

ORIGINAL CONTRIBUTION

Asthma Prevalence and its Risk Factors Among a Multi-Ethnic Adult Population

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Asthma is a substantial global health problem characterized by chronic airway inflammation, leading to intermittent symptoms. This study aims to establish the prevalence and risk factors of asthma in a multi-ethnic adult population. Data for the study were extracted from the Singapore Mental Health Study 2016, a population-based, cross-sectional, epidemiological study of Singapore residents aged 18 years and above. The data relating to asthma prevalence was captured using the modified World Mental Health Composite International Diagnostic Interview (CIDI) version 3.0 chronic conditions checklist. The prevalence of lifetime asthma in this population was 11.9% (95% CI, 10.83-13.12). Those of Malay and Indian ethnicity (versus Chinese), ex-smokers (versus never smoked) and those who were overweight and obese (versus normal weight) were more likely to be associated with asthma. Participants belonging to the age group of 35 years and above (versus 18-34 years of age), male gender (versus female) were less likely to be associated with lifetime asthma. Asthma was also more likely to be associated with bipolar disorder. Those with current asthma (ie, those who had received treatment during the past 12 months) were significantly associated with lower health-related quality of life in the physical component score (PCS) than those without asthma. The high prevalence and association with lowered health-related quality of life makes asthma a significant public health concern. Our study's findings can help create awareness and encourage integrated approaches for managing asthma in the health sector.

INTRODUCTION

Asthma is a substantial global health problem, characterized by chronic airway inflammation, leading to

intermittent symptoms of wheeze, shortness of breath, dyspnea, cough, and chest tightness that vary over time and intensity in combination with variable expiratory air-

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Abbreviations: SMHS 2016, Singapore Mental Health Study 2016; WMHCIDI, World Mental Health Composite International Diagnostic Interview; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, 4th edition; ICD-10, International Classification of Disease, 10th revision; MDD, Major Depressive Disorder; BP, Bipolar Disorder; GAD, Generalized Anxiety Disorder; OCD, Obsessive-Compulsive Disorder; AUD, Alcohol Use Disorder; SGD, Singapore Dollars; BMI, Body Mass Index; WHO, World Health Organization; SF-12, Short Form 12-item health survey questionnaire; PCS, Physical Component Summary scores; MCS, Mental Component Summary scores.

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way obstruction [1]. Approximately 339 million people worldwide are affected by asthma, and for those affected by asthma, the condition results in disability, affects healthcare utilization and impacts the quality of life [2]. Asthma has an early age of onset and, therefore, presents as the most common chronic disease among children and young adults [3].

According to the World Health Organization [4], asthma prevalence varies extensively among different countries, from a high of 21% in Australia to a low of 0.2% in China. Studies have observed a lower prevalence in Asian and African countries compared to the more developed countries, which may be related to environmental and lifestyle factors [5,6].

Asthma is associated with a high disease burden and accounts for a disproportionately high healthcare utilization in severe, uncontrolled cases compared to non-severe asthma [7]. A study conducted by Grant et al., found that poor socioeconomic status (including low income and a low level of education) correlated with higher asthma-related mortality [8]. Asthma has been directly related to impaired quality of life, resulting in increased work and school absences, an inability to perform household chores, and restriction of social activities [9]. The World Mental Health Survey conducted across 17 countries using general population sample reported that adults with asthma had an increased risk for anxiety disorder (95% CI, 1.4-1.7; OR 1.5) compared with adults who did not have asthma [10]. Other studies have similarly shown an association between asthma and mental disorders, in particular, anxiety disorder (95% CI, 1.4-5.2; OR 2.7), depression (95% CI, 1.4-1.8; OR 1.6), and bipolar disorder (95% CI, 1.6-2.9; OR 2.1) in several countries [11-14].

