# Can primary care and continuity of care prevent asthma-related emergency department use and hospitalizations amongst children?

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## ABSTRACT

### Objective

Having a primary care provider and a consistent, continuous relationship with said provider may be important for asthma outcomes. In Québec, children are mainly followed by family physicians in family medicine groups (FMGs), family physicians not part of FMGs, or by pediatricians. We sought to determine 1) whether having a usual provider of primary care was associated with asthma-related emergency department (ED) visits and hospitalization in Québec children with asthma and 2) whether continuity of care with a primary care provider was associated with acute asthma outcomes.

### Methods

This was a population-based retrospective cohort study that used Québec provincial health administrative data from 2010-2013. The population was children diagnosed with asthma, aged 2-16 years old (N=39, 341). The main exposure was the primary care model (FMGs, non-FMGs, or pediatricians, compared to no assigned usual provider of care (UPC)). For those with an assigned UPC, continuity of care was measured by the UPC Index (high, medium, low). The main and secondary outcomes were asthma-related ED visits and hospitalizations, respectively. Multivariate logistic regression analyses were used to test associations between exposures and outcomes.

### Results

Overall, 17.4% of children diagnosed with asthma in Québec had no assigned UPC. Compared to no assigned UPC, having a UPC was associated with decreased asthma-related ED visits (Pediatrician Odds Ratio (OR): 0.80, 95% confidence interval (CI) [0.73, 0.89], FMGs OR: 0.84, 95% CI [0.75,0.93], non-FMGs OR: 0.92, 95% CI [0.83, 1.02]) and hospital admissions

(Pediatrician OR: 0.67, 95% CI [0.59, 0.76], FMGs OR: 0.83, 95% CI [0.73, 0.94], non-FMGs OR: 0.77, 95% CI [0.67, 0.87]). Children followed by a pediatrician were more likely to have high continuity of care. Continuity of care was not significantly associated with asthma-related ED visits but compared to low continuity, medium or high continuity was associated with decreased asthma-related hospital admissions (Medium OR: 0.81, 95% CI [0.73, 0.90], High OR: 0.72, 95% CI [0.63, 0.82])

**Conclusion**

Having a usual provider of primary care was associated with reduced asthma-related ED visits and hospital admissions. For those who had a UPC, high continuity of care was associated with reduced likelihood of asthma-related hospital admissions.

**RÉSUMÉ**

**Objectif**

Avoir un fournisseur de soins primaires et une relation stable et continue avec celui-ci peut avoir un effet important sur les complications de l'asthme. Au Québec, les enfants sont principalement suivis par des médecins de famille dans les groupes de médecine de famille (GMF), des médecins de famille ne faisant pas partie des GMF, ou par des pédiatres. Nous avons cherché à déterminer 1) si le fait d'avoir un médecin de soins primaires était associé aux visites à l'urgence et à l'hospitalisation due à l'asthme chez les enfants québécois atteints d'asthme et 2) si la continuité des soins avec un fournisseur de soins primaires était associée à des complications aiguës reliées à l'asthme.

**Méthodes**

Ce projet était une étude de cohorte rétrospective à partir de données administratives de santé de la province du Québec pour la période 2010-2013. La population était constituée d'enfants âgés de 2 à 16 ans ayant eu un diagnostic d'asthme (N = 39341). L'exposition principale était le modèle SP (GMF, non-GMF, ou pédiatre, vs. pas de soins primaires). Pour ceux avec un fournisseur de soins primaires, la continuité des soins a été mesurée par l'Indice de Fournisseur Habituel de Soins (élevé, moyen, faible). Les résultats principal et secondaire étaient respectivement les visites à l'urgence et les hospitalisations liées à l'asthme. Des analyses de régression logistique multivariées ont été utilisées pour tester les associations entre les expositions et les résultats, ajusté en fonction des facteurs de confusion potentiels.

**Résultats**

Dans l'ensemble, 17,4% des enfants asthmatiques ayant reçu un diagnostic d'asthme n'ont pas été suivis par un fournisseur de soins primaires. Comparé à l'absence de soins primaires, avoir accès

aux soins primaires était associé à une diminution du nombre de visites aux urgences liées à l'asthme (OR de pédiatre: 0,80, 95% CI [0,73, 0,89], OR de GMF : 0,84, 95% CI [0,75, 0,93], OR de non-GMF : 0,92, 95% CI [0,83, 1,02] ) et du nombre d'hospitalisations (OR de pédiatre: 0,67, 95% CI [0,59, 0,76], OR de GMF: 0,83, 95% CI [0,73, 0,94], non-FMG: 0,77, 95% CI [0,67, 0,87]). Les enfants suivis par un pédiatre étaient plus susceptibles d'avoir une continuité de soins élevée. La continuité des soins n'était pas significativement associée aux visites aux urgences due à l'asthme, mais comparée à une continuité faible, une continuité moyenne ou élevée était associée à une diminution des hospitalisations due à l'asthme (OR moyen: 0,81, 95% CI [0,73, 0,90], OR élevé : 0,72, 95% CI [0,63, 0,82]).

**Conclusion**

Avoir un fournisseur de soins primaires est associé à une réduction du nombre de visites aux urgences et d'hospitalisations liées à l'asthme. Pour ceux qui ont un fournisseur de soins primaires, une continuité de soins élevée est associée à une probabilité réduite d'admissions à l'hôpital due à l'asthme.

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## PREFACE & CONTRIBUTION OF AUTHORS

This thesis was developed with the support and guidance of my co-authors. This manuscript (Chapter 5) is a product of the research that was conducted in this thesis. The manuscript that was developed will be submitted for publication in *Pediatrics,* the official peer-reviewed journal of the American Academy of Pediatrics. This high impact journal publishes contributions which are important to the field of pediatrics which include the following focuses; nutrition, surgery, dentistry, public health, child health services, human genetics, basic sciences, psychology, psychiatry, education, sociology, and nursing. The results from the manuscript are focused in the fields of child health services, making this a valid submission in this journal.

Sarah Cooper constructed the design of the project and the manuscript with the support and input of Dr. Patricia Li, Dr. Roland Grad, Dr. Sze Man Tse, and Dr. Elham Rahme. The data collection was facilitated by Dr. Patricia Li (owner of the data). Marc Dorais cleaned and verified the initial data from Régie de l'assurance maladie du Québec. Marc Dorais also withdrew all necessary variables from the original, larger dataset for this project. All programs executed and data analyses were conducted by Sarah Cooper. Results were also analyzed and interpreted by Sarah Cooper and Dr. Patricia Li. Sarah Cooper was the lead writer and drafted the manuscript. All five authors Sarah Cooper, Dr. Patricia Li, Dr. Roland Grad, Dr. Sze Man Tse, and Dr. Elham Rahme critically reviewed the manuscript during several rounds of critique and feedback. All five authors gave their final approval of the manuscript for this thesis along with giving the final approval of the thesis.

**LIST OF ABBREVIATIONS**

ED: Emergency Department

FMG/GMF: Family Medicine Groups/ Groupes de Médecine de Famille

UPC: Usual Provider of Care

HI: Herfinndahl Index

COC: Bice-Boxerman Continuity of Care Index

SECON: Sequential Continuity of Care Index

MMCI: Modified Modified Continuity Index

RAMQ: Régie de l'Assurance Maladie du Québec

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

Q: Socioeconomic Quintile

IQR: Interquartile Range

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## CHAPTER 1: INTRODUCTION

Of the few studies that have examined the role of primary care for asthma in children, having a primary care doctor and seeing them continuously has been shown to decrease costly and unplanned emergency department (ED) visits and hospitalizations (1). In the province of Québec, children can be enrolled with a primary care family physician, belonging to a multidisciplinary reform model known as Family Medicine Groups (FMGs) or with a family physician belonging to traditional models of primary care (2, 3). Alternatively, children can be followed by pediatricians, or not at all (2). No recent studies have evaluated the impact of primary care on asthma outcomes for children despite over a decade of primary care reforms.

Over 220 FMGs have been introduced in the province since 2002, as a response to some wide-recognized challenges facing Québec's health care system (2-5). An FMG is comprised of a group of family physicians working with nurses and other allied health professionals (3, 6, 7). FMGs were intended to increase accessibility and continuity of care by extending clinic hours and offering same-day appointments. However, there has been some contrasting results in terms of the impact that the creation of these FMGs have had on patients' health services, including accessibility and continuity of care (3).

Continuity of care is a core component of primary care especially for patients with chronic diseases such as asthma (8). Longitudinal continuity is a measure of the frequency of the interactions between the patient with his/her healthcare provider reflecting the concept of continuity of care (9, 10). Longitudinal continuity can be ascertained with the Usual Provider of Care (UPC) Index, which measures the proportion of primary care visits with an assigned UPC over a given period of time (10, 11).

The goal of this thesis is to present an empirical assessment of the role that primary care and continuity of care has on healthcare utilization for children with asthma living in Québec. We first measured the association between existing primary care models (family physicians in FMGs, pediatricians, family physicians in non-FMGs, and no assigned UPC) in Québec and acute care outcomes including ED visits and hospitalizations. Secondly, for those children with an assigned UPC, we measured the association of continuity of care (using the UPC Index) and the same acute care outcomes.

Our primary research question was:

1) Among Québec children diagnosed with asthma (aged 2- 16 years old on January 1, 2012), what is the extent to which having a assigned UPC (no UPC compared to family physicians in FMGs, family physicians in non-FMGs, or pediatricians) is associated with asthma-related healthcare utilization, as measured by emergency department (ED) use and hospital admissions?

Our secondary research question was:

2) Among Québec children diagnosed with asthma and who have an assigned UPC (family physicians in FMGs, family physicians in non-FMGs, and pediatricians), what is the extent to which continuity of care with a UPC is associated with healthcare utilization, as measured by asthma-related ED visits and hospital admissions?

Asthma continues to be one of the main reasons for ED visits and hospitalizations in children. The current thesis aims to gain insights into the role of primary care and continuity of care in the management of asthma. We will use the findings from this study to inform practice and policy through knowledge users.

## CHAPTER 2: BACKGROUND

### *2.1 Introduction to Primary Care*

According to the Government of Canada, primary health care is an approach to health, which focuses on health care services that promote health, prevent illness and injury, and that diagnose and treat illness and injury. When looking at primary health care, one must also consider other determinants such as income, housing, education, and environment, which are known to impact a patient's health (12). Primary health care services may be delivered by physicians (family physician or pediatricians for children) or nurses (13, 14). Characteristics of primary care usually include first-contact access for each new need, long-time person-focused care, comprehensive care for most health needs, and coordinated care when health services must be sought elsewhere (14).

Comprehensiveness has been defined by the Institute of Medicine as the delivery of accessible and integrated health care services "by clinicians who are accountable for addressing a large majority of the personal health care needs" (15). Primary care physicians or providers are responsible for the comprehensive care of their undifferentiated patient and takes continuing responsibility for providing their patient's care throughout their lifetime (16). The primary care physician is also responsible for referring their patient to other health care professionals for consultation when needed (16).

Strong primary care systems lead to a strong, sustaining health care system (16, 17). In countries that have strong primary care, including a high number of primary care physicians per capita, there are lower health care costs, improved health outcomes, and healthier populations (16). In the United States, it was found that adding one family physician per 10,000 people would result in 35 fewer deaths (14). Similarly, in Canada, a population-based cross-sectional study in Ontario children using administrative data concluded that there were differences in access to and outcomes

of primary care related to local physician supply (18). Areas that had low access to a primary care physician had a higher rate of ED visits (440 vs. 179 per 1000) (18). As of 2014, according to Statistics Canada, 14.9% of Canadians aged 12 and older (approximately 4.5 million people), do not have a regular medical doctor (19).

*2.2 Continuity of Care*

Continuity of care is a core attribute of the College of Family Physicians of Canada, as the "patient-physician relationship is central to the role of the family physician" (20). Continuity of care is defined as a health care service that extends over some time, where there is a timely and effective exchange of health information between a patient and their individual medical professional or within a medical team (21). It is the patient's experience of a continuous, caring relationship with a health care professional (22).

As health care becomes more specialized, patients are often seen by an increasing number of clinicians, teams, and organizations (23). Thus, this concept of continuity of care can take on a variety of definitions and measures. Continuity of care can reflect at least four domains: interpersonal continuity, which is the experience of a caring relationship between patient and provider; longitudinal continuity, which is the history a patient's interaction with the same provider over a period of time; informational continuity, which is the availability of clinical information through encounters with providers; and management continuity, which is the effective collaboration and coordination of health care teams (10). Continuity in primary care is often seen as the relationship between the single provider and patient that extends beyond specific episodes of illness (9).

There are several measures for continuity of care, which use claims-based data (Table 1) (11, 24). Continuity of care measures could include the following: Bice-Boxerman Continuity of

Care (COC) Index, Herfindahl Index (HI), Usual Provider of Care (UPC) Index, Sequential Continuity of Care (SECON) Index as well as the Modified Modified Continuity Index (MMCI) (11, 24, 25). Four out of the five indices mentioned (COC Index, HI, MMCI and UPC Index) evaluate the extent to which a patient's visits are concentrated among a single provider or a practice group (11, 24). The SECON Index, however, considers the order of visits between providers (11). In a retrospective cohort study using a sample of adults with congestive heart failure, chronic obstructive pulmonary disease, and diabetes mellitus, the COC Index, HI, SECON Index, and UPC Index in Table 1 were found to be highly correlated to one another within predefined episodes of care (11).

The UPC Index measures the proportion of visits with a usual provider over a given period (23). It is a proportion score (Table 1), where $n_i$ represents the total number of visits to the same provider and $n$ represents the total number of visits made to all physicians during that time. The UPC Index reflects longitudinal continuity, the history of interacting with the same healthcare professional over some time (10). The COC Index, however, accounts for the number of different providers seen and is more associated with coordination of care by multiple providers (23). It does so by weighting the frequency of visits to each provider and the dispersion of visits between providers (26). The COC Index represents management continuity by measuring how often a patient saw the same physician over a given period of time (10, 24). HI is similar to the COC Index as it reflects the extent to which an individual's visits are concentrated with a single or group of providers but uses a different mathematical formula. The SECON Index measures the sequential pairs of visits at which the same provider was seen (11). A higher SECON Index would result from the same provider seeing a patient for consecutive visits, whereas alternating providers in a given sequence of visits (e.g., provider A, then B, then

A again) would result in a lower SECON Index (11). The MMCI is another measure of dispersion, similar to the COC Index, and it accounts for the degree of dispersion and coordination among different providers (27).

The UPC Index and the COC Index were examined in this thesis as these two measures address longitudinal and management continuity; two common concepts of continuity seen in the management of asthma in the primary care context (23). Although these measures have not been validated against patient surveys (8), the UPC and the COC Index are the two most commonly used administrative measures of continuity in primary care research (28). These UPC Index and COC Index have also been used in provincial reports in Manitoba analyzing health administrative data in order to inform health policy (29).

Once a patient's score has been calculated using one of the measures in Table 1, they are usually classified as having low or high continuity in a derived classification between 0 to 1. In the current thesis, the UPC index and COC index were assigned only to children who had a UPC. Since the UPC was assigned based on at least one visit to the primary care physician, the UPC index, according to the formula, must be >0. Low continuity in this thesis was defined a priori as a UPC index score from > 0 to 0.4, the medium between 0.4 and 0.7, and high between 0.7 and 1, as in previous research (10). The COC index was used in the sensitivity analyses to verify the results in the main analyses with the UPC index, and the same classification was used. However, due to the difference in algorithms listed in Table 1, it was possible for a child to receive a Bice Index Score of 0, even for those children with an assigned UPC (for example, the child had one visit with UPC, and one visit with another primary care provider). Those children who were assigned a family physician from an FMG as their UPC had a visit with their UPC and no other

primary care visits, were assigned a score of 1. Therefore, our sensitivity analyses used the following classifications: low (0- 0.40), medium (>0.40-0.70), and high (>0.70-1.0).

| Measure | Equation | Definition |
|---|---|---|
| Bice- Boxerman Continuity of Care Index (COC) | $\frac{(\sum_{i=1}^{p} n_i^2) - n}{n(n-1)}$ | The degree of coordination between different providers |
| Herfindahl Index (HI) | $\sum_{i=1}^{p} (\frac{n_i}{n})^2$ | The degree of coordination between different providers |
| Usual Provider of Care Index (UPC) | $\frac{n_i}{n}$ | The concentration of care with the same primary provider |
| Sequential Continuity Index (SECON) | $\frac{\sum_{j=1}^{n-1} c_j}{n-1}$ | Number of handoffs of information required between providers |
| Modified Modified Continuity Index (MMCI) | $\frac{1 - (p/(n+0.1))}{1 - (1/(n+0.1))}$ | The degree of coordination between different providers |

p= total number of providers
n=total number of visits during an episode
$n_i$= number of visits to provider i
$c_i$= indicator of sequential visits to the same providers; equal to 1 if visits j and j+1 are to the same provider, 0 otherwise

Table 1 Summary of Claims-Based Measures of Continuity of Care, Adapted from the Literature (11, 24)

Continuity of care is a core component in primary care especially for patients with chronic diseases such as asthma (8). High continuity of care should be provided to patients to reduce the risk of complications, improve preventive care, increase patient satisfaction, and decrease the requirement for emergency and unnecessary acute care visits (30). A systematic review conducted in 2010 looking at the general population of adults and children, found that of the nine studies included, eight demonstrated a significant association between increased continuity and decreased health care utilization in terms of hospitalizations and ED visits (31). A cross-sectional study in Québec using provincial health administrative databases and the UPC

Index as a measure of relational continuity showed that among the elderly, an increased rate of ED use was associated with lack of a primary care physician (Risk Ratio (RR): 1.45, 95% CI [1.41-1.49]) and low or medium (versus high) continuity of care with a primary care physician (Low RR: 1.46, 95% CI [1.44-1.48]; Medium RR: 1.27, 95% CI [1.25-1.29]) (32).

