

Comprehensive risk factors, asthma control, and life quality pathways in adults with asthma: A structural equation modeling analysis

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ABSTRACT

Objectives: Previous studies reported that environmental factors, particularly the work environment, were related to quality of life (QoL) in patients with asthma. However, the pathway that links workplace and QoL in adults with asthma is still not clear. The aim of this study was to explore the comprehensive environmental factors, asthma control, and QoL pathways in patients with asthma.

Study Design and Setting: Two cohorts of patients with asthma were established, including a prospective phase cohort in 2006 and a cross-sectional phase cohort in 2012. The Asthma Control Test was used to determine the level of disease control, and QoL was assessed by using the Taiwanese version of an asthma quality-of-life questionnaire. In 2014, a structural equation model was applied to explore the pathways from the risk factors to QoL.

Results: The structural equation model for predicting QoL provided a good fit (χ^2 [degrees of freedom] = 43.81 [38]; root mean square error of approximation 0.021 [90% confidence interval, 0.001–0.044]) after combining the two cohorts. The wheeze frequency, allergic response frequency, parental asthma, and asthma control were directly associated with QoL. We found that patients who were obese and who worked in poor environments had increased work symptoms and wheeze frequency during the previous year in a cross-sectional phase cohort. However, we did not find that body mass index was a significant factor in a prospective cohort. The patients with obesity and with frequent work symptoms, which induced poor asthma control, were possible mechanisms in the pathway from workplace exposure to poor QoL in the observed adults with asthma in our combined data.

Conclusion: Body mass index, the work environment, and the wheeze frequency should be considered when assessing asthma control and QoL in adult patients with asthma. Patients who reduce their body weight or avoid exposure to poor workplaces may find this useful for their asthma control and improvement of their QoL.

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Asthma is a chronic inflammatory disease and a global public health problem. The World Health Survey reported that the clinical asthma prevalence in adults was ~4.5% worldwide.¹ Many studies demon-

strated asthma risk factors, including obesity, cigarette smoking, indoor environments, food allergens, and workplace exposures.^{2–8} These factors may induce the following symptoms: wheezing, dyspnea, chest tightness, nocturnal awakening, obstructive sleep apnea, and early morning cough, and these symptoms may further affect asthma control and quality of life (QoL).^{7,9–11}

Approximately 15% of adult asthma is attributed to workplace exposures.⁸ Work-related asthma includes occupational and work-aggravated asthma. Occupational asthma occurs when a patient has an airflow limitation or hyperresponsiveness with inflammation due to a particular occupational environment. Work-aggravated asthma is defined as asthma that displays syndrome worsening in a specific workplace.¹² Several chemical irritants were identified as workplace asthma disease or asthma severity risk factors in adults.^{13,14} Asthma exacerbation or more asthmatic symptoms in a workplace can influence daily QoL.^{12,15} A population-based study found that employed adults with asthma and with work-related asthma exhibited a more im-

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paired QoL than non-work-related patients with asthma.¹⁶

The relationship between body mass index (BMI) and asthma incidence was demonstrated in a cohort study.¹⁷ Results of a recent study in Taiwan indicated that low physical fitness and high sedentary time increased the central obesity risk, which led to asthma.¹⁸ Another study observed that patients who were obese and with asthma displayed poor asthma QoL and increased hospitalizations.¹⁹ Indoor allergens, including house-dust mites, animal allergens, and fungi, are associated with asthma.²⁰ Immunoglobulin E (IgE) sensitization with aeroallergens (furry animals and mold) and food allergens (wheat, peanut, soy, shrimp, egg, milk, and fish) was associated with local and systemic inflammatory biomarkers in asthma.⁶

A multinational cross-sectional study demonstrated that the Asthma Control Test (ACT) was useful in predicting asthma control.²¹ Compared with patients with well-controlled asthma, patients with not well-controlled asthma (ACT score of ≤ 19) required more emergency department visits and asthma medications.²² Both asthma control and asthma severity contributed to the QoL.²³ Structural equation modeling (SEM) is a methodology for defining and estimating latent variables, and for further representing and testing a network of relationships among variables. Few studies have reported the pathway that links workplace and QoL outcome in adult asthma. The findings from the SEM analysis were expected to provide a comprehensive insight regarding the relative influence of latent environmental factors on asthma outcome. Therefore, the aim of this study was to explore the pathway that links environmental factors, asthma control, and QoL outcome in adult subjects with asthma by using SEM.