Globally, there is a lack of standardized data regarding the prevalence of asthma due to variations in the operational definition and assessment techniques [15]. There is also a lack of community-based studies identifying the burden associated with asthma through spirometry, as most of the studies rely on self-reported questionnaires [16,17]. While “physician-diagnosed asthma” has been shown to have higher specificity than self-reported asthma in several epidemiological surveys worldwide, a sizeable proportion of asthma may still remain undiagnosed [18]. To address this concern, recent guidelines recommend a combination of questionnaire and spirometry-based information as the best method for determining asthma in epidemiological surveys [15,19].

Singapore is a city-state country in Southeast Asia with a population of approximately 5.6 million, of which 3.9 million are Singapore residents (Singapore citizens and permanent residents) [20]. It has a multi-ethnic urban population comprising mainly of Chinese (74.3%), Malays (13.4%), Indians (9.0%), and others (3.2%), each a major ethnic group in Asia, who represent more than

two-thirds of the world’s population. The National Health Survey conducted in Singapore reported a lifetime asthma prevalence of 10.5% and a current asthma prevalence of 3.9% in the adult population aged 18-69 [21]. The mortality rate of asthma is high at 16 per 100,000 in Singapore, 3 times that of other developed nations such as the United States and New Zealand [22,23]. Asthma in Singapore is managed mainly in the primary healthcare system, served by dual providers in the public polyclinics and private general practitioner clinics. No study in Singapore has established the prevalence and correlates of asthma in the general population. Especially the association of asthma with mental illnesses has not been examined in the general population.

The aims of the current study were, therefore, (i) to establish the prevalence of asthma in the Singapore population, (ii) to investigate socio-demographic variables, risk factors, and comorbid psychiatric conditions associated with asthma; and (iii) to examine the association of asthma and health-related quality of life in the Singapore resident population.

METHODS

Sample

The Singapore Mental Health Study 2016 (SMHS 2016) was a cross-sectional epidemiological survey among a representative household sample of Singapore citizens and permanent residents aged 18 years and above, who were fluent in English, Mandarin, or Malay. Participants were randomly selected from an administrative database that maintains names and socio-demographic details, including age, gender, ethnicity, and household addresses, of all Singapore residents. A disproportionate stratified sample (based on age group and ethnicity) was used for the study. The minority ethnic groups (Malays and Indians) were oversampled to ensure a sufficient sample size to improve the reliability of estimates for subgroup analysis. All participants provided written consent; for those aged 18-20 years, consent was also obtained from a parent or legally acceptable representative. Residents who were excluded comprised those who were incapable of completing an interview due to severe physical or mental conditions, language barriers, were living outside the country during the period of the survey, and those who were not contactable due to an incomplete or incorrect address. Data was collected between August 2016 to April 2018 following ethics approval from the National Healthcare Group’s Domain Specific Review Board. During this period, face-to-face interviews were completed with 6,126 respondents, yielding a response rate of 69.5%. Additional information relating to the methods and procedures employed has been reported in a

previous article [24].

MATERIALS

WHO Composite International Diagnostic Interview (WHO-CIDI)

We used the World Mental Health Composite International Diagnostic Interview version 3.0 (WMH-CIDI) [25] checklist of chronic medical conditions. The respondents were asked to report on the disorders listed in the checklist. The question was read as, "I'm going to read to you a list of health problems some people have. Has a doctor ever told you that you have any of the following..." This was followed by a list of 18 chronic medical conditions that are considered prevalent in Singapore's population. Among these chronic medical conditions, only asthma was included in this paper. If the participant stated that they were diagnosed with asthma, they were then asked, "how old were you when you were diagnosed with asthma?" It was subsequently used as the age of onset of asthma. Participants were also asked, "did you receive any treatment for it during the past 12 months?" This was used to determine the current prevalence of asthma.