Similar associations have been reported in children using Medicaid data in the United States (1). Compared with children with the highest continuity of care, children with the lowest COC Index were more likely to have visited the ED (Hazard Ratio (HR): 1.58, 95% CI [1.49-1.66]) and to be hospitalized (HR: 1.54, 95% CI [1.33-1.75]) (1). In the same study children with asthma with low COC Index compared to high COC Index had a higher risk of being hospitalized (HR:1.79, 95% CI [1.21-2.56]) (1).

*2.3 Gaps in Asthma Care for Children*

Expert guidelines from the National Asthma Education and Prevention Program of the National Heart, Lung, and Blood Institute stress the importance of longitudinal asthma care with a primary care provider (33). In Canada, children with asthma can receive primary care from a general practitioner or a pediatrician (18). Factors of high-quality primary care relevant to delivering asthma care are continuity, comprehensiveness, communication, contextual knowledge, coordination and accessibility (34).

Despite there being a continued development and improvements in asthma treatments, there is evidence that patients have poor control of their asthma in Canada (35). In a population-based, cross-sectional survey of 801 adults and 200 children, asthma control was assessed according to recommendations from the 1996 Canadian Asthma Consensus Guidelines, which included the following: daytime symptoms three or more days/week, frequent asthma exacerbations within a month, three or more doses/week of a short-acting bronchodilator and

missed school and/or work within a three month period. Over half (57%) of the patients were considered poorly controlled (failed to meet at least two of the six criteria for control). Similarly, 51% needed urgent care for their poorly controlled asthma in the year prior (36). This study was, however, completed almost 20 years ago, with many changes occurring since this time, notably in the medications available and with the most recent guidelines update occurring in 2012 (36, 37). Suboptimal asthma control is associated with reduced quality of life and increased risk of asthma exacerbations (35).

Approximately 14% of children worldwide have been diagnosed with asthma, making the need for appropriate care even more vital (38). In Canada, asthma is the most common chronic diseases with a prevalence of 10% (39), and it is the most common cause of hospitalization in children aged 1-14 years old (40). The most recent available estimate as of 2010, suggests that the direct and indirect costs of asthma are estimated to be $2.10 billion annually (41). The direct costs of asthma include hospitalization, healthcare professional services, and medications while indirect costs associated with asthma included decreased productivity (40). In 2015, there were over 70,000 emergency room visits in Canada due to asthma exacerbations (42). Poor asthma control is a burden on the Canadian health care system (35).

Asthma can be managed with timely and effective outpatient care, which would be expected to reduce the need for hospitalization (30). A collaborative partnership between a family and their physician along with regular asthma maintenance visits in order to provide education and support is needed to ensure asthma control and reduce visits to the ED and hospitalizations (33). High rates to the ED can sometimes be explained by these patients turning to the ED for a source of primary care since they do not have a regular family physician or they have problems in accessing their family physician when needed (43).

A population-based study conducted in Ontario found that those people with chronic diseases (those patients who have been diagnosed with high blood pressure, diabetes, arthritis, heart disease, stroke, cancer, asthma, other respiratory problems, or depression) were two times less likely to use the ED if they had a family physician (43). Results from a retrospective review of Medicaid claims data for children with asthma found that those children who had a greater number of asthma-related primary care visits were less likely to have asthma-related ED visits ($p<0.001$) (44). Another retrospective cohort study conducted in 2001 in the United States, found that hospitalization risk for children with asthma was significantly increased for medium or low compared to high continuity of care (Medium HR: 1.61, 95% CI [1.10-2.38]; Low HR: 1.79, 95% CI [1.21-2.56]) (1). Under the Canadian health care system, there are still differences in access to primary care and outcomes such as ED use and preventable admissions amongst children (18). In areas where there was a higher supply of primary care physicians, there was more use of recommended primary care visits, less use of ED visits, fewer hospitalizations and fewer acute exacerbations for children with asthma (18). The burden to the Canadian health care system by poor asthma control could, therefore, be reduced through the availability of a primary care physician and a continuous relationship with the said physician.

*2.4 Québec Context of Primary Care and the Importance of FMGs*

In Québec, the impact of primary care on asthma care and outcomes has not been evaluated, even after a decade of primary care reforms. Since 2002, there has been a complete reorganization of the delivery of primary care services (45). FMGs were created in response to the widely-recognized challenges facing Québec's health care system. The Health Ministry's objectives for these FMGs were to provide all Québec residents with access to a family doctor, increasing accessibility of services and improving the quality of continuity of care (45). Before the

introduction of FMGs, about 25% of all Québecers did not have access to a family doctor (46). The lack of available primary care services resulted in overburdened EDs (45).

In the Québec model, an FMG would consist of a group of 6-12 physicians working closely with other health professionals such as nurses in order to provide services to their registered patients assigned to their group(47). As of 2014, there were 258 FMGs across the province (48). There have been several studies which have been conducted in order to examine the performance of this new primary care delivery system with regards to accessibility of services, continuity of care, and patient perceptions of their care experiences (49-52). One such study found that lower continuity of care with a primary care physician was associated with increased ED use amongst older adults living in Québec (32). In Québec, children mainly receive their primary care from one of the following primary care models; pediatricians, family physicians belonging to an FMG, or family physicians not part of an FMG. Children who do not receive primary care from one of the primary care models do not have an assigned UPC. We do not know whether these different primary care models and continuity of care within these models affect outcomes for children with asthma in Québec.

# CHAPTER 3: LITERATURE REVIEW

## 3.1 Introduction

A systematic review was conducted in order to gain a sense of what was known in the literature regarding continuity of care in the primary care context and this concept's impact on asthma care for children. Specifically, the aim was to see how previous studies have measured continuity of care and its association with acute care outcomes in children with asthma. The methodology and results of these studies were analyzed in order to formulate a methodologic approach for the current thesis.

## 3.2 Review Question

This literature review aimed to answer the following question: what is the impact of continuity of care with a primary care physician on outcomes, as defined by ED visits and hospital admissions, for children with asthma?

## 3.3 Methods

The biomedical literature was searched using PubMed to identify and collect all relevant articles from 1979 to 2018. The search strategy was developed with the help of an expert librarian, Genevieve Gore. The search strategy employed five concepts: 1) continuity of care, 2) outcomes such as ED visits and hospitalizations, 3) children, 4) primary care, and 5) asthma. The final search strategy including the Medical Subject Heading (MeSH) terms and specific search terms can be found in Appendix A1 and A2.

For the purposes of this project, *"continuity of care"* was conceptualized as the primary care provider's ongoing commitment and loyalty to their patient in the primary care setting (53). Continuity of care reflected the extent to which an individual sees a given primary care provider for a visit over a specific period (29). There are a variety of approaches for quantifying and defining

continuity of care (24, 54). This diversity reflects the differences in views regarding continuity of care (24). Therefore any measure or definition of continuity of care was included in this review. Primary care according to the WHO is "first-contact, accessible, continued comprehensive and coordinated care" (55). This definition of primary care was used in the search. Terms and/or professions that come under the "*primary care physician"* umbrella include general practitioners and/or family medicine physicians and/or primary care teams and/or pediatricians (55). In conducting this review, articles which looked at the continuity of care delivered by primary care physicians were included.

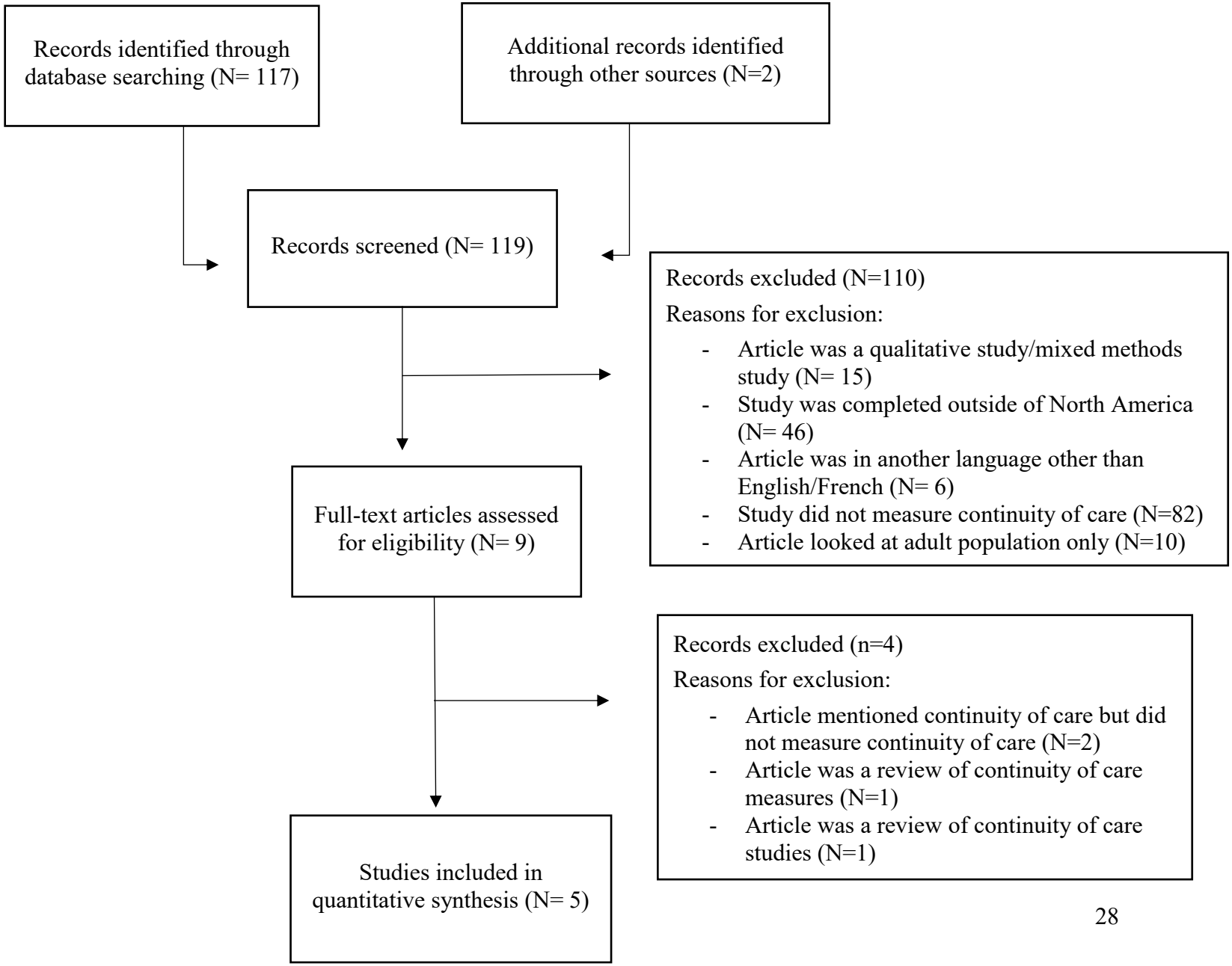
The specific inclusion/exclusion criteria for study selection can be found in Appendix A2. The review included children aged 0 to 18 years old who had pre-existing asthma. Pre-existing asthma was defined as individuals with recurrent symptoms and any sign of variable airway obstruction that was diagnosed to be asthma by a health care physician (56). The search was restricted to studies in North America for the purposes and context of the current thesis. Only primary research papers published in English or French were included. All study designs that involved primary care research were included except for research protocols, policy briefs, and commentaries. Only quantitative studies using acute care outcomes were included.

The results from PubMed were imported into a bibliographic management software program, EndNote X7.5.3 and no duplicate studies were detected. A total of 117 articles were retrieved (Figure 1). An additional two articles were included which were identified from the grey literature and referred to from other specialists in the field. After screening abstracts and titles, 8 articles were retrieved for full-text screening.

The second round of screening included going through a full-text screening of these 8 articles. Articles were then excluded according to the reasons listed in Figure 1. Five articles were

included in the final stages of data extraction and synthesis. Information on the characteristics of the studies along with the key findings were extracted and recorded in a data collection form. During the synthesis of this review, a meta-analysis was deemed to be not possible due to the heterogeneity of the exposure variable of continuity of care with a primary care physician. Thus, a narrative synthesis allowed us to synthesize the findings from these multiple studies in a clear and coherent way.

**Figure 1** **Flow Diagram of the Selection Process for the Literature Review**



### 3.4 Results

Of the five included studies, four of them were conducted in the United States (1, 57-59) and one was conducted in Alberta (60). The publication dates of the studies ranged from 1999 to 2017. Four studies were published between 1999-2006 (1, 57, 58, 60) and one study was published recently in 2017 (59). Three of the studies were primarily focused on a pediatric population (1, 57, 59) while the other two studies included both children and adults (58, 60). Only one of the studies focused on children with asthma solely (59) while the rest of the studies had asthma as a sub-population (1, 57, 58, 60). Four of the studies measured continuity of care with an Index (1, 57, 58, 60) while the last study defined continuity of care as having at least 2 visits with the same primary care provider in the prior 24 months (59). All the studies assessed the association between continuity of care and acute care outcomes (1, 57-60). See Table 2 for detailed study characteristics.

Two of the studies, Christakis et al. (57) and Christakis et al. (1), used the COC Index. The COC Index measured the number of visits made with the same provider and accounted for the dispersion, which could occur when a different provider was seen for every visit (1, 57). A COC Index score in these two studies would take on a value from 0 to 1, where 0 denoted that the patient did not have high continuity and that they had maximum dispersion (1, 57). A score of 1 signified minimum dispersion and that they saw the same provider at every visit. Overall, a low COC Index score was associated with a higher risk of ED utilization and hospitalization, especially for those children who had asthma (1, 57).

Christakis et al. (57) used data from Medicaid managed care children (N=785) to compare continuity of care provided by pediatric medical residents versus continuity of care by attending physicians. A total of 118 (15%) of the children in this study were identified with asthma. The

results from their adjusted survival analysis showed that resident continuity was not significantly associated with decreased ED utilization. However, high attending continuity, compared to low attending continuity, was associated with decreased ED utilization (HR: 0.65, 95% CI [0.50-0.80]). There were two major limitations to this study; 1) the sample size was too small to evaluate outcomes with low incidences, such as hospitalizations, 2) the setting was an outpatient teaching clinic, and therefore the results may not be generalizable in other, more common settings.

Christakis et al. (1) used a similar method to Christakis et al. (57). This study used data of patients enrolled in a group health cooperative clinic (N= 46097) to examine the continuity of care with a primary care provider (pediatrician or family physician) (1). The study population, similar to that of Christakis et al. (1999) (57), was a general population of children aged 0 to 19 years old. For the sub-group analysis looking at children with asthma (N=3559), there was no significant association between continuity of care and ED visits. However, there was a significant association between an increased hospitalization risk and decreased continuity of care; medium (versus high) continuity (HR: 1.61, 95% CI [1.10-2.38]) and low continuity (HR:1.79, 95% CI [1.21-2.56]). One limitation that was suggested was the possibility for residual confounding, which the authors suggest includes the degree of asthma severity and greater parental conscientiousness or family functioning which could have been identified as a potential confounder. Another limitation was the selection of the population, which was limited to a single Group Health Cooperative clinic in a large urban city.

Cree et al. (60) used the UPC Index, a well-known measure of continuity of care. The UPC Index is the proportion of the patients' most frequently visited physician divided by the total number of visits to all physicians. In contrast to the studies completed by Christakis, the population of this study included children and adults with asthma, between the ages of 5-45 years (N=2774).

They found that high continuity of care was associated with both a decreased risk of an emergency visit (OR:0.24, 95% CI [0.19-0.29]) and a decreased risk of the number of hospitalization (RR: 0.69, 95%CI [0.54, 0.89]). The data used in this study was from a single health region in Alberta, which was reported to have similar demographics and healthcare organization characteristics to the rest of Alberta. However, there could have been unidentified differences in patient or practice characteristics that could have influenced the study outcomes.

