EXPLORING THE IMPACT OF THE NEW BRUNSWICK PEDIATRIC INSULIN PUMP PROGRAM ON TYPE 1 DIABETES HEALTH OUTCOMES

by

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ABSTRACT

The purpose of this study is to evaluate the effect of the New Brunswick Pediatric Insulin Pump Program (PIPP) on health outcomes for patients with type 1 diabetes (T1D), by analyzing acute-care hospitalization length of stay (LOS) as measure of outcome relative to non-PIPP participants. The current study uses a retrospective population-based cohort design using administrative health and geospatial databases from 2012/13 to 2014/15. The population includes all New Brunswick inpatients 0-18 years with primary diagnosis of diabetes as the reason for the hospital stay. It was hypothesized a significantly shorter mean LOS among PIPP participants would be observed. To examine the research question, multiple linear regressions were conducted to investigate the hypothesis. Results showed that inpatients supported by the PIPP had significantly shorter hospital stays relative to non-participants (mean of 1.3 days less, $p<0.05$), after adjusting for age, sex, health region and neighbourhood deprivation level. These results have the potential to inform evidence-based future policy on insulin pump programs.

Keywords: *diabetes, insulin pump, government funded program, hospitalization, health capability*

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List of Abbreviations

Assistive Device Program (ADP)

Canadian Association for Health Services and Policy Research (CAHSPR)

Canadian Chronic Disease Surveillance System (CCDSS)

Canadian Marginalization Index (CAN-Marg)

Canadian Urban Environmental Health Research Consortium (CANUE)

Confidence interval (CI)

Diabetic ketoacidosis (DKA)

Discharge Abstract Database (DAD)

Hemoglobin A1c (HbA_{1c})

Institute for Clinical Evaluative Sciences (ICES)

International Classification of Diseases (ICD)

Length of Stay (LOS)

New Brunswick Institute for Research, Data and Training (NB-IRDT)

New Brunswick Pediatric Insulin Pump Program (PIPP)

Odds-ratios (OR)

Pediatric Ontario Diabetes Database (ODD)

Postal Code Conversion File (PCCF)

Research ethics board (REB)

Socioeconomic status (SES)

Statistical Package for the Social Science (SPSS)

Odds-ratio (OR)

Type 1 diabetes (T1D)

1 Introduction

Type 1 diabetes (T1D) is a chronic autoimmune disease with no known cure that is typically diagnosed in childhood or adolescence. The immune system of a person with T1D attacks and destroys the insulin producing cells in the pancreas and causes the pancreas to suddenly stop making insulin altogether (Department of Health, 2011). Insulin is a hormone that is necessary for the body to be able to regulate the glucose level (sugar) in the bloodstream within an appropriate range (JDRF, 2017). Both high blood sugar levels (hyperglycemia) or low blood sugar levels (hypoglycemia) can result in life-threatening complications. Hyperglycemia if left untreated, may lead to diabetic ketoacidosis (DKA) and turn a person's blood acidic. This condition requires immediate treatment and often leads to hospitalizations (JDRF, 2018). On the other extreme, hypoglycemia is especially dangerous as the brain requires a minimum level of sugar circulating in the blood at all times (Department of Health, 2011). Treatments are limited to insulin therapy and are vital for individuals with T1D to sustain life.

To date, there are two main forms of reliable delivery of insulin therapy, manual injections and the insulin pump, each with their own advantages and limitations. Both treatments are costly, however, the insulin pump is roughly three times more expensive (Diabetes Canada, 2017). Despite the higher associated costs of insulin pump therapy, this treatment is highly valued by physicians (Shulman et al., 2016a) and can better assist in regulating blood glucose levels compared to manual injections when used properly (Mack-Fogg, et al., 2005). Better regulation in turn reduces the risk of both hypo and hyperglycemia, and their associated risks towards hospitalizations. Additionally, a

systematic review from 2007 found the insulin pump to largely improve perceived quality of life for those with T1D (Barnard et al., 2007). Given the higher associated cost, however, the insulin pump is not always accessible for those without adequate financial resources and insurance.

Beginning in the early 2000's, universal funding programs emerged across Canadian provinces to help offset the cost of insulin pump therapy. Each province governs their own program, with different limits on age eligibility criteria. In 2012, the New Brunswick Pediatric Insulin Pump Program (PIPP) was introduced, and recently underwent a policy change in April 2018 to increase the age limit from 18 years and under to include those aged 25 and under (GNB, 2018). Current evaluations of the effectiveness of Canadian insulin pump programs are limited, and it is unclear how program participation affects the most expensive costs to the publicly-funded healthcare system, including length of stay (LOS) in hospital.

The purpose of this study was therefore to provide the first comprehensive evaluation of New Brunswick's Pediatric Insulin Pump Program on hospital-based outcomes, and to provide a baseline of evidence as age eligibility expands within the province. Specifically, my research addresses the following question: **Do patients under 19 who have benefited from the PIPP have shorter inpatient LOS for diabetes relative to those who are not in the program?** The proposed research question provides insight on the participation of those in the PIPP and whether participation in the PIPP predicts LOS among pediatric T1D patients in New Brunswick.

In order to test this, I used a retrospective population-based cohort design. The cohort included all pediatric inpatients aged 18 and under in New Brunswick with a

hospital stay for diagnosed diabetes between fiscal years 2012/13-2014/15, that is, for three years following the time of implementation of the PIPP. **My working hypothesis was:**

- **Hypothesis:** A shorter mean acute-care length of stay will be observed for PIPP participants compared to non-PIPP participants.

My rationale was that the PIPP directly influences economic resources. These economic resources provide access to an expensive health technology, the insulin pump, supporting the ability to manage T1D for program participants. Ability to manage T1D should theoretically be greater for participants while they have this financial support and thus decrease the need for prolonged hospital care. This rationale is further supported by the Health Capability model in Section 2.5.

This thesis explores the described research question by first summarizing a review of the literature, including the Health Capability model, in Chapter 2. Next, I present the main analysis in the form of a manuscript to be submitted for journal publication in Chapter 3. Finally, Chapter 4 concludes this thesis manuscript with discussion around the study's main findings, lessons learnt, and suggestions for future research.

2 Literature Review

There is hope that one day there may be a cure for T1D. With the relatively recent discovery of insulin in the 1920's, followed by the development of the insulin pump in the 1970's, and new innovative methods being developed today, research in this field is progressing (Diabetes Canada, 2017b; Lenhard, & Reeves, 2001). For now, manual injections remain the traditional method of treatment, and involve multiple injections a day via syringe. The more recent delivery method, the insulin pump, consist of a small electronic device that adheres to the user's body. Insulin pumps are becoming increasingly smaller and provide a continuous and adjustable insulin dosage, more closely mimicking the function of the pancreas (Prahalad et al., 2018). Both forms of treatment require ongoing management and require lifelong daily attention. With T1D having no known cause and most often being diagnosed in childhood, efforts to support this population are diverse, as neglect in treatment can be fatal. This chapter aims to highlight the role of government funded insulin pump programs as support to children and youth with T1D in the Canadian context, and ultimately provide adequate justification and feasibility for the proposed study concerning the PIPP and its effect on health outcomes.