The assessment of lifetime and 12-month psychiatric conditions was established using the CIDI 3.0 diagnostic modules according to the definitions and criteria outlined by the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) [26], and the International Classification of Disease, 10th revision (ICD-10) [27]. The current study included the following diagnostic modules: major depressive disorder (MDD), bipolar disorder (BP), generalized anxiety disorder (GAD), obsessive-compulsive disorder (OCD), alcohol use disorder (AUD) (including alcohol abuse and alcohol dependence). Diagnostic hierarchy rules and organic exclusion criteria were applied, where relevant.

Other Assessments

Socio-demographic Information: Socio-demographic information, including age (categorized as 18-34, 35-49, 50-64, or 65 years and above), gender, ethnicity (Chinese, Malay, Indian, or Others), educational level (primary and below, secondary, vocational institute, pre-university/junior college, diploma, or university), marital status (never married, married, divorced/separated, or widowed), employment status (employed, economically inactive, or unemployed) and monthly household income in Singapore dollars (SGD) (below 2000, 2000-3999, 4000-5999, 6000-9999, 10000 & above) was collected using a structured questionnaire.

Smoking: Information on smoking was collected from all the study participants by asking them, "Are you a

current smoker, ex-smoker, or have you never smoked?"

Body Mass Index: Interviewers measured the height and weight of each participant using standard tape and a weighing scale. Body Mass Index (BMI) was calculated using the formula: weight in kilograms divided by the height in meters squared (kg/m^2). Cut-off standards recommended by the World Health Organization (WHO) were used [28]. A BMI of less than 18.5 was classified as underweight, BMI of 18.5 to 24.9 as normal weight, BMI of > 25.0 up to 30.0 as overweight and a BMI of >30.0 was classified as obese.

SF-12: The Short Form 12-item (SF-12) Health Survey Questionnaire was used to measure the health-related quality of life [29]. It has been used in a number of studies conducted on asthma [30]. The SF-12 measures eight domains: physical functioning (PF), role limitations due to physical health problems (RP), bodily pain (BP), general health (GH), vitality (energy/fatigue) (VT), social functioning (SF), role limitations due to emotional problems (RE), and mental health (psychological distress and psychological well-being) (MH). The developers suggest calculating summary scores from the instrument to reduce the original eight-scale profile to two summary measures without substantial loss of information. The summary measures were constructed independently to reproduce corresponding SF-12 physical and mental health summary measures. Scores range from 1 (the worst possible health) to 100 (the best possible health). The Physical Component Summary Scores (PCS) and Mental Component Summary scores (MCS) have shown evidence of reliability, validity, and responsiveness in population studies [31].

Statistical Analysis

All estimates were weighted to adjust for oversampling, non-response, and post-stratified for age and ethnicity distributions between the survey sample and the Singapore resident population in 2014. Mean and standard error were calculated for continuous variables and frequencies and percentages for all other categorical variables. We also examined the mean and standard distribution of asthma across comorbid psychiatric conditions in the study sample. For the purpose of the study, a series of multiple logistic regression analyses were performed to study the impact of select socio-demographic factors and other risk factors (including BMI and smoking status) on the prevalence of asthma. We used asthma as the main outcome variable, with age, gender, ethnicity, marital status, education, employment status, monthly household income, BMI, and smoking status as predictor variables. The association between asthma and the self-reported lifetime and 12-month comorbid psychiatric conditions were also established after controlling for confounding variables. Also, the difference between the