METHODS

Study Population

Two independent Taiwan adult asthma cohorts were established in 2006 and in 2012. In the first cohort, the adult asthma cohort was a prospective phase cohort, which included 668 patients with asthma who were recruited from August 2006 to October 2009.²⁴ From 2012 to 2013, 180 patients with asthma from the Kaohsiung Chang Gung Memorial Hospital, a medical center in southern Taiwan, were invited to follow and have their Taiwan version of the Asthma Quality of Life Questionnaire (TAQLQ) and ACT information in the first asthma cohort. Patients ($n = 57$) were excluded if they did not complete the follow-up questionnaire ($n = 26$); rejected participation ($n = 3$); had physician-diagnosed tuberculosis, emphysema, chronic airway obstruction, or cancer ($n = 20$); or provided incomplete environmental factors ($n = 5$) or TAQLQ and ACT ($n =$

3) information. In the first cohort, 123 patients with current asthma (60 men and 63 women, 20–70 years of age) were further analyzed. From August 2012 to December 2013, a second, independent, cross-sectional phase asthma cohort ($n = 272$) was also established at the Kaohsiung Chang Gung Memorial Hospital. Patients ($n = 36$) were excluded if they rejected participation ($n = 3$); had physician-diagnosed tuberculosis, emphysema, chronic airway obstruction, or cancer ($n = 24$); or provided incomplete environmental factors ($n = 6$) or TAQLQ and ACT ($n = 3$) information. In the second cohort, 236 patients with current asthma (105 men and 131 women, 20–70 years of age) were further analyzed. Thus, there were a total of 359 patients with asthma who were eligible for this study and were analyzed in 2014. The flow chart for the recruitment is shown in Fig. 1. All of the participants provided informed written consent, which was reviewed and approved by the Kaohsiung Medical University and Kaohsiung Chang Gung Memorial Hospital institutional review boards.

Author contributions included the following. T.-N. Wang, C.-C. Wang, and M.-C. Lin were involved in the conception and design of the current analysis. C.-C. Wang, M.-C. Lin, and C.-C. Wu designed or collected data. H.-W. Hsiao, V.C.-H. Chen, and T.-N. Wang analyzed the data and drafted the manuscript. All the authors participated in the interpretation of results and revision of the manuscript. All the authors approved the final version of the manuscript.

The chest physicians (C.-C. W., M.-C. L., and C.-C. W.) diagnosed patients with asthma if they had symptoms such as episodic breathlessness, wheezing, cough, and chest tightness based on the Global Initiative for Asthma guidelines and/or if they demonstrated an increased forced expiratory volume in 1-second (FEV_1) of at least 12% and ≥ 200 mL after bronchodilator testing.^{25,26} Participants who met the above criteria were considered to have current asthma if they had at least one asthma attack or required the use of asthma medications in the 12 months before the interview.²⁷

Physical and Laboratory Examinations

Height and weight were measured on the same day of the clinic visit. Body mass index (BMI) was calculated with the following formula: weight (kg)/height (m^2).² The forced vital capacity (FVC) and FEV_1 were measured by trained respiratory technicians according to the American Thoracic Society standard methodology.²⁸ Every study subject performed the pulmonary function tests three times, and the highest value was recorded. Lung function was evaluated with the predictive FEV_1 (% predicted) and FVC (% predicted) values. Blood samples were collected from the patients

