

Maximizing the Effects of Asthma Interventions:

Predictors of Perceived Asthma Control over time

By

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August, 2012

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment
of the requirements for the degree of Master of Science in Rehabilitation Science

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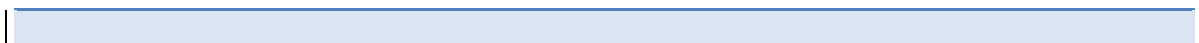


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Abstract

Background: Asthma is a common chronic disease that causes substantial morbidity and reduced quality of life when poorly controlled. Identifying clinical and psychosocial characteristics that influence long-term asthma control can help to match asthma management programs to the individuals' needs.

Objective: Study1: To estimate the extent to which symptom status, beliefs about medications, self-efficacy, emotional function, and health care utilization predict perceived asthma control over a 16 months period of time among a primary care population.

Study2: To estimate the extent to which symptom status, physical, mental, and social function, and healthcare utilization predict perceived asthma control over a 6 month period of time among individuals receiving care at a respiratory specialty clinic.

Methods: Study 1 and 2 are secondary analysis of data from two longitudinal studies that examined health outcomes of asthma. The first study recruited the participants from primary clinics, while the second one recruited the participants from a specialty clinic at a Montreal territory hospital. Evaluations on measures of symptom status, beliefs about medications, self-efficacy, physical, mental, and social function, and healthcare utilization were evaluated over 2 time points. Path analysis models were used to estimate the predictors of perceived asthma control in both studies, which were modeled based on the Wilson & Cleary and ICF models. The first study's path model hypothesized that symptoms, self-efficacy, beliefs about medications, emotional function, physical activity, and healthcare utilization are predictors of perceived asthma control. The second study's

path model hypothesized that FEV1, symptom, mental health, physical and social function, role emotional, and healthcare utilization are predictors of perceived asthma control.

Results: Study1: the path model indicated asthma symptom ($B = 0.35$, $p = 0.00$) and physical activity ($B = 0.24$, $p = 0.01$) had a significant positive total effect on perceived asthma control, while emotional function ($B = 0.08$, $p = 0.05$) and self-efficacy ($B = 0.07$, $p = 0.02$) were significant predictors indirectly through physical activity. The model explained 24% of perceived asthma control. Overall, the model fit the data well ($\chi^2 = 15.98$, $df = 10$, $P\text{-value} = 0.1$, $RMSEA = 0.045$, and $CFI = 0.98$).

Study 2: the path model indicated that FEV ($B = 0.12$, $p = 0.01$), asthma symptom ($B = 0.42$, $p = 0.001$), and social function ($B = 0.37$, $p = 0.02$) had a significant positive total effect on perceived asthma control. The model explained 34% of perceived asthma control. Overall, the model fit the data well ($\chi^2 = 39.83$, $df = 27$, $P\text{-value} = 0.053$, $RMSEA = 0.065$, and $CFI = 0.95$).

Conclusion: FEV1, asthma symptom, physical activity, emotional function, social function, and self-efficacy can be used to identify patients likely to have poor perceived asthma control in the future, and should be considered when planning patient management. Identifying these predictors is important to help the care team tailor interventions that will allow individuals to optimally manage their asthma, to prevent exacerbations, to prevent other respiratory-related chronic disease, and to maximise quality of life.

Resume

Contexte: L'asthme est une maladie chronique fréquente qui entraîne une morbidité importante et réduit la qualité de vie lorsqu'elle est mal contrôlée. L'identification des caractéristiques cliniques et psychosociales qui influent sur contrôle de l'asthme à long terme peut aider à faire concorder les programmes de gestion de l'asthme aux besoins des individus.

Objectif: Étude 1: Estimer la mesure dans laquelle le statut des symptômes, les croyances concernant les médicaments, l'auto-efficacité, l'émotion, et l'utilisation des soins de santé permettent de prédire le contrôle de l'asthme perçu sur une période de 16 mois dans une population des soins primaires.

Étude 2: Estimer la mesure dans laquelle le statut des symptômes physiques et mentaux, les fonctions sociales, et l'utilisation des soins de santé permettent de prédire le contrôle de l'asthme perçu sur une période de 6 mois chez les personnes recevant des soins dans une clinique spécialisée en pneumologie.

Méthodes: Les études 1 et 2 sont des analyses secondaires des données provenant de deux études longitudinales qui ont examiné les effets de l'asthme sur la santé. La première étude a recruté les participants de cliniques de soins primaires, tandis que la seconde a recruté les participants à partir d'une clinique spécialisée dans un hôpital à Montréal. Les évaluations sur les mesures de l'état de symptôme, les croyances concernant les médicaments, l'auto-efficacité, physique, mental, et les fonctions sociales, et l'utilisation des soins de santé ont été évaluées à 2 points dans le temps. Des modèles d'analyse de pistes causales ont été utilisés pour estimer les facteurs prédictifs de le

contrôle de l'asthme perçu dans les deux études. Les modèles utilisés se basent sur les modèles Wilson & Cleary et modèles ICF. Le modèle de piste pour la première étude a émis l'hypothèse que les symptômes, les auto-efficacités, les croyances au sujet des médicaments, l'émotion, l'activité physique, et l'utilisation des soins de santé sont des facteurs prédictifs du contrôle de l'asthme perçu. Le modèle de piste pour la deuxième étude a émis l'hypothèse que le VEMS, les symptômes, la santé mentale, les fonctions physiques et sociales, le rôle émotionnel, et l'utilisation des soins de santé sont des facteurs prédictifs du contrôle de l'asthme perçu.

Résultats: Étude 1: le modèle de piste causale a indiqué que les symptômes de l'asthme ($B = 0,35$, $p = 0,00$) et l'activité physique ($B = 0,24$, $p = 0,01$) ont eu un effet positif important sur le contrôle de l'asthme perçu totale, tandis que la fonction émotive ($B = 0,08$, $p = 0,05$) et l'auto-efficacité ($B = 0,07$, $p = 0,02$) étaient des prédicteurs significatifs indirectement au moyen de l'activité physique. Le modèle explique 24% de la le contrôle de l'asthme perçu. Les statistiques d'ajustement indiquent un bon ajustement du modèle ($= 15,98$ X², $df = 10$, $P\text{-value} = 0,1$, $RMSEA = 0,045$, et la $FCI = 0,98$).

Étude 2: le modèle de piste causale a indiqué que le VEMS ($B = 0,12$, $p = 0,01$), les symptômes d'asthme ($B = 0,42$, $p = 0,001$), et la fonction sociale ($B = 0,37$, $p = 0,02$) a eu un effet positif important sur le contrôle de l'asthme perçu totale. Le modèle explique 34% de la le contrôle de l'asthme perçu. Les statistiques d'ajustement indiquent un bon ajustement du modèle ($= 39,83$ X², $df = 27$, $P\text{-value} = 0,053$, $RMSEA = 0,065$, et la $FCI = 0,95$).

Conclusion: Le VEMS, les symptômes de l'asthme, l'activité physique, la fonction émotive, la fonction sociale, et l'auto-efficacité peuvent être utilisés pour identifier les

patients susceptibles d'avoir une mauvaise le contrôle de l'asthme perçu dans l'avenir, et devrait être considéré lors de la planification de gestion des patients. L'identification de ces prédictors est une étape importante pour aider les équipes d'interventions à administrer des soins sur mesure afin de contrôler l'asthme et les exacerbations des patients de façon optimale, mais également de prévenir les maladies chroniques associées, et de maximiser la qualité de vie.

Acknowledgments

I would like to express my sincere thanks to my supervisor Dr. Sara Ahmed for the continuous guidance, support, and patience throughout my Masters. I would also like to thank her for facilitating everything to do with my research through using her resources to write my thesis. Her guidance helped me to organize my thesis to be more scientific and coherent.

I would also like to thank my thesis committee Dr. Nancy Mayo and Dr. Pierre Ernst for their help to improve my thesis, and their feedback throughout the development of my project. A special thanks to Dr. Nancy Mayo for her creativity to improve thesis's methodology.

I especially want to thank my colleague Amede Gogovor for his help in preparing and organizing the thesis, and also his help to fix the English writing. Special thanks to McGill and the School of Physical and Occupational Therapy for giving me the chance to improve my research skills. I would also like to thank my colleagues in the School for their support and motivations, in particular, Omar Fawzy who helped me in abstract translation to French.

Last, but not least a big special thanks to my mother who spent her life for me, to my father who is spending his life for me, to my sisters, brothers, and family in Jordan. I would also like to thank my uncle, aunt, and cousins in Hamilton for their support and encouragement.

Regulation for a Manuscript-Based Thesis Faculty of Graduate Studies and Research, McGill University

The Faculty of Graduate Studies and Research (FGSR) of McGill University requires that the first five paragraphs of the Guidelines for Thesis Preparation be reproduced in the Preface section of this thesis. This is necessary to inform the external examiner of the regulations regarding a manuscript-based thesis.

- 1- Candidates have the option of including, as part of the thesis, the text of one or more papers submitted, or to be submitted for publication, or the clearly-duplicated text (not the reprints) of one or more published papers. These texts must conform to the Thesis Preparation Guidelines with respect to font size, line spacing and margin sizes and must be bound together as an integral part of the thesis.
- 2- The thesis must be more than a collection of manuscripts. All components must be integrated into a cohesive unit with logical progression from one chapter to the next. In order to ensure that the thesis has continuity. Connecting texts that provide logical bridges between the different papers are mandatory.
- 3- The thesis must conform to all other requirements of the "Guidelines for Thesis Preparation" in addition to the manuscripts. The thesis must include the following: title page, a detailed table of contents, an abstract in English and French, acknowledgements, an introduction which clearly states the rational and objectives of the research, a comprehensive review of the literature (in addition to

that covered in the introduction to each paper, a final conclusion and summary, and a thorough bibliography or reference list, according to disciplinary norms.

- 4- As manuscripts for publication are frequently very concise documents, where appropriate, additional material must be provided (e.g., in appendices) in sufficient detail to allow a clear and precise judgment to be made of the importance and originality of the research reported in the thesis.
- 5- In general, when co-authored papers are included in a thesis the candidate must have made a substantial contribution to all papers included in the thesis. In addition, the candidate is required to make an explicit statement in the thesis as to who contributed to such work and to what extent. This statement should appear in the single section entitled "Contributions of Authors" as a preface to the thesis.

Preface

This thesis presents work conducted to estimate the predictors of perceived asthma control. Despite an increase in our knowledge regarding the pathophysiology of asthma and the availability of effective therapies, the number of individuals with uncontrolled asthma is increasing. More than half of individuals with asthma have uncontrolled asthma. Identifying the predictors of perceived asthma control is important to tailor the intervention to the individuals with asthma to achieve the optimum level of asthma control, which in turn improves the functional level and QoL. Previous studies have mainly estimated the relationship between asthma control and sociodemographic and psychosocial variables using cross sectional studies. In this study, the predictors were estimated over time. Further, we used a path analysis that allowed us to model a map of relations between the predictors and the outcome.

Organization of the Thesis

This thesis consists of two studies, each of which estimated the predictors of perceived asthma control using a path analysis among two different patient populations. Both studies were a secondary data analysis from an existing data set. The first study was conducted among individuals receiving care for their asthma in a primary care clinic, while the second study recruited individuals from a specialist clinic.

Chapter 1 reviews the burden of chronic disease and asthma on health and QoL followed by the review of asthma control including the theoretical framework of health outcome levels. Background information on predictors of asthma control and the relationship between predictors is presented in Chapter 2. Chapter 3 outlines the rationale, objectives and hypotheses of the thesis.

The first manuscript (manuscript 1) is presented in chapter 4 and is entitled "Predictors of Perceived Asthma Control in Primary Care Clinics." In this manuscript the individuals with asthma were recruited from primary care clinics. The path analysis was used to estimate the predictors of perceived asthma control. Asthma symptoms, physical activity, self-efficacy, beliefs about medications, age, gender, smoking, and health care utilization were tested as potential predictors of perceived asthma control. Chapter 5 links between both manuscripts. The second manuscript (manuscript 2) is presented in chapter 6 and is entitled "Predictors of Perceived Asthma Control in a Specialist Clinic." In this manuscript the individuals with asthma were recruited from specialists' clinic and the path analysis was used to estimate the predictors of perceived asthma control. FEV1, asthma symptoms, physical, mental, and social functions, role of emotional, age, gender, smoking, body mass index, and health care utilization were tested as potential predictors of perceived asthma control.

Finally, Chapter 7, entitled "Summary and Conclusions", reviews the work in this thesis and presents considerations for future research. Corresponding tables and figures are presented at the end of each Chapter or Manuscript. References for all chapters and manuscripts are included at the end of the thesis.

Contribution of Co-authors

The data for the project presented in both manuscripts came from two longitudinal studies that examined the long-term health outcomes of asthma. The candidate developed the study questions, methodology, and content for this thesis with the help of his supervisor, performed all statistical analyses, wrote the manuscript, and interpreted the results with feed-back from the coauthors. In particular, Dr. Nancy Mayo

provided feedback on the study objectives and the structural equation modeling analyses that were used to answer the objectives in both manuscripts. In the context of the study, the candidate was responsible for designing the path models, preparing the data for analysis, performing the statistical analyses, interpretation of the findings and writing of the manuscripts. The co-authors functioned in consultant roles providing feedback on the study design, the analyses, and the final manuscripts.

Chapter 1: Introduction

1.1 The impact of chronic disease on health and quality of life

Almost all elderly people have at least one chronic disease (Clausen et al., 2005). Chronic diseases have a negative impact on daily function (Hays et al., 2000) and cause daily activity limitations (National Center for Health Statistics (U.S.), 2007). A previous Chinese study showed that individuals with chronic diseases had altered nutrition behaviours, which may lead to nutritional deficiency (Wang, Li, & Jiang, 2005; Zhao, Xi, & Zhang, 2005). In general, chronic diseases are associated with poorer quality of life (Aghamolaei, Tavafian, & Zare, 2010; Canbaz S, Sunter A.T, Dabak S, & Y, 2003; Hays et al., 2000; Rothrock et al., 2010), and have been shown to be negatively associated with the physical and mental components of the SF-36 (Luo & Hu, 2011). Further, Hunger et al. 2011 have shown that chronic diseases had a negative impact on mobility, usual activities, self care, pain, anxiety, and depression (Hunger et al., 2011).

In 2005, 35 million people were estimated to have died from chronic diseases worldwide. In 2007, 68% of Canadian deaths were due to chronic diseases (Canadian Cancer Society, 2007). Thirty three percent of youth and adult Canadians reported having at least one chronic disease. The proportion of individuals with chronic disease increases with increasing age, with more than 70% of people who are sixty years or older reporting having one or more chronic disease (Anne-Marie Broemeling, Watson, & Prebtani, 2008).

Chronic diseases place a large financial burden on Canadian society in terms of lost productivity due to missed work and treatment costs (Canadian Nurse Association, 2005). Quarter of all Canadian adults assist a family member or friend with the

management of their chronic disease at a cost of \$25 billion per year (Marcus J. Hollander & Neena, 2009). A total cost of chronic disease treatment is \$80 billion per year. (Anne-Marie Broemeling et al., 2008; Matthew W. Morgan & Michael, 2007).

1.2 Improving Outcomes for chronic disease

The chronic care model is an evidence-based client-centered framework that defines the important elements and strategies needed to improve care for individuals with chronic disease. The chronic care model presents the basic elements to improve the health care system. It proposes integration and interaction between patients and professional health teams to focus on patient-centred care to get the optimal functional and clinical outcomes. This model has been assessed in a variety of real-world settings, according to the literatures, implementation of its elements can promote population health and practice outcome. The chronic care model suggests improving the healthcare evidence-based in six areas which represent the main components of the model: 1) community resources and policies, 2) the health care system, 3) self-management support, 4) delivery system design, 5) decision support and 6) clinical information systems. Each one of these areas refers to potential interventions for chronic diseases (Kreindler, 2009).

The most successful and cost-effective interventions for chronic disease is patient self-management component (Bousquet & Michel, 1992). Self-management approach shifts the care towards a patient-centered approach; where the patient plays an active role in his/her own health care. Self-management refers to “an individual’s ability to manage the symptoms, treatment, physical, psychosocial consequences, and lifestyle changes

inherent in living with a chronic condition” (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002).