The Gill et al. (58) study used the Modified Modified Continuity Index (MMCI), a measure of continuity developed for family practices where medical residents are involved, in order to examine whether continuity care with an individual health care provider was associated with the number of ED visits in a statewide (Delaware) Medicaid population (N=11 474) aged 0 to 64 years old. This study was a 1-year cross-sectional study using claims data. This Index is modified from the COC Index to make the measure perform in a more linear fashion (61). The MMCI score accounts for the dispersion of visits among different providers. The authors justified that the MMCI was a "more sound" measure of continuity then the more commonly used UPC Index(58).

Similarly, the Gill et al. (58) article found that high continuity using the MMCI was associated with a lower likelihood of having a single ED visit (OR: 0.82, 95%CI [0.70-0.95]) and multiple ED visits (OR: 0.65, 95% CI [0.56-0.76]). They found that among those patients in the population with asthma, the effect of continuity was no greater when compared to the rest of the population. Limitations of this study included the fact that it was based on data from Medicaid patients (who were below a certain threshold of income). Its cross-sectional design was also a limitation because it did not allow the determination of the temporal relationship of continuity and the dependent variable of ED visits.

The last article by Utidjian et al. (59) aimed to examine the effect of ambulatory health care processes on asthma hospitalizations. The study population was children aged 2-18 years old who received asthma-related health care from one of five urban outpatient practices within a two-state practice-based research network (N=5712). The study was a retrospective cohort study where the authors measured access to primary healthcare along with frequent primary healthcare visits, defined as at least 2 visits in a 24-month period, as a proxy for continuity of care. This article was the only one which looked at the association between continuity of primary care and ED visits and hospitalizations without the use of an Index. This study found that children with asthma who had lacked primary health care continuity were at a higher risk of hospitalization (RR: 1.39, 95% CI [1.09-1.78]). The findings were limited by the study population, for which the majority was inner city and African American. This study also employed a very basic measure of continuity established using the number of visits.

### 3.5 Conclusions

Overall, there were few articles published, which looked at the impact of continuity of care in the primary care setting on acute care outcomes for children with asthma. Most of the studies (4 out of 5) were performed on cohorts almost two decades old (1, 57, 58, 60) and focused on specific populations (Medicaid or US-based private medical insurance cooperative) (1, 57-59) or a broad age range (child and adults) (58, 60). Although the study findings are overall promising, demonstrating an association between high continuity of care and decreased ED visits and/or hospitalizations, they cannot be generalized to the pediatric asthma population and the Canadian context.

**Table 2 Characteristics of studies included in the literature review**

| Authors (Year) | 1) Design<br>2) Setting<br>3) Study Period<br>4) Data Source | Patient Population | Definition of Asthma | N | Continuity of care measure and definition used | Statistical Analysis with Outcome(s) used |
|---|---|---|---|---|---|---|
| Christakis et al. (1999) | 1) Retrospective Cohort Study<br>2) Seattle, Washington, USA<br>3) September 1993-September 1997<br>4) Administrative healthcare data from Medicaid | Medicaid managed care children ages 0 to 19 years | Identified through asthma registry that contains all patient with an inpatient or outpatient diagnosis of asthma based on ICD-9 codes | 785 | COC Index= Modeling the dispersion in patient-provider contacts and establishing the concentration of care | Multiple event survival Analysis using ED visits for managed care |
| Christakis et al. (2001) | 1)Retrospective Cohort Study<br>2) Seattle, Washington, USA,<br>3) January 1, 1993-December 31, 1998<br>4) Claims data of patient enrolled at Group Health Cooperative, large staff-model health maintenance organization | Pediatric patients enrolled at Group Health Cooperative Clinic | Identified with an asthma registry | 46097 | COC Index= Degree to which a patient has experienced continuous care with a provider | Cox, proportional hazards regression, using an ED visit or a hospital admission |
| Cree et al. (2006) | 1)Population-based study<br>2) Alberta, Canada<br>3) April 1, 1996- March 31, 2000<br>4) Administrative healthcare data from Alberta Health and Wellness | Patients diagnosed with asthma between ages 5 and 45 | Identified through using ICD codes and counting two or more office visits for asthma | 2774 | UPC Index= Proportion of total physician visits made to the most frequently visited physician | Logistic, multiple linear and Poisson regression using hospitalizations and emergency room visits |
| Gill et al. (2000) | 1)Cross-sectional study<br>2)Delaware, USA<br>3)July 1, 1993-June 30, 1994 4)Claims data of patient enrolled at Group Health Cooperative, large | Medicaid clients aged 0 to 64 years who had made at least 3 physicians office visits | Identified through claims data | 11474 | MMCI= includes both the UPC Index definition and also accounts for the degree of | Polychromatous logistic regression, with 3 level categorization using ED visits as the dependent variable |

| | | | | | | |
|---|---|---|---|---|---|---|
| | staff-model health maintenance organization | | | | dispersion among different providers | |
| Utidjian et al. (2017 | 1)Retrospective Cohort Study<br>2) Philadelphia, Pennsylvania, USA<br>3)January 1, 2004-December 31, 2008<br>4)Electronic health records | Children aged 2-18 years old who received asthma-related health care from one of the five urban outpatient practices | Identified asthma as a diagnosis at the visit using a primary discharge billing code | 5712 | No measure used. Used access and frequency of primary healthcare as a measure of continuity of care | Poisson regression using asthma hospitalizations |

# CHAPTER 4: THESIS RATIONALE & OBJECTIVES

## 4.1 Rationale and Relevance of Study

There is still a significant burden in childhood asthma, despite much research and improved guidelines to inform practice (10, 15, 30). Children with asthma are more likely to have an ED and urgent care visit than adults with asthma (40, 62, 63). Continuity of care has been associated with better outcome in asthma (1, 57, 60). To our knowledge, no study has focused on the impact of both having a primary care provider and having continuity of care with a said provider on outcomes in children with asthma. One previous study performed in Canada has examined the continuity of care and its impact on kids and adults with asthma in a specific region in Alberta (60). The current thesis aims to determine whether the same associations exist within the province of Québec with the use of a large population-based dataset and whether there are differences in terms of access and continuity of primary of care, and asthma health utilization outcomes for this vulnerable population.

## 4.2 Objectives

The primary objective of this study was to determine the extent to which having an assigned UPC from one of the primary care models (family physicians in FMGs, family physicians in non-FMGs, or pediatricians compared no assigned UPC) is associated with improved asthma-related outcomes, as measured through ED visits and hospital admissions, among Québec children with asthma aged 2-16 years old.

The secondary objective was to determine among those children with an assigned UPC, the extent to which the UPC Index is associated with the same asthma-related acute outcomes.

The specific aims of this thesis were to:

1. Describe patient characteristics across the primary care model (a family physician in an FMG, a family physician in a non-FMG, a pediatrician and those who have no assigned UPC).
2. Describe patient characteristics for those with an assigned UPC across the UPC Index (low, medium and high)
3. Determine the association between having an assigned UPC, either through a family physician in an FMG, a family physician in a non-FMG, or a pediatrician and asthma-related acute care outcomes (ED visits and hospital admissions) in comparison to having no assigned UPC.
4. Determine amongst those children with asthma who have an assigned UPC, if continuity of care, as measured by the UPC Index, is associated with asthma-related acute care outcomes (ED visits and hospital admissions).

## CHAPTER 5: MANUSCRIPT

# Can primary care and continuity of care prevent asthma-related emergency department use and hospitalization amongst children?

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**Abbreviations:**

ED: Emergency Department

FMG: Family Medicine Groups

UPC: Usual Provider of Care

RAMQ: Régie de l'Assurance Maladie du Québec

COC : Bice-Boxerman Continuity of Care Index

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

Q: Socioeconomic Quintile

IQR: Interquartile Range

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**Conflicts of Interest:** All authors have no conflicts of interest to disclose.

**What's Known on This Subject**

Results of previous studies have shown the value of continuity of care on improving health care utilization. Little is known about the association of primary care and continuity of care on asthma acute care services for children under a system with universal healthcare coverage.

**What This Study Adds**

Under a system with universal insurance, primary care is associated with improved ED care use and hospital admissions. However, continuity of care may have an impact on the management of a chronic disease such as asthma. There should be further promotion and development of new and continued policy and interventions to improve primary care access and continuity of care.

## 5.1 Contributor's Statement Page

Sarah Cooper constructed the design of the project and the manuscript with the support and input of Dr. Patricia Li, Dr. Roland Grad, Dr. Sze Man Tse, and Dr. Elham Rahme. The data collection was facilitated by Dr. Patricia Li (owner of the data). Sarah Cooper executed all data programs and conducted data analyses. Results were also analyzed and interpreted by Sarah Cooper and Dr. Patricia Li. Sarah Cooper was the lead writer and drafted the manuscript. All five authors Sarah Cooper, Dr. Patricia Li, Dr. Roland Grad, Dr. Sze Man Tse, and Dr. Elham Rahme critically reviewed the manuscript during several rounds of critique and feedback. All five authors gave their final approval of the manuscript for this thesis.

## 5.2 Abstract


### Objective

Having a primary care provider and a consistent, continuous relationship with the said provider may be important for asthma outcomes. In Québec, children are mainly followed by family physicians in family medicine groups (FMGs), family physicians not part of FMGs, or by pediatricians. We sought to determine 1) whether having a usual provider of primary care was associated with asthma-related emergency department (ED) visits and hospitalization in Québec children with asthma and 2) whether continuity of care with a primary care provider was associated with acute asthma outcomes.

### Methods

This was a population-based retrospective cohort study that used Québec provincial health administrative data from 2010-2013. The population was children diagnosed with asthma, aged 2-16 years old (N=39, 341). The main exposure was the primary care model (FMGs, non-FMGs, or pediatricians, compared to no assigned usual provider of care (UPC)). For those with an assigned UPC, continuity of care was measured by the UPC Index (high, medium, low). The main and secondary outcomes were asthma-related ED visits and hospitalizations, respectively. Multivariate logistic regression analyses were used to test associations between exposures and outcomes.

### Results

Overall, 17.4% of children diagnosed with asthma in Québec had no assigned UPC. Compared to no assigned UPC, having a UPC was associated with decreased asthma-related ED visits (Pediatrician Odds Ratio (OR): 0.80, 95% confidence interval (CI) [0.73, 0.89], FMGs OR: 0.84, 95% CI [0.75,0.93], non-FMGs OR: 0.92, 95% CI [0.83, 1.02]) and hospital admissions

(Pediatrician OR: 0.67, 95% CI [0.59, 0.76], FMGs OR: 0.83, 95% CI [0.73, 0.94], non-FMGs OR: 0.77, 95% CI [0.67, 0.87]). Children followed by a pediatrician were more likely to have a high continuity of care. Continuity of care was not significantly associated with asthma-related ED visits but compared to low continuity, medium or high continuity was associated with decreased asthma-related hospital admissions (Medium OR: 0.81, 95% CI [0.73, 0.90], High OR: 0.72, 95% CI [0.63, 0.82])

**Conclusion**

Having a usual provider of primary care was associated with reduced asthma-related ED visits and hospital admissions. For those who had a UPC, high continuity of care was associated with reduced likelihood of asthma-related hospital admissions.

## 5.3 Introduction

Asthma is one of the most common causes of emergency department (ED) visits and hospitalizations for children internationally and in Canada (40). Asthma is considered to be the most common chronic disease amongst children, affecting approximately 10% of children in both the United States and in Canada (39). In Canada, the economic burden is high, with the most recent available estimate in 2010 calculated to be approximately $2.10 billion (41).

The National Institutes of Health in the United States recommends a collaborative partnership between the family and the physician, along with visits for asthma maintenance care, in order to optimize asthma control and reduce morbidity through education and asthma management (33, 64). Continuity of care, a concept embedded in primary care, is considered to be an important component of chronic disease management (9, 60). Continuity of care is defined as a health care service that extends over some time, where there is a timely and effective exchange of health information between a patient and their individual medical professional or within a medical team (21). This concept for adults has been associated with greater satisfaction, better medication compliance, better preventive care, fewer hospitalizations, and less emergency room use and better control of chronic diseases (14, 21). Of the few studies that have examined the role of continuity of primary care for asthma in children, increased continuity has been shown to decrease ED visits and/or hospitalizations in both Canada and the United States (1, 57-60).

In Québec, Canada, children who are residents of the province have access to primary care providers though public health insurance in the form of pediatricians, family physicians who belong to a Family Medicine Group (FMG), and family physicians not part of an FMG. Since 2002, there have been important reforms implemented in Québec with regards to the delivery of primary care services (45). FMGs were created in response to the widely-recognized challenges

facing Québec's health care system. Objectives for these FMGs were to provide all Québec residents with access to a family doctor, thereby increasing accessibility of services and improving continuity of care (45). In Québec, the impact of primary care on asthma outcomes has not been evaluated.

The purpose of this study was to evaluate the impact of having a usual provider of care (UPC) and continuity of care with the said provider on asthma-related acute outcomes care for children living in Québec, Canada. Our primary hypothesis was that having a UPC would be associated with fewer asthma-related ED visits and hospitalizations. Our secondary hypothesis was that amongst those children with an assigned UPC, high continuity of care would be associated with fewer asthma-related ED visits and hospitalizations.

## 5.4 Methods

### *5.4.1 Setting*

Québec is Canada's second largest province in terms of population with approximately 8.2 million inhabitants (65). All Québec permanent residents have access to public health insurance, administered by the Régie de l'Assurance Maladie du Québec (RAMQ), which covers all essential medical services provided in hospitals or other outpatient settings. RAMQ remunerates physicians for the medical services they provide.

### *5.4.2 Study Design and Data Sources*

This was a population-based retrospective cohort study linking Québec administrative data for individual children diagnosed with asthma across health settings from January 1, 2010 to December 31, 2013. This study used population-based data from a larger study examining the association between primary care reforms with health services utilization and quality of care outcomes among medically and socially vulnerable children in Québec, Canada. The current study included three databases, linked together using an encrypted health number. The registered persons database contained the encrypted health insurance number, sex, age, and postal code of all patients insured in Québec. The physician claims database contained all records for remunerated services provided through outpatient clinics or EDs. The hospital discharge database (Maintenance et exploitation des données pour l'étude de la clientèle hospitalière, Med-Echo) contained all admissions data collected from Québec hospitals. Rurality and socioeconomic status were assigned by linking postal codes from the registered persons databases to 2011 Statistics Canada census data.

*5.4.3 Study Population*

The population selected for this study were children aged 2-16 years old as of January 1, 2012, with administratively defined asthma, which was defined using a validated algorithm of two physician visits or one hospitalization for asthma (International Classification of Diseases [ICD]-9 and ICD-10 codes 493xx and J45X/J46X, respectively) in the RAMQ billings between the exposure period of January 1, 2010, and December 31, 2011. The validation of this algorithm was developed to validate a case definition of asthma using population-based outpatient administrative data in children under the age of 18 years old (66). The algorithm yielded good sensitivity (91.4%) and specificity (82.9%) and was found to be valid for use in primary care practices in Ontario in the identification of asthma with an administrative data diagnosis code (40, 66, 67) . The study population also had to have valid Québec healthcare insurance for the study period of 2010-2013.

*5.4.4 Main Exposure: Primary Care Models (FMGs, family physicians not part of FMGs, pediatricians, no assigned UPC)*

In Québec, children can access primary care and experience continuity of care from a pediatrician or a family physician (14). FMGs are groups of health care professionals, introduced through primary care reforms, working together to provide patients with a medical home and thereby improve access and continuity in healthcare (7, 68). Each child was assigned to one of the four primary care models: family physicians within the FMG, family physicians not part of an FMG, pediatrician or no assigned UPC. The assignment of a primary care model was based on the Usual Provider of Care (UPC) algorithm (Appendix B, Table 12). This was completed using the RAMQ physician claims from the two-year exposure of January 1, 2010, to December 31, 2011. The primary care model assigned to each child was based on their UPC. We used the following hierarchy: children who were enrolled with a family physician were assigned to the family

physician (FMG or non-FMG) as their UPC; the remaining children were assigned to a pediatrician if they had billing codes associated with growth and monitoring of development submitted by a pediatrician. For those children who did not have a code identifying a family physician or a pediatrician as their assigned UPC, the UPC was assigned based on the provider who delivered the most primary care visits, where at least 2 visits had to be made with the same provider in the 2-year exposure period. If no UPC had been identified thus far, then the child did not have a UPC and was classified as having no primary care. The algorithm was an adaptation of a version developed by the Institut National de Santé Publique du Québec (INSPQ) to identify patient attachment to a family physician in adults (68). This algorithm has also been used in a previous healthcare research study by members of the research team using RAMQ administrative databases to identify a child's UPC (69).

