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QUANTITATIVE METHODS SPECIAL SECTION

Predictors of perceived asthma control among patients managed in primary care clinics

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Abstract

Objective To estimate the extent to which symptom status, physical activity, beliefs about medications, self-efficacy, emotional status, and healthcare utilization predict perceived asthma control over a period of 16 months 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 and Cleary and International Classification of Functioning, Disability and Health frameworks, was used to estimate the predictors of perceived asthma control.

Results The path analysis identified initial perceived asthma control asthma ($\beta = 0.43$, $p < 0.0001$), symptoms ($\beta = 0.35$, $p < 0.0001$), physical activity ($\beta = 0.27$, $p < 0.0001$), and self-efficacy ($\beta = 0.29$, $p < 0.0001$) as significant predictors of perceived asthma control (total effects, i.e., direct and indirect), while emotional status ($\beta = 0.08$, $p = 0.03$) was a significant indirect predictor through physical activity. The model explained 24 % of the variance of perceived asthma control. Overall, the model fits the data well ($\chi^2 = 6.65$, $df = 6$, p value $= 0.35$, root-mean-square error of approximation $= 0.02$, Comparative Fit Index $= 0.999$, and weighted root-mean-square residual $= 0.27$).

Conclusion Initial perceived asthma control, current symptoms status, physical activity, and self-efficacy can be used to identify individuals likely to have good perceived asthma control in the future. Emotional status also has 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 maximize quality of life.

Keywords Physical activity · Emotion · Self-efficacy · Beliefs about medications · Healthcare utilization · Path analysis

Introduction

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 [1]. Asthma may cause substantial morbidity [2] such as sleeplessness, daytime fatigue, reduced activity levels, and school/work absenteeism.

The main goal of asthma treatment was to maintain control of symptoms, so that individuals with asthma who are well controlled are able to lead full active lives including engaging in strenuous physical activities, participating in life's roles, and avoiding emergency department visits and hospitalizations [3]. Currently, approximately two-thirds of individuals with asthma in the USA receive care from

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primary care clinicians, while the other third receive care from specialists, including allergists and pulmonologists [4]. Receiving care only from a primary care physician is associated with poorer asthma control in comparison with when care is managed by specialists [5]. In 2009, the prevalence of uncontrolled asthma among primary care patients in the USA was 58 % [6].

Asthma control is defined as "the extent to which the manifestations of asthma have been reduced or removed by treatment" [7]. 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) [8]. The current literature shows that better asthma control leads to better quality of life (QoL) related to asthma and lower costs of asthma treatment [9, 10].

Key recommendations in the Canadian asthma treatment guideline encompass prescription of reliever (inhaled fast-acting β2-agonists) and controller (inhaled corticosteroids) medications and self-management education, including oral and written action plans. Despite available asthma treatment guidelines, the level of asthma control among patients in primary care settings remains suboptimal [6]. This may in part be related to factors that are related to the disease itself, or to personal characteristics that may affect health outcomes, which are not routinely considered in asthma management [11]. For example, current guidelines do not focus on psychosocial characteristics, behavioral characteristics (e.g., self-efficacy), activity limitations (e.g., physical activity), and asthma comorbidities [12]. Identifying these factors is important for clinicians to tailor interventions to patient profiles in order to achieve an optimum level of asthma control [13].

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, such as age, gender, race, and duration of asthma, have been shown to be relatively weakly associated with asthma control [14–16]; results have been mixed for gender where most studies have shown no effect on asthma control [14–16]; one study found that women had poorer asthma control than men [17], and another found the opposite [18]. Individuals from nonwhite races in the USA were also more likely to have poor asthma control than white Americans [16, 19]. Lastly, there was no significant association identified between duration of asthma and level of asthma control [20, 21].

In contrast, there is evidence supporting the association of modifiable variables with better asthma control. These variables include stronger self-efficacy, adherence to medications, absence of depression and anxiety, regular exercise performance, higher psychosocial function, being a nonsmoker, and lower body mass index [14–16, 22–28].