To tailor the appropriate interventions to individuals, the individual characteristics, clinical, and psychosocial factors that influence long-term outcomes for chronic disease should be identified.

1.3 The Burden of Asthma

Asthma is a chronic inflammatory disease of the airways, characterized by increased responsiveness of the tracheobronchial tree to a variety of stimuli that result in airway constriction. Signs and symptoms of asthma are wheezing, dyspnea, and coughing (Hillegass & Sadowsky, 2001). During an asthma attack, the lining of the bronchial tubes become swollen which causes narrowing of the airways and reduces the flow of air into and out of the lungs. Asthma attacks may occur several times in a day or week in affected individuals, and, in some people, asthma symptoms become worse during physical activity or at night (WHO, 2011). Asthma may cause substantial morbidity (Mannino et al., 2002) such as sleeplessness, daytime fatigue, reduced activity levels and school/work absenteeism; it is the third leading cause of work loss and lower productivity according to Harrison and Pearson (Harrison & Pearson, 1993).

Despite increasing knowledge regarding the pathophysiology of asthma and the availability of effective therapies (Cloutier, Wakefield, Carlisle, Bailit, & Hall, 2002), asthma incidence continues to increase in Canada resulting in substantial health care costs and reduced individual quality of life (Asthma & Allergy Information Association, 2006).

According to statistics Canada (Statistic Canada, 2011), in 2010 there were more than 2 million people diagnosed with asthma, representing 8.5% of the population aged 12 and older. In 1999, 59% of Canadian individuals with asthma had uncontrolled asthma (FitzGerald, Boulet, McIvor, Zimmerman, & Chapman, 2006). This percentage has not improved since that year (McIvor, Boulet, FitzGerald, Zimmerman, & Chapman, 2007). Each year approximately 400 die in Canada due to poor asthma control (Asthma Society of Canada, 2005) , while in the USA nearly 4000 die each year from asthma (American Lung Association, 2011)

The American Lung Association estimated \$20.7 billion in 2010 as direct and indirect costs of asthma (American Lung Association). Inpatient hospital services represented the largest direct medical cost, at over \$5.1 billion in 2004 (American Lung Association, 2005). The Conference Board of Canada estimated \$12 billion in 2010 as direct and indirect cost of chronic lung diseases including asthma (The Conference Board of Canada, March 15, 2012). The costs for uncontrolled patients were two times more than costs for controlled patients (Sullivan, Rasouliyan, Russo, Kamath, & Chipps, 2007).

Asthma disease is associated with increased co-morbidities, resulting in increased healthcare use, decreased quality of life, and poor asthma control (Boulet & Boulay, 2011). Gastroesophageal reflux disease, sinusitis, allergic rhinitis, nasal polyposis, obstructive sleep apnea are some of the asthma co-morbidities (Cazzola et al., 2011; Stirling & Chung, 2001). Soriano et al. 2005 estimated depression, hypertension, diabetes, ischemic heart disease, degenerative joint disease, cardiac arrhythmia, cancer,

congestive heart failure, cerebrovascular disease and COPD as a high prevalent co-morbid conditions of asthma (Soriano, Visick, Muellerova, Payvandi, & Hansell, 2005).

1.4 Perceived Asthma Control

The main goal of asthma treatment is maintaining asthma control. Individuals with asthma who are well controlled are able to lead full active lives by engaging in daily roles, participating in strenuous physical activities, and avoiding emergency department visits and hospitalizations (The American Academy of Allergy Asthma & Immunology, 2000). This in turn may improve patient's quality of life. Asthma control is defined as "the extent to which the manifestations of asthma have been reduced or removed by treatment" (Reddel et al., 2009) . Criteria used to classify poor asthma control are symptoms (wheezing, nocturnal waking, and shortness of breath), functional impairment (difficulties engaging in physical activity), reduced pulmonary function, and/or increased bronchodilator use (more than four times in the past week) (E. F. Juniper, O'Byrne, Guyatt, Ferrie, & King, 1999).

Perceived asthma control is defined as "individuals' perceptions of their ability to deal with asthma and its exacerbations" (P. P. Katz, E. H. Yelin, M. D. Eisner, & P. D. Blanc, 2002). Perceived asthma control is different from self-reported asthma symptoms (i.e. asthma control) (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, 2009) as perceived asthma control is related to three constructs; self-efficacy, locus of control, and learned helplessness (P. P. Katz et al., 2002), while asthma control is measured through patients or physician self report based on day/night symptoms, forced expiratory volume, medication, and work/school absenteeism (E. F. Juniper et al., 1999).

Individuals with asthma underestimate the magnitude of uncontrolled asthma (FitzGerald

et al., 2006). Perceived asthma control is important to assess because it has been found to be positively correlated with asthma self-management. Katz et al. 1997 showed that the people with higher score of perceived asthma control on perceived control asthma questionnaire have a good self-management (Katz, Yelin, Smith, & Blanc, 1997). As noted previously, self-management is an important component of the asthma treatment guidelines (Bousquet & Michel, 1992) and poor self-management links to poor health outcome (Bailey et al., 1990). Therefore, assessing the predictors of perceived asthma control is important to measure and will allow the care team to identify individuals with greater need for self-management support, and to deliver interventions most likely to be effective for a given individual.

1.5 Placing Perceived Asthma Control within a Theoretical Framework: The Wilson and Cleary and International Classification of Functioning, Disability and Health

The Wilson & Cleary and the International Classification of Functioning Disability and Health (ICF) are two commonly used models of health that can be used to guide the evaluation of outcomes and development of interventions. Both models reflect health as encompassing more than the absence of disease, and put the emphasis on health, functioning. For the Wilson and Cleary Model, there is an emphasis on quality of life (WHO; **Wilson & Cleary**, 1995). These models can be applied to understand how people live with asthma, and how asthma control and perceived asthma control can be affected.

The ICF Model

ICF is a classification of Functioning, Disability and Health. It is also a classification of health and health related domains. It was developed by world health organization in 2001 to describe and measure health and disability (WHO). ICF consists of three key components: body structure and function, activity, and participations, (Figure 1). Body structure and function refer to psychological function, dysfunction of body structure and function (i.e. impairment). The activity component refers to task performance by the individuals. The participations component refers to involvement in life situations (Stucki, 2005).

These three main components may interact with personal and environmental factors. Personal factors refer to individuals' features, while environmental factors consist of physical and social environment (Stucki, 2005).

The Wilson and Cleary Model

The Wilson and Cleary model was developed in 1995 by Ira B. Wilson and Paul D. Cleary. It was developed following an increased the demand of a conceptual model to explain the relationships of clinical variables to measure health related quality of life. Wilson and Cleary divided the health outcome into five levels: biological & physiological variables, symptoms status, functional status, general health perception and overall quality of life, (Figure 2). Biological & physiological variables refer to function of cells, organs, and organs system. Symptoms status refers to patient's perception of abnormal physical, emotional, or cognitive state. Functional status refers to individual performance task. General health perception refers to health related domains. Lastly, overall quality of life refers to subject well-being (Wilson & Cleary, 1995).

Integration of the two models

Figure 3 presents the integration of the Wilson & Cleary and ICF conceptual models. As shown in Fig. 3 and table 1, similar constructs are evaluated in these two models. Wilson & Cleary divided health outcome into five levels: biological & physiological variables, symptoms status, functional status, general health perception and overall quality of life (QoL). The health state in ICF model was divided into three components: body structure & function, activities and participations (CAD, 2001). Body structure & function component of the ICF model corresponds to biological & physiological variables and symptoms status levels of Wilson & Cleary model. Activities and participations components of ICF correspond to functional status level of Wilson & Cleary model.

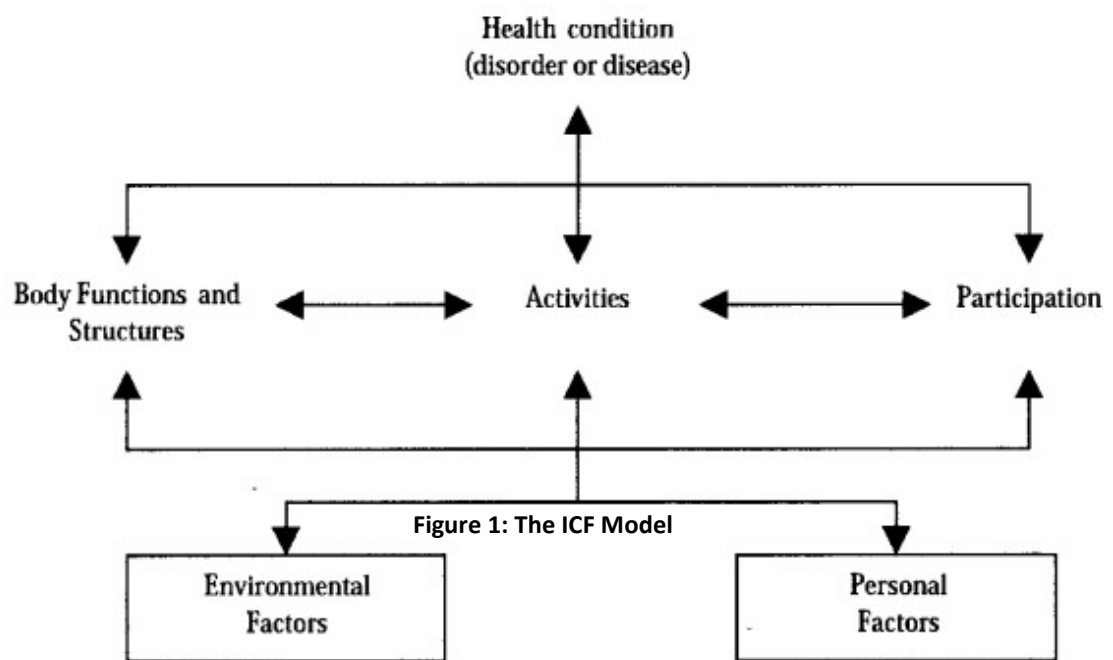
As supported by the asthma literature, changes in the biological & physiological/body structure & function of the airways may result in symptoms including coughing, wheezing, chest tightness and breathlessness (symptoms/ body structure & function Variable). The exacerbation of asthma symptoms leads to functional limitations (functional status/activities & participations). Symptom exacerbation and functional limitation (criteria of poor asthma control) may affect the asthma control and perceived asthma control, and in turn affect the level of general health perception and overall QoL levels.

Di Marco et al. 2009 (F. Di Marco et al., 2010) showed that forced expiratory volume (i.e. biological & physiological level/ body structure & function) correlates with and predicts the level of asthma control (i.e. symptom & function level/ body structure & function, activities, and participations). Also, exacerbation of asthma symptoms results in

school and work absenteeism (i.e. functional status level/participations). Vollmer et al. 1999 (Vollmer et al., 1999) and King et al. 2009 (King, Kenny, & Marks, 2009) found that asthma control (i.e. symptom & function level) is highly correlated with health related QoL. The literature has also supported the positive correlation between perceived asthma control and generic and disease- specific QoL (Patricia P. Katz, Edward H. Yelin, Mark D. Eisner, & Paul D. Blanc, 2002; Jennifer Olajos-Clow, Edith Costello, & M. Diane Loughheed, 2005). There are also other factors that affect the level of the health outcome levels in Wilson & Cleary and ICF models. These factors are divided into individual and environmental characteristics. Individual characteristics include sociodemographic characteristics, adherence to medication, self efficacy, beliefs about medication, physician continuity and emergency department visits all of which have been shown to affect the level of health outcome. As presented in the next section, correlations between these factors and health outcome levels were documented in the literature (symptom and functional status levels).

Table 1: The correspondence of the constructs are evaluated in both Wilson & Cleary, and ICF models

Wilson & Cleary Model	ICF Model
biological & physiological variables/ Symptoms Status	Body structure & function
Functional Status	Activities/ Participations
General Health Perception	Not tested
Overall Quality of Life (QoL)	Not tested
Characteristics of Individuals	Personal Factors
Characteristics of Environment	Environmental Factors