Table 1. Socio-demographic Characteristics of the Participants

		N=6107	Unweighted %	Weighted %
Age group (in years)	18-34	1703	27.9	30.4
	35-49	1493	24.4	29.6
	50-64	1622	26.5	26.8
	65+ above	1289	21.2	13.1
Gender	Male	3058	50.1	49.5
	Female	3049	49.9	50.5
Ethnicity	Chinese	1777	29.1	75.7
	Malay	1982	32.5	12.5
	Indian	1839	30.1	8.7
	Others	509	8.3	3.1
Marital status	Never married	1539	25.2	30.9
	Married	3834	62.7	59.8
	Divorced/separated	342	5.6	5.2
	Widowed	392	6.5	4.1
Education	Primary and below	1184	19.4	16.3
	Secondary	1638	26.9	23.0
	Pre-U/Junior College	303	5.0	6.0
	Vocational Institute/ITE	507	8.3	6.3
	Diploma	1023	16.7	19.0
Employment status	University	1452	23.8	29.5
	Employed	4048	66.2	72.0
	Economically inactive	1708	28.0	22.8
Income (SGD)	Unemployed	350	5.8	5.2
	Below 2,000	1141	16.5	16.5
	2,000-3,999	1327	20.0	19.9
	4,000-5,999	1111	21.4	21.4
	6,000-9,999	1002	2.2	21.9
Smoking status	10,000 & above	860	20.3	20.4
	Never smoked	4174	68.5	73.4
	Smoker	1173	19.3	16.1
	Ex-smoker	750	12.3	10.6
Body Mass Index (BMI)	Normal	2391	45.3	54.4
	Underweight	264	5.0	6.4
	Overweight	1691	32.1	28.0
	Obese	926	17.6	11.2

*Socio-demographic variables (ie, age, gender, ethnicity, BMI categories, and smoking status were adjusted in the regression models

mean physical component score (PCS) and mental component score (MCS) among individuals with asthma and individuals without asthma were assessed using a linear regression model. The model was controlled for significant socio-demographic variables (including age, gender, ethnicity, marital status, educational level, employment

status, monthly household income) and other risk factors (including BMI and smoking status). Standard errors (SE) and significance tests were determined using the Taylor series linearization method. Multivariate significance was evaluated using the Wald Chi-square test based on design-corrected coefficient variance-covariance matrices.

Statistical significance was set as $p < 0.05$ using two-sided tests. All statistical analyses were carried out using the SAS version 9.3 [32].

RESULTS

Socio-demographic Characteristics of the Sample

A total of 6,126 participants completed the study giving a response rate of 69.5%. Six thousand one hundred and seven individuals responded to the asthma-related questions and were included in this study. The lifetime prevalence of asthma in the Singapore general population was 11.9% ($n=789$), while the prevalence of current asthma was 2.6%. The mean age of onset of asthma was 12.4 ($SD=14.0$) years.

Table 1 shows the characteristics of the study participants. The majority were 18-34 years old (30.4%), women (50.5%), Chinese (75.7%), married (59.8%), had completed university education (29.5%), were employed (72.0%), and with a monthly household income of Singapore dollar (SGD) 6000-9999 (21.9%). The majority of participants had never smoked (73.4%) and the majority of participants had a normal BMI (54.4%).

Prevalence of Lifetime and Current Asthma, Socio-demographic, and Other Correlates

Table 2 shows the socio-demographic correlates of lifetime and current asthma. The prevalence of lifetime asthma was lower in the age group of 35-49 years ($p < 0.001$), 50-64 years ($p < 0.001$), and 65 years and above ($p < 0.001$) versus the age group of 18-34 years, and among females ($p=0.03$) (versus males), while lifetime asthma was higher among those who were obese ($p < 0.001$) (versus those with normal weight).

The prevalence of current asthma was lower among participants belonging to the age group of 35-49 years ($p=0.01$) and 50-64 years ($p=0.02$) (versus 18-34 years of age) and those with a monthly household income of 2000-3999 SGD ($p=0.03$) (versus below 2000 SGD). The prevalence of current asthma was higher among those of Malay ($p=0.02$) and Indian ethnicity ($p=0.00$) (versus Chinese ethnicity), overweight ($p=0.01$) and obese ($p=0.01$) (versus normal weight), and ex-smokers ($p=0.02$) (versus never smoked). Socio-demographic variables (ie, age, gender, ethnicity, BMI categories, and smoking status) were adjusted in the regression models.