*5.4.5 Secondary Exposure: Usual Provider of Care (UPC) Index Score*

Each child's continuity of care was assessed by using a published index, the UPC Index, that uses claims-based data to measure longitudinal continuity (9, 70). The UPC Index was defined as the proportion of a patient's medical visits was with their assigned UPC (9). This measure takes on a value of 0 to 1 with values close to 1 suggesting high continuity of care. The UPC Index was divided into 3 categories (>0-0.4= low, 0.41-0.70=medium, >0.70= high). An index score of 0 was not possible given the algorithm, therefore a score of 0 was excluded from our tertiles and analysis. The UPC Index score was determined using the algorithm in Appendix B, Table 14. The score was assigned to each child by dividing the total amount of visits with the child's determined UPC by the total amount of primary care visits with any primary care provider, between January 1, 2010, and December 31, 2011. A visual representation of this Index can be found below in Equation 1 where $n_i$ is the total amount of visits with the child's UPC and n is the total amount of primary

care visits. A sensitivity analysis was also conducted with the use of the Bice-Boxerman (COC) Index. The COC Index allowed us to take into account the dispersion and distribution of care for a patient across different primary care physicians. The algorithm and description for this Index can be found in Appendix B.7.

$$UPC\ Index = \max \frac{n_i}{n}$$

**Equation 1 Usual Provider of Care (UPC) Index** (11)

*5.4.6 Outcomes*

The primary outcome for this study was asthma-related ED visits made by a child in the two-year outcome period of January 1, 2012, to December 31, 2013. The secondary outcome for this study was asthma-related hospital admissions determined in the same outcome period. Asthma-related ED visits and asthma-related hospital admissions were measured as a binary outcome. ED visits were determined through the identification of physician claims where the establishment code was the ED. Hospital admissions were determined using the Med-Echo database. ED visits and hospital admissions were determined to be "asthma-related" by using ICD-9 and ICD-10 codes agreed upon by Québec asthma specialists (Appendix B, Table 17) (71). "Asthma-related" hospital admissions were identified in both primary and secondary diagnoses.

*5.4.7 Patient Characteristics at Baseline*

The co-variables that were used as potential confounders in this study were age, socioeconomic (SES) status, rurality, gender, other co-morbidities, and previous health care utilization (all-cause ED visits, all-cause hospital admissions, asthma specialist visits). All co-variables were determined in the exposure period of January 1, 2010, to December 31, 2011. SES was measured with the use of the Pampalon Index, a combined social and material deprivation

index based on census data. The study population was divided into five quintiles (Q1 to Q5, least deprived to most deprived). Rurality was defined using the Census Metropolitan and Census Agglomeration Influenced Zone developed by Statistics Canada and the Institut de Santé Publique du Québec (INSPQ) (72). The study population, through this definition, were divided into three categories; urban (population>100,000), small cities (population 10,000- 100,000), and rural (population <10,000). The study population was categorized into four different groups to account for any other co-morbidities this population had; asthma only, asthma & diabetes, asthma & children with medical complexity (CMC), asthma & diabetes & CMC. These other co-morbidities were chosen because they account for a large proportion of common chronic diseases seen in childhood and are associated with higher health care utilization (73). Children with medical complexity (CMC) are those children who have the most intensive health care needs (74). Examples of intensive health care needs that these children might possess are congenital or acquired the multisystem disease, a severe neurologic condition with functional impairment, or an ongoing disability in multiple areas (74). Health care utilization was accounted for by including previous all-cause ED visits, all-cause hospital admissions, and asthma specialist visits. Previous asthma specialist visits were counted for each child whenever the child had a visit with either a respirologist and/or a visit with a pediatrician in an asthma center (billing code for asthma [493X]), and the establishment was a hospital clinic [code 0X1].

*5.4.8 Statistical Analysis*

The unit of analysis was the patient. Means and standard deviations, or median and interquartile range (IQR) (depending on the distribution of the variable), as well as the counts and percentages, were computed and reported to summarize the distribution of continuous and categorical variables, respectively.

To test the association between the exposures and the outcomes, multivariable logistic models were used, and, results were reported as odds ratios (OR) with 95% confidence intervals (CI). The models were adjusted with the covariables mentioned above; age, gender, co-morbidities, rurality, SES quintiles (Q1-Q5) and previous healthcare utilization (ED visits, hospital admissions, asthma specialist visits). Those children without a Pampalon Index quintile were excluded in the statistical analyses.

All statistical analyses were completed in SAS 9.4.

*5.4.9 Sensitivity Analysis*

Several metrics have been known to measure continuity of care at the patient level. To ensure that the findings in this study in regards to our second objective were not sensitive to our metric of choice, an additional analysis was performed with the use of the COC Index. Therefore, the model completed with the second exposure was rerun with the COC Index as the exposure variable instead of the UPC Index. The COC Index takes on a value from 0 to 1. This index took into account only primary care visits. It is possible to achieve a score of 0 with this algorithm (for example, if there is only 1 visit with the child's assigned UPC plus one visit each with any number of primary care providers). Those children who were assigned a family physician from an FMG as their UPC had a visit with their UPC and no other primary care visits, were assigned a score of 1. Therefore, the COC Index was divided into the following 3 categories (0-0.4= low, 0.41-0.70=medium, >0.70= high). The algorithm used to calculate this score can be found in Appendix B.7.

## 5.5 Results

### *5.5.1 Descriptive analyses across the Primary Care Model and the UPC Index*

The study sample included 39, 341 children with administratively diagnosed asthma. Table 3 displays the patient characteristics within each primary care model. As of January 1, 2012, 17.4% of children diagnosed with asthma had no assigned UPC. The majority of our patient population were followed by a pediatrician, then enrolled in an FMG, and then in a non-FMG. Children who were determined to have no UPC were more likely to come from the older age categories, come from the most deprived socioeconomic quintile and live in non-urban settings in comparison to all of the other primary care models. Those children who had a pediatrician as the designated primary care model were more likely to come from the most affluent socioeconomic quintile and reside in large cities in comparison to FMG, non-FMG, or no primary care groups.

Table 4 displays patient characteristics across the UPC Index. This table only displays those children who had an assigned UPC (i.e., FMG, non-FMG or pediatrician). This included 32, 395 children. Overall, 38.1 % of these children who had a primary care provider had low continuity of care with their UPC. Children who had low continuity of care had a median of 2 visits with their UPC and 10 primary care visits with any primary care provider.

In contrast, those children who had high continuity of care had a median of 5 visits with their UPC and 6 primary care visits in total. Amongst those children who had low continuity of care, there were more children from the youngest age group and rural areas in comparison to the medium continuity of care category and the high continuity of care category. Those children who had high continuity of care with their UPC were more likely to come from the most affluent neighborhood, come from an urban setting, or have no prior ED visits and hospital admissions, in comparison to those children who had low and medium continuity of care. Children who had high

continuity of care were more likely to be followed by a pediatrician compared to those children with low continuity of care who were more likely to be followed by a family physician in an FMG.

**Table 3 Baseline characteristics of cohort by Primary Care Model**

| VARIABLE | Type of Primary Care Model | | | | ALL N (%) |
|---|---|---|---|---|---|
| | FMG N (%) | Non-FMG N (%) | Pediatrician N (%) | No Assigned UPC N (%) | |
| **Total** | 9, 464 (24.1) | 9, 286 (23.6) | 13, 743 (34.9) | 6, 848 (17.4) | 39, 341 (100) |
| **Age Category** | | | | | |
| 2-5 years old | 3, 958 (41.8) | 4, 000 (43.1) | 6, 346 (46.2) | 1, 822 (26.6) | 16, 126 (41.0) |
| 6-9 years old | 2, 587 (27.3) | 2, 353 (25.3) | 4, 032 (29.3) | 2, 065 (30.2) | 11, 037 (28.1) |
| 10-12 years old | 1, 298 (13.7) | 1, 347 (14.5) | 1, 937 (14.1) | 1, 415 (20.7) | 5, 997 (15.2) |
| 13-16 years old | 1, 621 (17.1) | 1, 586 (17.1) | 1, 428 (10.4) | 1, 546 (22.6) | 6, 181 (15.7) |
| **Gender** | | | | | |
| Female | 3, 918 (41.4) | 3, 758 (40.5) | 5, 402 (39.3) | 2, 693 (39.3) | 15, 771 (40.1) |
| **Other comorbidities** | | | | | |
| Asthma Only | 8, 688 (91.8) | 8, 460 (91.1) | 12, 536 (91.2) | 6, 004 (87.7) | 35, 688 (90.7) |
| Asthma & Diabetes | 28 (0.3) | 26 (0.3) | 23 (0.2) | 32 (0.5) | 109 (0.3) |
| Asthma & CMC | 740 (7.8) | 788 (8.5) | 1, 172 (8.5) | 790 (11.5) | 3, 490 (8.9) |
| Asthma & Diabetes & CMC | 8 (0.1) | 12 (0.1) | 12 (0.1) | 22 (0.3) | 54 (0.1) |
| **Material and Social Deprivation Quintile** | | | | | |
| Q1 (least deprived) | 2, 134 (23.4) | 1, 827 (20.5) | 3, 951 (29.7) | 1, 358 (20.8) | 9, 270 (24.5) |
| Q2 | 2, 415 (26.5) | 1, 996 (22.4) | 2, 984 (22.4) | 1, 346 (20.6) | 8, 741 (23.1) |
| Q3 | 1, 846 (20.2) | 1, 713 (19.2) | 2, 211 (16.6) | 1, 209 (18.5) | 6, 979 (18.4) |
| Q4 | 1, 464 (16.0) | 1, 552 (17.4) | 2, 112 (15.9) | 1, 235 (18.9) | 6, 364 (16.8) |
| Q5 (most deprived) | 1, 272 (13.9) | 1, 839 (20.6) | 2, 053 (15.4) | 1, 385 (21.2) | 6, 549 (17.3) |
| **Rurality** | | | | | |
| Urban (population >100k) | 5, 473 (58.2) | 6, 658 (72.2) | 11, 821 (86.6) | 4, 574 (67.3) | 28, 526 (73.0) |

| | | | | | |
|---|---|---|---|---|---|
| Small cities (population 10k-100k) | 1, 702 (18.1) | 967 (10.5) | 823 (6.0) | 955 (14.1) | 4, 447 (11.4) |
| Rural (population <10k) | 2, 228 (23.7) | 1, 595 (17.3) | 1, 004 (7.4) | 1, 262 (18.6) | 6, 089 (15.6) |
| **Previous ED Visits** | | | | | |
| 0 visits | 2, 326 (34.0) | 6, 016 (43.78) | 3, 392 (35.84) | 3, 270 (35.21) | 15, 004 (38.1) |
| 1 visit | 1, 513 (22.1) | 2, 857 (20.79) | 1, 850 (19.55) | 1, 844 (19.86) | 8, 064 (20.5) |
| 2-3 visits | 1, 676 (22.5) | 2, 743 (19.96) | 2, 130 (22.51) | 2, 137 (23.01) | 8, 686 (22.1) |
| Over 4 visits | 1, 333 (19.5) | 2, 127 (15.48) | 2, 092 (22.10) | 2, 035 (21.91) | 7, 587 (19.3) |
| **Previous Asthma Specialist Visits** | | | | | |
| 0 visit | 1, 867 (27.3) | 902 (6.6) | 5, 058 (53.4) | 4, 649 (50.1) | 12, 476 (31.7) |
| 1 visit | 1, 125 (16.4) | 1, 672 (12.2) | 1, 445 (15.3) | 1, 499 (16.1) | 5, 741 (14.6) |
| 2 visits | 2, 003 (29.3) | 5, 601 (40.8) | 1, 389 (14.7) | 1, 403 (15.1) | 10, 396 (26.4) |
| Over 3 visits | 1, 853 (27.1) | 5, 568 (40.5) | 1, 572 (16.6) | 1, 735 (18.7) | 10, 728 (27.3) |
| **Previous Hospital Admissions** | | | | | |
| No | 4, 616 (67.4) | 10, 577 (77/0) | 6, 231 (65.8) | 5, 979 (64.4) | 27, 403 (69.7) |
| Yes | 2, 232 (32.6) | 3, 166 (23.0) | 3, 233 (34.2) | 3, 307 (35.6) | 11, 938 (30.3) |
| **Number of previous visits made to their assigned UPC** | | | | | |
| Median [IQR] | 3.0 [1,5] | 3.0 [2,4] | 4.0 [3,7] | | 3.0 [1,6] |
| **Number of total previous primary care visits** | | | | | |
| Median [IQR] | 7.0 [4,12] | 8.0 [5,12] | 8.0 [5,12] | | 8.0 [5,12] |

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

IQR: Interquartile Range

**Table 4 Baseline characteristics of cohort by Usual Provider of Care (UPC) Index**

| VARIABLES | Level of Continuity of Care by UPC Index | | | ALL N (%) |
|---|---|---|---|---|
| | Low Continuity of Care (>0-0.40) N (%) | Medium Continuity of Care (>0.40-0.70) N (%) | High Continuity of Care( >0.70) N (%) | |
| **Total** | 12, 349 (38.1) | 10, 585 (32.7) | 9, 461 (29.2) | 32, 395 (100) |
| **Type of Primary Care Model** | | | | |
| FMG | 4, 953 (40.1) | 2, 759 (26.1) | 1, 723 (18.2) | 9, 435 (29.1) |
| Non-FMG | 4, 270 (34.6) | 2, 841 (26.8) | 2, 112 (22.3) | 9, 223 (28.5) |
| Pediatrician | 3, 126 (25.3) | 4, 985 (47.1) | 5, 626 (59.7) | 13, 737 (42.4) |
| **Number of previous visits made to assigned UPC** | | | | |
| Median [IQR] | 2.0 [2,3] | 4.0 [2,6] | 5.0 [3,8] | 3.0 [1,6] |
| **Number of total previous primary care visits** | | | | |
| Median [IQR] | 10.0 [6,14] | 7.0 [4, 12] | 6.0 [4,9] | 8.0 [5,12] |
| **Age Categorical** | | | | |
| 2-5 years old | 6, 476 (52.4) | 4, 531 (42.8) | 3, 246 (34.3) | 14, 252 (41.0) |
| 6-9 years old | 3, 297 (26.7) | 2, 946 (27.8) | 2, 708 (28.6) | 8, 951 (28.1) |
| 10-12 years old | 1, 313 (10.6) | 1, 546 (14.6) | 1, 712 (18.1) | 4, 571 (15.2) |
| 13-16 years old | 1, 264 (10.2) | 1, 562 (14.8) | 1, 795 (19.0) | 4, 621 (15.7) |
| **Gender** | | | | |
| Female | 4, 907 (39.7) | 4, 259 (40.2) | 3, 880 (41.0) | 13, 046 (40.1) |
| **Other comorbidities** | | | | |
| Asthma Only | 11, 167 (90.4) | 9, 687 (1.5) | 8, 746 (92.4) | 29, 600 (90.7) |
| Asthma & Diabetes | 36 (0.3) | 17 (0.2) | 24 (0.3) | 77 (0.3) |
| CMC & Asthma | 1, 137 (9.2) | 872 (8.2) | 677 (7.2) | 2, 686 (8.9) |
| Asthma & Diabetes & CMC | 9 (0.1) | 9 (0.1) | 14 (0.2) | 32 (0.1) |
| **Material and Social Deprivation Quintile** | | | | |
| Q1 (Least Deprived) | 2, 753 (23.2) | 2, 566 (25.1) | 2, 566 (28.0) | 7, 885 (25.2) |

| | | | | |
|---|---|---|---|---|
| Q2 | 2, 923 (24.6) | 2, 416 (23.6) | 2, 034 (22.2) | 7, 373 (23.6) |
| Q3 | 2, 248 (18.9) | 1, 928 (18.8) | 1, 580 (17.2) | 5, 756 (18.4) |
| Q4 | 1, 983 (16.7) | 1, 680 (16.4) | 1, 448 (15.8) | 5, 111 (16.3) |
| Q5 (Most Deprived) | 1, 964 (16.5) | 1, 649 (16.1) | 1, 537 (16.8) | 5, 150 (16.5) |
| **Rurality** | | | | |
| Urban (population >100k) | 8, 334 (67.9) | 8, 020 (76.3) | 7, 540 (80.3) | 23, 894 (74.3) |
| Small cities (population 10k-100k) | 1, 675 (13.7) | 1, 000 (9.5) | 800 (8.5) | 3, 475 (10.8) |
| Rural (population <10k) | 2, 257 (18.4) | 1, 495 (14.2) | 1, 054 (11.2) | 4, 806 (14.9) |
| **Previous ED Visits** | | | | |
| 0 Visit | 3, 140 (25.4) | 3, 997 (37.8) | 5, 535 (58.4) | 12, 662 (39.1) |
| 1 Visit | 2, 212 (17.9) | 2, 416 (22.8) | 1, 909 (20.2) | 6, 537 (20.2) |
| 2-3 Visits | 3, 129 (25.3) | 2, 490 (23.5) | 1, 353 (14.3) | 6, 972 (21.5) |
| Over 4 Visits | 3, 868 (31.3) | 1, 682 (15.9) | 674 (7.1) | 6, 224 (19.2) |
| **Previous Hospital Admission** | | | | |
| No | 7, 118 (57.6) | 7, 678 (72.5) | 7, 965 (84.2) | 22, 761 (70.3) |
| Yes | 5, 231 (42.4) | 2, 907 (27.5) | 1, 496 (15.8) | 9, 634 (29.7) |
| **Previous Asthma Specialist Visits Categorical** | | | | |
| 0 Visit | 4, 486 (36.3) | 3, 432 (32.4) | 2, 654 (28.1) | 10, 572 (31.7) |
| 1 Visit | 2, 172 (17.6) | 1, 538 (14.5) | 895 (9.5) | 4, 605 (14.6) |
| 2 Visits | 2, 599 (21.1) | 2, 744 (25.9) | 3, 030 (32.0) | 8, 373 (26.4) |
| Over 3 Visits | 3, 092 (25.0) | 2, 871 (27.1) | 2, 882 (30.5) | 8, 845 (27.3) |

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

IQR: Interquartile Range

*5.5.2 Association between Asthma-Related Acute Care and Primary Care Models*

Table 5 shows the distribution of asthma-related ED visits and hospital admissions amongst the primary care model from January 1, 2012, to December 31, 2013. Overall, 10.3% of Québec children with asthma had at least one asthma-related ED visit, while 6.5% had an asthma-related hospital admission. Children who were in the no primary care model had the highest percentage of asthma-related ED visits and hospital admissions, whereas the pediatrician model had the lowest.