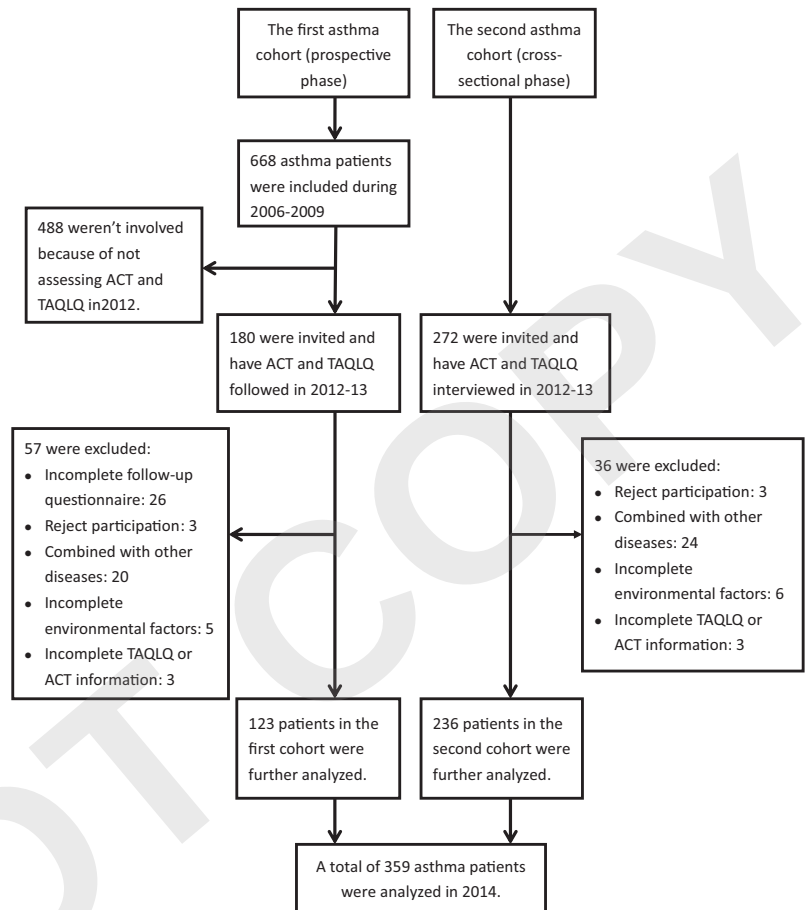


Figure 1. The consort flow chart for the recruitment of patients with asthma. TAQLQ = Taiwan version of the Asthma Quality of Life Questionnaire; ACT = asthma control test.

for total IgE concentration measurements on the day of the clinic visit.

Asthma Symptoms and Risk Factors Questionnaire

Self-administered health status questionnaires were performed during each clinic visit over the study period. The questionnaire included demographic variables (*e.g.*, age, sex, smoke, alcohol), parental asthma history, work environment, work symptoms, wheeze frequency during the previous year, and indoor environmental and allergic responses. With regard to smoking habits, ex-smokers and current smokers were represented by a “yes” answer, and subjects who never smoked were represented with a “no” answer. The parental asthma history was considered paternal or maternal asthma. The “yes” responses by the participants were coded as “1,” and “no” answers were coded as “0.” Health care utilization was defined as “1” when the patients experienced at least one emergency department visit or hospitalization during the previous year, whereas patients who had not used health care over the past year were coded as “0.” The asthma medication use included inhaled corticosteroids, inhaled bronchodilators, antihistamines, xanthine, and leukotriene modifiers. Some descriptions of associated risk factors are given in the Online Supplement. For the

SEM assumptions, we calculated the sum of the different medication types that a patient used according to the Global Initiative for Asthma.²⁶

Risk Factors Questionnaire

Several questionnaire data were binary (yes or no questions) or included a spectrum of responses (*i.e.*, the wheeze frequency during the previous year), and these data were transformed into “composite variables” to convert multiple options into a ranked ordinal scale. For example, the question “How do you feel about your work environment?” was used to assess the patient’s work environment. The five options (0 or 1) for this question included stuffiness, chemical solvent odor, exposure to second-hand smoke, dust, and others. The “yes” answers were coded as “1” and the “no” answers were coded as “0” for the above options. These options were consolidated into one variable by generating a ranked scale that ranged from 0 to 5 for work environment severity for the path analysis. The patients were asked the question, “Do you have any symptoms while you are working or after you have finished your work?” to understand the patient’s work symptoms. Six options were provided as answers for this question, including dizziness, breathlessness, headache, dry cough, sneeze, or nasal congestion. We

coded “no symptom” as “0,” whereas the other risk options were coded as “1” if the answer was “yes.”

These options were consolidated into one variable by generating a ranked scale that ranged from 0 to 6 for work symptoms severity for the path analysis. The five “negative” indoor environment options included animals with fur, cockroaches, mold, burning incense, and carpets, and the four “positive” indoor environment options included the use of an air cleaner, anti-mite bedding, air conditioner, or a dehumidifier. When the patients self-answered “yes” for the negative indoor environment options that are described above, then we coded each option as a “1.” If the negative option answer was “no,” then we coded a “0.” The positive options may have benefited the patients; therefore, we coded “0” when the answer was “yes.” If the answer to a positive option was “no,” then the answer was coded as “1.”