Prevalence and Odds Ratio of Psychiatric Conditions Among Participants With and Without Lifetime and Current Asthma

Table 3 shows the odds ratio (OR) of psychiatric conditions among those with lifetime and current asthma using multiple linear regression analysis after adjusting

for socio-demographic variables, BMI categories, and smoking status. The prevalence of bipolar disorder was significantly higher among individuals with lifetime (OR, 2.24; 95% CI, 1.14-4.41; $p=0.02$) and current asthma (OR, 4.92; 95% CI, 1.43-16.65; $p=0.01$).

Health-related Quality of Life Among Individuals With and Without Lifetime and Current Asthma

Table 4 shows the health-related quality of life domain scores (physical component score and mental component score) among individuals with and without current asthma. After adjusting for significant socio-demographic variables, BMI, and smoking status; current asthma was significantly associated with lower health-related quality of life in the physical component score (PCS) ($P=0.001$) as compared to those without current asthma. There was no significant association found in health-related quality of life scores among individuals with lifetime asthma versus those without asthma.

DISCUSSION

The current study using data from the SMHS 2016, found that the lifetime prevalence of self-reported asthma in this nationally representative survey was high (11.9%). The overall prevalence was slightly higher than a previous study conducted among the Singapore adult population where the prevalence, using a similar methodology, was 10.5% [21]. The prevalence of asthma has consistently increased in some countries over the last few decades, possibly reflecting greater awareness of this condition or changes in diagnostic practices [33-34]. For instance, in the United States, asthma prevalence increased from 7.3% in 2001 to 8.4% in 2010 in the general population [35]. Other possible reasons for the increase include increased urbanization, lifestyle habits, higher rates of obesity, and pollution in the developed countries [5,6,36].

Similarly, a possible explanation for the increase in asthma prevalence in Singapore could be the general improvement in diagnosis in primary healthcare services and other settings [37]. The increase observed in access to healthcare services in recent years could also explain the rise in prevalence, as more individuals with asthma could be receiving the diagnosis [22]. However, our study also found that the prevalence of current asthma (2.9%) was lower as compared to a previous study conducted in Singapore where it was reported to be 3.9% [21]. The possible reasons could be appropriate medical care, increased use of inhaled corticosteroids, improved patient education, and improved diagnosis that led to better asthma control over time [38].

Our study results identified age, gender, ethnicity, monthly household income, higher BMI, smoking status, and comorbid psychiatric conditions to be associated