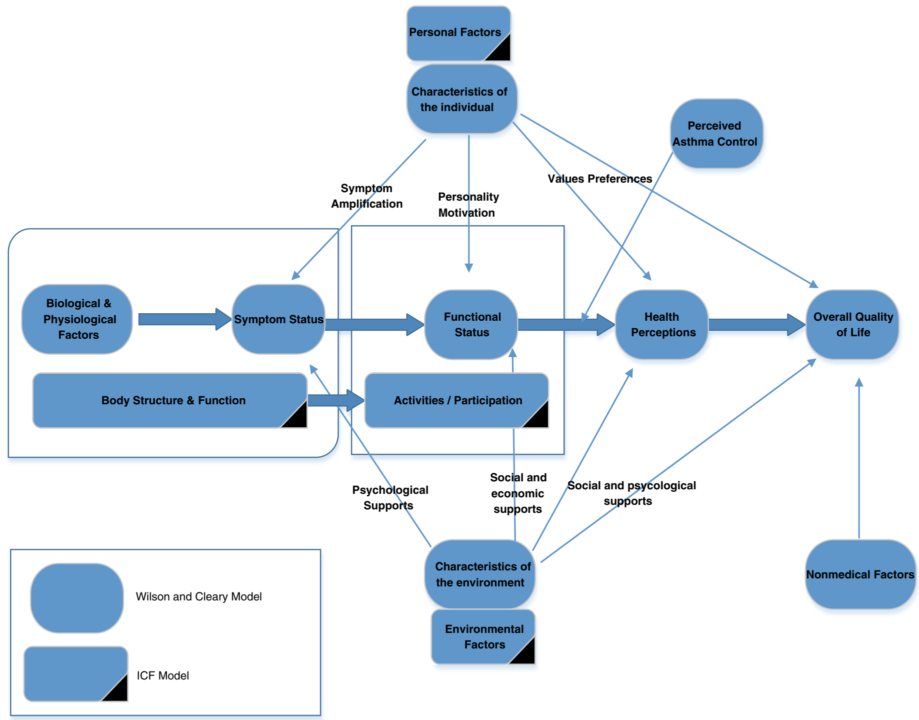
In the current study, we were interested in studying predictors of perceived asthma control rather than asthma control. Perceived asthma control is different from asthma control as perceived asthma control [29] is related to three constructs: self-efficacy, locus of control, and learned helplessness [30], while asthma control is related to patient or physician reports based on symptoms, work/school absenteeism, and forced expiratory volume (FEV) [8]. Also, people with asthma may report some life-aspect restrictions that are not discussed with healthcare providers and are not considered in asthma control measures [31]. Perceived asthma control is positively associated with asthma self-management [32]. Therefore, assessing the predictors of perceived asthma control is important 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.

Previous studies have focused on predictors of asthma control but none have studied the predictors of perceived asthma control. In this study, predictors of perceived asthma control were examined over time, which addresses the limitations of cross-sectional studies. In a cross-sectional design, 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 [33].

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. In contrast, path analysis that was used in this study overcomes the limitations of regression as it decomposes the sources of the correlations among the independent 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. Path analysis provides a more real world representation of the relationship between predictors and perceived asthma control [34, 35].

The purpose of this study was to identify direct and indirect predictors of perceived asthma control (representing asthma-specific health perception) among a primary care population followed over an average of 16 months. Guided by the Wilson and Cleary and International Classification of Functioning, Disability and Health (ICF) frameworks (Fig. 1) [11, 36], we proposed a theoretical framework to specify the relationships and guide the evaluation of predictors of perceived asthma control. These frameworks provide a useful foundation for examining how the perceived asthma control concept relates to different health-related quality of life (HQOL) domains and other individual and clinical characteristics.

Fig. 1 Integration of Wilson and Cleary Framework and ICF Framework



The Wilson and Cleary and the ICF are two commonly used frameworks of health that can be used to guide the evaluation of outcomes and development of interventions [11, 36]. Both frameworks reflect health as encompassing more than the absence of disease and put the emphasis on health and functioning, and for the Wilson and Cleary framework, there is an emphasis on quality of life. Wilson and Cleary divided health outcome into five levels: biological and physiological variables, symptoms status, functional status, general health perception, and overall QoL. While, the health state in ICF framework was divided into three components: body structure and function, activities, and participations [37]. Body structure and function component of the ICF framework corresponds to biological and physiological variables and symptoms status levels of Wilson and Cleary framework. Activities and participations components of ICF correspond to functional status level of Wilson and Cleary framework. In the context of asthma, we have conceptualized asthma control as asthma-specific health perception. We used the rubrics of the Wilson and Cleary framework to identify the key variables along the path to asthma-specific health perception (as measured by a single indicator variable, perceived asthma control).