These options were consolidated into one variable by generating a ranked scale, which ranged from 0 to 9, for indoor environment severity for the path analysis. The subjects answered whether they had allergic responses to four food allergen options (milk, eggs, beans, and sea food), and five environmental allergen options (dust mite, fungus, fur, pollen and others allergens). The nine options were consolidated into one variable by generating a ranked scale, which ranged from 0 to 9, for allergic response severity for the path analysis. The wheeze frequency during the previous year had four options, and the scale range was from 0 to 3 (no wheeze, less than once per month, less than once every week, and more than once every week).

ACT and QoL Questionnaire

The five-point, five-item ACT was used to assess the patient’s asthma control level during the 4 weeks before the test.²¹ The patients completed the test by themselves. The total ACT scores ranged from 5 to 25. A total cutoff score of ≤ 19 had a balanced sensitivity (71%) and specificity (71%) for detecting patients with poor asthma control.^{21,29} The internal consistency and reliability of the ACT was 0.84 (Cronbach α).

In the present study, the health QoL of each patient with asthma was assessed by using the TAQLQ. A 5-point, 27-item TAQLQ, which was an abbreviated form of the original 7-point, 32-item Asthma Quality of Life, was established with the Rasch model.^{22,30} The unidimensional TAQLQ displayed an increased reliability of 0.92. The TAQLQ could be further applied to Taiwanese adults with asthma, especially to older aged (≥ 66 years) and less educated patients.³⁰ We calculated the total scores of the QoL questionnaire. The higher QoL scores represented increasing impairment of the QoL of the patient with asthma.

Statistical Analysis

The *t*-test and one-way analysis of variance test were used to compare the continuous outcome variable differences (ACT and TAQLQ scores) in the categorical groups. The Pearson correlation coefficient was evaluated to compare the outcome variable and other continuous variable relationships. The total IgE level was evaluated with a logarithmic transformation to achieve an approximate normal distribution for multiple linear regression analysis and path analysis, which is one of the statistical analyses that was used with the SEM.

A multivariate linear regression with stepwise selection was used to assess the associations among the risk factors, ACT, and TAQLQ. A stepwise regression was used to choose the variables for the model building. A path analysis was developed to explore the associations between the predictors and outcome variables. According to previous article findings, we structured a hypothesized model (Supplemental Figure E1) and used a path analysis with maximum likelihood estimates to establish the model. The χ^2 test, comparative fit index, normed fit index, relative fit index, incremental fit index, Tucker-Lewis index, and the root mean square error of approximation were used to assess whether the model fit was appropriate. If the χ^2 test *p* value was >0.05 , then it fit the model better than a *p* value that was <0.05 . A good model fit had comparative fit index, normed fit index, relative fit index, incremental fit index, and Tucker-Lewis index values that were >0.90 . A root mean square error of approximation value that was <0.10 was an adequate fit, whereas values of <0.05 represented a very good fit of the hypothesized model to the data. Statistical analyses were performed by using SPSS version 19 (Chicago, IL) and AMOS version 6 (SPSS).

RESULTS

The demographic characteristics of the first and second cohorts and of the total subjects are summarized in Table 1. In total, the average (standard deviation [SD]) age was 55.23 ± 14.55 years. Overall, 54.03% of the study population ($N = 194$) were women. The mean (SD) BMI was 25.33 ± 4.21 kg/m², and the mean (SD) IgE level was 236.23 ± 539.50 kU/L. We assessed the relationship between the predictors and the TAQLQ and ACT scores of the total subjects with univariate and multivariate analyses (Tables 2 and 3). The variables, sex, age, work symptoms, indoor environment, allergic responses, wheeze frequency during the previous year, and health care utilization levels were associated with the ACT and TAQLQ scores. Furthermore, parental asthma and the ACT scores were significantly associated with the TAQLQ scores (Table 2). The multiple linear regression with