Table 2. Socio-demographic Correlates of Current and Lifetime Asthma

Variables	Current Asthma					Lifetime Asthma			
	%	OR	95%CI	p value	%	OR	95%CI	p value	
Age group (in years)*	18-34	3.3	Reference		20.3	Reference			
	35-49	1.7	0.31	0.14-0.70	0.01	9.9	0.40	0.28-0.58	<0.001
	50-64	2.3	0.41	0.20-0.85	0.02	7.0	0.31	0.21-0.46	<0.001
	65+ above	3.7	0.67	0.25-1.83	0.44	7.3	0.27	0.15-0.49	<0.001
Gender*	Male	2.5	Reference		10.3	Reference			
	Female	2.7	1.29	0.70-2.39	0.42	13.6	0.74	0.56-0.97	0.03
Ethnicity*	Chinese	1.9	Reference		11.1	Reference			
	Malay	5.1	1.96	1.15-3.35	0.02	15.2	1.17	0.88-1.56	0.28
	Indian	5.1	2.16	1.33-3.52	0.00	13.7	1.06	0.82-1.37	0.65
	Others	3.2	1.79	0.80-3.99	0.15	13.7	1.18	0.79-1.74	0.42
Marital Status	Never married	2.3	Reference		15.9	Reference			
	Married	2.7	1.70	0.84-3.47	0.14	10.0	1.22	0.87-1.71	0.25
	Divorced / separated	4.3	2.27	0.76-6.84	0.14	8.4	1.03	0.52-2.06	0.93
	Widowed	2.7	1.43	0.26-7.97	0.68	7.3	2.29	0.96-5.48	0.06
Education	Primary and below	3.8	Reference		7.1	Reference			
	Secondary	2.7	0.66	0.31-1.34	0.24	9.2	1.12	0.68-1.86	0.66
	Pre-U/Junior College	1.3	0.42	0.12-1.43	0.16	13.0	1.59	0.79-3.20	0.19
	Vocational Institute/ITE	3.2	0.67	0.23-1.71	0.40	14.8	1.20	0.64-2.23	0.57
	Diploma	2.4	0.48	0.20-1.19	0.12	16.6	1.59	0.92-2.77	0.98
	University	2.1	0.55	0.22-1.45	0.23	12.9	1.37	0.77-2.46	0.29
	Employment status	Employed	2.4	Reference		11.9	Reference		
	Economically inactive	3.1	1.17	0.58-2.32	0.66	11.0	1.22	0.87-1.73	0.25
	Unemployed	3.5	1.60	0.59-4.30	0.35	16.2	1.21	0.66-2.23	0.53
Income (SGD)*	Below 2,000	4.4	Reference		11.6	Reference			
	2,000-3,999	1.9	0.47	0.24-0.91	0.03	10.1	0.69	0.44-1.08	0.10
	4,000-5,999	2.4	0.83	0.39-1.75	0.62	12.6	0.86	0.54-1.36	0.52
	6,000-9,999	2.8	1.10	0.57-2.10	0.78	13.1	0.82	0.51-1.32	0.4
	10,000 & above	2.1	0.99	0.42-2.35	0.98	12.3	0.86	0.52-1.43	0.56
Body Mass Index (BMI)*	Normal	1.8	Reference		10.8				
	Underweight	1.9	1.07	0.32-3.61	0.91	9.3	0.80	0.46-1.41	0.44
	Overweight	4.2	2.30	1.28-4.14	0.01	12.5	1.25	0.92-1.69	0.15

Smoking Status*	Obese	5.0	2.35	1.24-4.47	0.01	18.8	1.90	1.32-2.74	<0.001
	Never smoked	2.2	Reference			11.1	Reference		
	Smoker	5.4	1.21	0.58-2.52	0.60	13.7	1.25	0.88-1.76	0.21
	Ex-smoker	2.8	2.23	1.12-4.45	0.02	14.6	1.20	0.81-1.76	0.37

*P value was derived using multiple linear regression analysis after adjusting for socio-demographic variables, BMI categories, and smoking status

with asthma. Older adults, ie, those aged 35 years and above, were less likely to have lifetime asthma than those aged 18-34 years. Similar findings were also reported by the National Health Survey conducted in Singapore [21]. This study showed that lifetime and current asthma were most prevalent among young adults aged 18-29 years. Another research study conducted by Ryan-Ibarra et al., revealed that younger adults have higher lifetime asthma prevalence than older adults. The authors suggested that this may result from the birth cohort effect, where younger cohorts are more likely to receive an asthma diagnosis [39].

Our study results indicate that females were less likely to have lifetime asthma compared to males. While in most age groups, females reported a lower prevalence of lifetime asthma, in some age groups (50-89 years), females reported a higher lifetime prevalence of asthma compared to males. Epidemiological data show that asthma incidence, prevalence, exacerbation rate, and mortality are higher among males compared to females during childhood. However, there is a decline in asthma prevalence and morbidity in males during adolescence compared to females [7]. The possible reasons could be ovarian hormones that increase and testosterone that decreases airway inflammation in asthma, resulting in increased asthma symptoms in females starting at puberty compared to males [40]. However, Almqvist et al., reported that young males had a higher prevalence of asthma compared to young females [41].