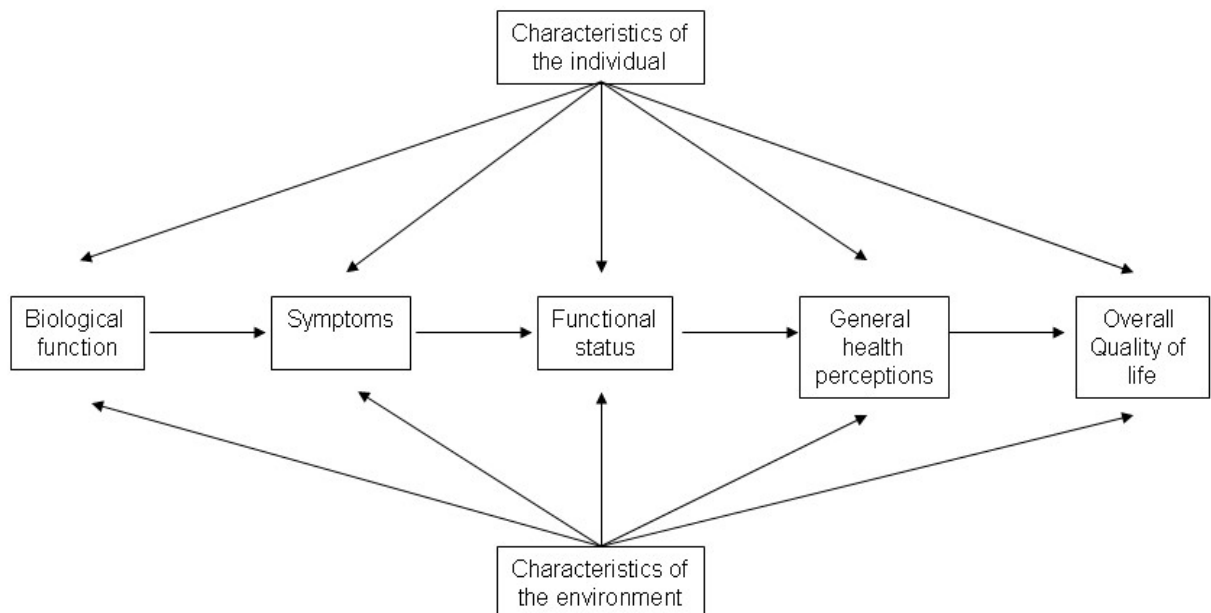


Figure 2: The Wilson & Cleary Model

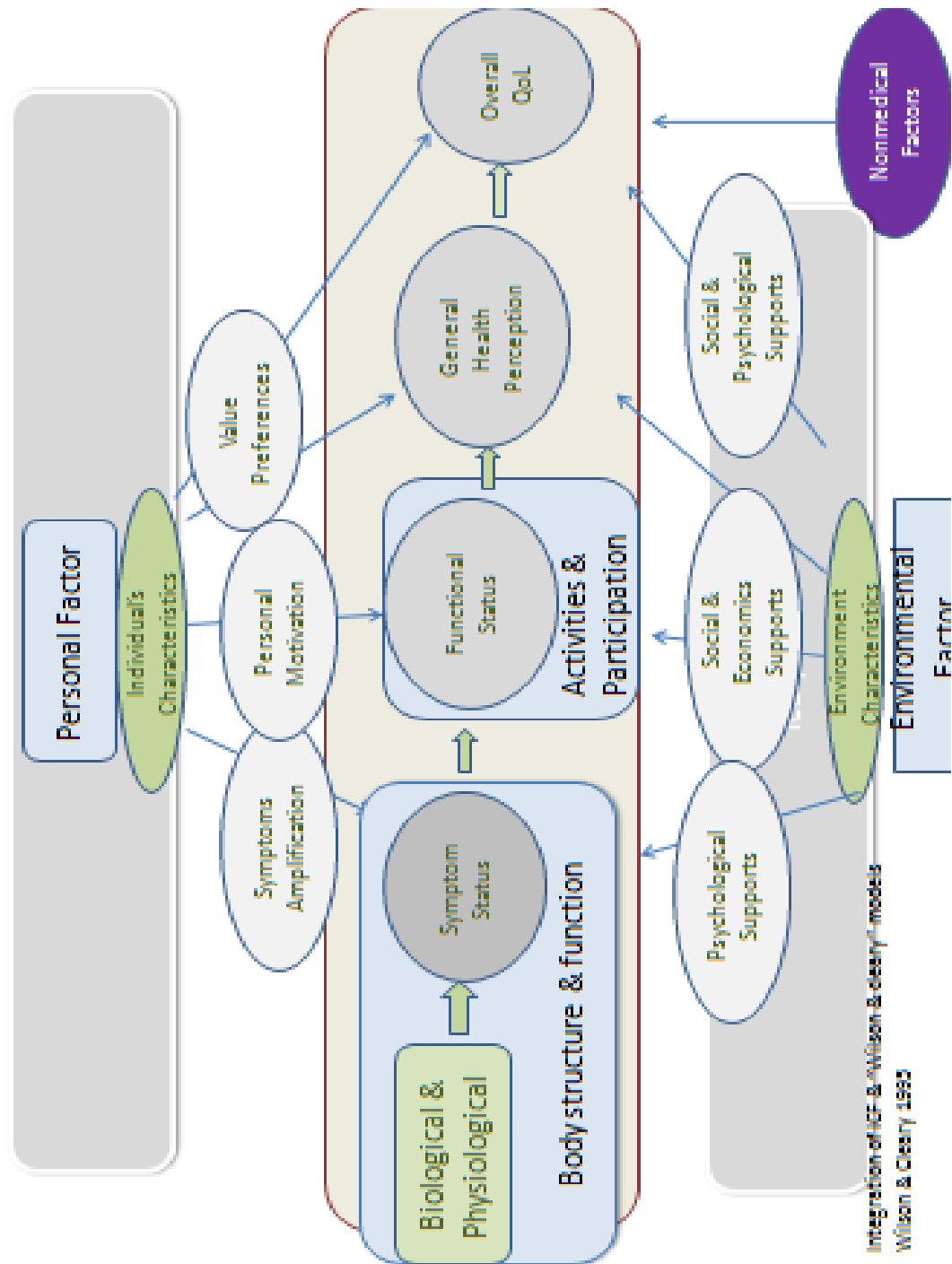


Figure 3: Integration of the Wilson & Cleary and the ICF Models*

*Blue quadrangular represent ICF, Oval shapes represents the Wilson & Cleary

Chapter 2: Background

2.1 Predictors of asthma control

To date, no studies have evaluated predictors of perceived asthma control, as defined in this thesis as “individuals’ perceptions of their ability to deal with asthma and its exacerbations” (P. P. Katz et al., 2002). The focus of previous studies was on predictor variables of asthma control level as measured by patient reported or physician reported evaluations of asthma control (i.e. based on physiological, symptoms, and function level) (F. Di Marco et al., 2010; Hermosa, Sanchez, Rubio, Minguez, & Walther, 2010; Kim L. Lavoie & Bacon, 2006; K. L. Lavoie et al., 2008; Y. K. Scherer & S. Bruce, 2001; Stanford et al., 2010; Strine, Mokdad, Balluz, Berry, & Gonzalez, 2008). Some of these predictors are considered as unmodifiable predictors, such as age, gender, duration of asthma, health care utilization, and race. Modifiable predictors include physician continuity of care, hospitalization, asthma education, depression, self efficacy, adherence to medication, smoking and environmental factors, Table 2.

Unmodifiable predictors

Age. Many studies showed that elderly people had poor asthma control compared to younger individuals. This worsening of asthma status is due to the effect of aging on the immune system and the cells that have a regulatory role in asthma, like T lymphocytes, neutrophils and epithelial cells. This impact may lead to the development of specific airway responsiveness and reduced responsiveness to anti-asthma drugs resulting in more asthma exacerbation (Vignola, Scichilone, Bousquet, Bonsignore, & Bellia, 2003). Virchow et al. 2010 showed that older persons (+50 years) had lower scores on asthma control test indicating poor levels of asthma control (Virchow, Mehta,

Ljungblad, & Mitfessel, 2010). Hermosa et al. 2010 also showed that elderly people (+50 years) had significantly higher scores on asthma control questionnaire indicating poor asthma control (Hermosa et al., 2010) and Di Marco et al. 2010 showed that older age (+65 years) was a significant predictor of poor asthma control (F. Di Marco et al., 2010). Also Stanford et al. 2010 showed that individuals who were older than 65 were more likely to develop uncontrolled asthma, but the result was not significant (Stanford et al., 2010).

Gender. There were mixed results regarding gender with some studies showing the female gender and others the male gender as a factor of poor asthma control. Hermosa et al. 2010 showed that women had significantly higher scores on the asthma control questionnaire (indicates poor asthma control) than men (Hermosa et al., 2010). Laforest L et al. 2006 showed that being female (most of them were obese and smoker) correlated with low asthma control (Laforest et al., 2006). Also Di Marco et al. 2010 showed that being female was significantly predictive of poor asthma control in a univariate analysis but the relationship was not significant in a multivariate model that adjusted for age, FEV, body mass index, depression, and anxiety (F. Di Marco et al., 2010). Conversely, Peters et al. 2007 showed that being male was associated with poor asthma control (Peters et al., 2007) as did Virchow et al. 2010 who also showed that men had higher scores (insignificant) on the asthma control test compared to women (Virchow et al., 2010).

Family History: based on the search in the databases, no study was conducted to estimate the relation between asthma control and asthma family history. However, Suzuki et al. 2011 showed that patients with an asthma medical history in their family

tend to have a higher rate of adherence to medication and fewer visits to the emergency department as they are assumed to get more information about the disease through family member with asthma, which may lead to improve asthma control (Suzuki, Saito, Adachi, Shimbo, & Sato, 2011).

Regarding the duration of asthma, Virchow et al. 2010 showed that patients with long duration of asthma tended to have poor asthma control (Virchow et al., 2010) while Van der Meer et al. 2009 did not find any correlation between the duration of asthma and asthma control level (van der Meer et al., 2009).

Previous studies have also supported the relationship between race and asthma control, with non-white races being associated with poor asthma control. Stanford et al. 2010 and Schatz et al. 2007 showed that the Hispanic and Black races were significant predictors of uncontrolled asthma than the white race (Schatz et al., 2007; Stanford et al., 2010). Nguyen et al. 2011 showed that the non-white race (Hispanic and black) was associated with uncontrolled asthma, but this result was not significant (Nguyen, Zahran, Iqbal, Peng, & Boulay, 2011).

Modifiable predictors

Modifiable predictors of asthma control are those that can be potentially changed to reduce the risk of an individual experiencing a loss of asthma control. Disease management programs for asthma are often designed to help improve modifiable predictors of asthma control including helping clinicians improve processes of care and individuals with asthma to improve health behaviours.

Self-efficacy is a term used to describe an individual's confidence and beliefs about his/her capacity to undertake certain actions that may lead to desired outcomes such as improved health (Bandura, 1977). Literatures have shown a relationship between asthma control and self-efficacy. Lavoie et al. 2008 showed that patients with lower scores on asthma self-efficacy scale had poor asthma control (nocturnal waking, waking symptoms, activity limitation, shortness of breath, wheezing, bronchodilator and corticosteroids use) (K. L. Lavoie et al., 2008). Also, higher scores on The Knowledge, Attitude, and Self-Efficacy Asthma Questionnaire were associated with better asthma control (including a decrease in emergency department visits and hospitalizations) (Y. K. Scherer & S. Bruce, 2001)

The literature has shown that individuals' beliefs about medications are strongly correlated to adherence to medications. Beliefs about medications is measured through Belief about Medicines Questionnaire, it consists of necessity and concern subscale. The score of belief about medication questionnaire is the difference between necessity and concern subscale scores. As the difference is positive the beliefs about necessity of medications increase, while if the difference is negative the beliefs about concerns of medications increase. Individuals beliefs about the necessity of medications correlated with the higher adherence to the medications while individuals beliefs about concerns regarding medications correlated with lower adherence (Emilsson et al., 2011; Horne & Weinman, 1999). Increasing the difference between medication necessity and concern could result in increase asthma control through adherence to asthma medications.

Stanford et al. 2010 showed that patients with poor adherence to asthma controller medications were more likely to have uncontrolled asthma than patients with

good adherence (Stanford et al., 2010). Another study showed the better patients adhere to asthma medications the more their asthma control improves (Suzuki et al., 2011). Also in the Hermosa et al 2010 study, patients who had higher adherence to treatment and knowledge about asthma had significantly higher level of asthma control (Hermosa et al., 2010). However, the relationship between adherence to medications and asthma control was not significant in Bender et al. 2010 study which included just 50 participants (Bender et al., 2010).

Depression may also result in worsening of asthma control due to its affect on daily self-monitoring abilities, treatment continuity (Kim L. Lavoie & Bacon, 2006) and self-efficacy (K. L. Lavoie et al., 2008). Individuals with depression have greater difficulty than non-depressed individuals monitoring asthma symptoms, which contributes to poor asthma control, emergency visits due to asthma (Diagnostic and statistical manual of mental disorders (DSM-IV), 1994), and higher healthcare utilization (Mancuso, Rincon, McCulloch, & Charlson, 2001). Studies that were conducted on the correlation between depression and asthma control have shown that depression and anxiety were associated with poor asthma control. Lavoie et al. 2006 showed that patients with depressive disorder were more likely to have poor asthma control compared to patients without depressive disorder (Kim L. Lavoie & Bacon, 2006). Another study conducted by Di Marco et al. 2010 showed that depression and anxiety were associated significantly with poor asthma control assessed using both the asthma control test and GINA (Global Initiative for Asthma) approaches (F. Di Marco et al., 2010). Odds ratio of poor controlled asthma for patients with anxiety and depression were 3.76 and 2.45, respectively. Also in this study, when patients were asked to rate their asthma control

(last question on the asthma control test), the results showed that depressed and anxious patients chose the worst level of asthma control (F. Di Marco et al., 2010). Strine et al. 2008 showed that patients with depression are more likely to have symptoms of poor asthma control like physical activity limitation, insufficient sleep, and fatigue (Strine et al., 2008).

The literature supported that regular exercise leads to improved levels of asthma control (Dogra, Jamnik, & Baker, 2010; Dogra, Kuk, Baker, & Jamnik, 2010). Regarding social function, based on database no studies was conducted on adults, however, children who had poor asthma control reported a problem in their psychosocial activity (Rhee, Belyea, & Elward, 2008). Social concern had an significant negative correlation with asthma control (McLeish, Zvolensky, & Luberto, 2011).

Many studies have shown that smoking is associated with poor asthma control (Althuis, Sexton, & Prybylski, 1999; Connolly, Chan, & Prescott, 1989; F. Di Marco et al., 2010; Niedozytko, Gruchala-Niedozytko, Chelminska, Sieminska, & Jassem, 2008; Siroux, Pin, Oryszczyn, Le Moual, & Kauffmann, 2000; Stanford et al., 2010; Strine et al., 2008; Tonnesen et al., 2005). In a study conducted on the impact of smoking on asthma, 54% of smokers had severe asthma symptoms. Smoking has also a negative impact on the treatment of asthma in patients with uncontrolled asthma (Niedozytko et al., 2008). Many studies have shown that smoking cessation led to significant reductions of asthma symptoms and a decrease in bronchial hyperreactivity resulting in improvement of QoL (Stein, Weinstock, Herman, & Anderson, 2005; Tonnesen et al., 2005).

There are also many studies that showed that current smokers had a higher frequency of asthma exacerbation, asthma attacks, and a higher level of asthma severity score than non-smokers (Althuis et al., 1999; Connolly et al., 1989; Siroux et al., 2000). Stanford et al. 2010 showed that current smokers and former smokers were more likely to have uncontrolled asthma (Stanford et al., 2010). Also Hermosa et al. 2010 showed that smoking was associated with poor asthma control, but the result was not significant ($p = 0.07$) (Hermosa et al., 2010). Di Marco et al. 2010 showed that smoking was not associated with poor asthma control, however, they had few smokers in their study (F. Di Marco et al., 2010).

The literature has shown that higher body mass index is associated with poor asthma control. Hermosa et al. 2010 showed that the higher body mass index ($> 25 \text{ kg/m}^2$) was a significant variable that led to poorer asthma control (Hermosa et al., 2010). Lavoie et al. 2006 showed that people with higher body mass index had a higher score of Asthma Control Questionnaire indicating poor asthma control (K. L. Lavoie, Bacon, Labrecque, Cartier, & Ditto, 2006). Also, Mosen et al. 2008 showed that the higher body mass index people had the more likely they were to report poor asthma control even after adjusting for demographics, smoking status, oral corticosteroid use, presence of gastroesophageal reflux disease, and inhaled corticosteroid use (Mosen, Schatz, Magid, & Camargo, 2008).

Regarding hospitalization and emergency department visits, Hermosa et al. 2010 showed that the frequency of hospitalizations and visits to physicians was associated with the level of asthma control; an increase in the number of hospitalizations or physician

visits was associated with a decrease in the level of asthma control (Hermosa et al., 2010; Lai, Duncan, Keighley, & Johnson, 2002; Nguyen et al., 2011).

Environmental factors (Breton, Zhang, Hunt, Pechter, & Davis, 2006; Frisk et al., 2006; Yssel, Abbal, Pene, & Bousquet, 1998) are associated with an increase in the prevalence of asthma (Yssel et al., 1998) and in asthma symptoms (Frisk et al., 2006). Environmental factors that aggravate asthma symptoms include dampness in residential dwellings, tobacco smoke, formaldehyde, nitrogen dioxide, and indoor allergens (dust mites, furred animals) (Breton et al., 2006) . In addition, Breton et al. showed that work related asthma (workplace exposures) was associated with poor asthma control.

A relatively small study demonstrated that low sodium intake may result in improvement of bronchial reactivity, asthma symptoms, and bronchodilator consumption (Burney et al., 1989; Carey, Locke, & Cookson, 1993; Javaid, Cushley, & Bone, 1988; Medici, Schmid, Hacki, & Vetter, 1993). While Pogson et al. 2008 conducted a study on 220 subjects and found that there was no difference in asthma control in patients who had low sodium intake compared to those with higher sodium intake (Pogson et al., 2008).

2.2 Correlations between predictors:

Personal characteristics like age, gender, smoking, and body mass index are associated with asthma symptoms, depression, physical activity, and function. Eagan et al. 2002 showed that the prevalence of cough, wheezing and dyspnoea was higher among females and the incidence of cough and dyspnoea was higher in the oldest age group (> 50 years), while the incidence of wheezing was higher in the youngest age group. Being a

current smoker had a higher incidence of asthma and developing its symptoms (Eagan, Bakke, Eide, & Gulsvik, 2002). Schachter et al 2001 showed that obese individuals had a higher prevalence of wheezing and shortness of breath (Schachter, Salome, Peat, & Woolcock, 2001).

The level of physical activity among individuals was affected by age and gender; males and younger people had a higher level of physical activity (Schroll, 2003). Physical activity was also affected by FEV, asthma symptoms (Dyer, Hill, Stockley, & Sinclair, 1999), depression (Dyer et al., 1999; Lai et al., 2002; Oakley, Khin, Parks, Bauer, & Sunderland, 2002), self-efficacy (McAuley et al., 2011), body mass index (Backholer, Wong, Freak-Poli, Walls, & Peeters, 2012), and smoking (Altman & Bernstein, 2008). With an increase in FEV and self-efficacy, the physical activity improves. Absence of depression, improving of asthma symptoms, decreasing weight, and smoking cessation improve the physical activity status.

The literature has also shown that depression and/or anxiety are more prevalent among individuals with asthma (Fabiano Di Marco, Santus, & Centanni, 2011; Thomas, Bruton, Moffat, & Cleland, 2011; Walters, Schofield, Howard, Ashworth, & Tylee, 2011), especially those who are female and older age (Akhtar-Danesh & Landeen, 2007; Stordal, Mykletun, & Dahl, 2003). A study that used structural equation modelling showed the higher body mass index was associated with severe depression (Dragan & Akhtar-Danesh, 2007). The literature has also supported the relationship between depression and social activity. In one study was conducted on patients with chronic fatigue syndrome; depression was associated with decreased level of social function (Morris et al., 1999). Also in another study that conducted on depressed people,

treatment of depression improved the social function (SCOTT et al., 2000). Asthma severity was also found to correlate with separation anxiety symptoms, and to affect the family interaction pattern in children with asthma (Fiese, Winter, Wamboldt, Anbar, & Wamboldt, 2010). In addition to that, depression may also affect daily self-monitoring abilities, remove treatment continuity (Kim L. Lavoie & Bacon, 2006) and self-efficacy (K. L. Lavoie et al., 2008).