2.1 Insulin Therapy Methods (Considerations, Cost, Concerns)

Benefits to insulin pump therapy compared to manual injections can have a wide variety of physical as well as psychological health benefits. Positive benefits range from perceived enhanced quality of life and autonomy (Barnard et al., 2007; Dajkovich & Barkley, 2015), improve control on blood glucose levels (Chase et al., 2010; Brown, 2012; Unger, 2013), improved patient satisfaction Skogsberg et al. (2008), as well as fewer

reports of hypoglycemia (low blood glucose) (Mack-Fogg, et al., 2005). Similar trends are reflected in a study by Shaban et al. (2017) that found distress related to diabetes was significantly reduced after 12 months of insulin pump therapy. Advantages of the insulin pump, however, are sometimes only marginal; some studies have found comparable long-term effectiveness with manual injection therapy, which can be the preferred treatment method (Nuboer et al. 2006; Phillip et al. 2007; Sulmont et al. 2011).

Individualized treatment is a decision that is best made in collaboration with a diabetes healthcare team and family (Visekruna et al., 2017). With two forms of available treatment, the literature comparing benefits between treatments is not conclusive. Patients can expect to pay at least $1,500 per year in out-of-pocket medical expenses to support manual injections as a form of treatment, compared to between $4,000 and $7,000 per year for those with insulin pumps (Diabetes Canada, 2017). The difference in cost of treatment means that financial resources to access insulin pump therapy may not be feasible for some patients with T1D, who otherwise may benefit from this treatment to better support self-management.

Self-management is multidimensional and is performed outside of the clinical health care setting and in individuals' daily lives. It encompasses the daily ongoing self-monitoring of blood glucose, administering insulin via insulin pump or manually via syringe, as well as other complex treatment decisions that occur multiple times per day influencing food management, carbohydrate counting, and exercise (Prahalad et al., 2018). Constraints to adhering to clinically recommended self-management practices can ultimately result in poor health for an individual with T1D. As many as 57% of Canadians with diabetes report being unable to comply with their prescribed treatment because they

are unable to afford the necessary medications, devices, and supplies (Canadian Diabetes Association., n.d.). In turn, government funded programs have become increasingly common to help offset the financial burden of treatment.

2.2 Insulin Pump Programs in Canada

In Canada, provincial/territorial governments have responsibility and accountability for delivering healthcare and publicly-funded universal healthcare insurance plans, which include all "medically necessary" health services (Visekruna et al., 2017). Provinces are thereby each responsible for their organization, delivery and funding of health and assistive device programs. The provincial governments determine what will work best within their respective budgets, populations and health goals. As a result, government funded insulin pump programs vary from province to province.

The prevalence of diabetes among children and adolescents has slowly but steadily been increasing in New Brunswick. Provincial data show the rate increased from 3.2 per 1,000 in 2002/03 (fiscal year) to 4.4 per 1,000 in 2013/14, as seen below in Figure 1 (New Brunswick Department of Health 2016).

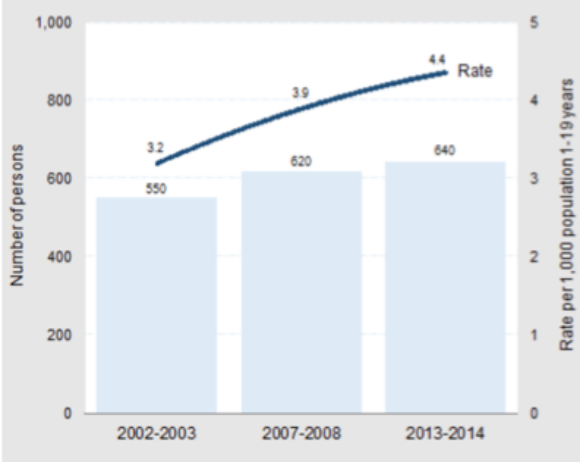

Figure 1. Trends in the prevalence of diabetes among children and youth under 20, New Brunswick, 2002-03 to 2013-2014.

Source: New Brunswick Department of Health, using the Canadian Chronic Disease Surveillance System infrastructure and case definitions. Note: Data on diabetes mellitus among New Brunswick residents one to 19 years.

To assist this vulnerable population, the New Brunswick Pediatric Insulin Pump Program (PIPP) was introduced in 2012. The purpose of this program was for participants to obtain equitable and affordable access to a range of insulin pump devices and basic operating supplies through universal coverage, with the amount of support depending on the family income (GNB, 2018). As of April 2018, the PIPP program's financial support is currently accessible to all those under the age of 25. Prior to this, the PIPP's age eligibility was limited to those 18 and under (GNB, 2015). Part of the eligibility criteria includes the demonstration that the individual already engages in clinically guided diabetes self-management, such as regular follow up with their diabetes health care team and regular monitoring of blood glucose, and the condition that the individual has not had more than 2 DKA episodes in the previous 6 months. Additional eligibility criteria are referenced in Appendix A.

Similar to New Brunswick, other provincial insulin pump programs across Canada exist to assist the financial costs associated with insulin pumps. Many Canadian provincial programs began as pediatric-only programs, with age cut-offs ranging from 17 to 19 years. It is becoming more common, however, to see these programs extend to the age of 25, if not remove age eligibility criteria completely. With each province and territory having their own unique approach on the delivery of their insulin pump programs, Table 1 below offers an overview of the provision of insulin pump programs by provincial and territorial governments across the country.

Table 1. Environmental Scan and Overview of Insulin Pump Programs in Canada.

Province/ Territory	Pump Coverage	Implement Date
British Columbia	All ages	● Pediatric (18 and under) program November 2008 ● Expanded (25 and under) February 2014 ● Expanded (all ages) February 2014
Alberta	All ages	● June 2013
Saskatchewan	Age 25 and under	● Pediatric (18 and under) program July 2007 ● Expanded (25 and under) January 2012
Manitoba	Age 17 and under	● April 2012
Ontario	All ages	● Pediatric (18 and under) program December 2006 ● Expanded (all ages) September 2008
Quebec	Age 17 and under	● April 2011
New Brunswick	Age 25 and under	● Pediatric (18 and under) program January 2012 ● Expanded (25 and under) April 2018
Nova Scotia	Age 25 and under	● September 2013
Prince Edward Island	Age 18 and under	● July 2014
Newfoundland and Labrador	Age 24 and under	● Pediatric (18 and under) program: November 2008 ● Expanded program (25 and under): April 2010
Nunavut/ Northwest Territories/ Yukon	All ages	● N/A

Information presented in the table is adapted from Diabetes Canada along with several provincial government websites for updated information.

2.21 Evaluations on Insulin Pump Programs

Few studies in Canada have focused on evaluations of provincial insulin pump programs; among those available, most are based on Ontario's Assistive Devices Program (ADP). Shulman and colleagues have published five studies specifically focused on the pediatric population of diabetes in Ontario (Shulman et al., 2016a, 2016b, 2016c, 2017a, 2017b). Four of these five studies used a combination of survey data and health administrative data for analysis. Canada has been recognized for having high-quality administrative health data that is being increasingly used for research purposes, to help inform health policy decisions and enhance patient outcomes (Lucyk et al., 2015). The strengths, weaknesses and results of using administrative health data for analyzing the ADP and other insulin pump programs are further discussed in the current section below.