Consistent with various research findings in the local settings, our study also found a significant association of asthma with ethnicity in Singapore. Those of Malay and Indian ethnicity were more likely to have asthma compared to those of Chinese ethnicity. Community-based studies in primary care clinics conducted in Singapore showed that Malays and Indians experience higher rates of asthma than those of Chinese ethnicity [42]. The plausible reason could be the greater exposure to airborne allergens from keeping rugs or carpets and pet cats, dogs, or birds at home among those of Malay and Indian ethnicity due to cultural or lifestyle practices [43]. Ethnic and cultural differences in health-seeking behavior were also suggested as possible reasons for the higher prevalence of asthma in Malays and Indians in Singapore [43]. Recent genome-wide association studies suggest that while cer-

tain asthma-susceptibility variants are relevant to all ethnic groups, others may have ethnic-specific effects [44].

Those who were overweight and obese had a substantially higher risk of asthma, which is consistent with other evidence [45,46]. This could be due to their sedentary lifestyle, corticosteroid use, and worsening of symptoms due to increased BMI [36,45,47]. A meta-analysis that found an association between BMI and asthma suggested that asthma risk increases as body weight increases. It has been suggested that interventions that result in weight loss could be associated with a decrease in asthma incidence [48]. Another study found that obesity and asthma share some etiological factors, such as a common genetic predisposition and effects of *in utero* conditions [49]. They may also have common predisposing factors such as physical activity and diet [49]. However, complications from sleep-disordered breathing and endocrine factors are some plausible biological mechanisms through which obesity could either cause or worsen asthma [49]. Understanding the link between obesity and asthma may have major public health implications. Therefore, an in-depth knowledge of the association between asthma and obesity is essential to design evidence-based prevention programs.

Smoking status has been shown to be a risk factor leading to the development of asthma symptoms [50]. The present study found that ex-smokers were twice as likely to experience current asthma than those who never smoked. In the study conducted by Godtfredsen et al., ex-smokers had a higher incidence of self-reported asthma than those who never smoked. In fact, the risk of asthma increased among ex-smokers for the first 5 years after quitting [51]. Various other studies have also reported an increased risk of asthma among ex-smokers [41-52]. This association has been attributed to the so-called "healthy smoker" effect. In contrast, the increased asthma risk in those who quit smoking is possibly due to their tendency to quit in response to respiratory symptoms of any etiology [53]. Godtfredsen et al. suggested that smokers may quit due to respiratory symptoms but report it as asthma subsequently [51]. Smoking also causes airway inflammation, increases airway epithelial permeability, modulates the immune system, and impairs normal repair processes [54], which may not be reversed when a person quits smoking. However, longitudinal studies are needed

Table 3. Prevalence and Odds Ratio of Co-morbid Psychiatric Condition Among Patients With and Without Asthma

Lifetime/12 Month Psychiatric Condition	Current Asthma (n=257)				Lifetime Asthma (n=789)			
	With Asthma	Without Asthma	OR	p value	With Asthma	Without Asthma	OR	p value
Major Depressive Disorder	3.5	2.3	1.78	0.31	7.0	6.1	1.16	0.52
Bipolar Disorder	3.2	0.8	4.92	0.01	3.0	1.4	2.24	0.02
Generalized Anxiety Disorder	1.4	0.8	1.55	0.37	2.0	1.5	1.31	0.46
Obsessive Compulsive Disorder	4.7	2.9	1.62	0.31	3.2	3.6	0.87	0.63
Alcohol Use Disorder	0.5	0.8	0.68	0.55	6.0	4.5	1.36	0.21

*P value was derived using multiple linear regression analysis after adjusting for socio-demographic variables, BMI categories, and smoking status

Table 4. Health-related Quality of Life (QOL) Among With and Without Asthma

Domains	Current Asthma			Lifetime Asthma		
	With Asthma Mean±SE	Without Asthma Mean±SE	p-value*	With Asthma Mean±SE	Without Asthma Mean±SE	p-value*
Physical component score (PCS)	50.69 ± 0.81	53.39 ± 0.11	0.001	53.55 ± 0.32	53.39 ± 0.11	0.222
Mental component score (MCS)	54.96 ± 0.61	55.72 ± 0.12	0.222	54.72 ± 0.31	55.72 ± 0.12	0.211

*P value was derived using multiple linear regression analysis after adjusting for socio-demographic variables, BMI categories, and smoking status

to assess the long-term impact of smoking and smoking cessation on asthma [55].