The results from the multivariable logistic regression analysis with the primary outcome, asthma-related ED visits, are shown in Table 6. Children whose assigned UPC was a pediatrician or a family physician from an FMG were less likely to have an asthma-related ED visit compared to those who had received no primary care. There was no significant difference in the odds of having an asthma-related ED visit between non-FMGs and no primary care. Other variables associated with an increased odds in having an asthma-related ED were male, lower SES, previous hospital admission and previous ED visit (all-cause). Compared to children who had only asthma, those children diagnosed with both asthma and a medical complexity had decreased odds of having an asthma-related ED visit.

Similarly, results showed that children with asthma who received any form of primary care (i.e., from a pediatrician, family physician in FMG, or family physician in non-FMG) had decreased odds of an asthma-related hospital admission compared to those who had no form of primary care (Table 7). Children with asthma from rural and small-town regions had greater odds of having an asthma-related hospital admission compared to those from urban regions. Children with other chronic diseases than asthma also had greater odds of having an asthma-related hospital admission compared to those children diagnosed with only asthma. Other variables associated with

an increased odds of having an asthma-related hospital admission had previous asthma specialist visits, having previous all-cause hospitalization and previous all-cause ED visits.

**Table 5 Asthma-related acute care outcomes by Primary Care Model**

| OUTCOME | Type of Primary Care Model | | | | ALL N= 39,341 |
|---|---|---|---|---|---|
| | FMG N= 9,464 (24.1) | Non-FMG N= 9,286 (23.6) | Pediatrician N=13,743 (34.9) | No Assigned UPC N= 6,848 (17.4) | |
| **Asthma-related ED visits** | | | | | |
| Yes (N [%]) | 961 (10.2) | 1, 054 (11.4) | 1, 225 (8.9) | 826 (12.1) | 4, 066 (10.3) |
| **Asthma-related hospital admissions** | | | | | |
| Yes (N [%]) | 618 (6.5) | 586 (6.3) | 643 (4.7) | 558 (8.2) | 2, 405 (6.1) |

ED: Emergency Department

FMG: Family Medicine Groups

UPC: Usual Provider of Care

**Table 6 Multivariable logistic regression testing association between Primary Care Model and asthma-related ED visits**

| | | OR (95% CI) | |
|---|---|---|---|
| Independent Variable | Levels | Unadjusted | Adjusted |
| Primary Care Models | No Assigned UPC | Reference | Reference |
| | Pediatrician | 0.71 (0.65, 0.78) | 0.80 (0.73, 0.88) |
| | FMGs | 0.82 (0.75, 0.91) | 0.84 (0.75, 0.93) |
| | Non-FMGs | 0.93 (0.85, 1.03) | 0.92 (0.83, 1.02) |
| Age Category | 2-5 yo | Reference | Reference |
| | 6-9yo | 0.71 (0.65, 0.77) | 1.09 (1.00, 1.18) |
| | 10-12yo | 0.65 (0.58, 0.71) | 1.17 (1.04, 1.30) |
| | 13-16yo | 0.54 (0.49, 0.60) | 0.94 (0.84, 1.06) |
| Gender | Female | Reference | Reference |
| | Male | 1.18 (1.10, 1.26) | 1.08 (1.01, 1.16) |
| Material and Social Deprivation Quintile | Q1 (least deprived) | Reference | Reference |
| | Q2 | 1.14 (1.04, 1.26) | 1.07 (0.96, 1.18) |
| | Q3 | 1.27 (1.15, 1.41) | 1.10 (0.99, 1.23) |
| | Q4 | 1.46 (1.32, 1.61) | 1.24 (1.11, 1.38) |
| | Q5 (most deprived) | 1.66 (1.50, 1.83) | 1.34 (1.21, 1.49) |
| Rurality | Urban (population >100k) | Reference | Reference |
| | Small cities (population 10k-100k) | 1.18 (1.06, 1.30) | 0.97 (0.87, 1.08) |
| | Rural (population <10k) | 1.37 (1.26, 1.50) | 1.07 (0.98, 1.18) |
| Other comorbidities | Asthma Only | Reference | Reference |
| | Asthma & Diabetes | 1.41 (0.82, 2.44) | 1.25 (0.71, 2.22) |
| | Asthma & CMC | 1.22 (1.10, 1.36) | 0.80 (0.71, 0.90) |
| | Asthma & Diabetes & CMC | 1.77 (0.87, 3.63) | 1.10 (0.52, 2.34) |
| Previous Hospital Admission | No | Reference | Reference |
| | Yes | 2.21 (2.07, 2.36) | 1.09 (1.01, 1.17) |
| Previous ED Visits | 0 Visit | Reference | Reference |
| | 1 Visit | 2.58 (2.28, 2.93) | 2.47 (2.17, 2.81) |
| | 2-3 Visits | 4.78 (4.27, 5.36) | 4.47 (3.98, 5.03) |
| | Over 4 visits | 11.30 (10.14, 12.58) | 10.13 (9.00, 11.39) |

| | | | |
|---|---|---|---|
| Previous Asthma Specialist Visits | 0 Visits | Reference | Reference |
| | 1 Visit | 1.30 (1.17, 1.45) | 1.15 (1.03, 1.29) |
| | 2 Visits | 0.91 (0.83, 1.00) | 0.99 (0.89, 1.10) |
| | Over 3 Visits | 1.82 (1.67, 1.97) | 1.51 (1.37, 1.66) |

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

**Table 7 Multivariable logistic regression testing association between Primary Care Model and asthma-related hospital admissions**

| | | OR (95% CI) | |
|---|---|---|---|
| Independent Variable | Levels | Unadjusted | Adjusted |
| Primary Care Models | No Assigned UPC | Reference | Reference |
| | Pediatrician | 0.55 (0.49, 0.62) | 0.67 (0.59, 0.76) |
| | FMGs | 0.79 (0.70, 0.89) | 0.83 (0.73, 0.94) |
| | Non-FMGs | 0.76 (0.67, 0.86) | 0.77 (0.67, 0.87) |
| Age Category | 2-5 yo | Reference | Reference |
| | 6-9yo | 0.63 (0.57, 0.70) | 0.90 (0.80, 1.01) |
| | 10-12yo | 0.59 (0.52, 0.67) | 0.86 (0.75, 1.00) |
| | 13-16yo | 0.68 (0.60, 0.77) | 0.88 (0.76, 1.01) |
| Gender | Female | Reference | Reference |
| | Male | 1.00 (0.92, 1.09) | 0.96 (0.87, 1.04) |
| Material and Social Deprivation Quintile | Q1 (least deprived) | Reference | Reference |
| | Q2 | 1.14 (1.00, 1.29) | 1.02 (0.90, 1.17) |
| | Q3 | 1.31 (1.16, 1.49) | 1.10 (0.96, 1.27) |
| | Q4 | 1.21 (1.06, 1.38) | 1.03 (0.90, 1.19) |
| | Q5 (most deprived) | 1.41 (1.24, 1.60) | 1.13 (0.99, 1.29) |
| Rurality | Urban (population >100k) | Reference | Reference |
| | Small cities (population 10k-100k) | 1.55 (1.37, 1.74) | 1.25 (1.10, 1.43) |
| | Rural (population <10k) | 1.50 (1.35, 1.67) | 1.12 (1.00, 1.27) |
| Other comorbidities | Asthma Only | Reference | Reference |
| | Asthma & Diabetes | 12.37 (8.34, 18.36) | 12.03 (7.92, 18.27) |
| | Asthma & CMC | 6.52 (5.94, 7.17) | 4.39 (3.964, 4.859) |
| | Asthma & Diabetes & CMC | 37.72 (21.66, 65.69) | 27.18 (14.98, 49.34) |
| Previous Hospital Admission | No | Reference | Reference |
| | Yes | 4.17 (3.83, 4.54) | 1.95 (1.76, 2.15) |
| Previous ED Visits | 0 Visit | Reference | Reference |
| | 1 Visit | 1.82 (1.57, 2.11) | 1.412 (1.21, 1.64) |
| | 2-3 Visits | 2.85 (2.50, 3.25) | 1.915 (1.66, 2.21) |

| | | | |
|---|---|---|---|
| | Over 4 visits | 6.26 (5.55, 7.07) | 3.12 (2.72, 3.59) |
| Previous Asthma Specialist Visits | 0 Visits | Reference | Reference |
| | 1 Visit | 0.97 (0.85, 1.11) | 0.94 (0.81, 1.08) |
| | 2 Visits | 0.61 (0.54, 0.69) | 0.83 (0.72, 0.95) |
| | Over 3 Visits | 1.55 (1.40, 1.71) | 1.36 (1.22, 1.53) |

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

*5.5.3 Association between Asthma-Related Acute Care and UPC Index*

Table 8 shows the distribution of asthma-related ED visits and hospital admissions across the UPC Index from January 1, 2012, to December 31, 2013. A total of 10.0% of children with asthma and an assigned UPC had an asthma-related ED visit, and 5.7% had an asthma-related hospital admission. Those children who had the lowest UPC Index score had the highest percentage of asthma-related ED visits and hospital admissions, compared to the highest UPC Index score.

The multivariable logistic regression model showing the relationship between the UPC Index and asthma-related ED visits is displayed in Table 9. There was no significant difference in the odds of having an asthma-related ED visit between the different levels of the UPC Index. This model also shows that the children from the most deprived income quintiles compared to the least deprived income quintile, males, and having previous hospitalizations, ED visits, and asthma specialist visits had a greater odds of having an asthma-related ED visit. Variables associated with decreased odds of having an asthma-related ED visit were having a pediatrician as the UPC and having medical complexity as another comorbidity.

In contrast, the adjusted model with asthma-related hospital admissions, the results were significant between the different categories of the UPC Index (Table 10). Those children with asthma and an assigned UPC had decreased odds of an asthma-related hospital admission when they had medium or high compared to low continuity of care. Characteristics related to having increased odds of an asthma-related hospital admission were living in a rural region, having another chronic disease other than asthma such as diabetes or medical complexity, and having previous hospitalizations, ED visits, and asthma specialist visits. Other variables associated with having decreased odds of an asthma-related hospital admission, when compared to having a family

physician from an FMG, were: having either a pediatrician or a family physician from a non-FMG as their assigned UPC.

**Table 8 Asthma-related acute outcomes by UPC Index**

| OUTCOME | Level of Continuity of Care by UPC Index | | | ALL N= 32,395 |
|---|---|---|---|---|
| | **Low Continuity of Care (>0-0.40) N= 12,349 (38.1)** | **Medium Continuity of Care (>0.40-0.70) N= 10,585 (32.7)** | **High Continuity of Care (>0.70) N= 9,461 (29.2)** | |
| **Asthma-related ED visits** | | | | |
| Yes (N [%]) | 1, 582 (12.8) | 991 (9.4) | 655 (6.9) | 3, 228 (10.0) |
| **Asthma-related hospital admissions** | | | | |
| Yes (N [%]) | 962 (7.8) | 543 (5.1) | 333 (3.5) | 1, 838 (5.7) |

ED: Emergency Department

UPC: Usual Provider of Care

**Table 9 Multivariable logistic regression testing association between UPC Index and asthma-related ED visits**

| | | OR (95% CI) | |
|---|---|---|---|
| Independent Variable | Levels | Unadjusted | Adjusted |
| Level of Continuity of Care by UPC Index | Low (>0-0.40) | Reference | Reference |
| | Medium (>0.40-0.70) | 0.72 (0.67, 0.78) | 0.96 (0.88, 1.04) |
| | High (>0.70) | 0.52 (0.47, 0.57) | 1.02 (0.92, 1.14) |
| Primary Care Model for those with an assigned UPC | FMG | Reference | Reference |
| | Pediatrician | 0.80 (0.74, 0.86) | 0.88 (0.80, 0.97) |
| | Non-FMG | 1.04 (0.96, 1.13) | 1.02 (0.94, 1.12) |
| Age Category | 2-5 yo | Reference | Reference |
| | 6-9yo | 0.71 (0.65, 0.77) | 1.10 (1.01, 1.20) |
| | 10-12yo | 0.65 (0.58, 0.71) | 1.19 (1.07, 1.33) |
| | 13-16yo | 0.54 (0.49, 0.60) | 0.96 (0.86, 1.08) |
| Gender | Female | Reference | Reference |
| | Male | 1.18 (1.10, 1.26) | 1.08 (1.01, 1.16) |
| Material and Social Deprivation Quintile | Q1 (least deprived) | Reference | Reference |
| | Q2 | 1.14 (1.04, 1.26) | 1.06 (0.96, 1.18) |
| | Q3 | 1.27 (1.15, 1.41) | 1.11 (0.99, 1.23) |
| | Q4 | 1.46 (1.32, 1.61) | 1.25 (1.12, 1.39) |
| | Q5 (most deprived) | 1.66 (1.50, 1.83) | 1.35 (1.22, 1.50) |
| Rurality | Urban (population >100k) | Reference | Reference |
| | Small cities (population 10k-100k) | 1.18 (1.06, 1.30) | 0.96 (0.86, 1.07) |
| | Rural (population <10k) | 1.37 (1.26, 1.50) | 1.06 (0.97, 1.16) |
| Other comorbidities | Asthma Only | Reference | Reference |
| | Asthma & Diabetes | 1.41 (0.82, 2.44) | 1.26 (0.72, 2.24) |
| | Asthma & CMC | 1.22 (1.10, 1.36) | 0.80 (0.72, 0.90) |
| | Asthma & Diabetes & CMC | 1.77 (0.87, 3.63) | 1.13 (0.53, 2.40) |
| Previous Hospital Admission | No | Reference | Reference |
| | Yes | 2.21 (2.07, 2.36) | 1.08 (1.00, 1.17) |
| Previous ED Visits | 0 Visit | Reference | Reference |
| | 1 Visit | 2.58 (2.28, 2.93) | 2.49 (2.19, 2.83) |

| | | | |
|---|---|---|---|
| | 2-3 Visits | 4.78 (4.27, 5.36) | 4.52 (4.01, 5.09) |
| | Over 4 visits | 11.30 (10.14, 12.58) | 10.19 (9.03, 11.49) |
| Previous Asthma Specialist Visits | 0 Visits | Reference | Reference |
| | 1 Visit | 1.30 (1.17, 1.45) | 1.17 (1.05, 1.31) |
| | 2 Visits | 0.91 (0.83, 1.00) | 1.02 (0.92, 1.13) |
| | Over 3 Visits | 1.82 (1.67, 1.97) | 1.54 (1.41, 1.69) |