Administrative health data was used in one study by Shulman et al. (2016c) that focused on providing a description of the Ontario Pediatric Diabetes Network. The study aimed to describe the distribution of patients, resources and insulin pump use across centers within the Ontario Pediatric Diabetes Network. This study used a cross-sectional survey of the pediatric diabetes centers within the province to measure center characteristics, patient volume and available clinical and social resources. Survey data was then linked to health administrative data from the provincial insulin pump program to describe and understand the patient population (under the age of 18) who were using insulin pumps as well as a measure of technology uptake. Applications for pump funding rather than actual pump use were recorded due to the nature of the administrative data, which did not capture information on individuals' behaviours in their everyday life. The linkage of these data sets ultimately allowed for the analysis of insulin pump uptake of the T1D population and

produce a clear picture of the provinces Pediatric Diabetes Network that otherwise would have required extensive data collection.

Similarly, two studies focusing on pediatric diabetes in Ontario used population-based cohort designs using linked administrative data to reach their research objectives (Shulman et al. 2016b, 2017b). In order to be able to describe adverse health events in pediatric insulin pump users in relation to socioeconomic status (SES), the researchers again linked survey data from pediatric diabetes centers to health administrative databases. Data sources included the Assistive Devices Program (ADP), the Pediatric Ontario Diabetes Database (ODD), the Hospital Discharge Abstract Database (DAD), the Ontario Health Insurance Plan Database, as well as several others. The ADP database of initial pump funding and renewal applications enabled the creation of cohorts in both studies; whereas the linkage to the other data sources enabled the analysis of insulin pump use and discontinuation (Shulman et al 2017b), as well as hospital-based health outcomes including DKA admissions and other diabetes-related admissions (Shulman et al., 2016b). Again, applications for pump funding rather than actual pump were measured and used due to the nature of health administrative data focusing on programs rather than everyday behaviours. The combination of data sets enabled the analysis of insulin pump use and discontinuation as well as the association between SES and adverse health outcomes among children using insulin pumps (Shulman et al 2017b., & Shulman et al., 2016b).

A report from the Institute for Clinical Evaluative Sciences (ICES) was released in 2017 specifically on Ontario's insulin pump program (Shulman et al., 2017a). This report used population-based health administrative data to examine the patterns of pump use and adverse events within the first ten years of the implementation of the ADP. Key findings

from this report are similar to the findings from the studies described above; pump use increased with the onset of the program, pump discontinuation is uncommon, physicians value insulin pump therapy (Shulman et al., 2016a), and the safety profile of pump use is generally very good (Shulman et al., 2017a). Major findings from Ontario's ADP evaluation suggest reason to support insulin pump programs. It is noted that none of the available studies explicitly looked at a transition component as the age eligibility range of the provincial program expanded beyond pediatric patients into adulthood.

Aside from the province of Ontario, another Canadian study considered the pediatric patient population of Newfoundland and Labrador. This study by Jackman et al. (2015) also used administrative health databases to analyze characteristics and precipitating factors associated with DKA episodes and their severity in those with T1D. The data used were mapped to the International Classification of Disease (ICD) standardized codes for diabetes and DKA episodes, and were linked to patient demographics, biochemical parameters, and whether the patient had been previously diagnosed with diabetes. For those who had pre-existing diabetes, data collected also included the method of insulin treatment. This study looked at hospitalization rates and DKA severity as an indicator of health, as DKA is the leading cause of morbidity and mortality for children with T1D (Jackman et al., 2015). Major findings suggested that the more severe cases of DKA occurred with younger newly diagnosed patients. This study did not however specifically target the direct impact of the provincial insulin pump program on pediatric T1D health outcomes.

Outside of Canada, the first study found through a review of the literature in the international context examined the prevalence and patterns of insulin pump use in patients

of all ages by McKergo et al. (2017) in New Zealand. New Zealand's universal funding program was analyzed in terms of the demographic and regional disparities in insulin pump utilization across the country. This study aimed to describe utilization of pumps by patient characteristics, and to estimate the overall proportion of patients with T1D. This particular study drew from several administrative data sets that allowed for linkage of patient-level demographic, hospital discharge, mortality, and pharmaceutical dispensing data. The authors concluded that it is essential to develop an understanding of the factors that drive insulin pump uptake and utilization, if all patients are to have equal opportunity to benefit from diabetes management opportunities (McKergo et al., 2017).

There is increasing recognition of the value of the availability of linked administrative data sets to inform evidence-based public health policy (Connelly et al., 2016; Jutte et al., 2011). Administrative health data is the data that governments and other health organizations collect for program service delivery and record keeping purposes, and not necessarily for research reasons. As demonstrated in previous universal funding program studies, the linkage of administrative health data provides a useful means to obtain more comprehensive information than would be available through a single source, and that is of direct relevance to health organizational decision-making. These databases, including ones on hospitalizations, provide a resource to analyze and interpret different patient-level and system-level factors that may be influencing health outcomes. Due to the unique nature of each program, there is an opportunity to gain a better understanding of what separates and determines the more effective programs, from those with less success. The outcome of each study provides insight into each program, and guides how to best inform relevant policy to positively influence health outcomes.

2.3 LOS as an Outcome Measure

The main clinical indicator of good health for an individual with T1D is reflected by blood glucose levels. When blood glucose levels are continuously maintained in normal range, the risk of health complications otherwise associated with T1D are reduced (Angus et al., 2007). Moreover, given its lifelong nature, diabetes is associated with a number of complications later in life such as heart disease, stroke, or kidney disease from inability to successfully manage the disease through appropriate clinical care and self-care (Public Health Agency of Canada, 2011). When blood glucose levels are not well maintained through poor self-management practices, there is a greater risk of hospitalization for diabetes related complications. Such hospitalizations are generally considered as potentially avoidable.

Hospital length of stay (LOS) is a good indication of the impacts of self-management ability for those with T1D, as longer stays have important negative consequences in terms of both the financial and social costs of care. Analyzing differences in patients' length of stay in acute-care hospitals has the ability to provide insight on self-management abilities and can be used to inform policy makers on the current utilization and costs to the healthcare system. Internationally, LOS is commonly used as a performance measure to assess health services efficiency with the intent to control health care costs while mitigating disease severity, by helping to inform pre-admission, in-hospital and post-discharge care plans (Buttigieg et al. 2018). For example, a study in Taiwan identified predictors of LOS using multivariate regression analysis in acute ischemic stroke patients (Huang et al., 2013). Results from this study were used to inform

public health policy to address issues related to health care expenditures for potentially avoidable hospitalizations.

Additionally, a systematic review by Angus et al. (2007) identified a shortage of studies on hospitalization patterns in T1D patients, especially among patients under the age of 15 years. This review did find that healthcare costs for those with T1D were higher than those of the general population. Future studies analyzing these trends were deemed to be necessary to best target interventions and programs that reduce the cost of hospitalizations.

For the current study, LOS was chosen as outcome measure due to the insight it provides on self-management abilities and ability to be used to inform policy makers on the current utilization and costs to the healthcare system.