Emergency department visits among individuals with asthma were associated with smoking, body mass index, and self efficacy. As smoking cessation, the probability of emergency department visits decreases (Ikeue et al., 2010; Silverman, Boudreaux, Woodruff, Clark, & Camargo, 2003). Higher body mass index was associated with urgent care visits (Grammer et al., 2010), and lower self efficacy was also associated with urgent care visits (Mancuso, Sayles, & Allegrante, 2010; Yvonne Krall Scherer & Susan Bruce, 2001).

Table 2: Predictors of asthma control; modifiable & unmodifiable.

Unmodifiable	Modifiable
Age	Self efficacy
Gender	Adherence to asthma medications
Race	Depression
Family history of asthma	Smoking
Duration of asthma	Body Mass Index
	Nutrition
	Environmental factor

Table 3: Correlations between Potential Predictors

Potential Predictors	Affected By
Asthma Symptoms	Age, Gender, Smoking, Depression
Adherence to Medications	Depression
Physical Activity	Age, Gender, Smoking, BMI, Depression, FEV, Asthma symptoms, Self Efficacy,
Depression	Age, Gender, BMI
Social Activity	Depression
Adherence to Medications	Depression
Asthma Symptoms	Age, Gender, Smoking, Depression

Chapter 3: Significance and Objective:

3.1 Significance

Identifying the predictors of perceived asthma control may help tailor interventions to the needs of individuals with asthma and help to improve lung capacity and optimise levels of physical activities. Improving outcomes for asthma by evaluating and identifying significant predictors of perceived asthma control may prevent co-morbidities associated with asthma (Vollmer et al., 1999) and future development of other chronic diseases (Silva, Sherrill, Guerra, & Barbee, 2004). Further the assessment of predictors of perceived asthma control in this study can be used as a model for evaluating predictors of poor outcomes among other patient populations such as chronic obstructive pulmonary disease, chronic pain, cancer, and diabetes.

Several studies have been conducted to estimate predictors of asthma control but not perceived asthma control. Almost all of these studies were conducted as cross sectional studies. They only assessed the relationship between predictors and asthma control at one time point. There is no indication of the sequence of the disease (i.e. the predictors or the factors came beforehand, after or during the onset of the disease) or the change in the status of the disease (Levin, 2006). The only longitudinal study found (Taegtmeyer et al., 2009) included a limited number of predictors, mainly, sociodemographics (age, gender and smoking) and adherence to medication variables as predictors of asthma control. They did not consider the other predictors in their study. Also, no studies measured perceived asthma control as the outcome. Furthermore, no studies were found in the database that used path analysis or structural equation modeling to estimate the predictors of perceived/asthma control.

Path analysis is an extension of multiple regression model. In the regression model, each independent variable is tested while adjusting for other independent variables, and there can only be one outcome. The association between these variables is adjusted for other independent variables during the run of the predictive model. For this reason, we can't estimate the direct and indirect effects on the outcome; i.e. we can't conclude which variables have higher effect on the outcome. Path analysis allows us to use more than one outcome at the same time and to test the direct and indirect effects of the predictors on the outcome. It allows us to use the same variable as predictor and as outcome at the same time. It also gives us a map for all studied variables to understand the overall relationship between them (Jeonghoon Ahn, 2002; Rex B. Kline, 2005a).

In this study we evaluated the predictors of perceived asthma control i) with the guidance of the Wilson & Cleary and the ICF model to specify the relationship between predictors simultaneously, which is likely a more realistic representation of predictors of perceived asthma control; ii) we used data from two longitudinal studies from primary and specialty care, which addresses the limitations of previous cross-sectional studies afore-mentioned; iii) we included a larger number of variables, including variables not considered in previous studies (i.e. beliefs about medicine, physical function, and role emotional) as a potential predictor of perceived asthma control; and iv) a path analysis was used to allow us to use more than one outcome to test the relationship between all predictors simultaneously. Also, previous studies have not used a direct measure of perceived asthma control as the outcome.

Identifying predictors of perceived asthma control is important for clinicians and physicians to tailor intervention to patient to achieve an optimum level of asthma control

(Rabe et al., 2004). That may decrease the risk of life threatening exacerbations and long-term morbidity (Vollmer et al., 1999). Also, improving perceived asthma control has been shown to lead to improved asthma self-management (Katz et al., 1997) which in turn results in an improvement of health outcome (Bailey et al., 1990).

The Canadian Thoracic Society, 2010, established treatment guidelines for asthma. The guidelines include environmental control, self-management, education, a written action plan, and pharmacotherapy. Environmental control is done by avoiding the stimuli factors that exacerbate asthma symptoms. Self-management, education and written action plan include preventive management strategies, adjusting the dose of reliever and controller therapy in proportion with level of asthma control, and clear instructions regarding urgent medical need, while pharmacotherapy line includes the reliever and the controller medications (Lougheed et al., 2010).

Despite these guidelines, asthma control level is suboptimal in Canada. Fifty nine percent of Canadians with asthma have uncontrolled asthma (FitzGerald et al., 2006). The reason of that may be because this guideline focuses just on two levels of health outcomes: biological and physiological variables and symptoms status. However, the guidelines do not focus directly on factors such as co-morbid factors (e.g. Depression), physical function, social function, self-efficacy, and adherence to medication, all of which may affect the health outcome levels. Identifying the relationship between these factors and perceived asthma control will help clinicians to direct intervention to these factors to achieve optimum levels of asthma control for their patients.

3.2 Objective:

3.2a: First study's objective: To estimate the extent to which beliefs about medicine, self-efficacy, asthmatic symptoms, emotional function, physical activity, and healthcare utilization predict the perceived asthma control over a 16 months period of time among individuals with asthma in primary care clinics.

3.2b: Second study's objective: To estimate the extent to which asthma symptoms, physical, mental, & social function, and healthcare utilization predict the perceived asthma control over a 6 month period of time among individuals with asthma in specialist clinic.

3.3 Hypotheses:

3.3a: First study's Hypotheses:

H1: Asthma symptoms will have a significant negative total effect on perceived asthma control.

H2: Physical activity and emotional function will have a significant positive total effect on perceived asthma control.

H3: Beliefs about asthma medications will have a significant positive total effect on perceived asthma control.

H4: Self-efficacy will have a significant positive total effect on perceived asthma control.

H5: Health-care utilization will have a significant negative total effect on perceived asthma control.

3.3b: Second study's Hypothesis:

Physical and social function, mental health, and role emotional will have a significant positive direct effect on perceived asthma control, while health-care utilization will have a significant negative total effect on perceived asthma control.

Chapter 4: Manuscript 1: Predictors of perceived asthma control in primary care clinics.

Abstract

Background: Asthma is a common chronic disease that causes substantial morbidity and reduced quality of life when poorly controlled. Identifying clinical and psychosocial characteristics that influence long-term asthma control can help to match asthma management programs to the individuals' needs.

Objective: To estimate the extent to which symptom status, physical activity, beliefs about medications, self-efficacy, emotional function, and healthcare utilization predict perceived asthma control over a period of 16 month among a primary care population.

Methods: The current study is a secondary analysis of data from a longitudinal study that examined health outcomes of asthma among participants recruited from primary care clinics. Path analysis, based on the Wilson & Cleary and ICF models, was used to estimate the predictors of perceived asthma control.

Results: The path analysis identified asthma symptoms ($B = 0.35$, $p = 0.00$) and physical activity ($B = 0.24$, $p = 0.01$) as significant predictors of perceived asthma control (total effects, i.e. direct and indirect), while emotional function ($B = 0.08$, $p = 0.05$) and self-efficacy ($B = 0.07$, $p = 0.02$) were significant indirect predictors through physical activity. The model explained 24% of the value of perceived asthma control. Overall, the model fit the data well ($\chi^2 = 15.98$, $df = 10$, $P\text{-value} = 0.1$, and Comparative Fit Index = 0.98).

Conclusion: Current symptoms and physical activity status can be used to identify individuals likely to have poor perceived asthma control in the future. Self-efficacy and

emotional function have also an impact on perceived asthma control mediated through physical activity and should be considered when planning patient management.

Identifying these predictors is important to help the care team tailor interventions that will allow individuals to optimally manage their asthma, to prevent exacerbations, to prevent other respiratory-related chronic disease, and to maximise quality of life.

4.1 Introduction:

Asthma may cause substantial morbidity (Mannino et al., 2002) such as sleeplessness, daytime fatigue, reduced activity levels, and school/work absenteeism; it is the third leading cause of work loss and lower productivity according to Harrison and Pearson (Harrison & Pearson, 1993). Approximately two-thirds of individuals with asthma in the U.S. received care from primary care clinicians, while the other third received care from specialists, including allergists or pulmonologists (Janson & Weiss, 2004).

According to the literature, receiving care from a primary care physician is associated with uncontrolled asthma (Badiola et al., 2009). In 2009, the prevalence of uncontrolled asthma among primary care patients in the USA was 58% (Mintz et al., 2009). These findings are partly related to the barriers associated with implementing asthma treatment guidelines in primary care including lack of provider awareness, inadequate knowledge regarding treatment guidelines, disagreement with guidelines, and lack of confidence in implementing guidelines (Grol & Wensing, 2004).

Key recommendations in the Canadian asthma treatment guideline encompasses prescription of reliever (inhaled fast-acting beta2-agonists) and controller (inhaled corticosteroids) therapy medications and self-management education, including oral and written action plans, but it doesn't focus on psychosocial characteristics, activity limitations (e.g. self efficacy and physical activity) and on asthma co-morbidities (Lougheed et al., 2010). Despite asthma treatment guidelines are available, the level of asthma control in primary care settings remains suboptimal (Mintz et al., 2009). This may in part be related to factors that are related to the disease itself, or to personal

characteristics that may affect health outcomes that are not routinely considered in asthma management (**Wilson & Cleary**, 1995). Identifying these factors is important for clinicians and physicians to tailor interventions to patient profiles to achieve an optimum level of perceived asthma control (Rabe et al., 2004).

Previous studies have evaluated predictors of asthma control among patients in primary care clinics. The potential predictors were divided into unmodifiable and modifiable variables. Unmodifiable variables like age, gender, race, and duration of asthma, which have not been shown to be strongly associated with asthma control. For example, aging is not associated significantly with poor levels of asthma control (Gonzalez Barcala et al., 2010; Nguyen et al., 2011; Stanford et al., 2010), mixed results have been shown for gender where most studies show no effect on asthma control (Gonzalez Barcala et al., 2010; Nguyen et al., 2011; Stanford et al., 2010), except for Laforest et al. that found that being female was associated with low asthma control (Laforest et al., 2006), and Peters et al. showing the same relationship but for men (Peters et al., 2007). Individuals from non-white races in the U.S. were also more likely to have poor asthma control (Schatz et al., 2007; Stanford et al., 2010). Lastly, there were no significant association identified between duration of asthma and level of asthma control (Ponte et al., 2007; van der Meer et al., 2009).

There is evidence supporting the association of modifiable variables such as stronger self-efficacy, beliefs about medications, adherence to medications, absence of depression and anxiety, regular exercise performance, higher psychosocial function, being a non-smoker, and lower body mass index with higher levels of asthma control (Dogra, Jamnik, et al., 2010; Dogra, Kuk, et al., 2010; Gonzalez Barcala et al., 2010;

Martin et al., 2009; Mosen et al., 2008; Nguyen et al., 2011; Rhee et al., 2008; Y. K. Scherer & S. Bruce, 2001; Stanford et al., 2010; Stein et al., 2005).

Perceived asthma control is different from asthma control as perceived asthma control (Janssens et al., 2009) is related to three constructs: self-efficacy, locus of control, and learned helplessness (P. P. Katz et al., 2002), while asthma control is related to patient or physician reports based on symptoms, work/school absenteeism, and FEV (E. F. Juniper et al., 1999). perceived asthma control is associated positively with asthma self management (Katz et al., 1997). Therefore, assessing the predictors of perceived asthma control is important to measure and will allow the care team to identify individuals with greater need for self-management support and to deliver interventions most likely to be effective for a given individual.

Currently in the literature, previous studies have focused on predictors of asthma control but none have examined the predictors of perceived asthma control. Furthermore, previous studies have used regression analyses to estimate predictors of asthma control. When there are two or more dependent variables, regression analyses are limited as they do not allow for more than one outcome. In the regression model, each independent variable is tested while adjusting for other independent variables. For this reason, we cannot estimate the correlations between the variables simultaneously nor the direct and indirect effects on the outcome. In contrast, path analysis overcomes the limitations of regression as it decomposes the sources of the correlations among the dependent variables. Each variable in a path model can be a predictor and an outcome at the same time; it allows us to use more than one outcome at the same time and to test the correlations and the direct and indirect effects between predictors themselves and the

outcome. The path analysis is likely a more realistic representation of the results regarding predictors of perceived asthma control (Jeonghoon Ahn, 2002; Rex B. Kline, 2005a).

In the present study we estimated the predictors of perceived asthma control among a primary care population followed over an average of 16 months. Guided by the Wilson & Cleary and International Classification of Functioning, Disability and Health (ICF) models (Figure1), we proposed a theoretical model of health and perceived asthma control to specify the relationship between predictors simultaneously using path analysis.

Therefore, the objective of this study was to estimate the extent to which beliefs about medications, self-efficacy, symptoms, emotional function, physical activity, and healthcare utilization predict perceived asthma control over a period of 16 months. We hypothesised that asthma symptoms, physical activity, emotional function, beliefs about asthma medications, and self-efficacy will have a significant positive total effect on perceived asthma control, while healthcare utilization will have a significant negative total effect on perceived asthma control.

4.2 Methods:

This study is a secondary analysis using data from a longitudinal study that examined health outcomes of asthma in primary care settings. The study was conducted to evaluate and compare the ability of measures of patient-reported asthma control and self-efficacy to predict long-term asthma control and subsequent emergency department and hospital utilisation. Individuals in this study were evaluated over two time points, at baseline and one year later.

Participants for this study were identified through primary care physicians (PCP) participating in the (Medical Office of the 21st Century) MOXXI study who were in full-time fee-for-service practice in a large metropolitan area. PCPs were identified by professional association master lists and contacted by letter and telephone to determine their interest in participating in the MOXXI project. Patients of these physicians were identified from the Quebec provincial health database (RAMQ) medical service claims, physician, and beneficiary files. Individuals with probable asthma were identified through the MOXXI system using information on written and dispensed prescriptions, and medical services claims diagnostic codes, based on algorithms validated in prior research

Two hundreds and ninety nine participants 18 years of age and older, who consented to the MOXXI project, who had a confirmed diagnosis of asthma were called by a member of the research team and invited to participate in the larger longitudinal study. This study was limited to individuals who supplied information at both baseline and the one year follow-up. Ethical approval was obtained from the Research Ethics Board of McGill University, and written informed consent was obtained from all participants.

Measures and Data collection

Predictors and explanatory variables

All potential predictors were measured at baseline, while perceived asthma control was measured 16 months later.

Provincial health insurance database: La Régie de l'assurance maladie du Québec (RAMQ).

Sociodemographic characteristics including patient sex and age were obtained from RAMQ. The number of admissions to the emergency department due to asthma during the last year (0 or ≥ 1) was also obtained from RAMQ.

Beliefs about Medicine Questionnaire (BMQ)

The BMQ consists of two five-item scales (necessity and concerns) evaluating patients' beliefs about the necessity of prescribed medications for controlling their illness and their concerns about the potential adverse effects of taking the medications (Horne & Weinman, 1999).

Self-efficacy

Self-efficacy is a term used to describe an individual's personal confidence regarding his/her capacity to avoid asthma symptoms and exacerbations to reach optimal health (Bandura, 1977). Self-efficacy in this study was measured using the knowledge, attitude, and self-efficacy asthma questionnaire (KASE-AQ). The self-efficacy subscale contains 20 items measured on a 5 point Likert scale, where the highest possible score is 100 and the lowest possible score is 20 (Wigal et al., 1993).

Mini Asthma Quality of Life Questionnaire subscales (MAQLQ)

The MAQLQ was developed to measure QoL in clinical trials in asthma. It consists of 15 questions and 4 domains: symptoms, emotion, activity limitation, and environment stimuli. The range score of the MAQLQ is 1-7 points; 7 indicates highest level of QoL, while 1 indicates the lowest level of QoL (E F Juniper et al., 1992).