The theoretical model of perceived asthma control evaluated in this study was guided by relationships reported in the literature and by the Wilson and Cleary and ICF theoretical frameworks [11, 36]. Generally, the asthma literature supports that changes in the biological and physiological/body structure and function of the airways may result in symptoms including coughing, wheezing, chest tightness, breathlessness, lower emotional status ("i.e., frustration, afraid, bothering, concern"), and lower self-efficacy (symptoms/body structure and function variable). The exacerbation of asthma symptoms leads to functional limitations (functional status/activities and participations). Symptoms exacerbation and functional limitation (criteria of poor asthma control) may affect asthma control and the perceived level of asthma control, which in turn affect the level of general health perception and overall QoL levels [22, 27, 38–41]. Thus, our measure of perceived asthma control fits between functional status and health perception in the Wilson and Cleary framework (Fig. 1), but this does not mean that perceived asthma control is an intermediate variable between functional status and health perception as functional status can directly influence health perception.

Furthermore, the literature supports that there are significant correlations between asthma symptoms (i.e., coughing, wheezing, chest tightness, and breathlessness), self-efficacy, and emotional status ("i.e., frustration, afraid, bothering, concern"). Asthma symptoms may increase the likelihood of low emotional status ("i.e., frustration, afraid, bothering, concern") [42–44]. We also hypothesized that increasing severity of asthma symptoms may affect beliefs about medications and lead to disbelief about medications. Emotional status ("i.e., frustration, afraid, bothering, concern") may also affect daily self-monitoring abilities, treatment continuity [45], and self-efficacy [40]. However, based on the definition of self-efficacy, an individual's personal confidence regarding his/her capacity to avoid asthma symptoms and exacerbations to reach optimum health [46], we hypothesized that self-efficacy may affect asthma symptoms and emotional status ("i.e., frustration, afraid, bothering, concern"). Mancuso et al. [47] showed that higher self-efficacy was associated with better asthma symptoms and better emotional status as measured by the Asthma Quality of Life Questionnaire. Physical activity is also affected by age and gender [48], FEV, asthma symptoms [49], emotional status [49–51], self-efficacy [52], and smoking [53]. Emergency department visits among individuals with asthma are associated with smoking, body mass index, and self-efficacy [54–57]. Lastly, we hypothesized that perceived asthma control can be affected directly by asthma symptoms, emotional status, self-efficacy, physical function, healthcare utilization, smoking, age, and gender.

The objective of this study was to estimate the extent to which baseline perceived asthma control, beliefs about medications, self-efficacy, symptoms, emotional status ("i.e., frustration, afraid, bothering, concern"), physical activity, and healthcare utilization predict perceived asthma control over a period of 16 months. We hypothesized that healthcare utilization will have a significant negative total effect on perceived asthma control, while baseline perceived asthma control, asthma symptoms status, physical activity, good emotional status ("i.e., frustration, afraid, bothering, concern"), beliefs about asthma medications, and self-efficacy will have a significant positive total effect on perceived asthma control.

Methods

Study population and procedure

This study is a secondary analysis using data from a longitudinal study, Medical Office of the Twenty First Century (MOXXI), that examined health outcomes of asthma in primary care settings. Individuals in this study were evaluated over two time points, at baseline and one year later [58].

The sample comprised 299 adult participants in the MOXXI project who had a confirmed diagnosis of asthma and who supplied information at both baseline and the one-year follow-up. Individuals with probable asthma were identified through the MOXXI system using information on written and dispensed prescriptions, and medical service claims diagnostic codes, based on the algorithms validated in prior research [59]. The participants were called by a member of the research team and invited to participate in the longitudinal study. Participants were recruited from Montreal-based primary care clinics. 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

Predictor variables

All potential predictors were measured at baseline, while perceived asthma control was measured at baseline and 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 admission 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 domains (necessity and concerns) querying beliefs about the necessity of prescribed medications for controlling illness and concerns about the potential adverse effects of taking the medications [60]. The reliability (0.60–0.78) and criterion-related validity (0.19–0.45) of BMQ were supported by Horne et al. [61].