2.4 Effect of Funding on Hospitalization Risk in T1D

Diabetes self-management is largely considered the responsibility of the individual, and yet is heavily shaped by a person's ability and available resources (Weaver et al., 2014). This concept is supported with the Health Capability model shown in Figure 2. The concept is based on the idea that those who are provided an economic resource, will see improved health capabilities and in turn healthiness. The Health Capability model, proposes that economic resources have the potential to shape health capability and choice, ultimately enabling those with T1D the tools to more effectively self-manage their disease and overall health (Weaver et al., 2014).

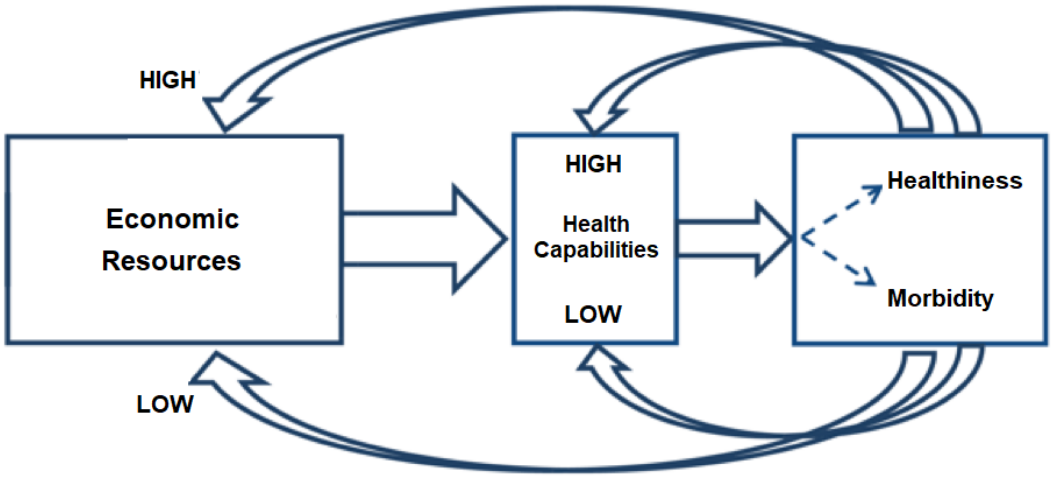

Figure 2. Health Capability model.

Source: Adapted from *Health capabilities and diabetes self-management: The impact of economic, social, and cultural resources* (Weaver et al., 2014)

My study is based on the idea that the PIPP directly influences economic resources (i.e. funding from the PIPP). These economic resources provide access to an expensive health technology, the insulin pump, supporting health capability by enabling self-management practices for program participants. Ability to manage T1D should theoretically be greater for participants while they have this financial support and increase general "healthiness"; thereby decreasing the need for prolonged hospital care. This should theoretically lead to shorter LOS, the outcome measure that is investigated in this study.

2.5 Summary

This thesis aims to better understand the role of universal insulin pump therapy programs as an effective and efficient healthcare financing policy decision to better influence health outcomes for pediatric patients with T1D. Using the Health Capability

model as rationale and basis for building the initial hypothesis, this study draws from the findings of previous research as presented above in this chapter. The next chapter of this thesis is presented in the form of a manuscript prepared for journal submission. It will add to the existing literature by analyzing the relationship between a universal funding insulin pump program and LOS for pediatric inpatients with T1D in the province of New Brunswick, Canada, drawing on linked administrative datasets. Although this evaluation is limited to the study setting of New Brunswick, the evidence obtained will enhance the broader understanding of how insulin pump funding programs are associated with health and health system outcomes, and ultimately inform policy program design and funding for future revisions and implementation of related programs.

3 Research Article — A Population-Based Assessment on the Role of a Universal Insulin Pump Program with Hospital Length of Stay Among Pediatric Patients with Diabetes in New Brunswick

Abstract

Objective: To assess whether New Brunswick's Pediatric Insulin Pump Program (PIPP) has a measurable impact on hospital-based health outcomes of program participants.

Methods: This retrospective population-based cohort study uses linked administrative and geospatial databases among all pediatric inpatients <19 years of age who were hospitalized for diabetes (n=386) during a three-year period of observation (2012/13-2014/15). Multiple linear regression analysis was used to assess the associations of PIPP participation on hospital length of stay (LOS), controlling for patients' sociodemographic characteristics.

Results: Inpatients supported by the PIPP had shorter diabetes-attributable hospital stays on average (*M*=3.25 days, *SD*=2.55) relative to non-participants (*M*=4.03, *SD*=3.14). PIPP participants were found to have significantly shorter LOS (1.3 days less, $p<0.05$), after adjusting for age, sex, health region and neighbourhood deprivation level.

Conclusion: Results suggest that public financing for insulin pumps among pediatric diabetes patients can lead to a decrease in the more costly resourcing implications of acute-care hospitalizations.

Introduction

Insulin treatment for individuals with type 1 diabetes (T1D) is vital to sustain life. Since the turn of the century, advancements in microelectronics allowed for portable automated insulin pumps to challenge the conventional treatment method of manual injections. By more closely regulating blood glucose levels, the insulin pump is increasingly closer to mimicking the function of the pancreas; having measured advantages when considering both a psychosocial and clinical lens for the right candidate (Blackman et al. 2014, Choudhary et al. 2019, Zuijdwijk et al. 2013). This health technology comes at a steep price with upfront costs ranging between $4000-$9000, remaining financially inaccessible to many. To help offset the cost of insulin pump therapy, Canadian provinces and territories began to establish their own universal funding programs beginning in the early 2000s as pediatric programs. Expansion from pediatric programs is becoming increasingly popular, with some eliminating the age restriction completely as seen in Ontario, British Columbia, Alberta and the territories. Despite the importance of these programs for treatment accessibility across socioeconomic statuses (SES), there are limited program evaluations measuring their impact on health outcomes, leaving policy makers without necessary feedback to adjust future policies and distribution of funds.

To date, the most comprehensive program evaluation in the Canadian context focuses on outcome measures around dynamics underlying pump use and adverse events (Shulman et al. 2016a, Shulman et al. 2016b, Shulman et al. 2017b). Their findings are useful from a policy perspective as key findings revealed a need to intervene to reduce social disparities and adverse health outcomes. Similarly, others have found that

socioeconomically disadvantaged patients with T1D often have less optimal metabolic control and to be at greater risk for long term complications (McKergow et al. 2017, Zuijdwijk et al. 2013), with income and neighbourhood characteristics widely considered as key social determinants of health (Government of Canada, 2013, Okere et al. 2016). Another study from Newfoundland and Labrador, while not a program evaluation, identified characteristics and precipitating factors associated with diabetic ketoacidosis (DKA), the leading cause of morbidity and mortality among children with T1D, and therefore one of the leading causes of hospitalizations (Jackman et al. 2015). This study found a proportional relationship between severity of DKA, longer time to resolution of acidosis and longer length of stay to be observed. Additional indicators could be used to inform on the health outcomes of those with T1D, and further still of the benefits (or lack thereof) of public funding for insulin pump therapy. There remains a gap, however, in our understanding of whether participants within universal insulin pump programs experience a noticeable change in health outcome compared to those who self-manage with manual injections. A study that would investigate whether there are tangible health impacts from universal pump programs today would offer policymakers invaluable information. Specifically, this study uses secondary data from provincial administrative health datasets for all acute-care inpatient stays for diagnosed diabetes, and length of stay (LOS) as a proxy to represent hospital-based health outcomes between those in the New Brunswick Pediatric Insulin Pump Program (PIPP) versus those who are not. Relative to other Canadian jurisdictions, New Brunswick is a small Atlantic Canadian province (747 thousand residents) that is more rural and of lower wealth (Statistics Canada, 2017). LOS was chosen as outcome measure to represent health outcomes as it indicates the severity