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

**Table 10 Multivariable logistic regression testing association between UPC Index and asthma-related hospital admissions**

| | | OR (95% CI) | |
|---|---|---|---|
| Independent Variable | Levels | Unadjusted | Adjusted |
| Level of Continuity of Care by UPC Index | Low (>0-0.40) | Reference | Reference |
| | Medium (>0.40-0.70) | 0.623 (0.57, 0.70) | 0.87 (0.77, 0.97) |
| | High (>0.70) | 0.42 (0.38, 0.48) | 0.79 (0.68, 0.91) |
| Primary Care Model for those with an assigned UPC | FMG | Reference | Reference |
| | Pediatrician | 0.63 (0.57, 0.70) | 0.81 (0.72, 0.92) |
| | Non-FMG | 0.87 (0.78, 0.96) | 0.88 (0.79, 0.99) |
| Age Category | 2-5 yo | Reference | Reference |
| | 6-9yo | 0.63 (0.57, 0.70) | 0.91 (0.82, 1.02) |
| | 10-12yo | 0.59 (0.52, 0.67) | 0.89 (0.77, 1.03) |
| | 13-16yo | 0.68 (0.60, 0.77) | 0.91 (0.79, 1.04) |
| Gender | Female | Reference | Reference |
| | Male | 1.00 (0.92, 1.09) | 0.96 (0.88, 1.05) |
| Material and Social Deprivation Quintile | Q1 (least deprived) | Reference | Reference |
| | Q2 | 1.14 (1.00, 1.29) | 1.02 (0.90, 1.16) |
| | Q3 | 1.31 (1.16, 1.49) | 1.11 (0.97, 1.27) |
| | Q4 | 1.21 (1.06, 1.38) | 1.04 (0.91, 1.20) |
| | Q5 (most deprived) | 1.41 (1.24, 1.60) | 1.15 (1.00, 1.31) |
| Rurality | Urban (population >100k) | Reference | Reference |
| | Small cities (population 10k-100k) | 1.55 (1.37, 1.74) | 1.23 (1.08, 1.40) |
| | Rural (population <10k) | 1.50 (1.35, 1.67) | 1.11 (0.99, 1.25) |
| Other comorbidities | Asthma Only | Reference | Reference |
| | Asthma & Diabetes | 12.37 (8.34, 18.36) | 12.04 (7.92, 18.28) |
| | Asthma & CMC | 6.52 (5.94, 7.17) | 4.44 (4.01, 4.91) |
| | Asthma & Diabetes & CMC | 37.72 (21.66, 65.69) | 28.52 (15.69, 51.84) |
| Previous Hospital Admission | No | Reference | Reference |
| | Yes | 4.17 (3.83, 4.54) | 1.92 (1.74, 2.13) |
| Previous ED Visits | 0 Visit | Reference | Reference |
| | 1 Visit | 1.82 (1.57, 2.11) | 1.40 (1.20, 1.62) |

| | | | |
|---|---|---|---|
| | 2-3 Visits | 2.85 (2.50, 3.25) | 1.87 (1.62, 2.15) |
| | Over 4 visits | 6.26 (5.55, 7.07) | 2.98 (2.58, 3.43) |
| Previous Asthma Specialist Visits | 0 Visits | Reference | Reference |
| | 1 Visit | 0.97 (0.85, 1.11) | 0.94 (0.82, 1.08) |
| | 2 Visits | 0.61 (0.54, 0.69) | 0.84 (0.74, 0.97) |
| | Over 3 Visits | 1.55 (1.40, 1.70) | 1.39 (1.24, 1.55) |

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

*5.5.4 Sensitivity Analyses*

We calculated the COC Index score for the 32, 395 children who had an assigned UPC. There were 31997 children who received a COC Index score, there were 398 children with missing values and were therefore not included in the analysis. When the models were repeated using the COC Index, those children who had a high COC Index score compared with those who had a low COC Index score had an increased odds of having an asthma-related ED visit (High OR: 1.12, 95% CI [1.02, 1.22]). However, children who had a medium COC Index score had a decreased odds of having an asthma-related ED visit compared to those who had a low COC Index score (Medium OR: 0.89, 95% CI [0.79, 1.00]). A factor associated with a decreased odds of having an asthma-related ED visit was having another comorbidity such as medical complexity (OR: 0.82, 95% CI [0.72, 0.94]). Characteristics associated with having an increased odds of an asthma-related ED visit were being male (in comparison to female), having a family physician from a non-FMG (in comparison to pediatrician), coming from the most deprived SES (in comparison to least), and having asthma specialist visits and all-cause hospital admissions and ED visits.

When the model was repeated for asthma-related hospital admissions and with the COC Index replacing the UPC Index, the results were shown to be significant for both from the medium level of continuity of care and high continuity of care. Those children with administratively defined asthma and an assigned UPC had the lowest odds of having asthma-related hospital admission when they had medium COC Index score (Medium OR: 0.82, 95% CI [0.82, 0.82]). When looking at those children with high versus low continuity of care, the trend was also towards a decreased odds of having an asthma-related hospital admission (High OR: 0.95, 95% CI [0.95, 0.95]). Characteristics associated with increased odds of an asthma-related hospital admission were the following: coming from the most deprived SES (in comparison to least), coming from a small city

(in comparison to urban), having other comorbidities such as diabetes or CMC (in comparison to asthma alone), and having previous hospital admissions, asthma specialist visits and ED visits (no reason/diagnosis).

The results from this sensitivity analysis using the COC Index proved similar to those analyses using the UPC Index.

## 5.6 Discussion

*Main Findings*

We observed that of the 39, 341 children diagnosed with asthma in Québec, 17.4% were not assigned a UPC. The majority of the children in our population were followed by a pediatrician (34.9%). Of those who had an assigned UPC, 38.1% had low continuity of care. Children who had high continuity were more likely to be followed by a pediatrician (59.7%). Children who had low continuity of care were more likely to be followed by a family physician in an FMG (40.1%). The multivariable regression analyses showed that for children with asthma, having a UPC compared to having no assigned UPC was associated with decreased asthma-related ED visits (Pediatrician OR: 0.80, 95% CI [0.73, 0.89], FMGs OR: 0.84, 95% CI [0.75, 0.93], non-FMGs OR: 0.92, 95% CI [0.83, 1.02]) and hospital admissions (Pediatrician OR: 0.67, 95% CI [0.59, 0.76], FMGs OR: 0.83, 95% CI [0.73, 0.94], non FMGs OR: 0.77, 95% CI [0.67, 0.87]). There were no significant differences in the odds of having an asthma-related ED visit between the different levels of continuity of care using the UPC Index. In contrast, when compared to low continuity of care, medium or high continuity was associated with decreased asthma-related hospital admissions (Medium OR: 0.87, 95% CI [0.77, 0.97], High OR: 0.79, 95% CI [0.68, 0.91]). The results conducted with the COC Index from our sensitivity analyses proved similar from those conducted with the UPC Index. Results were significant in the odds of having an asthma-related ED visit between the levels of continuity of care using the COC Index (Medium OR: 0.89, 95% CI [0.79-1.00], High OR: 1.12, 95% CI [1.02-1.22]). Even though the results were insignificant with the use of the UPC index, the trends are still in the same direction. The results seen for asthma-related hospital admissions with the use of the COC Index proved similar to those with the UPC, where there is a decreased odds of having an asthma-related hospital admission between the different

levels of the COC Index (Medium OR: 0.82, 95% CI [0.82-0.82], High OR: 0.95, 95% CI [0.95-0.95]). Thus the results seen through the sensitivity analysis support the results conducted in the secondary analysis.

*Interpretation*

The current study provides support for the beneficial outcomes of having a primary care provider along with having a continuous relationship with the same provider for children with asthma.

The findings are in line with several previous studies, which have found that in general, having a regular source of care compared to none may decrease the odds of ED visits (57, 58, 75-79). In a telephone survey of 8, 502 Ontario residents 16 years and older, among those with a chronic disease, having a regular family physician was associated with a decreased likelihood of ED use (OR=0.47, p=0.01) (43). This study was supported by findings from a study conducted by Glazier et al. (80) that found that patients from the general population with at least 1 chronic condition and without a family physician were 1.22 times more likely to have an ED visit than those who had a regular physician. Among children with asthma, Lafata et al. (81) reported that an increase in the frequency of visits (1-14 visits) to a primary care physician for asthma led to a decrease in the odds of asthma-related ED utilization (OR=0.82, 95% CI [0.70 -0.96]). There are several mechanisms by which primary care may play a role in reducing ED visits and hospitalizations for asthma. Primary care providers may deliver asthma education according to international asthma guidelines (82). Guided self-management, regular medical review, self-assessment and asthma education with a primary care provider have all been shown to reduce hospitalizations and ED visits (56). As well, children may use the ED for primary care when they do not have a regular family physician or when they have problems accessing a family physician

(83). In the current study, children without a UPC may have used the ED for medication renewals or treatment of minor asthma exacerbations, that could otherwise have been managed by a primary care physician.

The results from the current study may also reflect differences in care received from the different primary care models in Québec. Children whose assigned UPC was a pediatrician, compared to other models, were less likely to have asthma-related ED visits and hospital admissions, as well as more likely to have high continuity of care, in the unadjusted data. This could be partly due to residual confounders – for example, pediatricians are more likely to follow children who have less severe asthma and who have less need for acute care use. However, the latter scenario is unlikely. We believe that the study findings more likely reflect differences in the providers – for example, a pediatrician's compared to family physician's approach to asthma management or their ability/resources available to manage children during acute exacerbations. However, results from a survey of Québec primary care physicians found that there were no differences in the approach of asthma management amongst pediatricians, family medicine physicians and emergency medicine physicians (84). Most physicians that were surveyed in this study conducted by Ducharme et al. (84) felt comfortable with diagnosing asthma, distinguishing between intermittent and persistent asthma, assessing asthma control, and initiating long-term inhaled corticosteroids. Further research is needed to better understand the gaps in physicians' knowledge and actual practices, and how these could be improved within different primary care models to affect the quality of care and patient outcomes.

Prior studies, which have looked at the impact of continuity of care on ED visits and hospital admissions for children with asthma have produced mixed results and had limitations (1, 57-60). Most of these prior studies have shown an association between increased continuity of care

and decreased ED use (57, 58, 60). However, the studies were limited by small sample sizes (57, 59, 60), which were insufficient to detect significant differences in outcomes with low prevalence including hospital admissions, had a focus on specific populations (such as Medicaid recipients in the US) (1, 57-59), or had a cross-sectional design (58), which limited the ability to interpret the temporal relationship between continuity of care and outcomes. Cree et al. (60), which was the only study conducted in Canada using administrative data from 2774 children and adults with asthma limited to one health region in Alberta, found that high continuity of care was associated with decreased risk of an emergency visit (OR= 0.24, 95% CI [0.19-0.29]) and a decreased risk of the number of hospitalizations (RR=0.69, 95% CI [0.54-0.89]).

The results from the current study showed that continuity of care with a UPC decreased the odds of having a hospital admission but had no significant effect on the odds of having an ED visit, which differs from previous studies (1, 60). The latter may have been due to the context of primary care services in Québec, whereby despite high continuity of care with a UPC, an ED visit was made when access to the UPC was not possible for the asthma exacerbation. Meanwhile, hospitalizations may indicate a more severe asthma exacerbation, and higher continuity of care with a UPC may have played a role in better control of the disease to prevent a more serious presentation of asthma.

In a setting where health care is "universal," there was still 17.4% of children with asthma who did not have an assigned UPC. It is well known that for certain groups of children with asthma, those who are more deprived in terms of social and material needs, are less likely to receive high-quality primary care and are thus more vulnerable to poor health outcomes (34). It was seen in our study that those children who had no primary care were more likely to come from the most deprived socioeconomic quintiles. Barriers to accessing to a primary care provider can include low

parental education, poverty, and/or language barriers where it is limited to English or French (34). Failure to provide primary care to this vulnerable population is a missed opportunity to better population health and lower healthcare costs. There are some studies which have shown that those children who come from a more deprived neighborhood will have an increased likelihood of suffering worse health status and outcomes compared to those children who come from a least deprived neighborhood (85-88). Under the Canadian health care system, each citizen should be ensured equitable and uniform access to hospital and physician service regardless of socioeconomic status (88). However, this may not be the case currently in Québec, putting these children at risk for higher rates of asthma emergency visits and hospital admissions.

*Limitations*

Administrative data can only portray a partial picture in terms of the role of primary care or continuity of care can play on health care utilization of a population. The algorithm that was used to determine one's UPC was based on the concept that this is a physician who routinely follows their patient and plays a fundamental role in the medical care of that patient. There could have been an instance where a child with asthma could have been healthy during the two year exposure period and thus did not visit their primary care provider. This child would have then been placed in the no primary care group, which may bias the results.

Our algorithm to determine a patient's continuity of care also only captures a small part of what continuity of care means, which is longitudinal continuity. Thus, it does not take into account other concepts of continuity of care such as informational continuity or management continuity (9). Our sensitivity analysis, however, should have addressed this issue, as the COC Index is most often associated with management continuity, the effective collaboration, and coordination of health care teams (11).

The asthma population is one of the most frequent users of the ED, and some visits are unavoidable (89). When using RAMQ administrative data, there is no way to identify and discriminate between unnecessary versus unavoidable visits. Asthma exacerbations can also be unpredictable and fast, even with the best preventive care, some visits are unavoidable.

This population also included two types of sub population; those who had incident cases of asthma and those who had prevalent cases of asthma. The incident cases were those who were not diagnosed with asthma before the baseline exposure period (2010-2011) and thus had either two medical encounters or one hospitalization for asthma during the baseline period. The prevalent cases were those who had been diagnosed with asthma before the baseline period and had episodes of care for their asthma during the baseline period. However, these two sub-populations were not analyzed separately since the time of diagnosis was not available. This could lead to unmeasured confounding if there was a difference between the prevalent and incident groups in terms of asthma control or asthma education knowledge. Further, children with prevalent asthma who had a milder disease or had good control may not have been identified in the cohort if they did not consult for asthma in the baseline years.

The dataset does not have all of the clinical data for these children. Our model only accounted for diabetes and children with medical complexity, using validated algorithms. These co-morbidities, along with asthma, account for the highest morbidity and cost to the health care system in the pediatric population. However, other co-morbidities could potentially be confounding our models such as the adherence to prescribed medication or the asthma phenotype.

## 5.7 Conclusions

Having a usual provider of care in Québec is associated with reduced asthma-related ED visits and hospital admissions for children diagnosed with asthma. For those children who have a usual provider of care, low continuity of care is associated with an increased odds of asthma-related hospital admission. To date, there have not been many studies which have evaluated the impact of primary care and continuity of care for children with asthma in general. This study not only evaluates the impact of primary care on asthma outcomes in Québec, but it also reveals the importance of access and continuity of care with a usual provider of care for improved asthma-related acute outcomes. The findings from this study support the development of interventions and policies aimed at building and maintaining relationships between children with asthma and their primary care provider.

# CHAPTER 6: DISCUSSION & CONCLUSIONS

## 6.1 Summary of Findings

This thesis is a quantitative analysis of the impact of the primary care provider on asthma-related acute outcomes for asthmatic children in Québec, in terms of access to and continuity of care.

The introduction, background and literature review (Chapter 1-3) summarizes the current knowledge available in terms of measuring continuity of care and the impact this concept has on asthma care, along with discussing the context in which this thesis was produced. No studies have examined the role of primary care and outcomes for children with asthma in Québec, after the introduction of primary care reforms. To date, there are few studies looking at the impact of continuity of care on children with asthma (1, 57-60). Of the few studies that have examined this complex concept, four studies have shown that high continuity of care with a primary care provider can lead to reduced ED visits (1, 57, 58, 60, 90), while three studies have shown that high continuity can lead to reduced hospitalizations (1, 59, 60). There has only been one study conducted in Canada looking at this concept, conducted in one health region in Alberta examining both children and adults (60). Results from the current study not only address the importance of having a primary care provider but also the importance of continuity of care for asthma.

Results (Chapter 5) showed that 17.4% of children with asthma were not assigned a UPC. The majority of children who were followed by a primary care provider were followed by a pediatrician (34.9%). Those children who were determined to have no primary care were more likely to be older, come from the most deprived SES quintile and live in a rural setting. Children who had high continuity of care were more likely to be followed by a pediatrician, rather than a family physician from an FMG or a non-FMG setting. Having a primary care provider was associated with improved

asthma-related ED visits and hospital admissions amongst this population. Amongst those children who had a primary care provider, continuity of care was found to be not significant when looking at asthma-related ED visits as an outcome. However, compared to low continuity of care, medium or high continuity was associated with decreased asthma-related hospital admissions.

### 6.2 Significance to Field of Family Medicine

Continuity of care has long been a fundamental principle in the field of Family Medicine. The concept of continuity of care is even embedded in one of the four principles of family medicine by the College of Family Physicians of Canada (CFPC). The CFPC's fourth principle is "The doctor-patient relationship is central to the role of the family physician," and according to Kelly, this principle is a "widely accepted core concept of family medicine [and] uphold patient-centered interviewing and continuity of care" (91). Thus, research in the mechanisms behind this concept is very important in this field in order to make sure family physicians uphold one of the significant principles behind the specialty.