Smoking Status

Smoking status was expressed using an indicator variable with a value of 0 if an individual did not smoke regularly over a one-year period prior to recruitment.

Outcome variable

Asthma Control Measure

Asthma control test (ACT) includes five items ask patients about asthma symptoms, use of rescue medications, the impact of asthma on daily activities, and rating of overall asthma control in the past four weeks. The range scores of ACT is from 5 to 25; whereas scores less than 20 considered as uncontrolled asthma, while scores equal to or more than 20 considered as controlled asthma (Nathan et al., 2004).

Perceived asthma control was measured using question 5 of the ACT. The question is “How would you rate your asthma control over the past 4 weeks?” The score range is 1–5, with 5 indicating high perceived asthma control and 1 indicating low perceived level (Nathan et al., 2004).

Procedure

Information on sociodemographic data, smoking, Asthma Control Test, Knowledge, Attitude, Self-Efficacy Asthma Questionnaire, and Mini Asthma Quality of Life Questionnaire were taken from the MOXXI study. Whereas, sociodemographic data

was obtained from RAMQ, while smoking status, ACT, KASE, and MAQLQ were measured through structured telephone interview.

Statistical analyses:

All descriptive, correlation and regression statistical analyses in this study were done using SAS guide 4.3 (SAS, 2012). Path analysis was conducted using MPLUS 6.2 (Linda K. Muthén & Muthén, 2010). Pearson and spearman correlations were used to assess the correlation between predictor variables to determine multicollinearity.

Predictor variables were considered as either categorical or continuous variables. The following variables were considered as categorical: gender, smoking, and healthcare utilization. Age, self-efficacy, beliefs about medications, and the MAQLQ domains were considered as continuous variables. Perceived asthma control, the outcome variable, was considered as a dichotomous variable; the scores of 4 and 5 represent good perceived control and the scores of 1, 2, and 3, represent poor perceived control.

Path analysis was used to evaluate the direct and indirect effect of predictor variables on perceived asthma control. The strength of association between perceived asthma control and its predictors is presented by β coefficient. Figure 4 presents the proposed path diagram of the study, which was modeled based on the literature and the integration of Wilson & Cleary and ICF models (Figure 1) (Altman & Bernstein, 2008; Fabiano Di Marco et al., 2011; Dyer et al., 1999; Eagan et al., 2002; Ikeue et al., 2010; Lai et al., 2002; K. L. Lavoie et al., 2008; Mancuso et al., 2010; McAuley et al., 2011; Schroll, 2003; Thomas et al., 2011; **Wilson & Cleary**, 1995). The arrows in the figure present the direct and indirect paths between predictors and outcomes. The letter “D” represents the error of measurement of outcomes variables. The goodness of fit of the

path model was examined by model chi square (X^2), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). A small and non-significant X^2 , CFI value greater than 0.9, and RMSEA value less than 0.5 indicate a good fit model (Rex B. Kline, 2005a).

The proposed Path model (Figure 4) shows that symptom status, emotional function, physical activity, beliefs about medications, healthcare utilization, personal factors (e.g. age and gender), and smoking effect perceived asthma control directly. It also shows that perceived asthma control can be affected indirectly by 1) personal factors and smoking through emotional function, physical activity, beliefs about medications, and healthcare utilization; 2) symptoms status through emotional function, physical activity, and healthcare utilization; 3) self-efficacy through, physical activity, beliefs about medication, and healthcare utilization; 4) emotional function through physical activity, self-efficacy, and healthcare utilization; 5) beliefs about medication through physical activity.

Sample size:

Sample size in the path analysis modelling depends upon the number of parameters (i.e. variance, covariance and number of paths). The proposed model (Figure 2) included 44 parameters. According to the sample size calculation for path analysis, 440 subjects were needed. However, Kline recommended that a minimum ratio of numbers of parameters to number of cases be 1 to 5 (Rex B. Kline, 2005a). Meeting this criterion required 220 subjects to run the path model.

4.3 Results

The characteristics of study participants are presented in Table 4. Two-hundred ninety-nine participants were enrolled into the MOXXI study that had the data at both times. Sixty nine percent were female and the mean age of the sample was 62 years. The mean score of symptoms, activity, and emotional subscales of the MAQLQ was 5.2, 5.5, and 5.8 respectively which indicate that the sample had a few symptoms, activity limitations, and emotional dysfunction related to asthma. Seventy nine percent of the sample had good perceived asthma control.

The fit statistics of the proposed model presented in Figure 4 showed that the model was not the best fit for the sample data ($\chi^2 = 55.95$, $df = 5$, $p = 0.000$), the value for CFI was 0.90 and RMSEA was 0.185, indicative of poor fit. Thus, we had to re-specify the model based on the literatures and modifications suggestions of the MPLUS program.

The proposed model (Figure 4) was altered in order to find the best fitting statistics model based on the modifications indices produced by MPLUS. This re-specified model is presented in Figure 5. The changes that we made included: removing the direct paths between personal characteristics and smoking to perceived asthma control, between personal characteristics and healthcare utilization, between smoking and beliefs about medications, between personal characteristics and smoking to self-efficacy, between emotional function and beliefs about medications, and the last change was to reverse the path direction between emotion and self-efficacy (i.e. the path goes from self-efficacy toward emotion). All removed paths are presented in Figure 4 as “long dash

arrows”. These modifications increased the model fit ($\chi^2 = 15.98$, $df = 10$, $p = 0.1$), the value for CFI was 0.98 and RMSEA was 0.045, indicative of good model fit.

According to the re-specified model (Figure 5), there were 5 independent and 5 dependent variables. The independent variables were age, gender, smoking, self efficacy, and symptoms status, while the dependent variables were emotional function, physical activity, healthcare utilization, beliefs about medications, and perceived asthma control. The re-specified model explained the emotional function, physical activity, healthcare utilization, beliefs about medications, and perceived asthma control by 48%, 48%, 4.6%, 2.7%, and 24% respectively (i.e. R-square values).

To simplify the presentation of the path model results, the model was divided into 3 parts based on health outcome according to the integration of Wilson & Cleary and ICF models (Figure 3). The first part presents the results related to symptom variables, second part presents the results related to the functional variables and the last part presents the relation between the study variables and the outcome (i.e. perceived asthma control).

Symptom variables: according to the model, emotional function was affected significantly by asthma symptoms and age. Increasing one unit of asthma symptoms on the MAQLQ and increasing one unit of age increased 0.65 and 0.13 standard deviations of emotional function as measured by the MAQLQ respectively. P-values were 0.00 and 0.01 respectively.

Functional variable: physical activity was affected significantly through asthma symptoms, emotional function, self-efficacy, and beliefs about medications. One unit increase of asthma symptoms, emotional function, and self efficacy increased physical

activity by 0.37, 0.24, and 0.22 standard deviations, respectively. P-values were 0.00s. Increasing one unit of beliefs about medications on the BMQ decreased the physical activity by 0.08 standard deviations. P-value was 0.02.

Perceived asthma control: it was predicted significantly by asthma symptoms and physical activity; increasing one unit of asthma symptoms and physical activity on MAQLQ the predicted probability of perceived asthma control was increased by 0.35 and 0.24 respectively. P-values were 0.00 and 0.01 respectively. In addition, increasing one unit of self efficacy on KASE and emotional function on MAQLQ increased the predicted probability of perceived asthma control indirectly through physical activity by 0.15 and 0.16 respectively. P-values were 0.02 and 0.046 respectively. The total, direct, and indirect effects on perceived asthma control are presented in Table5.

4.4 Discussion

As hypothesized, fewer asthma symptoms and physical activity had a significant positive total effect on perceived asthma control. Emotional function and self-efficacy had a significant positive indirect effect on perceived asthma control.

The proposed model was re-specified to get a good fit model. Some paths were removed from the proposed path model according to modifications suggestions of the MPLUS program, and other paths were removed because their beta coefficients were not significant. Most paths that were removed were related to the personal characteristics and smoking.

The other changes were removing the path between emotion and beliefs about medications and altering the path direction between emotional function and self-efficacy;

the new direction went from self-efficacy toward emotional function. The literature has shown depression (emotion) affects self-efficacy (K. L. Lavoie et al., 2008). However, self-efficacy based on its definition, an individual's confidence and beliefs about own's capacity to undertake certain actions to have desired outcomes (Bandura, 1977), can affect emotion by preventing the consequences of asthma (frustration, being afraid, concerned). Therefore, emotion and self-efficacy could have a bi-directional effect on each other, but we selected to have a unidirectional effect (i.e. self-efficacy affects the emotional function) to have a good fit model according to the MPLUS program modifications.

The percentage of good perceived asthma control in this study was around 79%, which is higher than the percentage of asthma control reported in previous studies (58%) (Mintz et al., 2009). This difference was probably because approximately only one-third (37%) of our sample had emergency department visits and the score of AQLQ-Symptoms was relatively high (the mean score = 5.16 out of 7), indicating few asthma symptoms. Another reason might be, as supported in the literature, that individuals with asthma overestimate their level of asthma control (FitzGerald et al., 2006).

The re-specified model explained very little about beliefs about medications; it just explained 2.7%. The reason might be because there are other factors could explain beliefs about medications that we didn't include in the model like type and dose of medications, quality of care, and emotion status (the path between emotional function and beliefs about medications was removed from the re-specified model to get good model fit).

To date, no studies have evaluated predictors of perceived asthma control. Previous studies have shown that there were many variables affect the asthma control that measured by patient reported or physician reported based on day/night symptoms, FEV, and school/work absenteeism measures using regression analyses. This study used path analysis that allowed us to use more than one outcome, to use the same variable as a predictor and an outcome, and to test the direct and indirect effects on the outcome; to have more realistic results regarding predictors of perceived asthma control.

The results of path analysis showed that the physical activity and asthma symptoms were the significant predictors of perceived asthma control as total effects. These results are supported by previous literatures, perceived asthma control measured by Perceived Control of Asthma Questionnaire was correlated cross-sectionally significantly with symptoms and physical activity subscales of Asthma Quality of Life Questionnaire (AQLQ) (P. P. Katz et al., 2002; J. Olajos-Clow, E. Costello, & M. D. Lougheed, 2005); these two studies (i.e. Katz et al. 2002 and Olajos-Clow et al. 2005) were not aimed to estimate predictors of perceived asthma control, they just test the correlation between perceived asthma control and QoL. In our study, symptoms didn't have a significant direct effect of perceived asthma control, and this might be because the effect of symptoms on perceived asthma control is mainly through physical activity. In removing physical activity from the model, symptoms became a significant predictor of perceived asthma control, although the correlation between symptom and physical activity wasn't high ($r = 0.61$).

Self-efficacy and emotional function predicted perceived asthma control indirectly through physical activity. Previous studies have supported the association of

asthma control with depression and self-efficacy (Mancuso et al., 2001; Martin et al., 2009; Nguyen et al., 2011; Schachter et al., 2001; Strine et al., 2008). Regarding emotion, it wasn't a direct predictor of perceived asthma control due to the effectiveness of physical activity and symptoms on the direct model of perceived asthma control. When symptoms and physical activity variables were removed from the model, emotion became a significant direct predictor of perceived asthma control. Also, previous literatures have shown that emotional subscale of AQLQ was not correlated significantly with perceived asthma control (P. P. Katz et al., 2002; J. Olajos-Clow et al., 2005). Self-efficacy had not had a significant total effect on perceived asthma control because of its mediator factors, emotional function and healthcare utilization, on perceived asthma control were not correlated significantly to perceived asthma control.

In this study, age and gender were not predictors of perceived asthma control and this is in line with what previous studies have found among patients from primary care clinics (Laforest et al., 2006; Nguyen et al., 2011; Stanford et al., 2010). However, smoking, emergency department visits, and beliefs about medications were not predictors of perceived asthma control although previous studies identified these as predictors of asthma control. These differences might be derived from the difference in the estimation approach used (i.e. regression vs path analysis and cross sectional vs longitudinal evaluation) and from the difference between the measurement of perceived asthma control and asthma control; perceived asthma control is measured by direct self report, while asthma control is measured based on day/night symptoms, forced expiratory volume, and school/work absenteeism (E. F. Juniper et al., 1999). In addition, belief about medications was not a significant predictor of perceived asthma control. The

reason is might be related to not having available measurement of adherence to medication in the model, which has been shown to be a mediator of beliefs about medication on perceived asthma control (Emilsson et al., 2011; Horne & Weinman, 1999; Stanford et al., 2010).

The results of this study have shown there were two main predictors of perceived asthma control: asthma symptoms and physical activity. There were also two other variables that predicted perceived asthma control indirectly through physical activity: emotional function and self-efficacy. In addition, physical activity was affected significantly by another factor; beliefs about medications.

Dealing with and targeting predictors of perceived asthma control identified in this study through asthma management programs may increase individuals' ability to self manage their asthma and in turn increase the level of perceived asthma control. Physicians and clinicians can work on minimizing asthma symptoms through medications, patient education, and programs that include interventions aimed at increasing physical activity and self-management programs. Furthermore, physicians and clinicians can implement an intervention program to improve individuals' self-efficacy to manage their condition through enhancing needed skills such as self-monitoring, and problem solving when there is a change in symptoms. In addition, the results of this study indicate the importance of evaluating and managing individuals' emotional status through psychosocial support.

4.7 Conclusion:

In conclusion, we proposed a path model of the predictors of perceived asthma control among patients from primary care; it explained 24% of the value of perceived asthma control. The path model provided two main predictors of perceived asthma control: asthma symptoms and physical activity. Physical activity was a mediator of emotional function and self-efficacy on perceived asthma control. Identifying these four predictors of perceived asthma control may help physicians and clinicians tailor interventions to the individuals with asthma to improve self-management, to achieve the optimal level of asthma control, to prevent future development of other co-morbidities and chronic diseases (Silva et al., 2004), and to maximize QoL (Rabe et al., 2004).

4.5 Limitations

The duration between the two evaluation points was varied; the mean duration between the two evaluation points was about 16 months, ranged from 11 months to 36 months. Some predictors were not covered in the current study, like social function, body mass index, adherence to medication, and environmental and nutrition factors; because the larger longitudinal study didn't collect data regarding these factors.

4.6 Future Direction

A more comprehensive model that includes other potential predictors of perceived asthma control among individuals with asthma from primary clinics will be assessed included in future analyses including adherence to medications, dose of the medications, duration of asthma disease, social function, and nutritional and environmental factors. Furthermore, we will assess the predictors of perceived asthma

control at more than two time points to assess changes in predictors of perceived asthma control over time. In addition, the path model will be extended to confirmatory factor analysis (i.e. structural equation modeling) to assess the relation between perceived asthma control predictors, and between perceived asthma control and health related and overall QoL. Structural equation modeling is an extension of path analysis, which includes both path and measurement models. Measurement models represent latent variables and provide a better adjustment for error in measurement of a construct (Rex B. Kline, 2005b). Finally, we will recruit enough participants to meet the sample size that needed for structural equation modeling and inclusion of reciprocal relationships.