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 [46]. Self-efficacy is a component of mental function, and it is considered as an impairment of confidence [36]. It is a component of body structure and function, and therefore, in our path model, it is situated as same level of symptom [11] (Table 1). Self-efficacy in this study was measured using the Knowledge, Attitude, and Self-efficacy Asthma Questionnaire (KASE-AQ). The self-efficacy domain comprises 20 items measured on a 5-point Likert scale, where the highest possible score is 100 and the lowest possible score is 20 [62]; higher scores indicate better self-efficacy. Reliability ($a = 0.89$) and validity were supported by Wigal et al. [63]. Factor analysis revealed three distinct factors of knowledge, attitude, and self-efficacy according to Kaiser's correction.

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 within four domains: symptoms, emotion, activity limitation, and environmental stimuli. The highest score of seven indicates highest level of QoL, while the lowest score, one, indicates the lowest level of QoL [64]. Reliability and validity of MAQLQ were supported by the literature; intraclass correlation coefficient is 0.83; and the construct validity was examined through correlation with Asthma Quality of Life Questionnaire and SF-36 [65]. Symptoms (i.e., coughing and breath shortness), emotional status (i.e., specific mental functions related to the feeling and affective components of the processes of the mind [36]), and activity limitation domains were separately used as predictors of perceived asthma control.

In this study, we did not have a measure of QOL as this construct includes elements far beyond health and is individually determined [66]. We used the other health profiles in this study to create a measurement model recognizing that each separate domain of the health profile measured a construct within the Wilson and Cleary framework [11]. The Wilson and Cleary framework's constructs that were examined in this study were symptom status (i.e., physical, psychological, and emotional symptoms) and functional status (i.e., physical function, social function, role function, and psychological function) [11]. Consequently, MAQLQ-symptom and MAQLQ-emotion measured the construct of symptom, while MAQLQ-activity measured the construct of physical function (Table 1).

Smoking status

Smoking status was expressed using a binary 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 relating to asthma symptoms, use of rescue medications, the impact of asthma on daily activities, and rating of overall asthma control in the past 4 weeks. ACT scores range from 5 to 25; individuals with scores less than 20 are considered as uncontrolled, while scores equal to or more than 20 considered as controlled [67].

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 [67]. The literature supports validity and reliability to use a single-item tool [68].

Table 1 Average values of sociodemographic variables and questionnaires

Characteristics	Predictor's measures	M (SD)	Skewness (kurtosis)
Personal factor			
Gender, female	Male/female	207 (69 %)	
Age	Years	62.1 (14.4)	−0.44 (−0.4)
Beliefs about medications	Beliefs about medications questionnaire/5	4.6 (5.5)	0.23 (−0.1)
Environmental factor			
Smoking	Smoker/nonsmoker	43 (14 %)	
Healthcare utilization	Single item (The admission to the emergency department)	111 (37 %)	
Symptom status			
Physical symptoms	MAQLQ-symptoms/7	5.2 (1.3)	−0.56 (−0.2)
Emotional symptoms	MAQLQ-emotion/7	5.8 (1.4)	−1.3 (1.3)
Self-efficacy	Knowledge, attitude, and self-efficacy asthma questionnaire—self-efficacy subscale	83.2 (13.3)	−1.3 (2.9)
Functional status			
Physical function	MAQLQ-activity/7	5.5 (1.5)	−0.8 (−0.3)

Statistical analyses

All descriptive, correlation, and statistical analyses in this study were done using SAS 9.2 [69]. Path analysis was conducted using Mplus 6.2 [70]. Pearson and spearman correlations were used to assess the correlation among predictor variables to determine multi-collinearity. The proportional odds assumption for ordinal regression was also examined using SAS 9.2.

Gender, smoking, and healthcare utilization were treated as categorical variables. Age, self-efficacy, beliefs about medications, and the MAQLQ domains were considered as continuous variables. Perceived asthma control, the outcome variable, was considered as an ordinal variable.

