44146	.996	-6.0188	7.7526
	DEP Q4	8.52298*	2.44146	.008	1.6373	15.4087
	DEP Q5	15.36246*	2.44146	< .001	8.4767	22.2482
DEP Q3	DEP Q4	7.65608*	2.44146	.022	.7704	14.5418
	DEP Q5	14.49556*	2.44146	< .001	7.6099	21.3813
DEP Q4	DEP Q5	6.83948	2.44146	.052	-.0462	13.7252
PRAIRIE NORTH	**Tukey HSD**					
DEP Q1	DEP Q2	-2.45250	2.63858	.884	-9.8942	4.9892
	DEP Q3	1.70047	2.63858	.967	-5.7412	9.1421
	DEP Q4	1.36192	2.63858	.985	-6.0797	8.8036
	DEP Q5	19.45003*	2.63858	< .001	12.0084	26.8917
DEP Q2	DEP Q3	4.15298	2.63858	.520	-3.2887	11.5946
	DEP Q4	3.81443	2.63858	.601	-3.6272	11.2561
	DEP Q5	21.90253*	2.63858	< .001	14.4609	29.3442
DEP Q3	DEP Q4	-.33855	2.63858	1.000	-7.7802	7.1031
	DEP Q5	17.74955*	2.63858	< .001	10.3079	25.1912
DEP Q4	DEP Q5	18.08810*	2.63858	< .001	10.6464	25.5298
PRINCE ALBERT	**Tukey HSD**					
DEP Q1	DEP Q2	2.27516	2.05124	.801	-3.5100	8.0603
	DEP Q3	3.59159	2.05124	.412	-2.1936	9.3768
	DEP Q4	12.44194*	2.05124	< .001	6.6568	18.2271
	DEP Q5	16.09321*	2.05124	< .001	10.3080	21.8784
DEP Q2	DEP Q3	1.31643	2.05124	.967	-4.4688	7.1016
	DEP Q4	10.16679*	2.05124	< .001	4.3816	15.9520
	DEP Q5	13.81805*	2.05124	< .001	8.0329	19.6032
DEP Q3	DEP Q4	8.85036*	2.05124	.001	3.0652	14.6355
	DEP Q5	12.50162*	2.05124	< .001	6.7164	18.2868
DEP Q4	DEP Q5	3.65126	2.05124	.395	-2.1339	9.4364

*. The mean difference is significant at the 0.05 level.

7.13 Appendix M: Test of Homogeneity of Variances comparing the RHA peer groups for Location and Deprivation Quintiles among the on-time for 2nd dose measles dose

Annex A: Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
City percentage	3.781	2	33	.033
Not City percentage	0.201	2	33	.819
Deprivation QI	0.131	2	33	.878
Deprivation Q2	1.873	2	33	.170
Deprivation Q3	3.126	2	33	.057
Deprivation Q4	4.669	2	33	.016
Deprivation Q5	2.943	2	33	.067

7.14 Appendix N: Means and Standard Deviations Comparing the five Deprivation Quantiles and place of residence across the three RHA peer groups for on-time for 2nd dose of measles immunization

	Peer A *n* *M* *SD*	**Peer D** *n* *M* *SD*	**Peer H** *n* *M* *SD*
City	12 61.639569 7.930243	12 66.619391 4.956240	12 53.334755 4.116797
Not City	12 70.060979 4.738733	12 70.251877 4.306998	12 62.936514 5.602115
DEP Q1	12 76.017752 5.640959	12 73.374920 5.256539	12 65.789970 5.111651
DEP Q2	12 71.408210 6.936328	12 70.553212 6.084633	12 66.991700 4.212615
DEP Q3	12 63.734288 8.610880	12 66.827103 6.114540	12 64.402943 5.105627
DEP Q4	12 58.985936 8.703198	12 66.637119 5.988162	12 60.397769 4.293884
DEP Q5	12 49.367590 8.283229	12 57.537910 6.955158	12 50.310334 4.914229

7.15 Appendix O: NACI recommendations for measles post-exposure prophylaxis

Who is exposed?	Exposure since	Is Injection volume a concern?	How administered?	Intramuscular Immunoglobulin (IMIg)	Intravenous Immunoglobulin (IVIg)
6mth and older	within 72hrs	No	Multiple Injection sites	0.5mL/kg up to 15mL	
6mth - 12mths old	after 72hrs until 6days	No		0.5mL/kg up to 15mL	
Under 6mths		No		0.5mL/kg up to 15mL	
Pregnant or Immunocompromised		No		0.5mL/kg up to 15mL	
pregnant or Immunocompromised		Yes			400mg/kg