Table 4: Average values of sociodemographic variables and questionnaires

		Perceived Asthma Control	
Characteristics		≥ 4 n=258 (79%)	< 4 n=68 (21%)
Gender, female	207 (69%)	160 (77%)	47 (23%)
Age	62.1 (14.4)	62.6 (14.8)	60.3 (13.0)
MAQLQ-Symptoms	5.2 (1.3)	5.4 (1.2)	4.3 (1.5)
MAQLQ-Activity	5.5 (1.5)	5.7 (1.3)	4.5 (1.7)
MAQLQ-Emotion	5.8 (1.4)	6.1 (1.1)	5.0 (1.9)
Self efficacy	83.2 (13.3)	84.9 (12.7)	76.8 (13.8)
Beliefs about Medications	4.6 (5.5)	4.5 (5.47)	5.0 (5.8)
Healthcare Utilization	111 (37 %)	75 (82%)	17 (18%)
Smoking	43 (14 %)	32 (74%)	11 (26%)

Table 5: Standardized beta coefficients estimate of Perceived Asthma Control

Predictors	Total Effect	Direct Effect	Indirect Effect
Age	0.003	-	0.003
Gender	0.01	-	0.01
Smoking	0.02	-	0.02
Asthma Symptom	0.35*	0.17	0.17*
Emotion	0.16	0.08	0.08*
Physical Activity	0.24*	0.24*	-
Healthcare Utilization	-0.08	-0.08	-
Self Efficacy	0.15	0.09	0.07*
Beliefs about Medicine	0.04	0.06	-0.02

*** Significant at < 0.05.**

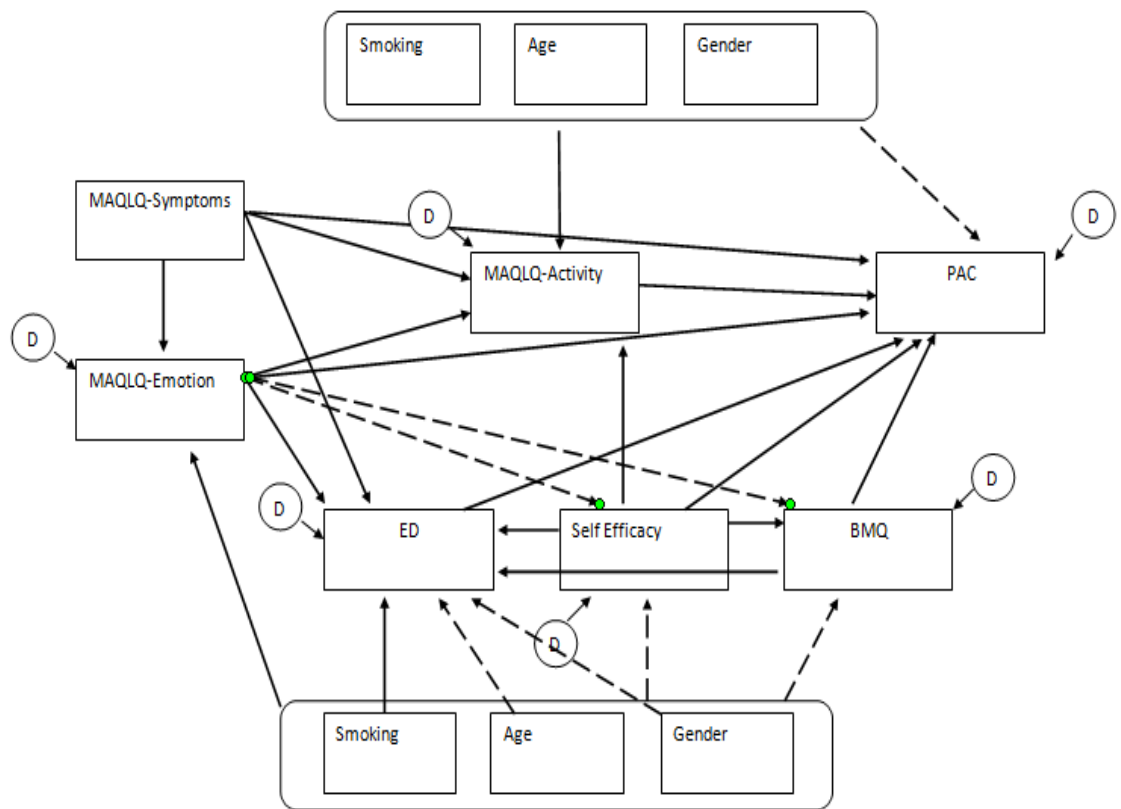


Figure 4: The proposed path model

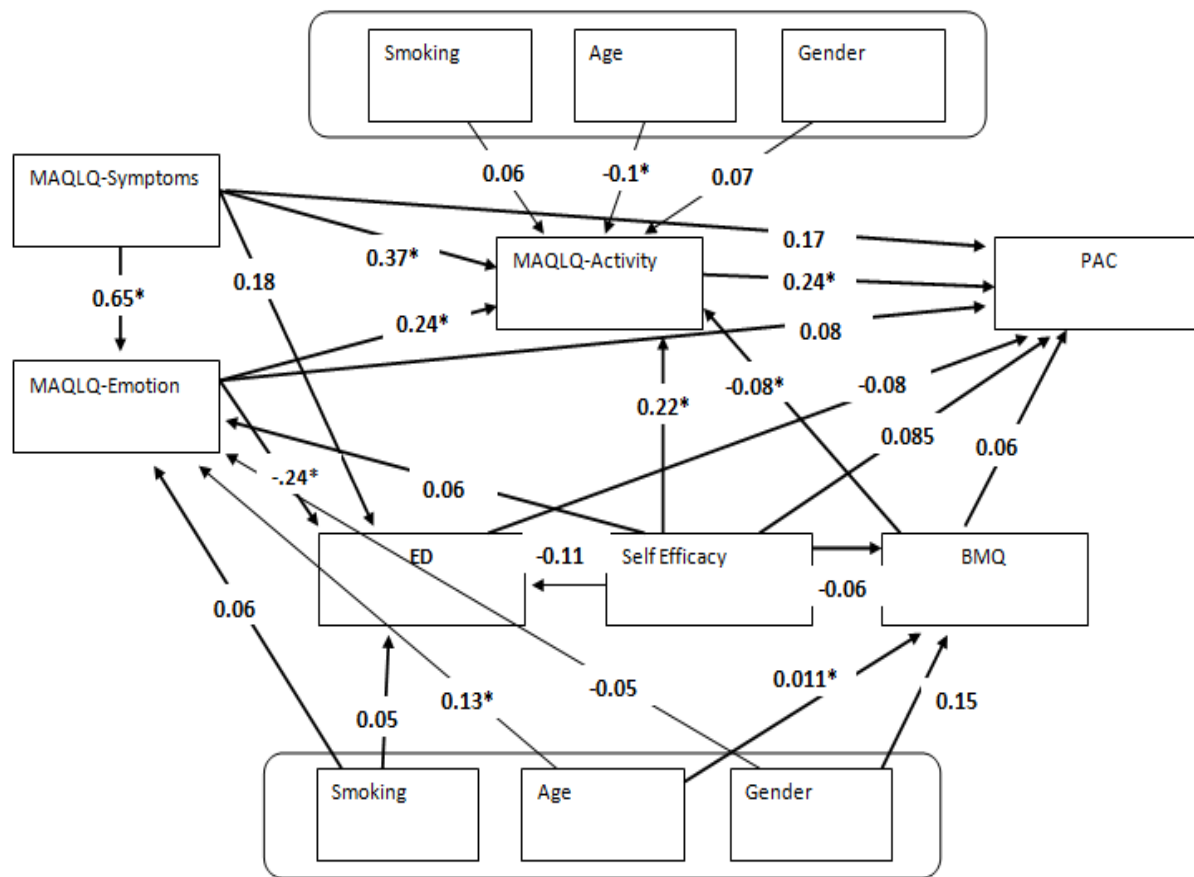


Figure 5: Re-specified path model
 *Significant at level of 0.05

Chapter 5: Integration between manuscript 1 & 2:

The current thesis includes two manuscripts. Both of them estimated the predictors of perceived asthma control among individuals with asthma. The first manuscript was conducted on patients recruited from primary clinics, while the second one was conducted on patients recruited from specialist clinics.

5.1 Objective and hypotheses of manuscript 1 & 2

Manuscript 1: To estimate the extent to which beliefs about medicine, self efficacy, asthma symptoms, emotion, physical activity, and healthcare utilization predict perceived asthma control over a 16 month period of time among individuals with asthma in primary care clinics.

Specific hypotheses that we tested included:

H1: Asthma symptoms will have a significant positive total effect on perceived asthma control.

H2: Physical activity and emotional function will have a significant positive total effect on perceived asthma control.

H3: Beliefs about the necessity of asthma medications will have a significant positive total effect on perceived asthma control.

H4: Self efficacy will have a significant positive total effect on perceived asthma control.

H5: Health-care utilization will have a significant negative total effect on perceived asthma control.

Manuscript 2: Physical and social function, mental health, and role emotional will have a significant positive direct effect on perceived asthma control, while health-care utilization will have a significant negative total effect on perceived asthma control.

5.2 Tested variables in manuscript 1 & 2

Both manuscripts had an overlap in variables that were tested as potential predictors of perceived asthma control, Table 6. Age, gender, smoking, healthcare utilization, asthma symptoms, emotional function, and physical function were tested in both manuscripts. Each manuscript also evaluated predictors in a different care setting, mainly primary care versus specialty care, and each study had a unique set of variables that were not tested in the other one. For instance, self-efficacy and beliefs about medications were only available and tested in the first manuscript, while FEV1, body mass index, role emotional, and social function were only tested in the second manuscript.

5.3 Integration between manuscript 1 & 2

Two-thirds of individuals with asthma received care from primary care clinicians, while the other third received the care from specialists, including allergists or pulmonologists (Janson & Weiss, 2004). Fifty eight percent of primary care individuals with asthma have uncontrolled asthma (Mintz et al., 2009). The challenges of asthma treatment implementation at primary care settings are lack of provider awareness of the guidelines, inadequate knowledge of asthma treatment, disagreement with guidelines, and lack of confidence in implementing guidelines (Grol & Wensing, 2004).

One-third of individuals with asthma received care from specialists. The percentage of uncontrolled asthma among patients from specialist care clinics is around 58%. Care mainly from specialist physicians is a factor of improving asthma control.

Therefore, the literature has shown that the percentage of uncontrolled asthma is almost the same among patients from primary and specialist care settings, although the primary care setting has greater limitations of asthma treatment implementation, which indicates there are certain factors other than treatment itself that may affect the level of perceived/asthma control. Understanding these factors and considering whether they vary across different care settings can help inform the development of care management programs and better identify individuals at risk of poor outcomes.

Identifying the predictors of perceived asthma control will help physicians and clinicians identify the factors that can affect the health outcomes other than the treatment and include the intervention of these factors in asthma treatment guidelines to achieve the optimum level of perceived asthma control. In turn such strategies may improve individuals' self management, functional level, QoL, and reduce the costs of asthma care (Patricia P. Katz et al., 2002; Katz et al., 1997; Jennifer Olajos-Clow et al., 2005). As it stands, the Canadian asthma treatment guidelines do not consider asthma co-morbidities (e.g. emotional, social, and physical dysfunctions), and personal characteristics (e.g. self-efficacy). As such, the application of the guidelines to specific patient profiles is limited.

The results of Manuscript 1 showed that these co-morbidities and personal characteristics were factors that predicted the level of perceived asthma control. Manuscript 2 will evaluate predictors in a specialty care population.

Table 6: Correspondence of tested variables in both studies

Wilson & Cleary Model	ICF Model	Manuscript 1	Manuscript 2
biological & physiological variables/ Symptoms Status	Body structure & function	AQLQ-Symptoms, AQLQ-Emotion.	FEV, AQLQ- Symptoms, SF-36- Mental Health
Functional Status	Activities/ Participations	AQLQ-Physical Activity	SF-36- Physical and Social Functions, and Role Emotional
Characteristics of Individuals	Personal Factors	Age, Gender, Smoking, Healthcare Utilization, Beliefs about Medications, and Self Efficacy.	Age, Gender, Smoking, Body Mass Index, and Healthcare Utilization.

Chapter 6: Manuscript 2: Predictors of perceived asthma control in specialist clinic.

Abstract

Background: Asthma is a common chronic disease that causes substantial morbidity and reduced quality of life when poorly controlled. Identifying clinical and psychosocial characteristics that influence long-term asthma control can help to match asthma management programs to the individuals' needs.

Objective: To estimate the extent to which symptom status, physical, mental, and social functions, and healthcare utilization predict perceived asthma control over a period of 6 months among individuals receiving care at a respiratory specialty clinic.

Methods: The current study is a secondary analysis of data from a longitudinal study examined health outcomes of asthma among participants recruited from a specialty care clinic. Evaluations on measures of symptom status, physical, mental, and social functions, and healthcare utilization were evaluated over 2 time points. Path analysis, based on the Wilson & Cleary and ICF models, was used to estimate the predictors of perceived asthma control.

Results: The path model indicated that FEV1 ($B = 0.12$, $p = 0.01$), symptoms ($B = 0.42$, $p = 0.001$), and social function ($B = 0.37$, $p = 0.02$) were the significant predictors of perceived asthma control (total effects; direct and indirect). The model explained 34% of the value of perceived asthma control. Overall, the model fit the data well ($X^2 = 39.83$, $df = 27$, $P\text{-value} = 0.053$, and Comparative Fit Index = 0.95).

Conclusion: FEV1, asthma symptoms, and social function can be used to identify individuals likely to have poor perceived asthma control in the future. Identifying these predictors may assist the care team in identifying individuals at risk of a future exacerbation and for designing tailored asthma interventions to achieve the optimum level of perceived asthma control, to prevent developing other chronic disease, and to maximize QoL.

6.1 Introduction

Asthma may cause substantial morbidity (Mannino et al., 2002) such as sleeplessness, daytime fatigue, reduced activity levels, and school/work absenteeism; it is the third leading cause of work loss and lower productivity according to Harrison and Pearson (Harrison & Pearson, 1993). Two-thirds of individuals with asthma in the U.S. received care from primary care clinicians, while the other third received care from specialists, including allergists or pulmonologists (Janson & Weiss, 2004).

According to the literature, receiving care from a specialist is associated with controlled asthma (Badiola et al., 2009). Key recommendations in the Canadian asthma treatment guideline encompasses prescription of reliever (inhaled fast-acting beta2-agonists) and controller (inhaled corticosteroids) therapy medications and self-management education, including oral and written action plans, but it doesn't focus on psychosocial characteristics, activity limitations (e.g. self efficacy and physical activity) and on asthma co-morbidities (Lougheed et al., 2010). Despite asthma treatment guidelines are available; the level of asthma control in Canada remains suboptimal. This may in part be related to factors that are related to the disease itself, or to personal characteristics that may affect health outcomes that are not routinely considered in asthma management (**Wilson & Cleary**, 1995). Identifying these factors is important for care team to tailor interventions to the patients to achieve an optimum level of perceived asthma control (Rabe et al., 2004).

Previous studies have evaluated predictors of asthma control among patients in specialist care clinics. The potential predictors were divided into unmodifiable and modifiable predictors. Unmodifiable predictors like age, gender, race, and duration of

asthma that were considered as factors that may affect the level of asthma control. Aging, being female, non-white race, and long duration of asthma were associated with poor asthma control (F. Di Marco et al., 2010; Hermosa et al., 2010; Schatz et al., 2007; Stanford et al., 2010; Virchow et al., 2010). Regarding to asthma family history, Suzuki et al. 2011 have shown that individuals with a family history of asthma tend to have a higher rate of adherence to medications and low visits to emergency department compared to patients without a family history of asthma, which may lead to good asthma control (Suzuki et al., 2011).

Regarding the modifiable variables, previous studies have shown that adherence to medications, stronger self-efficacy, absence of depression and anxiety, being non-smoker, lower body mass index were associated with higher levels of asthma control (Aboussafy, 1999; F. Di Marco et al., 2010; Hermosa et al., 2010; K. L. Lavoie et al., 2006; K. L. Lavoie et al., 2008; Mancuso et al., 2001; Stein et al., 2005).

Perceived asthma control is different from asthma control. Perceived asthma control (Janssens et al., 2009) is related to three constructs: self-efficacy, locus of control, and learned helplessness (P. P. Katz et al., 2002), while asthma control is related to patient or physician reports based on symptoms, work/school absenteeism, and FEV₁ (E. F. Juniper et al., 1999). Perceived asthma control is correlated positively with asthma self-management (Katz et al., 1997). Therefore, assessing the predictors of perceived asthma control is important to measure and will allow the care team to identify individuals with greater need for self-management support and to deliver interventions most likely to be effective for a given individual.

Currently in the literature, previous studies have focused on predictors of asthma control but none have examined the predictors of perceived asthma control. Further, previous studies have used regression analyses to estimate predictors of asthma control. When there are two or more dependent variables, regression analyses are limited as they do not allow for more than one outcome. In the regression model, each independent variable is tested while adjusting for other independent variables; for this reason, we cannot estimate the correlations between the variables simultaneously nor the direct and indirect effects on the outcome. In contrast, path analysis overcomes the limitations of regression as it decomposes the sources of the correlations among the dependent variables. Each variable in a path model can be a predictor and an outcome at the same time; it allows us to use more than one outcome simultaneously and to test the correlation and the direct and indirect effects between predictors themselves and the outcome can be tested. The path analysis is likely a more realistic representation of the result regarding predictors of perceived asthma control (Jeonghoon Ahn, 2002; Rex B. Kline, 2005a).