of the hospitalization event, as well as care plans and self- management practices (Buttigieg et al. 2018). At the time under observation, the PIPP offered funding for pediatric patients (<19 years) to purchase an insulin pump and supplies among all residents that are eligible for the publicly funded provincial healthcare coverage—known as New Brunswick Medicare. Our objective was to assess whether PIPP participation is associated with hospital LOS. We hypothesized that we would observe significantly shorter mean acute LOS among PIPP participants, through better self-management abilities. All administrative data was accessed at the New Brunswick Institute for Research Data and Training (NB-IRDT) in a secure lab facility.

Methods

Data sources

This study used a retrospective population-based cohort approach using linked health administrative and geospatial databases. The administrative datasets included information on all acute-care hospitalizations, Medicare eligibility, PIPP participation, and individual demographics. To ensure protection of privacy and personal health information, all personal health information accessed has been de-identified prior to receipt by the NB-IRDT and is only accessible in a de-identified format in a secure environment. First, the provincial hospital Discharge Abstract Database (DAD) was used to identify the study population. The DAD captures administrative and clinical information on all acute-care inpatient stays (CIHI, 2018). This database is considered a valid source for diabetes surveillance in hospital settings (Jiang et al. 2016). Diabetes-attributable admissions were identified based on the International Classification of

Diseases, Tenth Revision (ICD-10 codes E10-E14) and included multiple years of observation (fiscal years 2012/13 to 2014/15) to ensure sufficient sample sizes for analysis. While the ICD-10 codes included hospitalizations for both types 1 and 2 diabetes, given the restriction to pediatric patients, cases in this study could be considered to reflect T1D alone. The New Brunswick Citizen Database contains information on patient's age, sex and place of residence. Those who were found to have moved from the province of New Brunswick during the period of observation were omitted from the analysis. We used the PIPP database to identify any individuals with at least one submitted application to the PIPP within the three-year period and censored those who surpassed their 19th birthday.

We linked the data with geospatial measures of socioeconomic status from the Canadian Marginalization Index (CAN-Marg), as the administrative datasets are lacking information that can be used to gage individuals' access to economic resources independent of government programs. The CAN-Marg comprises area-based measures derived from census data that can be used to identify socioeconomically vulnerable population groups, who may in turn be at greater risk of adverse health outcomes such as diabetes and its complications (Matheson et al. 2012). We linked neighborhood deprivation information to the individual-level data based on annual residential postal codes.

Study Population

The study population consists of all New Brunswick inpatients 0-18years who were recorded to have diabetes as the primary reason for hospital stay. Inpatients with

valid residential and neighborhood deprivation information and who were eligible for New Brunswick Medicare were included in the study population.

Outcome of interest

LOS was chosen as outcome measure to represent health outcomes for this study as it is indicative of the severity of the hospitalization event and provides insight on self-management practices (Buttigieg et al. 2018). Diabetes-related hospitalizations are considered largely preventable through appropriate access to primary care and effective self-management practices (Gibson et al. 2013, Petrosyan et al. 2017). Further, LOS is a commonly used indicator for health care utilization and performance (Zhong et al., 2018, Bueno et al., 2010, Buttigieg et al., 2018, Huang et al., 2013).

Predictor Variables

The primary key predictor variable was participation in the PIPP. The variable was measured dichotomously to indicate whether an individual submitted an application to access PIPP benefits or not. This approach has been used in similar Canadian studies to create study cohorts using the provincial Assistive Device Program (ADP) data from Ontario (Shulman et al., 2017b). Similar to the ADP database, the PIPP contains records of initial application for pump funding and annual renewal applications for pump supplies. All individuals who had an initial application for insulin pump funding within the study period were included.

Patient demographics including age, sex and place of residence were obtained from the Citizen Database. With respect to age, the population was divided into three age groups. Sex was recorded as female or male. Health region of residence (zones 1-7) was

included as a potential confounding factor, that is, geographically defined areas across the province delineated for purposes of administrative healthcare planning and resourcing (Statistics Canada, 2018).

Socioeconomic status was captured indirectly at the residential neighbourhood level using an indicator of material deprivation from the CAN-Marg. Quintiles were created from Canadian census data by sorting area-based information on different dimensions of social and economic marginalization into five groups of households across the country (Matheson et al., 2012). For this study, material deprivation was used as the key composite measure, with a quintile value of 5 reflective of the highest magnitude of marginalization (least affluent households) and a quintile value of 1 the least deprivation (most affluent households).

Statistical analysis

Descriptive statistics were calculated for the outcome and predictor variables. A bivariate analysis was conducted between length of stay and the key predictor variable, PIPP participation, using an independent samples T-test. Multiple linear regression analysis was then conducted to assess the associations of our set of predictor variables on LOS. Assumptions of validity of a linear regression approach were found to be met and the residual of the regression was observed to follow a roughly normal distribution. Confidence was set at 95% for all statistical tests (α=0.05). The analyses were conducted using SPSS 25 statistical software package.

Ethics

This study was approved by the University of New Brunswick's Research Ethics Board, for compliance with ethics protocols for conducting secondary analyses using de-identified administrative health data sets (REB #2017-076).

Results

Data flow

The cohort of T1D inpatients was found by first identifying all unique patients 0-18 years old with primary diagnosis of diabetes in the DAD (N=279). Since patients may have more than one hospital stay, we then looked at the total number of hospital records among patients with NB Medicare eligibility (N=392). Total LOS thus reflects a combination of both single admissions as well as readmissions during the period of observation. Excluding those lacking a valid residential postal code history in New Brunswick or neighborhood deprivation information, our final cohort included a total of 386 hospital stays in the period of observation.

Descriptive statistics

As seen in Table 2, one-fifth (21%) of pediatric inpatients had participated in the PIPP. Age groups were roughly divided between those <9 years old (N=111), 10-14 years old (N=152), and 15-18 years old (N=123). There were more female inpatients compared to male patients, with a higher proportion of inpatients living in the most socioeconomically deprived neighborhoods (N=161) compared to the least deprived neighborhoods (N=78). Further, there was a notably lower proportion of PIPP

participants in both Saint John and Fredericton regions (HR 2 and HR 3), with a much higher proportion of PIPP participants in the northern areas of the province (HR 4-7). For all other variables, the distribution of PIPP and non-PIPP were found to be fairly consistent.

Table 2. Baseline characteristics of inpatient stays for pediatric diabetes by PIPP participation.