Table 1 The demographic characteristics of the patients with asthma

Variable	First Cohort (n = 123)	Second Cohort (n = 236)	Total No. Patients with Asthma (n = 359)
Age, mean (SD), y	56.65 ± 13.57	54.50 ± 15.00	55.23 ± 14.55
Sex, no. (%)			
Men	60 (48.8)	105 (44.5)	165 (45.97)
Women	63 (51.2)	131 (55.5)	194 (54.03)
BMI, mean (SD), kg/m ²	25.45 ± 3.83	25.26 ± 4.40	25.33 ± 4.21
IgE, mean (SD), kU/L	241.9 ± 739.7	233.2 ± 395.4	236.2 ± 539.5
Smoker, no. (%)			
Yes	32 (23.0)	49 (20.8)	81 (22.6)
No	91 (77.0)	187 (79.2)	278 (77.4)
Alcohol use, no. (%)			
Yes	23 (18.7)	33 (14.0)	56 (15.6)
No	100 (81.3)	203 (86.0)	303 (84.4)
Parental asthma, no. (%)			
Yes	26 (24.3)	38 (17.2)	64 (19.5)
No	81 (75.7)	183 (82.8)	264 (80.5)
Emergency utilization, no. (%)			
Yes	8 (6.5)	19 (8.1)	27 (7.5)
No	115 (93.5)	217 (91.9)	332 (92.5)
Asthma medication use, no. (%)			
Yes	120 (97.6)	216 (91.5)	336 (93.6)
No	3 (2.4)	20 (8.5)	23 (6.4)
FEV ₁ % predicted, mean (SD)	82.99 ± 22.83	84.32 ± 17.18	83.86 ± 19.27
FVC% predicted, mean (SD)	85.81 ± 23.34	90.41 ± 14.90	88.80 ± 18.33
ACT score, mean (SD)	21.30 ± 3.71	20.86 ± 3.19	21.01 ± 3.38
TAQLQ score, mean (SD)	47.08 ± 19.47	48.18 ± 16.99	47.80 ± 17.87

SD = standard deviation; BMI = body mass index; IgE = immunoglobulin E; FEV₁ = forced expiratory volume in 1 second; FVC = forced vital capacity; ACT = Asthma Control Test; TAQLQ = Taiwanese version of an asthma quality-of-life questionnaire.

the stepwise selection is presented in Supplementary Table S1.

Hypothesized Model Testing and Patient QoL Predictions

The path analytic hypothesized model was structured with all of the variables. In Supplemental Figure S1, a hypothesized model was constructed to examine the relationship among the comprehensive risk factors, asthma control, and asthma QoL. After removing the insignificant directions and variables, the reduced models had improved model fits compared with the hypothesized models for the first and second cohorts as well as for the total number of patients (Figs. 2–4 and Table 3). All of the significant pathways ($p < 0.05$) among the variables are presented in Fig. 4, and the direct, indirect, and total effects between the predictors and the ACT and TAQLQ scores are presented in Table 3. The model fit indexes with the path analysis for the direct effects are described in Supplementary Table S2.

In the pathway analysis, we did not find that BMI was a significant factor in a prospective cohort. After combining the two cohorts, BMI had an indirect effect ($\beta = 0.013$) on the TAQLQ scores through the work symptoms, wheeze frequency, and the ACT scores (Fig. 4 and Table 3). The work environment had an indirect effect on the TAQLQ scores ($\beta = 0.023$) through the work symptoms, wheeze frequency, and the ACT scores. The health care utilization level had a direct negative effect on the ACT scores ($\beta = -0.136$) and an indirect effect on the TAQLQ scores ($\beta = 0.139$) (Fig. 4 and Table 3). The IgE levels had a direct effect on the allergic responses ($\beta = 0.310$) and an indirect effect on the TAQLQ scores ($\beta = 0.058$). The subjects with parental asthma had higher TAQLQ scores ($\beta = 0.098$). Smoke and lung function (FEV₁% predicted and FVC% predicted) had negative relationships; however, we did not find that smoke and lung function affected the ACT or TAQLQ scores. Overall, asthma control most strongly predicted asthma QoL ($\beta = -0.606$, $p < 0.001$) (Table 3).

Table 2 The associations between the risk factors and the ACT and TAQLQ scores in the total number of patients ($n = 359$)