In the present study we estimated the predictors of perceived asthma control among a specialist care population followed over an average of a 6 month period. Guided by the integration of the Wilson & Cleary and the International Classification of Functioning, Disability and Health (ICF) models (Figure 3), we proposed a theoretical model of health and perceived asthma control to specify the relationship between predictors of perceived asthma control simultaneously using path analysis.

Therefore, the objective of this study was to estimate the extent to which asthma symptoms, physical, mental, and social function, and healthcare utilization predict perceived asthma control over a 6 month period of time. We hypothesized that asthma

symptoms, physical and social function, mental health, and role emotional will have a significant positive direct effect on perceived asthma control, while healthcare utilization have a significant negative direct effect.

6.2 Methods

This study is a secondary analysis using data from a longitudinal study that examined health outcomes of asthma in specialist care settings. The study was conducted to develop an item response theory (IRT) asthma control scale by combining items from existing patient-reported measures of asthma control. Participants were recruited from a specialty clinic in a large tertiary hospital, the Montreal General Hospital (MGH). One-hundred fifty-two patients 18 years of age and older, who had a confirmed diagnosis of asthma, and who had information at both times of assessment were included in the study presented here.

Measures and Data collection

Predictors and explanatory variables

All potential predictors were measured at baseline, while perceived asthma control was measured 6 months later.

Sociodemographic characteristics

Information on patient sex, age, smoking (smoker, or not smoker), and body mass index were obtained from the screening form of the study

Hospitalization (Health Care Utilization)

Number of admissions to the emergency department due to asthma and its exacerbations during the last year (0 or ≥ 1) were obtained from the 30 second asthma test.

SF-36 subscales

The SF-36 is a short form questionnaire with 36 items that measure eight dimensions of health status (O'Mahony, Rodgers, Thomson, Dobson, & James, 1998). These eight domains are: physical functioning, role limitations–physical, bodily pain, general health, vitality, social functioning, role limitations–emotional and mental health. The scores of each subscale were transformed to norm based score (i.e. 0 to 100). Higher scores indicate better health status and lower scores indicate poorer health status (Hagen, Bugge, & Alexander, 2003).

Asthma Quality of Life Questionnaire subscales (AQLQ)

The AQLQ was developed to measure QoL in clinical trials in asthma. It consists of 32 questions and 4 domains: symptoms, emotion, activities limitation, and environment stimuli. The range score of AQLQ is 1-7 points; 7 indicates highest level of QoL while 1 indicates the lowest level of QoL (E F Juniper et al., 1992).

Forced Expiratory Volume in 1 second:

FEV1 was evaluated during the patient visit; the best FEV1 measurement over the previous 1 year was also recorded. FEV1 was measured to estimate the level of asthma control. It was calculated through the ratio of FEV1 at the day of visit to the best observed measure of FEV1; ($FEV1_{control} = FEV1_{today} / FEV1_{best}$). Poor asthma control defined as $FEV1_{control} < 90\%$.

Outcome variable

Asthma Control Measure

Asthma control test (ACT) includes five items ask patients about asthma symptoms, use of rescue medications, the impact of asthma on daily activities, and rating of overall asthma control in the past four weeks. The range scores of ACT is from 5 to

25; whereas scores less than 20 considered as uncontrolled asthma, while scores equal to or more than 20 considered as controlled asthma (Nathan et al., 2004).

Perceived asthma control was measured using question 5 of the asthma control test. The question is “How would you rate your asthma control over the past 4 weeks?” The scores range is 1–5, with 5 indicating high perceived asthma control and 1 indicating low perceived level (Nathan et al., 2004).

Procedure

Patients’ information on sociodemographic, Asthma Control Test, Asthma Quality of Life Questionnaire, and SF-36 were taken from the longitudinal study (MGH). Whereas, sociodemographic data was obtained from the screening form, while ACT, AQLQ, and SF-36 were measured through structured telephone interview.

Statistical analyses:

All descriptive, correlation and regression statistical analyses in this study were done using SAS 4.3 (SAS, 2012). Path analysis was conducted using MPLUS 6.2 (Linda K. Muthén & Muthén, 2010). Pearson and spearman correlations were used to assess the correlation between predictor variables to determine multicollinearity.

Predictor variables were considered as either categorical or continuous variables. The following variables were considered as categorical: gender, smoking, and number of emergency department visits. Age, BMI, AQLQ domains and SF-36 subscales were considered as continuous variables. Perceived asthma control, the outcome variable, was considered as a dichotomous variable; the scores of 4 and 5 represent good perceived control and the scores of 1, 2, and 3, represent poor perceived control.

Path analysis was used to evaluate the direct and indirect effects of predictor variables on perceived asthma control. The strength of association between perceived asthma control and its predictors is presented by β coefficients. Figure 6 presents the proposed diagram of the study, which was modeled based on the literatures and the integration of Wilson & Cleary and ICF models (Figure 3) (Altman & Bernstein, 2008; Fabiano Di Marco et al., 2011; Dyer et al., 1999; Eagan et al., 2002; Ikeue et al., 2010; Lai et al., 2002; K. L. Lavoie et al., 2008; Mancuso et al., 2010; McAuley et al., 2011; Schroll, 2003; Thomas et al., 2011; **Wilson & Cleary**, 1995). The arrows in the figure present the direct and indirect paths between predictors and outcomes. The letter “D” represents the error of measurement of outcomes variables. The goodness of fit of the path model was examined by model chi square (X^2), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). A small and non-significant X^2 , CFI value greater than 0.9, and RMSEA value less than 0.5 indicate a good fit model (Rex B. Kline, 2005a).

In the proposed model (Figure 6), symptoms, mental health, role emotional, physical and social function, healthcare utilization, personal factors (i.e. age, gender, and body mass index), and smoking affect perceived asthma control directly. It also shows that perceived asthma control could be affected indirectly by 1) FEV1 through symptoms, physical function, and healthcare utilization; 2) symptoms through mental health, physical function, social function and healthcare utilization; 3) mental health through role of emotional, physical function, social function, and healthcare utilization; and 4) physical function and role emotional through social function.

Sample size:

The sample size in the path analysis modeling depends upon the number of parameters (i.e. variance, covariance and number of paths). The proposed model (Figure 6) included 50 parameters. According to the sample size calculation for path analysis 500 subjects are needed. However, Kline recommended that a minimum ratio of numbers of parameters to number of cases be 1 to 5 (Rex B. Kline, 2005a). Meeting this criterion required 250 subjects to run the path model. One-hundred fifty-two participants had the required information for this study, which is not an optimal sample size. However, an initial analysis was ran, and non-significant paths were removed to reduce the number of parameters estimated.

6.3 Results

The characteristics of the study participants are presented in Table 7. One hundred and fifty two patients were enrolled into the study and had data at both times. Sixty six percent were female and the mean age of the sample was 43.7 year. The mean score of physical function, mental health, social function, and role emotional subscales of SF-36 were 48.5, 48.8, 49.2, and 48.5 respectively which indicate that the sample had poor health compared Canadian norms. Seventy one percent of the sample had good perceived asthma control.

The fit statistics of the proposed model presented in Figure 6 showed that the model was not the best fit for the sample data ($\chi^2 = 34.94$, $df = 17$, $p = 0.006$). The value for CFI was 0.92, and RMSEA was 0.08, indicative of inadequate fit.

The proposed model (Figure 6) was altered in order to find the best fitting statistics model based on the modifications indices produced by MPLUS. This re-specified model is presented in Figure 7. The changes that we made included: removing the direct paths between (age, gender, & smoking) and perceived asthma control, between smoking and healthcare utilization, and the last change was removing the path between mental health and FEV1 and indicating covariance between them. All removed paths are presented in Figure 6 as “long dash arrows”. These modifications increased the model fit ($\chi^2 = 39.83$, $df = 27$, $p = 0.053$), the value for CFI was 0.95, and RMSEA was 0.056, indicative of good model fit.

According to the re-specified model (Figure 7), there were 5 independent and 7 dependent variables. The independent variables were age, gender, smoking, body mass index, and FEV1. The dependent variables were physical function, mental health, social function, role emotional, health care utilization, symptoms status, and perceived asthma control. The re-specified model explained the mental health, social function, role emotional, health care utilization, symptoms status, and perceived asthma control by 48%, 35%, 48%, 2.7%, 57%, 27%, and 34% respectively (i.e. R-square).

To simplify the presentation of the path model results, the model was divided into 3 parts based on the integration of Wilson & Cleary and ICF models (Figure 3). The first part presents the results that are related to symptom variables, second part presents the results that are related to functional variables and the last part presents the relation between all study variables and the outcome (i.e. perceived asthma control).

Symptom Variables: asthma symptoms were affected significantly by FEV1, body mass index, age, and gender. Increasing one unit of FEV1 and one unit of age increased the score of asthma symptoms as measured by AQLQ by 0.27 and 0.38 standard deviations respectively. The p-values were 0.00 and 0.03 respectively. Also, being male improved asthma symptoms by 0.18 (p-value = 0.43) standard deviations. Increasing one unit of body mass index decreased the score of asthma symptom by 0.27 standard deviations. Also, being male improved asthma symptoms by 0.18 standard deviations. The p-value was 0.004.

Mental health was affected significantly by FEV1, asthma symptoms, and body mass index. Increasing one unit of FEV1 and one unit of asthma symptoms on AQLQ increased the level of mental health on SF-36 by 0.16 and 0.59 standard deviations. The p-values were 0.03 and 0.00 respectively. Increasing one unit of body mass index decreased the level of mental health by 0.19 standard deviations. The p-value was 0.02. In addition, FEV1 and asthma symptoms predicted the admission to the emergency department significantly; improving FEV1 and asthma symptoms reduced the predicted probability of the emergency department admission by 0.13 and 0.46 respectively. The p-values were 0.01 and 0.00 respectively.

Functional Variables: physical function was affected significantly by FEV1, asthma symptoms, body mass index, and gender. Increasing one unit of FEV1 and asthma symptoms increased the physical function on SF-36 by 0.18 and 0.6 standard deviations respectively. The p-values were 0.01 and 0.00 respectively. Being male also improved the physical function by 0.23 standard deviations. The p-value was 0.02.

Increasing one unit of body mass index decreased the physical function by 0.34 (p-value = 0.00) standard deviations.

Role emotional was affected significantly by FEV1, asthma symptoms, body mass index, and mental health. Increasing one unit of FEV1, asthma symptoms, and mental health increased the level of role emotional on SF-36 by 0.12, 0.45, and 0.75 standard deviations respectively. The p-values were 0.00s. Increasing one unit of body mass index decreased the level of role emotional by 0.15 (p-value = 0.02) standard deviations.

Lastly, social function was affected significantly by FEV1, asthma symptoms, body mass index, mental health, role emotional, and age. Increasing one unit of FEV1 (0.00), asthma symptoms, mental health, role emotional (0.01), and age increased the level of social function on SF-36 by 0.17, 0.62, 0.36, 0.17, and 0.17 standard deviations respectively. The p-values were 0.00, 0.00, 0.00, 0.01, and 0.04 respectively. Increasing one unit of BMI decreased the level of social function by 0.18 (p-value = 0.01) standard deviations.

Perceived asthma control: it was predicted significantly by FEV1, asthma symptoms, and social function. Increasing one unit of FEV1, asthma symptoms, and social function, the predicted probability of perceived asthma control was increased by 0.12, 0.42, and 0.37 respectively. The p-values were 0.01, 0.00, and 0.02 respectively. The total, direct, and indirect effects on perceived asthma control are presented in Table 8.

6.4 Discussion

As hypothesized, the higher percentage of FEV1, fewer asthma symptoms reported, and higher social function were found to significantly predict higher levels of perceived asthma control. Contrary to what we hypothesised, physical function, mental health, and role of emotional were not significant predictors of perceived asthma control. A previous study has found similar results as in our study and did not support these variables as important predictors (J. Olajos-Clow et al., 2005); this study was not aimed to estimate predictors of perceived asthma control, they just test the correlation between perceived asthma control and QoL.

The proposed model was re-specified to obtain good model fit. Some paths were removed from the proposed path model according to modifications suggestions of the MPLUS program, and other paths were removed because their beta coefficients were not significant. Most paths that were removed were related to personal characteristics (i.e. age, gender, and body mass index) and smoking. Another change that was made to improve model fit was altering the relationship of FEV1 and mental health by replacing a causal path with a covariance.

The percentage of good perceived asthma control in this study was approximately 70% which is higher than the percentage of asthma control reported in previous studies. This difference was probably due to the fact that approximately only one-third (27%) of our sample had emergency department visits and the score of AQLQ-Symptoms was relatively high (the mean score = 5.44 out of 7), indicating few asthma symptoms.

Another reason might be, as supported in the literature, that individuals with asthma overestimate their level of asthma control (FitzGerald et al., 2006).

To date, no studies have evaluated predictors of perceived asthma control. Previous studies have shown that there were many predictor variables of asthma control as measured by patient reported or physician reported based on day/night symptoms, FEV₁, and school/work absenteeism measures using regression analyses (E. F. Juniper et al., 1999). This study used path analysis which allowed us to use more than one outcome, to use the same variable as a predictor and an outcome, and to test the direct and indirect effects on the outcome providing a more realistic representation of predictors of perceived asthma control and the relationship between the predictors.

The results of the current study showed that FEV₁, asthma symptoms, and social function were significant predictors of perceived asthma control based on the total effects. These results were supported by literature, Rhee et al. 2010 showed that social support was associated positively with asthma control (Rhee, Belyea, & Brasch, 2010), and Olajos-Clow et al. 2005 showed that social function subscale of SF-36 was significantly correlated cross sectionally with perceived asthma control that measured by perceived control of asthma questionnaire (J. Olajos-Clow et al., 2005). Urritia et al. 2012 showed that higher FEV₁ and fewer asthma symptom reported were associated with higher levels of asthma control (Urrutia et al., 2012); these studies were not aimed to estimate predictors of perceived asthma control, they just test the correlation between perceived asthma control and QoL.

In this study, age, gender, smoking, body mass index, and emergency department visit were not predictors of perceived asthma control, although previous studies identified these as predictors of asthma control among individuals from specialist clinics (F. Di Marco et al., 2010; Hermosa et al., 2010; Schatz et al., 2007; Stanford et al., 2010; Virchow et al., 2010). These differences might be derived because of the difference in the estimation approach used (i.e. regression vs path analysis and cross sectional vs longitudinal evaluation), and the difference between perceived asthma control and asthma control; perceived asthma control is measured by direct self report, while asthma control is based on day/night symptoms, forced expiratory volume, and school/work absenteeism (E. F. Juniper et al., 1999).

The results of this study have shown that there were three main predictors of perceived asthma control: FEV1, asthma symptoms and social function. These predictors were affected significantly by other modifiable factors. For instance, asthma symptoms were affected by body mass index, while social function was affected by mental health, role emotional, and asthma symptoms. Therefore, based on the path model, there were six modifiable predictors that were significantly associated with perceived asthma control over time: FEV1, asthma symptoms, social function, mental health, role emotional, and body mass index.

Dealing and treating these factors through physicians and clinicians may increase the level of perceived asthma control and in turn improves self-management, achieve the optimum level of asthma control, and improve QoL among individuals with asthma (Patricia P. Katz et al., 2002; Katz et al., 1997; Jennifer Olajos-Clow et al., 2005). The physicians and clinicians should work on minimizing asthma symptoms and improving

lung function through medications, education, and adherence to the Canadian asthma treatment guideline. In addition, physicians and clinicians should improve the emotion and social status of individual with asthma through psychosocial support. The care team should also work on some of the personal characteristics like body mass index through a specific program to reduce the weight of individuals with asthma. Reducing the weight would improve the asthma symptoms, social and emotional status, which in turn may improve perceived asthma control. And lastly, individuals with asthma should quit smoking as in line with expectations this was clearly shown to affect asthma symptoms.

6.5 Conclusion

In conclusion, we proposed a path model of predictors of perceived asthma control among patients from specialist care; it explained 34% of the value of perceived asthma control. The path model provided three main predictors of perceived asthma control; FEV1, asthma symptoms and social function. Asthma symptoms and social function were mediator effects of FEV1. Identifying these three predictors of perceived asthma control may help physicians and clinicians tailor interventions to the individuals with asthma to improve self-management, achieve the optimum level of asthma control, prevent future development of other co-morbidities and chronic diseases (Silva et al., 2004), and maximize QoL (Rabe et al., 2004).