Variable	**Categories**	**Total**	**PIPP participants**	**Non-PIPP participants**
Age group	0-9 years	111	24 (21%)	87 (78%)
	10-14 years	152	37 (24%)	115 (75%)
	15-18 years	123	20 (16%)	103 (83%)
Sex	Male	171	39 (22%)	132 (77%)
	Female	215	42 (19%)	173 (80%)
Health region	1 (Moncton area)	99	24 (24%)	75 (75%)
	2 (Saint John area)	93	13 (14%)	80 (86%)
	3 (Fredericton area)	108	15 (13%)	93 (86%)
	4-7 (northern areas)	86	29 (33%)	57 (66%)
Neighborhood deprivation quintile	1-2 (least deprived)	78	22 (28%)	56 (72%)
	3-4	147	27 (18%)	120 (82%)
	5 (most deprived)	161	32 (20%)	129 (80%)

TOTAL	**386**	**81 (21.0%)**	**305 (79.0%)**

Source: Linked administrative health and geospatial datasets, 2012/13-2014/15.

Bivariate analysis

A significant association was found between PIPP participation and acute length of stay. Those in the PIPP had shorter hospital stays on average (M=3.25, SD=2.55) compared to those not in the PIPP (M=4.03, SD=3.14); $t(384)$= -2.08 , p=0.14.

Results from the multiple linear regression analysis

As seen in Table 3, PIPP program participation significantly predicted acute-care LOS, where inpatients stayed 1.3 days less on average in acute care for a diabetes-related admission compared to inpatients without PIPP participation, after controlling for other variables ($P<0.05$).

Those in the oldest pediatric age group (15-18 years) were found to be significantly associated with shorter length of stay, by roughly 1 day, compared to those in the youngest age group (0-9 years). Some differences were observed by health region, with inpatients residing in Health Regions 2 (Saint John area) and 3 (Fredericton areas) having shorter average lengths of stay compared to those residing in Health Region 1 (Moncton area). Both sex and residential neighborhood deprivation (representing SES) were not found to be significant predictors of acute-care length of stay.

Table 3. Results from the linear regression analysis for predictors of hospital length of stay.

Variable	B	*p*	95% Confidence Interval	
			Lower Bound	Upper Bound
Program participation (ref: non-PIPP)				
PIPP participation	-1.342	0.000	-2.054	-0.631
Age group (ref: ages 0-9)				
Ages 10-14	0.282	0.425	-0.414	0.978
Ages 15-18	-1.036	0.006	-1.767	-0.306
Sex (ref: male)				
Female	0.278	0.338	-0.292	0.849
Health region (ref: region 1)				
Health region 2	-2.239	0.000	-3.065	-1.412
Health region 3	-1.449	0.000	-2.228	-0.671
Health region 4-7	0.467	0.303	-0.423	1.357
Neighborhood deprivation quintile (ref: Q1-Q2)				
Neighborhood deprivation Q3-Q4	0.276	0.493	-0.516	1.068
Neighborhood deprivation Q5	0.407	0.339	-0.430	1.244

Source: Linked administrative health and geospatial datasets, 2012/13-2014/15.

Discussion

In this retrospective population-based study comparing hospital-based health outcomes among PIPP participants and those not benefitting from the program, we found a significantly shorter mean LOS for diabetes complications among pediatric patients who were receiving support from the PIPP. Specifically, we found the intervention of program participation to have a positive impact on limiting acute length of hospital stay, by roughly 1.3 days. These findings support the original hypothesis where it was thought that PIPP participation would support health outcomes overall, and thereby reduce the LOS for those inpatients. Among published studies on the predictors of hospital-based outcomes among pediatric diabetes patients, to our knowledge this is the first conducted comparing LOS for hospitalizations by universal funding support for insulin pump supplies.

Our comparison of those in the PIPP with non-participants revealed a significant difference in health outcomes through LOS. This outcome is indicative of better health outcomes and overall indirectly reflective of better pre-admission and post-discharge care plans and self-management abilities for those who are with the PIPP. These results align with findings from Ontario's evaluation of the Assistive Device Program (ADP), whose key findings suggest reason to support insulin pump programs with more focus on the safety profile, physician's perspective, predictors of adverse events and the role of SES (Shulman et al., 2016a, Shulman et al., 2017a). The present study thus adds to the small but growing body of literature surrounding Canadian funding schemes and patient outcomes focused on pediatric hospital stays for type 1 diabetes patients (Angus et al. 2007). Further, our findings are supportive of the insulin pump as an effective health

technology for managing T1D impacts on the publicly-funded healthcare system. With the shorter LOS observed among PIPP participants, our results are consistent with other studies that show benefits to utilizing an insulin pump to support positive health and healthcare outcomes (Blackman et al. 2014, Choudhary et al. 2019).

Interestingly, neighborhood deprivation quintiles, our indicator of SES, was not found to be a significant predictor of acute-care LOS in this study. These results do not align with the literature which consistently shows SES to be positively correlated with health outcomes for those with T1D (McKergow et al. 2017, Zuijdwijk et al. 2013). It is possible that, due to New Brunswick's relatively small and homogeneous population in the Canadian context, there lacked sufficient statistical power in terms of population sizes across all five deprivation index quintiles to show or account for disparity.

Limitations of the study

The use of administrative data, collected for purposes of program administration rather than research use, was the main source of limitations for this study. Given the available data, applications for pump funding were measured rather than actual pump use. It is therefore possible that some individuals may have applied for funding but eventually choose not to use the pump, or there may have been individuals using a pump who did not apply for funding through the PIPP. Further, while LOS is a useful indicator for hospital-based health outcomes, additional patient-level variables such as family income, parental education and ethnicity, as well as measures of primary care use and guideline-informed clinical care received, could have offered a more complete understanding surrounding the barriers to access and impacts of the PIPP. Additionally, due to privacy

concerns when using a small sample size, we were unable to distinguish DKA-related hospitalizations from other diagnostic reasons. More generally, there is a lag between administrative data capture and data readiness for research use (Lucyk et al., 2015). This limitation made it so that we could not analyze the most current data, being limited up to fiscal year 2014/15.

Conclusions

Participation in a universal funding insulin pump program was associated with shorter hospital LOS among pediatric patients with diagnosed diabetes. This is indicative of a noticeable impact on the health of individuals and is suggestive that the long-term investment in pump coverage programs, such as the PIPP, may already be having financial returns. These findings should be considered when informing future evidence-based policy and program development, particularly for new efforts supportive of the expansion of pediatric programs. Future work should include a cost-benefit analysis component for these models of care.

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4 Discussion

This thesis analyzed the relation between PIPP participation and hospital-based health outcomes among pediatric T1D inpatients in New Brunswick. I used a retrospective population-based study approach using linear regression methods to understand the patterns of PIPP participation and adverse events as observed through LOS in hospital. This chapter will summarize the key findings of the study, discuss these findings more broadly, highlight the strengths and weaknesses of the research, as well as discuss the possible implications and meaning of the study and future research. Lastly, I discuss ethical considerations that were taken, identify the ongoing knowledge translation efforts of this study as well as plans for future dissemination.