Our study also found a significant association between asthma and bipolar disorder. The participants with current asthma were about 5 times more likely to be diagnosed with bipolar disorder. A study conducted by Wu et al., similarly found high comorbidity of asthma and bipolar disorder; individuals with asthma were 2.1 times more likely to be associated with bipolar disorder [56]. The possible explanation was that both asthma and bipolar disorder share a similar underlying inflammatory dysfunction and pathophysiology leading to the comorbidity [56]. Another possible reason could be that prednisone, a corticosteroid commonly prescribed to treat asthma, may increase the risk of mood disorders in a dose-response manner [57]. However, it was not possible to evaluate the temporality between asthma and bipolar disorder, which is an inherent limitation of the cross-sectional design.

Interestingly, the current study established that individuals with current asthma have a lower health-related quality of life in the physical component score as compared to those without asthma. In contrast, the health-related quality of life in the mental component score was not significantly associated with current asthma. Various

studies have shown that asthma has been associated with reduced health-related quality of life [58-60]. Studies show that asthma symptoms, exacerbations, and triggers are associated with lower quality of life, activity limitation, negative effects on social life, tiredness, problems with sustainable employment, and reduced productivity [61]. The European community survey conducted by Voll-Aanernud et al. revealed that respiratory symptoms are important determinants of reduced health-related quality of life among individuals with asthma. Participants with cough symptoms with asthma had lower physical component scores than participants with cough symptoms without asthma. This difference might be explained by the frequency and intensity of these symptoms, which are more likely higher in individuals with asthma than those without asthma [58]. However, the current study questionnaire did not assess the frequency and intensity of asthma attacks.

There are some limitations to this study. First, the prevalence of asthma was assessed through a single question. It relied on participants' self-report, which may be subject to unintended response biases leading to the under or over-reporting of results. While this provides an overview of the prevalence of asthma among the general

population in Singapore, a more precise tool such as spirometric testing may be required to understand asthma better in the local population. We acknowledge that clinical diagnosis through the physician review and spirometric confirmation tends to underestimate the prevalence. Second, the absence of objective clinical measures of asthma such as accurate measurement of symptom frequency, intensity, and treatment, especially those with current asthma who received some form of “Western” treatment during the past 12 months, limited more in-depth analysis. Third, the determination of current asthma was based on treatment in the past 12 months for their asthma. It is possible that either due to poor accessibility of services or self-management of symptoms, some of those with asthma had not sought treatment for their condition and were thus excluded from the diagnosis. Fourth, the study excluded residents who were physically or mentally too unwell to do the study, those hospitalized throughout the study period, and those who were not in Singapore during the study period. Thus, the study results may reflect an under-estimation of the true prevalence of asthma or the comorbid psychiatric conditions associated with asthma. Fifth, the information on lifetime asthma was obtained retrospectively and could be subject to recall bias and social desirability bias, inherent in interviewer-administered surveys. Finally, the cross-sectional design of this study limited any causal inferences from being made.

These limitations notwithstanding, our cross-sectional study had several strengths which include an adequately large sample size with a good response rate of 69.5% and inclusion of a representative sample of the resident population. This study also used a standardized questionnaire to determine the prevalence of asthma and associated factors which allow cross-national comparisons to be made.

CONCLUSION

The present study estimated a self-reported prevalence of lifetime asthma of 11.9% among the Singapore general population. The study found a significant association of asthma with higher BMI, previous smoking, bipolar disorder, and physical health-related quality of life. These findings may be potentially useful to policy makers, clinicians, and researchers in designing programs to address services for asthma.

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