6.6 Limitations

The time lag between the two evaluation points varied; the mean duration between the two evaluation points was about 6 months, ranged from 1 month to 25 months. Some potential predictors were not covered in the current study like self-

efficacy, adherence to medications, environmental and nutrition factors; because the longitudinal study didn't collect data regarding these factors. The last limitation was the sample size. We were limited to 152 subjects even though 220 participants were needed, based on the modified model; this limits the stability of the results.

6.7 Future Directions

A more comprehensive model that includes other potential predictors of perceived asthma control among individuals with asthma from primary clinics will be included in future analyses including beliefs about medications, adherence to medications, dose of the medications, duration of asthma disease, self efficacy and nutritional and environmental factors. Furthermore, we will assess the predictors of perceived asthma control at more than two time points to assess changes in predictors of perceived asthma control over time. In addition, the path model will be extended to confirmatory factor analysis (i.e. structural equation modeling) to assess the relation between perceived asthma control predictors, and between perceived asthma control and health related and overall QoL. Structural equation modeling is an extension of path analysis, which includes both path and measurement models. Measurement models represent latent variables and provide a better adjustment for error in measurement of a construct (Rex B. Kline, 2005b). Finally, we will recruit enough participants to meet the sample size needed for structural equation modeling and inclusion of reciprocal (bi-directional) relationships.

Table 7: Average values of sociodemographic variables and questionnaires

Perceived Asthma Control			
Characteristics		≥ 4 n=115 (71%)	< 4 n=48 (29%)
Gender, female	111 (66%)	73 (69%)	33 (31%)
Age	43.7 (13.7)	44.2 (13.9)	41.4 (12.8)
AQLQ_Symptoms	5.44 (1.04)	5.6 (1.0)	5.06 (1.1)
Physical Function	48.5 (7.8)	49.6 (7.2)	44.4 (8.8)
Mental Health	48.8 (10.0)	49.5 (9.6)	47.0 (10.9)
Social Function	49.2 (9.1)	51.4 (7.7)	44.6 (10.3)
Role Emotional	48.5 (10.0)	49.1 (9.6)	47.2 (10.8)
Body Mass Index	26.8 (6.3)	26.7 (6.0)	26.6 (6.6)

Table 8: Standardized beta coefficients estimate of Perceived Asthma Control

Predictors	Total Effects	Direct Effects	Indirect Effects
Age	0.16	-	0.16
Gender	0.07	-	0.07
Smoking	-0.05	-	-0.05
Body Mass Index	0.011	-	-0.1
FEV1	0.12*	-	0.12*
Asthma Symptom	0.42*	0.28	0.14
Mental Health	-0.23	-0.43	0.2
Physical Function	0.05	0.01	0.04
Social Function	0.37*	0.37*	-
Role Emotional	0.21	0.115	0.06
Healthcare Utilization	-0.21	-0.21	-

* Significant at < 0.05.

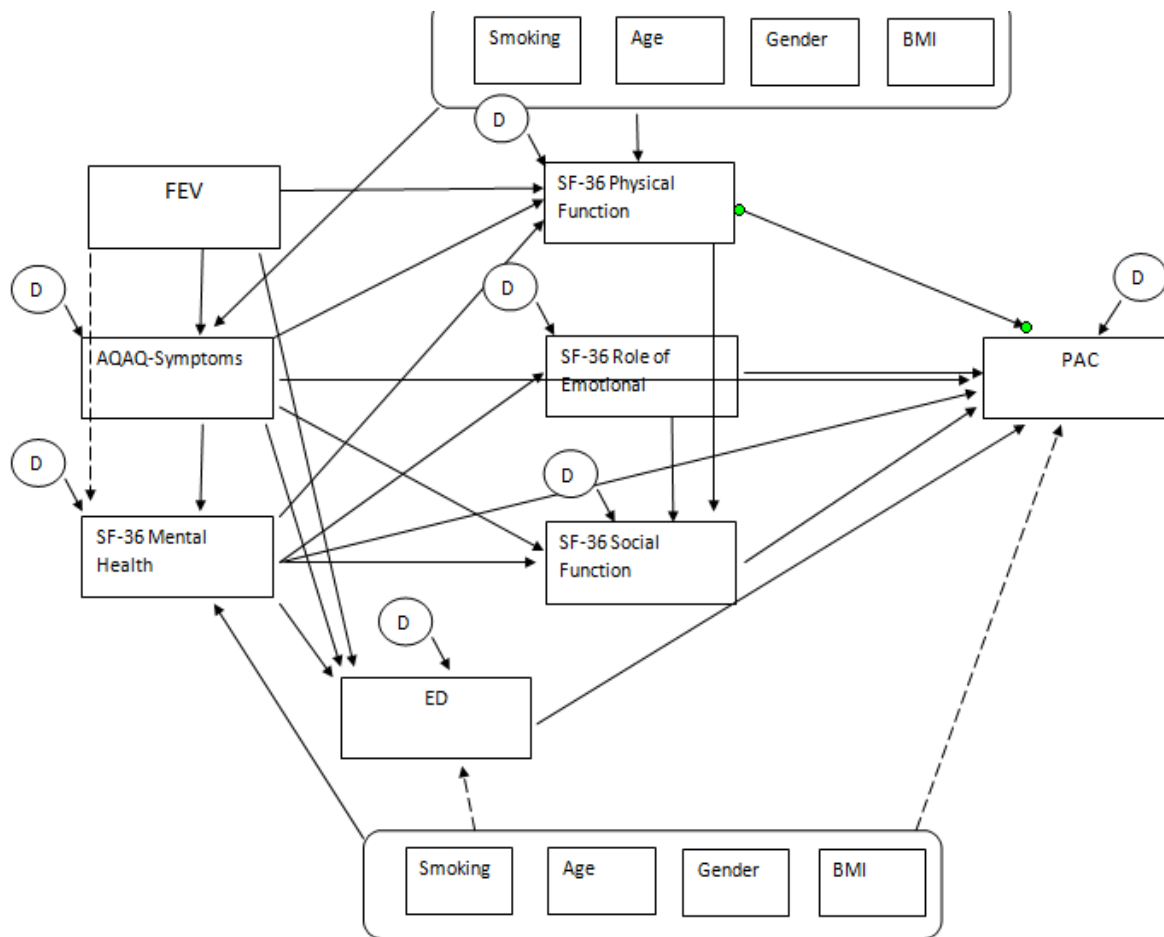


Figure 6: Proposed path model

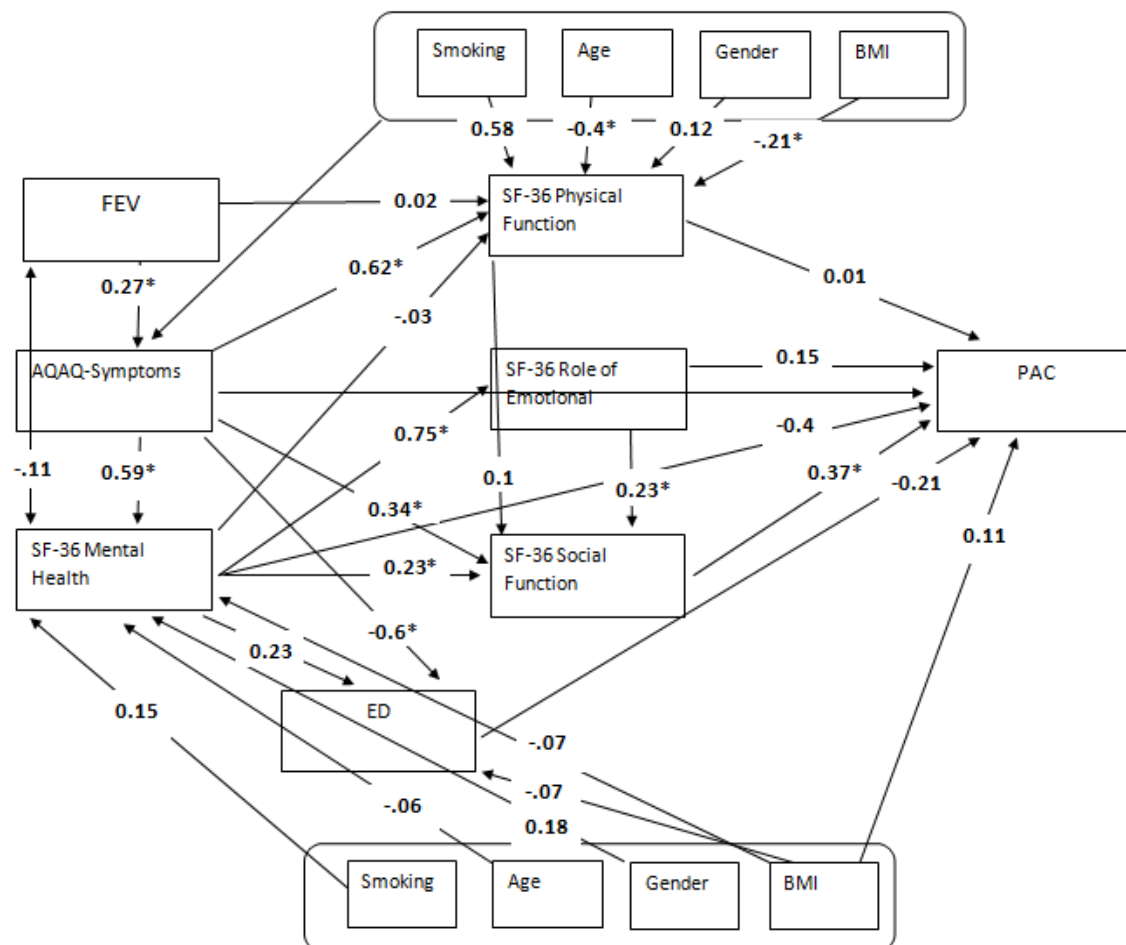


Figure 7: Re-specified path model

*Significant at level of 0.05

Chapter 7: Summary & Conclusion

Asthma control is the main outcome of asthma treatment. Approximately 59 % of individuals with asthma have uncontrolled asthma (FitzGerald et al., 2006). Asthma control enables individuals with asthma to have full active lives by participating in strenuous physical activities, engaging in daily roles, and avoiding emergency department visits and hospitalizations (The American Academy of Allergy Asthma & Immunology, 2000). It is important to assess because it is associated positively with self-management, which is the most important cornerstone of asthma and other chronic disease treatment (Katz et al., 1997).

Therefore, identifying the predictors of asthma control and perceived asthma control is very important for physicians and clinicians to tailor the intervention to the patient to achieve the optimum level of asthma control and perceived asthma control, which in turn improves the self-management and QoL (Patricia P. Katz et al., 2002; Katz et al., 1997; Jennifer Olajos-Clow et al., 2005).

In this thesis, path analysis was used to identify the predictors of perceived asthma control with the guidance of the integration of Wilson & Cleary and ICF models (Figure 3). It was used to give us a more realistic representation of the relationships between the predictors and perceived asthma control as compared to regression modeling. Path analysis allowed us to use more than one outcome at the same time and to pick variables to be predictors and outcomes simultaneously. It also allowed us to test the direct and indirect effects between predictors and perceived asthma control, and to assess the relationship between them (Rex B. Kline, 2005a).

In this thesis, data sets of two longitudinal studies were used to estimate the predictors of perceived asthma control. The first study was conducted among individuals with asthma recruited from primary care clinics. The results showed that asthma symptom and physical activity were the two main predictors of perceived asthma control. Emotional function and self-efficacy were indirect predictors of perceived asthma control through physical activity. These four predictors were affected significantly by other factors. For example, physical activity was affected by beliefs about medications. Based on the full path model, five predictors were associated with perceived asthma control over time; asthma symptom, physical activity, emotional function, self efficacy, and beliefs about medications.

The second data set was conducted among individuals with asthma recruited from a specialist clinic. The results showed that FEV1, asthma symptom and social function were the three main predictors of perceived asthma control. These predictors were affected significantly by other modifiable factors. For example, asthma symptom was affected by body mass index. Social function was also affected by mental health and role emotional. Based on the path model map; FEV1, asthma symptoms, social function & mental health, role emotional, and body mass index were the six modifiable predictors were associated with perceived asthma control over time.

Although there were similarities between the two studies presented in this thesis, we didn't have exactly the same assessed predictors in both manuscripts. For example, the first manuscript had self-efficacy, and beliefs about medications as potential predictors but these variables were not available for the second manuscript. In addition, the second manuscript had FEV1, social function, and body mass index as potential

predictors that were not included in the first manuscript. The similarity between the two manuscripts in term of participants' characteristics was the distributions of female, smoking, emergency department visit, perceived asthma control was greater than 70%, and the mean score of AQLQ-Symptoms was similar in both manuscripts. The people who recruited through the MOXXI study in manuscript 1 were older than those recruited from the MGH in manuscript 2 (62.1 vs 43.6).

Similarities in the results of the path analysis between the two manuscripts were that asthma symptoms were associated with level of perceived asthma control. Symptom status variables (asthma symptom and emotion) were associated with function level variables (physical & social functions, and role of emotion). Lastly, emergency department visit was not a significant predictor of perceived asthma control in both studies.

The differences in the results between the two manuscripts was that physical function/activity in the first study (primary care) was a predictor of perceived asthma control but not in the second one (specialist care). One potential reason may be that patients receiving care in the specialist clinics were more concerned about their asthma symptoms, emotional status, and social support due to their disease severity.

The contributions of these two manuscripts might help care teams tailor intervention to individuals with asthma by evaluating and working on improving the modifiable predictors of perceived asthma control identified in this thesis. Interventions that minimize asthma symptoms, improve lung function (FEV), improve emotional and physical status, social support, and support patients to smoking cessation and reduce weight are likely to have the greatest impact on long-term outcomes. Which aspects to

focus on for a given individual can be determined by conducting an evaluation profile that includes the predictors presented in this thesis. Once evaluated, the care team can identify the areas that need to be emphasized in the care plan and self-management training for a given patient.

The work presented in this thesis can also serve as a model for evaluating predictors of outcomes for other chronic disease. As noted earlier in this thesis, in 2005, 35 million people were estimated to have died from chronic diseases worldwide. In 2007, 68% of Canadian deaths were due to chronic diseases (Canadian Cancer Society, 2007). Thirty three percent of youth and adult Canadians reported having at least one chronic disease. The proportion of individuals with chronic disease increases with increasing age, with more than 70% of people who are sixty years or older reporting having one or more chronic disease (Anne-Marie Broemeling et al., 2008). Evaluating the potential to improve outcomes using a similar modeling approach based on a complete biomedical portrait as suggested for example by the Wilson and Cleary model and presented in this thesis, it will be critical for devising effective interventions and programs that will avert the negative effects of chronic disease on individuals' well-being and on society.

Future Directions

A more comprehensive model that includes other potential predictors of perceived asthma control among individuals with asthma from primary and specialist clinics included in future analyses including adherence to medications, dose of the medications, duration of asthma disease, and nutritional and environmental factors. We will assess the exactly same predictors of perceived asthma control among individuals with asthma from primary and specialist clinics to be able to compare between the two

results more effectively. Furthermore, we will assess the predictors of perceived asthma control at more than two time points to assess changes in predictors of perceived asthma control over time. In addition, the path model will be extended to confirmatory factor analysis (i.e. structural equation modeling) to assess the relation of perceived asthma control predictors, perceived asthma control with health related and overall QoL. Structural equation modeling is an extension of path analysis, which includes both path and measurement models. Measurement models represent latent variables and provide a better adjustment for error in measurement of a construct (Rex B. Kline, 2005b). In the future we will also recruit enough participants to meet the sample size that is needed to include other important predictors in a structural equation model.

Finally, it is important that the results derived from the studies in this thesis, and the planning of future studies be shared with clinicians to ensure ongoing translation of the knowledge gained to clinical teams. In turn, future research that will examine predictors of asthma control will also be informed by the realities of clinical care, and ensure that the predictors included and the method with which they are measured provide the needed information to design interventions and programs. As such, future research will ensure that the results are continually being feedback as part of asthma treatment recommendations, and integrated into clinician and patient workshops aimed at improving participants' knowledge, confidence, and skills to optimally apply best approaches for asthma care and self-management.

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