Seeing a family physician can be for some people the first point of contact that they have with the health care system in general (92). Continuity in primary care is often seen as the relationship between a single practitioner and a patient that extends beyond a patients' specific episodes of illness or disease (9). The benefits that come from a patient's affiliation with their primary care physician or family medicine physician could be improved communication, trust, and responsibility for one's health (9, 53). Seeing a family physician can have a long term impact on future use of hospital services and numerous past studies have shown that having access to and seeing a family medicine physician over a period of time can be linked to improved health outcomes (93, 94) and reductions in both ED use and hospitalizations (1, 10, 26, 95). The results of this thesis are significant to the field of family medicine research for the uniqueness of the

chosen topic and population and the use and analysis of population-based data to describe current gaps in the Québec primary care health system.

This study is the first of its kind to use health administrative data comprising the whole population of asthmatic children in Québec in order to look at the benefits that access and continuity of care with a primary care physician can have on improved hospital outcomes. This study's dataset used physician billing data along with hospital discharge data and ED data. In line with the literature, access to a primary care provider along with increased relational continuity of care was found to decrease the odds of using the ED and being admitted to the hospital.

This thesis reinforces the importance of the primary care provider in the management of asthma for children. This thesis also supports the importance of a continuous relationship with a single primary care provider for a patient's improved health outcomes. There are currently many barriers to achieving proper primary care and continuity of care, and this study reinforces this statement. Opportunities to improve and increase access and continuity of care within the primary health care system could augment patient-provider relationships and help in the management of chronic illnesses. The list below are recommendations based on the results of this thesis, in order to improve the primary health care system in Québec and thus hopefully improve the family medicine specialty.

### 6.3 Recommendations

1. Approximately 17.4% of children with administratively defined asthma in Québec currently do not have a usual source of primary care. The Canadian Paediatric Society states that all children, in general, must have a primary care provider (96). Other guidelines for asthma care from the National Health, Lung, and Blood Institute in the United States

recommend regular asthma care for children with asthma by a primary care provider (97). Primary care for children with asthma should be a priority in policy.

2. Children who had no primary care were more likely to come from a more deprived neighborhood. Asthma has been shown previously to disproportionately affect the poor, especially children living in urban areas (98). Asthma prevalence rates were reported to be high in low-socioeconomic populations (99, 100). Socioeconomically deprived children in the past have been more likely to not receive care for asthma from a primary care provider and were more likely to received care in the ED (101-103). Strategies should be implemented in order to target this vulnerable asthmatic population, to ensure these children receive continuous care for asthma, rather than episodic and in the ED.
3. Having access to a primary care provider was associated with reduced asthma-related acute outcomes for children with asthma. Compared to no primary care, having a primary care provider was associated with decreased asthma-related ED visits (Pediatrician OR: 0.80, 95% CI [0.73, 0.89], FMGs OR: 0.84, 95% CI [0.75, 0.93], non-FMGs OR: 0.92, 95% CI [0.83, 1.02]) and hospital admissions (Pediatrician OR: 0.67, 95% CI [0.59, 0.76], FMGs OR: 0.83, 95% CI [0.73, 0.94], non FMGs OR: 0.77, 95% CI [0.67, 0.87]). There should be continued policies and interventions to promote primary care within the healthcare system.
4. Continuity of care was shown to not have a significant impact on asthma-related ED visits for children with asthma. However, when compared to low continuity of care, having medium or high continuity of care was associated with decreased asthma-related hospital admissions (Medium OR: 0.865, 95% CI [0.772-0.970], High OR: 0.788, 95% CI [0.683, 0.908]). Thus, it has been shown that there is some value in having a continuous

relationship with a primary care provider. New strategies should be implemented to promote the continuous involvement of the primary care provider with the child and their family when it comes to their asthma education and management.

5. Further research needs to be completed in order to understand the mechanisms that underlie continuity of care for children with asthma in Québec. Our results were less clear in regards to continuity of care with a primary care provider and the impact this concept has on acute care outcomes for children with asthma. Future quantitative studies could include using physician demographic information such as physician year of graduation, physician income, average number of patients seen daily by the physician or location of physician office in order to understand more about the clinician's role when it comes to continuity of care. Future qualitative studies could shed insight into patients' and parents' perceptions of their relationship with their primary care provider and the impact on their asthma care.

## 6.4 Conclusion

The findings generated from this thesis give an evaluation of the current role that primary care providers and continuity of care with said providers may play in the management of asthma for children living in Québec. The literature review conducted in this thesis showed that there were very few studies that have looked at the impact of continuity of care on the asthmatic children population. Past studies showed that high continuity of care was associated with better acute care outcomes, thus improved health care outcomes. This study showed that there is evidence to support the positive role that having a usual provider of care can have on improved acute-care outcomes. It is less clear what the role of continuity of care is in regards to improving health care outcomes. However, there is some value in having continuity of care with a primary care provider, as there were a decreased odds of being admitted to the hospital

for this child with high continuity of care. There should be continued policies and interventions to promote primary care within the healthcare system along with more studies to try and understand continuity and the mechanisms to improve continuity of care with a primary care healthcare provider.

## APPENDIX A1: SEARCH STRATEGY

**Table 11 Search strategy used for the literature review**

| |
|---|
| 1. “Asthma”[MeSH Terms], asthma [Text Word] OR asthmatics [Text Word] |
| 2. emergency services, hospital[MeSH Terms] OR emergency medical services[MeSH:noexp] OR emergency treatment[MeSH Terms] OR emergency care[Text Word] OR acute care[Text Word] OR emergency department*[Text Word] OR emergency room*[tw] OR emergency ward*[tw] OR outcome*[Text Word] OR admission*[Text Word] OR ambulatory care[MeSH Terms] OR hospitalization[MeSH Terms] OR hospitaliz*[tw] OR hospitalis*[tw]) |
| 3. (("Primary Health Care"[mh] OR "primary care"[all fields] OR "Physicians, Family"[mh] OR general pract*[all fields] OR "family"[ad] OR family pract*[all fields] OR family physician*[tw]) OR (pediatrician[Text Word] OR paediatrician (Text Word) OR pediatricians (Text Word)) |
| 4. ("continuity of patient care"[MeSH Terms] OR "comprehensive health care"[MeSH Terms] OR “continuity of care”[tw] OR “continuity of patient care”[tw] OR care continu*[tw] OR “continuity of primary care”[Text Word] OR COC index[Text Word] OR herfindahl index[Text Word] OR “usual provider of care”[Text Word] OR sequential continuity index[Text Word]) |
| 5. ("child"[all fields] OR children[tw] OR childhood[tw] OR premature[Text Word] OR preterm[Text Word] OR neonat*[Text Word] OR newborn*[Text Word] OR infan*[Text Word] OR baby[Text Word] OR babies[tw] OR toddler*[Text Word] OR boy[Text Word] OR boys[tw] OR girl[Text Word] OR girls[tw] OR kid[Text Word] OR kids[tw] OR school*[Text Word] OR juvenile[Text Word] OR teen*[Text Word] OR youth[Text Word] OR adolescen*[all fields] OR pediatric*[all fields] OR paediatric*[all fields]) |
| Complete search strategy: 1 and 2 and 3 and 4 and 5 |
| |

## APPENDIX A2: ELIGIBILITY CRITERIA

Eligibility criteria included:

**Inclusion Criteria:**

- Is a quantitative investigation.
- Studies which include human individuals of the age specified in the "children" definition. Will also include studies which look at all age groups that include the children age group.
- Studies which include children that are suffering from the study definition of "asthma".
- Studies that (1) provide number of visits to a general practitioner and/or pediatrician and/or family physician as the primary health care provider involved in the individual's continuity of care within a primary care setting and (2) provide outcomes, (3) both of which were evaluated with chart/medical records and/or claims data and/or administrative database and/or surveys.
- Studies focused on providers who were a general practitioner and/or a pediatrician and/or family physician as mentioned in the definition of "continuity of care" above.

To ensure that the search is feasible and to better understand the North American context of "continuity of primary care," this search will be restricted to studies in North America

**Exclusion Criteria:**

- Is not quantitative investigation (i.e., those studies which are qualitative and mixed methods).
- Any and all duplicated results.
- Any studies which only look at individuals above the age that is specified in the study definition of children
- Studies which did (1) not provide number of visits to a general practitioner and/or pediatrician and/or family physician as the primary health care provider involved in the individual's continuity of care within a primary care setting and (2) not provide outcomes, (3) and both were not evaluated with chart/medical records and/or claims data and/or administrative database and/or surveys.
- Studies focused on providers who were physicians in training, such as residents and fellows. These were excluded because these training sites might not reflect longitudinally in the provider-patient relationship as the definition suggests above for *"continuity of care."*
- Studies which addressed continuity of care with a physician in an inpatient care facility and/or mental health facility and/or chronic care facility. This is due to the fact that this study is focused on looking at the *"continuity of care"*, thus the patient-provider relationship in a primary care setting.

**Limits:**

- Only studies that are available in English or French
- Due to there being not an excessive number of studies pertaining to the topic of continuity of primary care and the impact on emergency department outcomes on individuals, no time period will be strictly enforced in the search.

## APPENDIX B: DETAILED METHODS

### B.1 Data Sources

This project used population-based data made available from the Regie de l'assurance maladie du Québec (RAMQ). The data from the RAMQ administers includes three databases:

1. Registered Persons Database
    a. Contains the encrypted health insurance number, sex, age, and postal code of all patients insured
2. Physician Claims Database
    a. Contains all records for remunerated services provided through the outpatient clinic or the emergency department.
    b. Each record has patient information which includes; 1. Patient characteristics such as their encrypted health number, age, sex, healthcare region of residence, postal code, and 2. The services rendered by each patient which includes the date, physician specialty, diagnostic codes, billing codes, establishment codes, and region of establishment
3. Hospital Discharge Database (Maintenance et Exploitation des donnees pour l'etude de la clientele hospitaliere, Med-Echo)
    a. Contains data from hospital admissions collected from each hospital in Québec.
    b. Each record had patient information which includes; 1. Patient characteristics such as their encrypted health insurance number, age, and sex, and 2. Principal diagnoses coded by International Classification of Diseases, Tenth Revision, Canada (ICD-10CA), along with dates of both admission and discharge.

The three databases were linked together by RAMQ using the encrypted health insurance number.

### B.2 Study Population

Study participants were the population of children who had a diagnosis of asthma as of January 1, 2012. A diagnosis of asthma was determined to be at least two outpatient billings or one hospitalization for asthma between January 1, 2010 and December 31, 2011. Children must also be two to sixteen years old as of January 1, 2012. Children must have been at least one year old at the time of their diagnosis of asthma. This population also includes children with medical complexity and asthma, children with diabetes and asthma, and children with diabetes, asthma and medical complexity.

### B.3 Primary Exposure

The primary exposure of interest for the first objective of this project was the primary care model. Children with asthma were assigned to one of the four possible primary care models; family physicians in FMGs, family physicians in non-FMGs, pediatricians or no primary care. This was determined by assigning a "usual provider of care" by looking at RAMQ data and visits from January 1, 2010, to December 31, 2011. The usual provider of care for each child was determined according to the algorithm below in Table 12.

**Table 12 Algorithm for determining usual provider of care (UPC)**

| **Algorithm to identify "usual provider of care (UPC)"** |
|---|
| **STEP 1**<br>Use codes for "enrollment" under a family physician. If subject has one of the following codes, then "primary care model" is a family doctor (FMG or non-FMG): 08875, 08877, 15144, 15145, 00059, 15158, 15159, 15148, 15169, 15170, 15171, 19952, 19951, 19954, 19955, 15156, 15157, 15189, 19074<br>The "Usual Provider of Care" is the family physician who billed any of the above codes, except for 19074 |
| **STEP 2**<br>If subjects do not have a code identifying a family physician, search for enrollment by a pediatrician using the 09194 code. This code is not specific to "enrollment" of patients under a pediatrician but it is used by pediatricians for follow-up or growth and development milestones. If this code is found, the "primary care model" is pediatrician.<br>The "usual provider of care" is the pediatrician who has billed the most 09194 codes. |
| **STEP 3**<br>If a subject does not have a code identifying a family physician or pediatrician, calculate the number of visits by a family physician (09092, 08870 (00005), 08871 (00056), 08872 (00097), 08901 (08807), 08902 (08809), 15161, 15230, 00474, 00002, 08873, 08874, 08855, 00007, 00075—brackets indicate these codes are billed by CHSGS/CLSC* outpatient clinic—and for each visits by a pediatrician (09129, 09127, 09171, 09172 – ALL billed by a pediatrician and not any other specialist).<br>Only one act per day per doctor can be included when calculating a number of visits. Only physicians with at least 2 visits can be considered for STEP 3. The following are ways that a |

| |
|---|
| usual provider of care can be assigned in STEP 3:<br><br>a. Family Physician (FMG or non-FMG) is assigned for the "primary care model": if the number of visits by the **same** family physician > the number of visits by the **same** pediatrician. The "usual provider of care" in this case is the family physician with the most complete major exams (00872 or 00097). If there are no complete major exams, select the family physician with the most visits.<br><br>b.A pediatrician is assigned for the "primary care model": if the number of visits by the **same** pediatrician > the number of visits by the **same** family physician. The "usual provider of care" is the pediatrician with the most visits.<br><br>c. For the "primary care model" if the number of visits (>=2) by the **same** pediatrician = number of visits (>=2) by the **same** family physician, then Family Physician (FMG or non-FMG) is assigned if there are at least 2 complete major exams (00872, 00097) by the same family physician; otherwise, Pediatrician is assigned. For the "usual provider of care," if the Family physician is assigned as the "primary care model," select the family physician with the most complete major exams (00872 or 00097). If there are no complete major exams, select the family physician with the most visits. If the "primary care model" is Pediatrician, the "usual provider of care" is the pediatrician with the most visits. |
| **STEP 4**<br>If no UPC is identified through STEPS 1 through 3, then the subject does not have a UPC and is classified as "no primary care." |

If the usual provider of care was determined to be a family physician, Table 13 was used to determine if the model of care was an FMG or a non-FMG. The codes were displayed below are in a hierarchy. Therefore code d'acte 08875 was searched for first, followed by code d'acte 19074, then looking at the establishment code of each FMG.

**Table 13 Algorithm to determine family physicians in FMGs**

| Code | Coding | Details |
|---|---|---|
| First, use the code d'acte 08875 (for any visits) | FMG | Inscription of patients in FMG |
| Then, use code d'acte 19074 (for any visits) | FMG | Temporary inscription of pregnant patient in FMG (followed by another MD in the same FMG) |
| Then look at list of FMGs. If patient had visit with UPC (family physician) at any time from Jan 1, 2010-December 31, 2011 in an établissement listed as an FMG during Jan 1 2010 to December 31, 2011, then primary care model is FMG. | FMG | Medical clinic coded for Family Medicine Groups |

**B.4 Secondary Exposure**

The secondary exposure variable for the secondary objective was the Usual Provider of Care Index. A child's usual provider of care (UPC) Index score was determined by looking at a visit with their usual provider of care determined in Table 12 between January 1, 2010 and December 31, 2011. The algorithm presented in Table 14 was used to determine the UPC Index score each patient. This algorithm was created by using the standard definition of the UPC Index and adapting it to the primary care health system in Québec (60). Each child's score was first determined by calculating the total amount of visits that the child had with their determined primary care model between January 1, 2010, and December 31, 2011. If the family physician (FMG or non-FMG) was assigned for their primary care model, then all visits with any code d'acte were counted. If the pediatrician was assigned for their primary care model, then all visits with any code d'acte were counted. This first number is the numerator in the algorithm. Secondly, the total amount of primary care visits billed with each child was collected with the help of Table 15 and Table 16. This was completed by adding up all and any type of visit with a family physician, along with primary care visits with pediatricians (see Table 16 for codes for primary care visits only for a pediatrician). This number, known as the denominator, also included all visits that were "counted" in the first step of the algorithm. The numerator was then divided by the denominator in order to give a ratio value that ranged from 0 to 1. If they were to determined to have no primary care through Table 12, then the child's index score was 0. Once each child's individual UPC Index score was determined, each child was then categorized into one of the following tertiles; >0-0.4=low, >0.40-0.70=medium, and >0.70-1= high.