Variable	ACT			TAQLQ		
	Mean (SD)	r	p Value	Mean (SD)	r	p Value
Sex			0.015*			0.001*
Men	21.47 $\pm$ 2.98			50.61 $\pm$ 19.31		
Women	20.62 $\pm$ 3.63			44.45 $\pm$ 15.37		
Smoker			0.682			0.728
Yes	20.88 $\pm$ 3.56			48.41 $\pm$ 17.54		
No	21.05 $\pm$ 3.33			47.62 $\pm$ 17.98		
Parental asthma			0.412			0.023*
Yes	20.73 $\pm$ 3.73			52.69 $\pm$ 20.05		
No	21.12 $\pm$ 3.27			46.39 $\pm$ 17.16		
Health care utilization			<0.001*			<0.001*
Yes	18.70 $\pm$ 4.30			59.67 $\pm$ 19.78		
No	21.20 $\pm$ 3.22			46.83 $\pm$ 17.38		
Asthma medication use			0.55			0.95
Yes	21.04 $\pm$ 3.42			48.04 $\pm$ 13.45		
No	20.61 $\pm$ 2.79			47.78 $\pm$ 18.15		
Frequency of wheeze during the previous year			<0.001*			<0.001*
None	22.09 $\pm$ 2.45			42.08 $\pm$ 14.70		
$\leq 1/\text{mo}$	21.21 $\pm$ 2.95			46.89 $\pm$ 15.34		
$\leq 1/\text{wk}$	20.05 $\pm$ 3.63			52.09 $\pm$ 19.88		
$> 1/\text{wk}$	17.75 $\pm$ 4.90			66.00 $\pm$ 21.79		
Age		0.167	0.002*		-0.222	<0.001*
Log transformed IgE		-0.024	0.648		0.086	0.104
BMI		0.047	0.371		-0.014	0.798
Indoor environment		0.069	0.193		-0.101	0.056
Work environment		-0.029	0.594		0.023	0.670
Work symptoms		-0.173	0.001*		0.200	<0.001*
Allergic responses		-0.081	0.164		0.246	<0.001*
FEV ₁ % predicted		-0.039	0.464		0.036	0.500
FVC% predict		-0.088	0.095		0.057	0.285
ACT		—	—		-0.665	<0.001*

ACT = Asthma Control Test; TAQLQ = Taiwanese version of an asthma quality-of-life questionnaire; SD = standard deviation; IgE = immunoglobulin E; BMI = body mass index; FEV₁ = forced expiratory volume in 1 second; FVC = forced vital capacity.

* $p < 0.05$.

DISCUSSION

The present study demonstrated associations between risk factors, asthma control, and QoL by using an SEM in two independent asthma cohorts. In addition to BMI, most findings in the first patient cohort were also validated in the second patient cohort. In addition, work symptoms, wheeze frequency, and ACT scores were intermediate factors in the comprehensive risk factor to asthma QoL pathway analysis. Previous studies found that patients with asthma and with higher BMIs had a higher risk of asthma-related hospitalizations, worse asthma control, and a lower QoL.^{4,19,31} We found that the patients with asthma and

with higher BMIs displayed more work symptoms, which indirectly resulted in lower asthma control and QoL in a cross-sectional phase cohort.

This SEM analysis demonstrated that patients who worked in poor environments were associated with more work symptoms, reduced asthma control, and lower asthma QoL. The occupational exposures or pollutants (*e.g.*, high concentrations of chemical materials, metals, smoking, dust, other exposures) were related to work-related asthma.¹² Three cohort studies presented a causality relationship among dust exposure, chemical irritants, and asthma or asthma-like symptom incidence.^{2,32,33} A previous study found that damp and

Table 3 Standardized direct and indirect path coefficients for the environmental factors, asthma control, and asthma quality of life pathways for the total number of patients with asthma *via* a structural equation model ($n = 359$)#

Outcome Variable	Predictor Variable	Standardized Direct Estimate (β)	Standardized Indirect Estimate (β)	Standardized Total Effect (β)
Allergic responses	IgE	0.310***	—	0.310***
Work symptom	BMI	0.156**	—	0.156**
	Work environment	0.290***	—	0.290***
Frequency of wheezes during the previous year	BMI	—	0.037*	0.037*
	Work environment	—	0.068*	0.068*
	Work symptoms	0.235***	—	0.235***
	Health care utilization	0.165**	—	0.165***
Asthma control	BMI	—	−0.013*	−0.013*
	Work environment	—	−0.023*	−0.023*
	Work symptoms	—	−0.081*	−0.081*
	Frequency of wheezes during the previous year	−0.344***	—	−0.344***
	Health care utilization	−0.136**	−0.057*	−0.193**
Asthma quality of life	BMI	—	0.013*	0.013*
	Work environment	—	0.023*	0.023*
	Work symptoms	—	0.081*	0.081*
	Wheeze frequency during the previous year	0.135***	0.209*	0.344***
	IgE	—	0.058*	0.058*
	Allergic responses	0.188***	—	0.188***
	Health care utilization	—	0.139*	0.139*
	Parental asthma	0.098*	—	0.098*
	Asthma control	−0.606***	—	−0.606***

IgE = immunoglobulin E; — = no existence relationship; BMI = body mass index.