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 2 presents the proposed path diagram, which was modeled based on the literature and the integration of the Wilson and Cleary and ICF frameworks (Fig. 1c) [11, 40, 42, 44, 48, 49, 51–54, 71, 72]. The arrows in the figure present the direct and indirect paths between predictors and outcomes. The letter "D" represents the error of measurement of outcome variables. The goodness of fit of the path model was evaluated by the model chi square (χ^2), Comparative Fit Index (CFI), root-mean-square error of approximation (RMSEA), and weighted root-mean-square residual (WRMR). A small and nonsignificant χ^2, CFI value greater than 0.95, RMSEA value less than 0.05 [73], and WRMR less than value of 1 [74] indicate a good fit model. Weighted least-squares estimator was used to estimate the path analysis model. This type of estimation was chosen since the current path model has both categorical and continuous outcome variables [75], and it has also performed well except with small sample size [76].

The proposed path model (Fig. 2) specified initial perceived asthma control, symptom status, emotional status ("i.e., frustration, afraid, bothering, concern"), physical activity, self-efficacy, healthcare utilization, smoking, and personal factors (e.g., age and gender) as effecting directly perceived asthma control at follow-up. It also specified that perceived asthma control at follow-up can be indirectly affected by (1) personal factors and smoking through symptoms, emotional status ("i.e., frustration, afraid, bothering, concern"), self-efficacy, physical activity, healthcare utilization, and perceived asthma control at baseline; (2) symptom status through emotional status ("i.e., frustration, afraid, bothering, concern"), physical activity, healthcare utilization, and perceived asthma control at baseline; (3) emotional status ("i.e., frustration, afraid, bothering, concern") through physical activity, healthcare utilization, and perceived asthma control at baseline; (4) self-efficacy through symptoms, emotional status ("i.e., frustration, afraid, bothering, concern"), physical activity, healthcare utilization, and perceived asthma control at baseline; (5) beliefs about medication through healthcare utilization. The rationale of anticipating these hypotheses was mentioned in the introduction section.

Sample size

Sample size in path analysis depends upon the number of parameters (i.e., variances, covariances, and number of paths). The proposed model (Fig. 2) included 60 parameters. According to the sample size calculation for path analysis, an ideal sample size to parameter ratio is 20:1, which means we need 20 subjects for each parameter (required sample size would be 1,200). However, less ideal would be ratio of 10:1 (sample size required = 600) or 5:1 (sample size required = 300), but it gives us trustworthy results [77].

Results

The characteristics of the 299 study participants who were recruited from primary care clinics with data at both time points are presented in Table 1. The majority (69 %) were women, and the mean age of the whole sample was 62 years. The mean score of symptoms, activity, and emotional subscales of the MAQLQ was 5.2, 5.5, and 5.8 out of 7, respectively, which indicate that the sample did not have severe symptoms, activity limitations, and emotional dysfunction related to asthma. Approximately, 80 % of participants reported the higher two levels of perceived asthma control at both times, baseline and follow-up. Distribution of perceived asthma control levels is presented in Table 2.

Multi-collinearity was tested using a correlation matrix between the dependent variables. The correlations showed that there was no multi-collinearity among dependent variables (highest r value was less than 0.7). The fit statistics of the proposed path model (Fig. 2) showed that the model fits for the sample data ($\chi^2 = 6.65$, $df = 6$, $p = 0.35$). The value of the CFI, RMSEA, and WRMR was 0.999, 0.02, and 0.27, respectively, indicative of good fit.

The proposed model explained the variances of symptom, emotional status ("i.e., frustration, afraid, bothering, concern"), physical activity, healthcare utilization, beliefs about medications, and perceived asthma control at baseline and follow-up by 24, 48, 50, 4, 8, 49, and 33 %, 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 outcomes classification according to the integration of Wilson and Cleary and ICF models (Fig. 1). The first part presents the results related to symptom variables; second part presents the results related to the physical function variable; and the last part presents the relation between the tested variables and the outcome (i.e., perceived asthma control). To make the results clearer, higher scores of asthma symptom, physical activity, and emotional status ("i.e., frustration, afraid, bothering, concern") indicate better outcomes.