4.1 Summary of Key Findings and Results

The current research aimed to better understand the impact of the PIPP on health outcomes, with the specific intent to better understand whether participation in the PIPP predicts LOS among pediatric T1D inpatients in New Brunswick. Although no causal relationship can be inferred, the LOS for those in the PIPP when compared to non-participants was found to average a significantly shorter time in overnight stays, demonstrating that program participation has a positive impact on health outcomes. By comparing PIPP participants to non-participants, I was able to clearly distinguish hospital-based health outcomes between both groups. The results of this study show PIPP inpatients spent less time when admitted to hospital for diabetes complications, thus requiring less allocation of hospital resources through the provision of acute care to mitigate disease severity. Given that healthcare costs for those with T1D have previously

been found to be higher than those of the general public (Buttigieg et al. 2018), this information is important for policy makers to be aware of when considering public funding for assistive devices and other self-management aids for pediatric patients with chronic disease. Policy-makers can use this information to better target interventions and programs to limit potential risk of this vulnerable population to the need for acute care. It can be inferred from the current study that by investing in the self-management and capability of those with T1D (through the funding of access to health technology), that healthcare dollars can be saved in the long-term. How much could be determined in future analyses.

Although these results are statistically significant in indicating an inverse association between PIPP resourcing and burden to the hospital system, it is nevertheless important to note that PIPP participation is not the only predictor variable for hospital LOS, and many potential confounders remained unmeasured. The R-squared value for the multiple linear regression was 0.17, indicating only 17% of the variance in LOS across patients was accounted for by the variables within the model. Such a relatively lower R-squared value is not unexpected where human behavior, including self-management practices, are more difficult to predict. Expanded data linkages including greater breadth of patient-level characteristics, physician service use in primary care, and other health system and policy characteristics could expand opportunities for future research.

4.2 Interpretation through the Health Capability Model

The approach of the Health Capability Model (elaborated in section 2.4) is to acknowledge that individuals' function under social structures over which they have very little control, while also acting as an autonomous individual making their own health and well-being decisions. Within this framework, this research explored how access to an economic resource (the insulin pump), directly influences an individual's ability to utilize this resource to manage their health. Essentially from Figure 2, the program permits access to an otherwise financially expensive health technology (an economic resource), which should have a noticeable impact on health capabilities and healthiness (which the current study captures through LOS).

Results show the LOS for those in the PIPP to be significantly shorter when compared to those who were not in the PIPP. This suggests that when individuals have greater health capability though the support of economic resources, health capability increases. The increase in health capability may be demonstrated by an increased ability to act with agency and generate habits and a lifestyle that is conducive to needing less intense or prolonged care when accessing services.

Further study, particularly of the qualitative nature, is recommended to explore how the Health Capability framework may have an impact on self-management practices, care plans and health outcomes. Additional research is also recommended to analyze the broader picture of factors that influence LOS versus number of times a person may be admitted to hospital. The inclusion of other social determinants of health could provide a more holistic picture of why certain health outcomes may be occurring and thus have greater potential to inform health in all policies.

4.3 Ethical Considerations

Approval for the use of data from the PIPP and other provincial administrative health databases accessed through the NB-IRDT for secondary analysis was granted by the University of New Brunswick–Fredericton's Research Ethics Board (REB) for compliance with the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (CIHI, 2014). This approval was granted following a rigorous review process by the NB-IRDT, including a feasibility review, scientific peer review, government data stewardship review, and privacy review under the auspices of a larger research project entitled "Assessing effective coverage of comprehensive healthcare for diabetes prevention and management" (REB file #2017-076).

Before data analysis began, successful transfer of the PIPP first had to occur in order to link with the other administrative data sets. This is the first independent research evaluation of the PIPP, as such the program data set was not previously available at the NB-IRDT or any other data custodian outside the New Brunswick Department of Health. Protection of personal information remained prioritized throughout the process, and data was only made available at the NB-IRDT given strict protocols to allow my access to the de-identified administrative data on program participants and hospitalizations. All data sets contained pseudonymous information with original Medicare identifiers of individuals removed, and a temporary code for each individual was assigned and secured by approved Government and NB-IRDT personnel for linking participants between datasets. This was unavoidable in order to answer the current research question to match program participants with hospital admissions. The data was accessed in the computer lab at the NB-IRDT in a

locked and secure office only accessible to researchers with projects that had been approved and vetted for legitimate research purposes.

4.4 Strengths, Limitations and Future Research

The greatest advantage of the study was the availability and access to data from the health administrative databases available at the NB-IRDT. Drawing on multiple linked administrative data sets allows for a more comprehensive understanding of the pediatric T1D population in the province of New Brunswick and the related social determinants of adverse health outcomes. The linkage of the PIPP database to other health administrative databases enabled access to records of more than 300 pediatric patients. Without these linkages, it would otherwise not be feasible to make distinction between non-PIPP and PIPP participants in their respective health outcomes. Moreover, further linkage to the Can-MARG geospatial database allowed consideration of socioeconomic status in the absence of household income information for all T1D patients in the provincial administrative data. While the present study used only the material deprivation composite indicator, other measures reflective of marginalization are also captured in this dataset, including indicators of residential instability, population dependency and ethnic concentration. Consideration of such additional socioeconomic information could be an area for future research.

This is the first study to analyse the PIPP database in an academic context, and as such is the first independent investigation to help inform evidence-based decisions related to current provincial pediatric insulin pump funding policy; having the potential to directly influence health outcomes of this population. Being the first team to analyse the

PIPP database outside of the provincial government also presented some major challenges through significant delays in data access. This is due not only to the PIPP being a relatively new program, but also in part due to lags between data collection and data readiness for research use. An additional dataset from administrative sources, which captured patient-level information on all children and youth diagnosed with diabetes in the province from primary care physicians as well as hospital records based on the Canadian Chronic Disease Surveillance System (CCDSS) infrastructure, was not available for use in the NB-IRDT at the time of this study. Therefore, it was not possible to investigate the risk of hospitalization among the whole T1D population. Such lags between moving data and research into practice is the current reality and highlights the necessity of implementing new innovative measures to improve and effectuate the broader knowledge translation process.

Given I was limited to current administrative health data in the NB-IRDT, it was not possible to represent the other variables within the Health Capability model (social and cultural resources). Despite this, the model still provided a reasonable theoretical foundation to base the current research question and hypothesis from.

A limitation to the current study's approach is that it was not yet possible to observe inpatients past the newly raised age limitation of the PIPP coverage. Transition experiences from pediatric to adult care is recognized as a critical area of study that is important for both research and policy. Due to the many benefits associated with insulin pumps for those with T1D as described in Chapter 2, it is important that financial barriers are well understood and addressed to avoid potential health inequalities. Further work should focus on better understanding the transition experiences of those in pump programs to understand

their effectiveness, more specifically, whether they remain able to self-manage their T1D once they transition out of the program.

4.3 Knowledge Translation Plans

Results will be shared with government partners and senior practitioners in the regional health authorities to inform policy and planning decisions, as well as Diabetes Canada and the New Brunswick Health Research Foundation who provided financial support for this work. The funding agencies had no role in the study design, research implementation, or interpretation of the results. This research aimed to build on literature of insulin pump government funded programs and the relationship these programs have on self-management ability. Findings revealed that the PIPP is having positive effects on reduced hospital LOS for those in the program. This evidence can be used to inform decision makers around continuing the financing of medical supplies for those with T1D during adulthood, as a preventative measure to reducing hospitalization stays and perhaps reducing overall costs on the healthcare system.