**Table 14 Algorithm for determining UPC Index score**

| **Algorithm to identify the UPC Index score** |
|---|
| **STEP 1**<br>The patient's assigned UPC should be determined first with the algorithm in Table 12. Once their UPC has been determined, the total amount of visit with their determined primary care model will be collected between January 1, 2010, and December 31, 2011.<br>a. Family physician (FMG or non-FMG) is assigned for "primary care model": count all visits with any code d'acte<br>b. Pediatrician is assigned for "primary care model": count all visits with any code d'acte |
| **STEP 2**<br>The total amount of primary care visits billed with the patient will be collected between January 1, 2010, and December 31, 2011. Add up all visits with a family physician (any type of visit) plus PRIMARY CARE VISITS with pediatricians (use pediatrician codes in Table 16). The denominator will also include all the visits that were "counted" in STEP 1 (that have not been already "counted," i.e., no repeated visits). |
| **STEP 3**<br>The value determined in STEP 1 will be divided by the value determined in STEP 2 in order to give a ratio value that should range from 0 to 1. This value is their index score. |
| **STEP 4**<br>If no UPC is identified though in Table 12, then the subject does not have a UPC and their index score is 0. |

**Table 15 Primary care visit codes**

| **Description** | **Cabinet, CLSC, UMF-CH** | **CHSGS (clinique externe)** |
|---|---|---|
| Patient<br>ordinary exam <60 years | 08870 | 00005 |
| Patient<br>complete exam <60 years | 08871 | 00056 |
| Patient<br>major complete exam <60 years | 08872 | 00097 |

| | | |
|---|---|---|
| Home visit <70 years, first patient, non-urgent | 00002 | Same (home) |
| Home visit, additional patients, ordinary exam | 08873 | Same (home) |
| Home visit, additional patients, complete exam | 08874 | Same (home) |
| Home visit, additional patients, complete psychiatric exam | 08855 | Same (home) |
| Home visit, loss of autonomy, first patient, all other times than 0-7h | 00007 | |
| Home visit, loss of autonomy, additional patients | 00075 | |
| Exam/Pregnancy “prise en charge” | 00059 | 00059 |
| Psychiatric complete | 08901 | 08807 |
| Psychiatric complete major | 08902 | 08809 |

**Table 16 Primary Care visits ONLY for Pediatricians**

| Code | Details |
|---|---|
| **OFFICE** | |
| 09194 | General exam in office by pediatrician |
| 09127 | Main (non-consultative) visit in office by pediatrician |
| 09129 | Follow-up visit by pediatrician |
| 15164 | Multidisciplinary or parent meeting in regards to a complex pathology |
| **HOME VISIT** | |
| 09171 | Main visit by pediatrician |
| 09172 | Follow-up visit by pediatrician |
| 15552 | Palliative care visit by pediatrician |

**B.5 Covariates**

All covariates for each child were determined in the exposure period, January 1, 2010, to December 31, 2011. Age and sex were determined with the use of the registered persons database. Socioeconomic status (SES) was determined using the Pampalon Index, a social and material deprivation index using census data. The material component of this index looks at the amount of available economic resources while the social component looks at the quality of the social network surrounding the individual. The census data that is used includes education, employment, income, and other household information. This variable is divided into quintiles (Q1= least deprived, Q5= most deprived). Children's SES quintile was determined by RAMQ using postal codes.

Rurality was determined using the Census Metropolitan and Census Agglomeration Influenced Zone (MIZ) developed by Statistics Canada. MIZs are assigned by census subdivision using postal codes. MIZs are also used by the Institut de Sante Publique du Québec (INSPQ) and other researchers. The INSPQ divides patients into rurality zones according to the population total o the city in which the patient lives in. The condensed version was used in this project. Children were then categorized into three categories; urban cities with populations of over 100,000 (ex. Montreal and Québec), small cities with population total between 10,000 to 100,00, and rural towns with populations below 10,000.

We accounted for other co-morbidities that these children might have by including the other comorbidities variable. Children were then categorized into one of four categories; asthma only, asthma & diabetes, asthma & medical complexity, or asthma &diabetes & medical complexity.

Previous healthcare utilization for these children was accounted for by deriving three variables, accounting for previous emergency department (ED) use, previous hospital admission use and any previous asthma specialist visits. The previous ED use covariate created using the establishment code 0X7 to identify emergency department visits. The number of ED visits were counted from January 1, 2010, to December 31, 2011, to any provider. Each child was then categorized into four categories based on the number of ED visits they had during this period. These categories were determined by looking at the median amount of previous ED visits during this period and categorizing in order to make the variable uniform. The four categories were 0 ED visits, 1 ED visits, 2-3 ED visits, and over 4 ED visits.

The previous hospital admission covariate was created using Med-Echo services and counting the number of hospital admissions from January 1,2010 to December 31, 2011 to any provider. Hospital transfer were to be counted as a new hospital admission. A binary variable was used for this variable since the median number of hospital admissions for all children was not high.

The previous asthma specialist covariate was created by counting visits taken between January 1, 2010 to December 31, 2011. Visits were counted whenever a patient had a visit with either 1) respirologist (i.e., when professional specialist variable from Fichier "Services medicaux"= respirologist AND/OR 2) a visit with a pediatrician that was billed for asthma (493X) and the establishment code was the hospital outpatient setting (0X1). Each child was then categorized into four categories based on the number of asthma specialist visits they had during this period. These categories were also determined by looking at the median amount of previous asthma specialist visits and categorizing in order to make the variable uniform. The four

categories were 0 asthma specialist visits, 1 asthma specialist visit, 2 asthma specialist visits, or over 3 asthma specialist visits.

### B.6 Outcomes

Two outcome variables were created for this project; asthma-related ED visits and asthma-related hospital admissions. These two variables were measured during the outcome period of January 1, 2012 to December 31, 2013. The establishment code 0X7 was used to identify ED visits that occurred during this outcome period. The ICD-9 and ICD-10 Codes in Table 17 were to differentiate those asthma-related ED visits from the rest. These codes were determined to be asthma-related based on a previous project that looked to develop an index of asthma control specific to children and adolescents and the investigators of this project determined these ICD codes to be asthma-related based on a definition of asthma control from the Canadian Thoracic Society 2012 Asthma Guidelines (71). A binary variable that separates those children who had at least one asthma-related ED from those who did not have asthma-related ED visit was created. The asthma-related hospital admissions variable was created with the use of Med-Echo services during the outcome period of January 1, 2012, to December 31, 2013. The ICD codes in Table 17 were also used to determine those hospital admissions which were asthma-related. A binary variable was created which determined those children who had an asthma-related hospital admission versus those children who did not.

**Table 17 Asthma-related ICD codes**

| ICD 9 Code | ICD 10 Code | Details |
|---|---|---|
| 493xx | J45X, J46X | Asthma |
| 786.0 | R06.2 | Wheezing |
| 466xx | J20X, J21X | Acute Bronchitis and Bronchiolitis |

| | | |
|---|---|---|
| 490 | J40X | Bronchitis not specified as acute or chronic |
| 519.1 | J98.0 | Acute Bronchospasm |

The statistical analysis was as described in the manuscript section.

**B.7 Sensitivity Analyses**

Sensitivity analyses were completed to ensure findings were not sensitive to the choice of metric and to test the association of coordination of care. The UPC Index was replaced with the Bice-Boxerman Continuity of Care (COC) Index (104). A child's COC Index score was determined by looking only primary visits made with primary care providers between January 1, 2010 and December 31, 2011. The algorithm presented in Table 18 was used to determine the COC Index score for each patient. This algorithm was created by using the standard definition of the COC Index created by Bice created in 1977 (104). Only children who were assigned a UPC in Appendix B.3 were given a COC Index. Each child's score was first determined by calculating the total amount of visits made to each unique provider l between January 1, 2010, and December 31, 2011. The total amount of primary care visit (including primary care, pediatrician, etc. visits in Tables 15 and 16 along with asthma specialist visits) billed with the patient were collected between January 1, 2010, and December 31, 2011. The equation used to calculate the COC Index score was then presented in Step 4 of the algorithm where $n_i$ was the number of visits to each provider and n was the total number of primary care visits. The score should give a value between 0 to 1. If they were to be determined to have no primary care through Table 12, then the child's COC Index score was not accounted for. For those children who had no pc visits with their assigned UPC, however, they had other visits billed through the use of the codes in Step 1 of Table 12, they were given a COC score of 1. Once each child's individual COC Index score was determined, each child was then categorized into one of the following categories; 0-0.4=low, >0.40-0.70=medium, and >0.70-1= high.

**Table 18 Algorithm for determining COC Index using primary care visits and primary care providers**

| **Algorithm to identify the index score** |
|---|
| **STEP 1**<br>This algorithm can only be used if the patient is classified as having a usual provider of primary care according to Table 12. No score should be given if the assigned UPC was "no primary care." |
| **STEP 2**<br>Determine the number of visits to each unique provider. Ex. A patient visits their UPPC= 7 times, pediatrician#1= 5 times, and pediatrician#2=2 times, etc. |
| **STEP 3**<br>The total amount of primary care visits (including PC, pediatrician, etc. visits in Table 15 and Table 16, along with asthma specialist visit) billed with the patient will be collected between January 1, 2010, and December 31, 2011. The denominator will also include all the visits that were "counted" in STEP 2 (that have not been already "counted," i.e., no repeated visits). |
| **STEP 4**<br>The following equation shown below will be used to find each patient's index score. "$n_i$" is the number of visits to each provider, which was determined in STEP 2. The value found in STEP 2 is "n" in the equation.<br>$\frac{(\sum_{i=1}^{p} n_i^2)-n}{n(n-1)}$<br>Ex. If the patient had visits with their UPPC 7 times, a pediatrician 5 times, and a different provider 2 times. "n" would be 14. The score would look like this. $(((7^2)+ (5^2) + (2^2)) – 14))/ (14(14-1)) = ((49+25+4)-14)/182 = 64/182= 0.351$.<br>This score should never exceed 1 because each of the visits with the different provider should be counted for in STEP 2. |
| **STEP 5**<br>The following scores will be given according to the following statements.<br>a. Among the children who were first assigned a UPC according to Table 12, then check if these patients were assigned one of the following codes: 08875, 08877, 15144, 15145, 00059, 15158, 15159, 15148, 15169, 15170, 15171, 19952, 19951, 19954, 19955, 15156, 15157, 15189, 19074. If they were assigned one of these codes and had pc visits=0, assign them an index_bice_pc_cont=1 |

b. Only include those children who received an index_bice_pc_cont=0 if they were assigned a UPC provider according to Table 12. (See STEP 1 in Table 18 for clarification).

Detailed results of the sensitivity analyses can be viewed in Tables 19 and 20.

**Table 19 Multivariable logistic regression testing association between COC Index and asthma-related ED visits**

| | | OR (95% CI) | |
|---|---|---|---|
| Independent Variable | Levels | Unadjusted | Adjusted |
| Level of Continuity of Care | Low | Reference | Reference |
| | Medium | 0.852 (0.763, 0.950) | 0.888 (0.791, 0.997) |
| | High | 1.020 (0.937, 1.110) | 1.116 (1.019, 1.223) |
| Primary Care Model for those with a assigned UPC | FMG | Reference | Reference |
| | Pediatrician | 0.795 (0.737, 0.859) | 1.034 (0.930, 1.150) |
| | Non-FMG | 1.041 (0.960, 1.128) | 1.155 (1.045, 1.276) |
| Age Category | 2-5 yo | Reference | Reference |
| | 6-9yo | 0.707 (0.653, 0.765) | 1.094 (0.995, 1.203) |
| | 10-12yo | 0.646 (0.583, 0.714) | 1.204 (1.061, 1.367) |
| | 13-16yo | 0.540 (0.486, 0.601) | 0.934 (0.815, 1.069) |
| Gender | Female | Reference | Reference |
| | Male | 1.180 (1.103, 1.262) | 1.126 (1.040, 1.219) |
| Material and Social Deprivation Quintile | Q1 (least deprived) | Reference | Reference |
| | Q2 | 1.144 (1.037, 1.263) | 1.071 (0.956, 1.200) |
| | Q3 | 1.272 (1.148, 1.410) | 1.112 (0.986, 1.255) |
| | Q4 | 1.457 (1.315, 1.614) | 1.272 (1.128, 1.435) |
| | Q5 (most deprived) | 1.656 (1.500, 1.828) | 1.302 (1.157, 1.465) |
| Rurality | Urban (population >100k) | Reference | Reference |
| | Small cities (population 10k-100k) | 1.177 (1.064, 1.302) | 0.978 (0.865, 1.106) |
| | Rural (population <10k) | 1.374 (1.262, 1.495) | 1.058 (0.951, 1.177) |
| Other comorbidities | Asthma Only | Reference | Reference |
| | Asthma & Diabetes | 1.414 (0.819, 2.441) | 1.267 (0.631, 2.546) |
| | Asthma & CMC | 1.222 (1.098, 1.361) | 0.820 (0.720, 0.935) |
| | Asthma & Diabetes & CMC | 1.772 (0.866, 3.628) | 0.775 (0.259, 2.320) |
| Previous Hospital Admission | No | Reference | Reference |
| | Yes | 2.213 (2.072, 2.363) | 1.077 (0.988, 1.174) |
| Previous ED Visits | 0 Visit | Reference | Reference |
| | 1 Visit | 2.582 (2.275, 2.930) | 2.482 (2.148, 2.868) |

| | | | |
|---|---|---|---|
| | 2-3 Visits | 4.782 (4.268, 5.359) | 4.600 (4.030, 5.250) |
| | Over 4 visits | 11.295 (10.141, 12.580) | 10.667 (9.343, 12.177) |
| Previous Asthma Specialist Visits | 0 Visits | Reference | Reference |
| | 1 Visit | 1.303 (1.174, 1.446) | 1.157 (1.023, 1.308) |
| | 2 Visits | 0.907 (0.825, 0.998) | 0.965 (0.857, 1.087) |
| | Over 3 Visits | 1.818 (1.674, 1.974) | 1.501 (1.351, 1.669) |

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

**Table 20 Multivariable logistic regression testing association between COC Index and asthma-related hospital admissions**

| | | OR (95% CI) | |
|---|---|---|---|
| Independent Variable | Levels | Unadjusted | Adjusted |
| Level of Continuity of Care | Low | Reference | Reference |
| | Medium | 0.785 (0.680, 0.906) | 0.820 (0.818, 0.823) |
| | High | 0.858 (0.767, 0.960) | 0.951 (0.948, 0.953) |
| Primary Care Model for those with a assigned UPC | FMG | Reference | Reference |
| | Pediatrician | 0.795 (0.737, 0.859) | 1.185 (1.183, 1.188) |
| | Non-FMG | 1.041 (0.960, 1.128) | 1.132 (1.130, 1.134) |
| Age Category | 2-5 yo | Reference | Reference |
| | 6-9yo | 0.631 (0.569, 0.700) | 0.905 (0.903, 0.907) |
| | 10-12yo | 0.590 (0.516, 0.674) | 0.890 (0.887, 0.893) |
| | 13-16yo | 0.679 (0.599, 0.769) | 0.838 (0.835, 0.841) |
| Gender | Female | Reference | Reference |
| | Male | 1.002 (0.921, 1.090) | 0.937 (0.936, 0.939) |
| Material and Social Deprivation Quintile | Q1 (least deprived) | Reference | Reference |
| | Q2 | 1.136 (1.004, 1.285) | 0.988 (0.986, 0.990) |
| | Q3 | 1.313 (1.157, 1.490) | 1.063 (1.060, 1.066) |
| | Q4 | 1.212 (1.062, 1.384) | 0.994 (0.991, 0.997) |
| | Q5 (most deprived) | 1.406 (1.238, 1.596) | 1.031 (1.029, 1.034) |
| Rurality | Urban (population >100k) | Reference | Reference |
| | Small cities (population 10k-100k) | 1.547 (1.373, 1.742) | 1.349 (1.345, 1.353) |
| | Rural (population <10k) | 1.500 (1.349, 1.668) | 1.108 (1.105, 1.111) |
| Other comorbidities | Asthma Only | Reference | Reference |
| | Asthma & Diabetes | 12.371 (8.335, 18.362) | 12.034 (7.928, 18.267) |
| | Asthma & CMC | 6.524 (5.938, 7.169) | 4.433 (4.004, 4.907) |
| | Asthma & Diabetes & CMC | 37.721 (21.662, 65.687) | 27.922 (15.378, 50.698) |
| Previous Hospital Admission | No | Reference | Reference |
| | Yes | 4.168 (3.826, 4.540) | 1.991 (1.988, 1.994) |
| Previous ED Visits | 0 Visit | Reference | Reference |
| | 1 Visit | 1.819 (1.572, 2.106) | 1.062 (1.059, 1.065) |

| | | | |
|---|---|---|---|
| | 2-3 Visits | 2.851 (2.500, 3.251) | 1.510 (1.506, 1.513_ |
| | Over 4 visits | 6.264 (5.551, 7.067) | 3.378 (3.373, 3.384) |
| Previous Asthma Specialist Visits | 0 Visits | Reference | Reference |
| | 1 Visit | 0.969 (0.847, 1.107) | 0.975 (0.972, 0.978) |
| | 2 Visits | 0.611 (0.538, 0.693) | 0.974 (0.972, 0.977) |
| | Over 3 Visits | 1.545 (1.398, 1.707) | 1.498 (1.495, 1.501) |

OR: Odds Ratio

CI: Confidence Interval

CMC: Children with Medical Complexity

ED: Emergency Department

Q: Socioeconomic Quintile

FMG: Family Medicine Groups

UPC: Usual Provider of Care

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