Symptom status variables: according to the model, asthma symptom was significantly affected by self-efficacy (p value <0.001). Increasing one unit of self-efficacy, increased 0.47 standard deviations of asthma symptoms as measured by the MAQLQ. Being a smoker (p value $= 0.048$) decreased score of asthma symptoms as measured by the MAQLQ by 0.12 standard deviations.

Emotional status ("i.e., frustration, afraid, bothering, concern") was significantly affected by asthma symptom

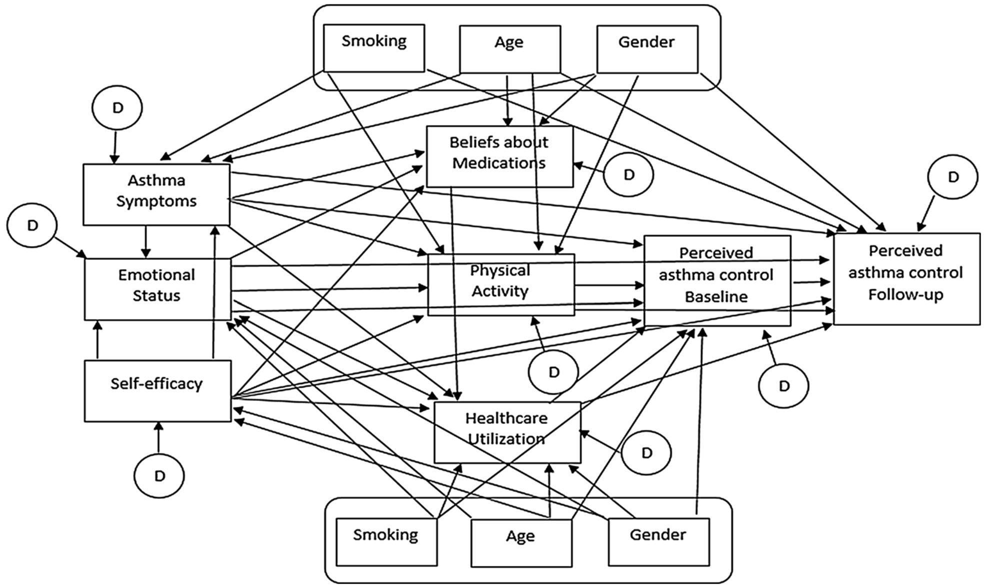


Fig. 2 Proposed path model. All variables were assessed at baseline except perceived asthma control was measured at follow-up. *D* Measurement error

Table 2 Distribution of perceived asthma control

Categories	Baseline perceived asthma control *N* (%)	Follow-up perceived asthma control *N* (%)
Not controlled at all	2 (0.7)	5 (1.7)
Poorly controlled	20 (6.7)	12 (4)
Somewhat controlled	34 (11.4)	47 (15.7)
Well controlled	152 (50.8)	136 (45.5)
Completely controlled	91 (30.4)	99 (33.1)

and self-efficacy (p value <0.001). Increasing one unit of asthma symptom on the MAQLQ and one unit of self-efficacy, increased 0.67 and 0.04 standard deviations of emotional status ("i.e., frustration, afraid, bothering, concern") as measured by the MAQLQ, respectively.

Functional status variable: physical activity was significantly affected through asthma symptom, emotional status ("i.e., frustration, afraid, bothering, concern"), and self-efficacy. One unit increased in asthma symptoms, emotion, and self-efficacy increased physical activity (p values <0.0001) by 0.55, 0.21, and 0.49 standard deviations, respectively.

Perceived asthma control at baseline: asthma symptoms (p value <0.0001), physical activity (p value $= 0.02$), self-efficacy (p value <0.0001), and smoking (p value $= 0.03$) are significantly associated with the perceived asthma control at baseline. Increasing one unit of asthma symptom and physical activity on the MAQLQ, we would expect a 0.55 and 0.15 increase in the log-odds of being in a higher level of perceived asthma control. In addition, increasing one unit of self-efficacy, we would expect a 0.46 increase in the log-odds of being in a higher level of perceived asthma control. Being a smoker, we would expect a 0.14 decrease in the log-odds of being in a higher level of perceived asthma control. While, emotion ("i.e., frustration, afraid, bothering, concern") status on the MAQLQ (p value $= 0.04$) is significantly associated with perceived asthma control indirectly. Increasing one unit of emotion ("i.e., frustration, afraid, bothering, concern") on the MAQLQ, we would expect a 0.05 increase in the log-odds of being in a higher level of perceived asthma control.