To target an audience that has potential to adopt these research methods and findings to influence policy across jurisdictions, the protocol for this research was presented at the 2019 Canadian Association for Health Services and Policy Research (CAHSPR) annual conference (Appendix B), which has a focus on health services research for knowledge exchange. The author intended to present the final results at the New Brunswick Health Research Conference originally scheduled for November 2020, however it was announced in July 2020 that this event was cancelled due to ongoing COVID-19

pandemic disruptions. A seminar with the NB Department of Health had also been planned to disseminate results to inform future policy decisions concerning the PIPP.

Finally, this work is presented in an article-based format to facilitate prompt preparation of the findings for publication consideration after defense completion. The article will be submitted to the *Canadian Journal of Diabetes*, a peer-reviewed scientific journal that is aimed at diabetes health services and policy research, to add to the literature in this field.

Conclusion

Pediatric inpatients living with diabetes receiving support from a universal insulin pump program were found to have a significantly shorter mean hospital length of stay compared to those who had not benefitted from program resourcing, after adjusting for other potential demographic and socioeconomic confounding factors. This is indicative of a noticeable impact on the health of individuals and mitigation of disease severity, and is suggestive that the long-term investment in pump coverage programs, such as the PIPP, may already be having an economic impact downstream. These findings should be considered when informing future evidence-based policy and program development for chronic disease management, particularly for new efforts supportive of the expansion of pediatric programs into young adulthood. Overall, this work adds a new layer of understanding on the role of provincial pediatric insulin pump programs, in hopes to ultimately support health outcomes for this population.

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Appendix A: Eligibility criteria for the PIPP during the period of study

Section 4: Applicant Eligibility for Program Benefits

The following criteria must be met.

VALID MEDICARE NUMBER

The applicant must be insured as defined in the New Brunswick Medical Services Payment Act and have a valid New Brunswick Medicare Number.

PERMANENT RESIDENCE

The applicant must hold permanent residency in New Brunswick.

Eligibility Criteria for Insulin Pumps and Supplies

Children and youth, eighteen (18) years of age and under with Type 1 diabetes, will be eligible for funding assistance if they meet the following established criteria as ascertained by the managing Pediatrician and pediatric diabetes clinic team:

- Patients and their caregivers must already be involved in regular follow up by their diabetes health care team and be reviewed at least 3 times per year and demonstrate a sound knowledge of diabetes self management.
- Patients and/or caregivers (age dependent) must already demonstrate sound knowledge of carbohydrate counting.
- Patients/caregivers must already be practicing self monitoring of blood glucose, a MINIMUM of four times/day (at least before meals and at bedtime) and agree to continue to do as such.
- The patient and their caregivers must complete an insulin pump educational program, given by a certified insulin pump instructor.
- There is evidence of appropriate, ongoing family support.The child is actively attempting to meet and/or maintain the A1c goal that is identified in their care plan (reflecting the CDA clinical practice guidelines for pediatric management[1]).
- The child has not had more than two (2) diabetic ketoacidosis (DKA) in the previous 6 months.

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[1] Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2008 clinical practice guidelines for the prevention and management of diabetes in Canada: Type 1 Diabetes in Children and Adolescents. *Can J Diabetes. 2008;32(suppl 1):* S151

Appendix B: Poster presented at the CAHSPR Annual Conference

Impact of the New Brunswick Pediatric Insulin Pump Program on Type 1 Diabetes Health Outcomes: A Population Based Cohort Analysis

Heather Higgins, Master's student of Applied Health Services Research, Faculty of Interdisciplinary Studies, University of New Brunswick
Dr. Neeru Gupta, Associate Professor & Diabetes Research Chair, Department of Sociology, University of New Brunswick

BACKGROUND

- Type 1 diabetes (T1D) is a chronic autoimmune disease with no known cure. Insulin therapy is vital to sustain life.
- Treatment options are manual injections or an insulin pump. The pump is roughly 3 times more expensive.
- Beginning in the early 2000's, universal funding programs emerged across Canadian provinces to help offset the cost of insulin pump therapy.

Overview of Insulin Pump Programs

Provinces	Pump coverage by age
Alberta, British Columbia, Ontario	All ages
Manitoba, Prince Edward Island, Quebec	Ages 17-18 and under
New Brunswick, Newfoundland and Labrador, Nova Scotia, Saskatchewan	Ages 24-25 and under

NEW BRUNSWICK PEDIATRIC INSULIN PUMP PROGRAM (NB-PIPP)

→ Introduced in 2012 for ages 18 and under
→ Expanded in 2018 to ages 25 and under

Manual injections

Insulin pump

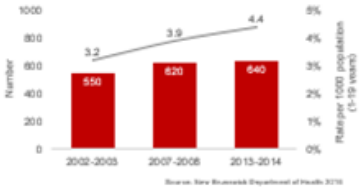
OBJECTIVES

1. To provide the first impact evaluation of the NB-PIPP
   — Does it lead to better and equitable health outcomes among children and adolescents
2. To provide a baseline of evidence on the transition to young adulthood

METHODS

- Longitudinal population-based cohort study
- Includes all those ≤18 years with T1D in 2012 (time of introduction of the NB-PIPP)
- Assessment of the risk of a diabetes-related hospitalization from 2012/13 to 2015/16 (three years follow up period)

Prevalence of diabetes among children and youth, New Brunswick



DATA SOURCES

Linked provincial administrative datasets:
→ Canadian Chronic Disease Surveillance System
→ NB-PIPP Database
→ Hospital Discharge Abstract Database
→ NB Citizen Database
→ Geostatistical data from the Postal Code Conversion File

METHODS

VARIABLES

- Outcome: Hospitalized at least once for diabetes
- Key predictor: Participation in the NB-PIPP (yes/no)
- Controls: Age, sex, rurality, neighbourhood income level

STATISTICAL ANALYSIS

- Multiple logistic regression — Results will be presented as odds-ratios, using the Wald test for significance of each predictor ($p<0.05$)

SIGNIFICANCE

- Results will be shared with partners in the provincial government and other health system stakeholders to help inform financing policy decisions and accountability

ACKNOWLEDGEMENTS

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UNB EST. 1785 UNIVERSITY OF NEW BRUNSWICK

NB-IRDT New Brunswick Institute for Research, Data and Training

Halifax, May 29–31, 2019

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Conference Presentations:

Higgins, H. & Gupta, N. (May 2019). *Impact of the New Brunswick Pediatric Insulin Pump Program on Type 1 Diabetes Health Outcomes: A Population Based Cohort Analysis*. Canadian Association of Health Services and Policy Research (CAHSPR). Halifax, NS.

Higgins, H. & Gupta, N. (March 2019). *Impact of the New Brunswick Pediatric Insulin Pump Program on Type 1 Diabetes Outcomes: A Population Based Cohort Analysis*. University of New Brunswick Graduate Research Conference (UNBGRC). Fredericton, NB.