#The indices of model fitness: χ^2 (p value), root mean square error of approximation, normed fit index, relative fit index, incremental fit index, Tucker-Lewis index, and comparative fit index were 0.238, 0.021, 0.907, 0.838, 0.987, 0.975 and 0.986, respectively.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

moldy work environments were related to QoL in patients with asthma.³⁴ Adult patients with asthma who reported high trigger burdens experienced more severe asthma attacks and hospitalizations than those who reported lower trigger burdens. This also had a significantly increased impact on daily life and job choice.³⁵ Al-Zahrani *et al.*³⁶ explored multiple factors that affect asthma control, including inappropriate device use by the patient, active smoking, passive smoking, an unsealed mattress, and workplace triggers. To our knowledge, this is the first study to explore relationships between the pathogeneses from working in a poor environment and asthma QoL. Moreover, this study showed that increased work symptoms and reduced asthma control were possible pathways that link working in a poor environment and QoL in adult patients with asthma, based on a study with both prospective and cross-sectional phases.

We discovered that asthma control was a strong predictor and was also a pathway that was linked to asthma QoL, as indicated in previous studies.^{23,37} A 1-year prospective study explored asthma control improvements with real-life monitoring and found that this was associated with improved QoL and decreased hospital visits.³⁷ A previous prospective study, after 12 months of follow-ups, found an inverse relationship between the asthma control problem number and QoL.²³ Schmier *et al.*³⁸ also observed that inadequately controlled asthma had a great influence on asthma-specific QoL, school productivity and attendance, and work productivity in children and their caregivers.

In this study, we explored novel mechanisms among workplace environments, work symptoms, ACT scores, and QoL levels that controlled various confounders and the robustness in the multivariate linear regression and SEM used. There were several

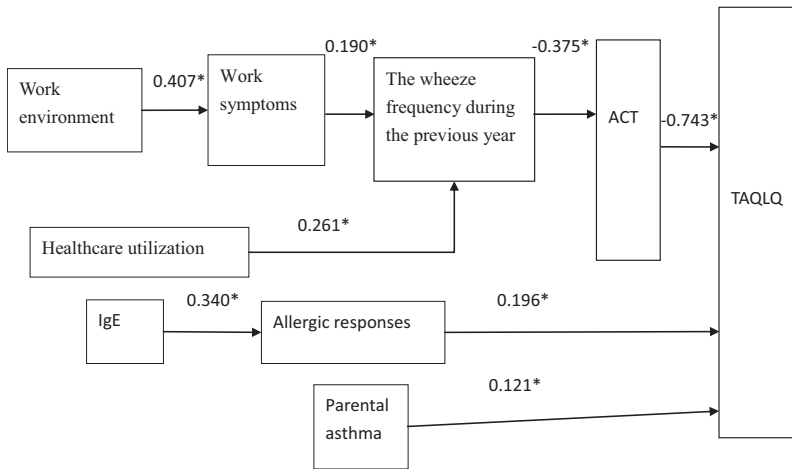


Figure 2. A structural equation model with standardized path coefficients for building pathways from comprehensive risk factors, asthma control, and life quality in the first asthma cohort ($n = 123$) ($\chi^2 = 19.97$, degrees of freedom = 28, $p = 0.866$, comparative fit index = 1.00, incremental fit index = 1.047, Tucker-Lewis index = 1.084, root mean square error of approximation = 0.0001 [0.0001–0.038 90% confidence interval]). * $p < 0.05$. TAQLQ = Taiwan version of the Asthma Quality of Life Questionnaire; ACT = asthma control test; IgE = immunoglobulin E; BMI = body mass index.