As well, asthma symptom (p value <0.0001), physical activity (p value >0.0001), self-efficacy (p value <0.0001), and perceived asthma control at baseline (p value <0.0001) significantly predicted the perceived asthma control at follow-up. Increasing one unit of asthma symptom and physical activity on the MAQLQ, we would expect a 0.35 and 0.27 increase in the log-odds of being in a higher level of perceived asthma control. In addition, increasing one unit of self-efficacy, we would expect a 0.29 increase in the log-odds of being in a higher level of perceived asthma control at follow-up. Furthermore, being in the highest level of perceived asthma control, we would expect a 0.44 increase in the log-odds of being in a higher level of perceived asthma control at follow-up. Lastly, emotion status ("i.e., frustration, afraid, bothering, concern") on the MAQLQ (p value $= 0.04$) significantly predicted perceived asthma control indirectly through self-efficacy and physical activity. Increasing one unit of emotion ("i.e., frustration, afraid, bothering, concern") on the MAQLQ, we would expect a 0.08 increase in the log-odds of being in a higher level of perceived asthma control. The total direct and indirect effects on perceived asthma control are presented in Table 3.

Table 3 Standardized beta coefficient estimate of perceived asthma control

Predictors	Total effect	Total direct effect	Total indirect effect
Age	0.03	0.05	−0.02
Gender	0.02	0.01	0.01
Smoking	−0.06	−0.01	−0.06
Perceived asthma control - baseline	0.43*	0.43*	–
Asthma symptom	0.35*	−0.02	0.37*
Emotion	0.09	0.02	0.08*
Physical activity	0.27*	0.21*	0.07*
Healthcare utilization	0.00	0.05	0.00
Self-efficacy	0.29*	−0.02	0.31*
Beliefs about medicine	0.00	–	0.00

* Significant at <0.05

Discussion

To date, this is the only study that we know of that evaluated predictors of perceived asthma control overtime among primary care clinics population. Previous studies have shown that there were many variables that affect asthma control as represented by patient reported or physician reported measures of day/night symptoms, FEV, and school/work absenteeism. Earlier work relied exclusively on regression approaches in which each variable in the model is adjusted for the other variables clouding the interpretation. 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 an outcome. In turn, this allowed us to more realistically represent the relationship between the predictor variables and their direct and indirect associations with perceived asthma control.

Belief about medications was not included in the proposed model as a direct predictor of perceived asthma control as adherence to medication was not measured. Adherence to medication has been shown to be an intermediate variable between beliefs about medications and perceived asthma control [16, 60, 78]. The proposed model explained little (8 %) of beliefs about medications. There are other factors that could explain beliefs about medications that we did not include in the model such as type and dose of medications and quality of care.

The percentage of individuals reporting the two higher levels of perceived asthma control in this study was high at 80 %, which is higher than the percentage of asthma control reported in previous studies (58 %) [6]. This difference was probably because approximately only one-third (37 %) of our sample had emergency department visits, and the participants did not have severe symptoms, activity limitations, and emotional dysfunction related to asthma. Another reason might also be, as supported in the literature, that individuals with asthma overestimate their level of asthma control [79].

The results of the path analysis showed that the magnitude of the relationship between physical activity and asthma symptoms and perceived asthma control was significant and higher than other predictors (e.g., age and gender). These results are supported by previous studies, where the perceived control of asthma was significantly correlated cross-sectionally with symptoms and physical activity subscales of the Asthma Quality of Life Questionnaire (AQLQ) [30, 80]. Neither of these two studies (i.e., Katz et al. 2002 and Olajos-Clow et al. 2005) identified predictors of perceived asthma control as their studies were cross-sectional, instead they presented the correlation between perceived asthma control and QoL. Furthermore, the magnitude of the relationship between self-efficacy and perceived asthma control was significant and higher than other predictors (e.g., age and gender) in the current study. Previous studies have supported the association of asthma control with self-efficacy [15, 24, 41, 55, 81]. In our study, symptoms status and self-efficacy did not have a significant direct effect on perceived asthma control, and this might be because the effect of symptoms status and self-efficacy on perceived asthma control is mainly through physical activity.

Emotional status ("i.e., frustration, afraid, bothering, concern") indirectly predicted perceived asthma control through physical activity. Previous studies have supported the association of asthma control with depression [15, 24, 41, 55, 81]. Emotional status ("i.e., frustration, afraid, bothering, concern") did not have a higher significant magnitude of total effect to predict perceived asthma control; this might also be because the effect of emotion ("i.e., frustration, afraid, bothering, concern") on perceived asthma control is mainly through physical activity. Previous studies have also shown that the emotional subscale of AQLQ was not significantly correlated with perceived asthma control [30, 80]. However, neither of these studies identified predictors of perceived asthma control as their studies were cross-sectional, instead they presented the correlation between perceived asthma control and QoL.

In this study, age and gender had low insignificant relationship with perceived asthma control and this is in line with what previous studies have found among patients from primary care clinics [15–17]. However, smoking and emergency department visits had a low insignificant relationship with perceived asthma control although previous studies identified these as significant 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 criteria [8].

The results of this study supported four main predictors of perceived asthma control: initial perceived asthma control, asthma symptoms, physical activity, and self-efficacy. There was also another variable that indirectly predicted perceived asthma control through physical activity, emotional status ("i.e., frustration, afraid, bothering, concern"). Results of cross-sectional and longitudinal models in the current study support that there are four main predictors of perceived asthma control and an indirect predictor, which means that we have a consensus conclusion on perceived asthma control predictors. The results of proposed path model are just applied to people from primary care clinics, and we cannot generalize our conclusion to all individuals with asthma.

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 can work on minimizing asthma symptoms through medications, patient education, and programs that include interventions aimed at increasing physical activity. Furthermore, physicians can implement programs 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 ("i.e., frustration, afraid, bothering, concern") through psychosocial support.

This path model may have other model equivalences that should be examined. However, we have selected this path model since it is specified based on the literature review and Wilson and Cleary and ICF theoretical frameworks [11, 36]. In addition, given relationships and the need for a larger sample size, exploratory approach could be conducted by weighting the result of the lack of power in the future studies.

Lastly, we tested the assumption of ordinal proportional odds for perceived asthma control and found that the odds assumption was not supported as indicated by "score test for the proportional odds assumption". The implication is that the path model predicted better the higher levels of perceived asthma control compared with lower perceived asthma control, since the frequency of people in the lower two levels of perceived asthma control was too small.

Limitations

The duration between the two evaluation points was varied; the mean duration between the two evaluation points was about 16 months and ranged from 11 to 36 months. Some predictors were not covered in the current study, such as social function, body mass index, adherence to medication, and environmental and nutrition factors, as the longitudinal study did not collect data regarding these factors. Another limitation is sample size, ideally we would have 1,200 subjects to run the path model according to rule of 20:1 (i.e., 20 subjects for 1 parameter). However, ratio of 10:1 or 5:1 would be less ideal, but it gives us trustworthiness results [77]. Hancock and Freeman [82] created tables to calculate power of SEM models; according to the tables, the power of the current model is 0.15–0.25. To achieve power of 0.8, we need 1,500 subjects [82]. The implication of having small sample size and low power is that the model would be unstable [77]. Lastly, the outcome measurement (single item) lacks psychometric information.

Conclusion

In conclusion, we specified a path model of the predictors of perceived asthma control among patients from primary care. The model explained 24 % of the variance of perceived asthma control. The path model provided four main predictors of perceived asthma control: initial perceived asthma control, asthma symptoms, physical activity, and self-efficacy. Physical activity was a mediator of emotional status ("i.e., frustration, afraid, bothering, concern") on perceived asthma control. Identifying these four predictors of perceived asthma control may help physicians tailor interventions to individual's needs to improve self-management, to achieve the optimal level of asthma control, to prevent future development of other comorbidities and chronic diseases [83], and to maximize QoL [13].

Conflict of interest We commit that we did not get any financial, consulting, and personal relationships with other people or organizations that could influence our work.

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