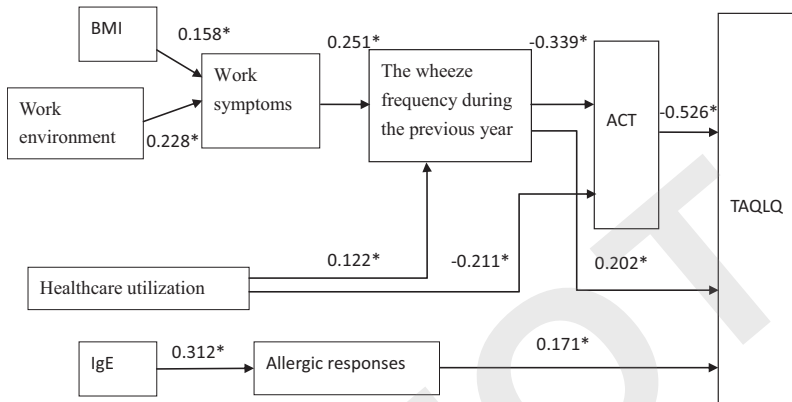


Figure 3. A structural equation model with standardized path coefficients for building pathways from comprehensive risk factors, asthma control to life quality in the second asthma cohort ($n = 236$) ($\chi^2 = 31.84$, degrees of freedom = 26, $p = 0.198$, comparative fit index = 0.974, incremental fit index = 0.976, Tucker-Lewis index = 0.954, root mean square error of approximation = 0.031 [0.001–0.063 90% confidence interval]). * $p < 0.05$. TAQLQ = Taiwan version of the Asthma Quality of Life Questionnaire; ACT = asthma control test; IgE = immunoglobulin E; BMI = body mass index.

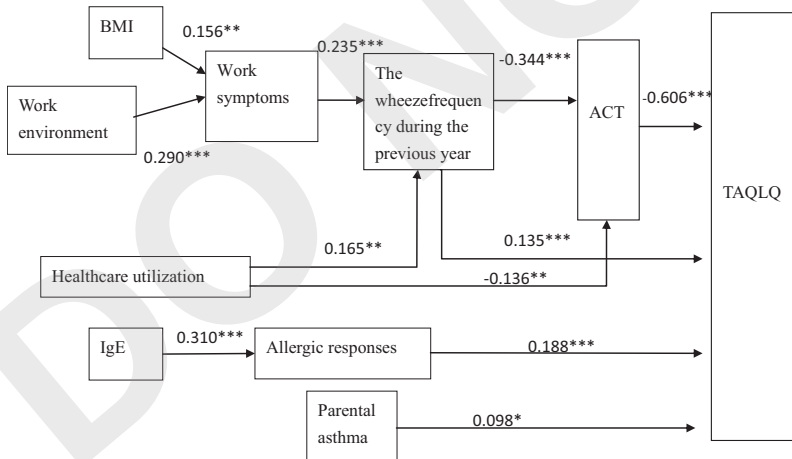


Figure 4. A structural equation model with standardized path coefficients for pathways built from comprehensive risk factors, asthma control, and life quality in the total number of patients with asthma ($n = 359$) ($\chi^2 = 24.57$, degrees of freedom = 34, $p = 0.883$, comparative fit index = 1.000, incremental fit index = 1.024, Tucker-Lewis index = 1.041, root mean square error of approximation = 0.001 [0.001–0.019 90% confidence interval]). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. TAQLQ = Taiwan version of the Asthma Quality of Life Questionnaire; ACT = asthma control test; IgE = immunoglobulin E; BMI = body mass index.

limitations in this study. First, one of the assumptions of path analysis was that only continuous variables could be used in the SEM. We summarized the items of some variables (e.g., work environment, work symptoms, indoor environment, allergen responses); therefore, we did not know the degree of influence for each item. However, path analysis, which is an extension of multiple regression techniques, can provide more information than a multiple regression analysis.³⁹ Second, direct information regarding past occupational exposures from workplaces was difficult to obtain after

the subjects quit or retired from their jobs. Therefore, if the patients with asthma had worked in more than one place, we evaluated the work exposure for the current or most recent workplace to reduce recall problems. The reliability for the job exposure assessment was as high as 97.3% in our previous study, in which we randomly sampled 10% of the study subjects to reevaluate their job history.²⁴ Third, allergic responses (e.g., milk, eggs, beans, seafood, dust mites, fungus, fur, pollen) were evaluated from patient self-reports; therefore, the potential misclassification of the predictor

variable assessments was possible. However, the relationships were consistent with those reported in the literature. With regard to the allergic assessments, better experimental tools, such as the skin-prick test or specific IgE concentrations, are more accurate than a questionnaire. Fourth, generalizability of the findings for the two cohorts in this study was derived from mostly patients with well-controlled asthma.

CONCLUSION

According to the results of the path analysis, we suggest potential pathways from exposure to comprehensive factors to life quality in adult patients with asthma. Patients with asthma and with higher BMIs who worked in poor environments had increased work symptoms and wheeze frequencies that were associated with poor asthma control and poor QoL in the observed adult patients with asthma. Therefore, body weight and poor workplace management are required for controlling asthma symptoms and improving QoL in patients with asthma. For the clinical implications of our findings, assessing a high-risk workplace and further removing a patient with work-related asthma from occupational asthmogen exposures has been recommended by many physicians and professionals to lessen symptoms and improve QoL for patients with asthma.

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