Risk factors for hospitalization due to exacerbations among adult asthma patients in a district of Sri Lanka: a case–control study.

Dhanusha Harshinie Punyadasa

dhanusha@wyb.ac.lk

Wayamba University of Sri Lanka https://orcid.org/0000-0002-6738-2619

Vindya Kumarapeli

Directorate of Non-Communicable Diseases, Ministry of Health, Colombo, Sri Lanka

Wijith Senaratne

National Hospital for Respiratory Diseases, Welisara, Sri Lanka

Research Article

Keywords: Asthma, exacerbations, hospitalization, risk factors, Sri Lanka

Posted Date: May 22nd, 2024

DOI: https://doi.org/10.21203/rs.3.rs-4454729/v1

Additional Declarations: The authors declare no competing interests.

Abstract

Background

The exacerbation of asthma is a leading contributor to hospitalization. Information on the risk factors for hospitalization due to exacerbated asthma will help to identify high-risk asthma patients for specialized care. We aimed to identify the risk factors for hospitalization due to exacerbations among adult asthma patients in a district of Sri Lanka.

Methods

A hospital-based, case–control study was carried out on asthma patients aged ≥ 20 years. A total of 466 asthma patients (116 cases, 350 controls) were recruited from all tertiary care hospitals in the district. The data were collected by pre-intern medical officers via a pretested interviewer-administered questionnaire on asthma control, asthma comorbidities, risk behaviors, and physiological and sociodemographic factors. Risk factors were evaluated using bivariate and multivariate logistic regression. The data were analyzed using SPSS version 20.

Results

The risk factors were age ≥ 60 years (OR 2.1; 95% CI 1.2–3.7), educated G.C.E. O/level or less (OR 2.2; 95% CI 1.1–4.4), having diabetes mellitus (OR 2.0; 95% CI 1.1–3.7), having symptomatic gastroesophageal reflux disease (GORD) (OR 3.4; 95% CI 1.8–6.4), exposure to vehicular traffic (OR 3.2; 95% CI 1.8–5.7), exposure to secondhand tobacco smoke (OR 2.1; 95% CI 1.2–3.5), having ever smoked (OR 2.4; 95% CI 1.2–4.6), ever intubated/given ICU care (OR 3.5; 95% CI 1.5-8.0), previous hospitalizations due to exacerbations (OR 5.5; 95% CI 2.6–11.4), having uncontrolled asthma (OR 3.4; 95% CI 1.6–7.1) and having a BMI ≥ 25 kg/m^2 (OR 2.3; 95% CI 1.4-4.0).

Conclusions

Preventive strategies need to address the modifiable risk factors smoking and obesity and manage comorbid conditions, diabetes, and symptomatic GORD appropriately in asthma patients.

Introduction

Asthma is one of the most common noncommunicable diseases and is responsible for extensive healthcare use.[1] Despite being a controllable disease, the hospitalization rate for asthma remains high worldwide.

Asthma is more prevalent among Sri Lankan adults compared to other South Asian countries.[2] It has been a leading cause of admissions to government hospitals in Sri Lanka over the past two decades. In 2019, asthma was the most common noncommunicable disease among hospital admissions to government hospitals, accounting for 177,225 live discharges and 569 deaths.[3] This has resulted in a large but preventable burden on the Sri Lankan healthcare system.

Acute exacerbations of asthma requiring hospitalization often indicate poor management of the disease and its risk factors. Research from the developed world has studied possible risk factors, such as disease severity, inadequate clinical care, poor adherence to treatment, the presence of comorbidities, familial factors, behavioral factors and environmental risk factors [4,5,] and has shown that older age (> 45 years), female sex, increased disease severity, previous exacerbations requiring hospitalization, overuse of beta agonists, tobacco smoke and asthma comorbidities, such as chronic rhinitis and gastroesophageal reflux disease (GORD), are associated with hospitalizations due to exacerbated asthma.[4,6,7] However, the existing evidence from developed countries is not generalizable to Sri Lankan asthma patients due to differences in sociodemographic background, lifestyle, and healthcare provision.

Knowledge of the risk factors for hospitalization in Sri Lankan asthma patients who remain vulnerable to hospitalization while receiving asthma care is scarce.

A Sri Lankan study describing factors associated with severe asthma among 548 preschool children showed that passive smoking, living in a house with a clay floor, having pet dogs at home, and frequent consumption of tuna fish were independent risk factors for severe asthma.[8] A cross-sectional analytical study conducted among 202 adult asthma patients at the Colombo North Teaching Hospital revealed a strong association between gastroesophageal reflux disease symptoms and asthma severity.[9] The risk factors for asthma exacerbations are likely to differ across age groups. Although a number of studies have evaluated the risk factors for asthma,[10,11] hardly any studies on asthma exacerbations requiring hospitalization, particularly among adults with asthma in Sri Lanka, exist. In this context, we designed a case–control study to identify behavioral, familial, environmental and disease-related risk factors for hospitalizations due to exacerbated asthma among adult asthma patients.

Methods

A hospital-based unmatched case–control study was carried out from October 2018 to December 2018 in the district of Gampaha. The cases and controls were recruited from all tertiary care hospitals in the district where patients with asthma can access both inward and follow-up care directly.

A case was defined as a person aged ≥ 20 years who was diagnosed with asthma more than one year, who was currently hospitalized for an exacerbation at any of the selected hospitals and who resided in the district of Gampaha for a minimum period of one year prior to the commencement of the study. Patients with a respiratory rate > 30/min, pulse rate > 120 bpm, or O2 saturation (on air) < 90% during

admission and who required both regular nebulization and systemic steroids on admission were included in the study.

Patients diagnosed with other chronic respiratory diseases (e.g., chronic obstructive pulmonary disease (COPD) or interstitial lung disease) or tuberculosis in addition to asthma, patients diagnosed with heart failure in addition to asthma and patients who insisted on hospital admissions were excluded. Patients were recruited when they were hospitalized due to an exacerbation of asthma at any of the selected hospitals.

A control was defined as a person who was aged ≥ 20 years, had been diagnosed with asthma for more than 1 year, was not hospitalized for an exacerbation during the past year and had resided in the district of Gampaha for a minimum period of one year prior to the commencement of the study. Patients diagnosed with other chronic respiratory diseases (e.g., chronic obstructive pulmonary disease (COPD) or interstitial lung disease (ILD)) or tuberculosis in addition to asthma, patients diagnosed with heart failure in addition to asthma, patients admitted to the private sector for an exacerbation during the past year, patients who had taken treatment at the ETU and were discharged for an exacerbation during the past year, or patients who were advised to be admitted for an exacerbation but refused during the past year were excluded. Controls were recruited when they were presented to asthma/medical clinics in any of the selected hospitals.

The sample size (n) was calculated using the formula for unmatched case–control studies with multiple controls per case.[12] The sample size was calculated separately for each of the selected risk factors for hospitalization for asthma, and the risk factor with the largest sample size was used to calculate the sample. The odds ratios (ORs) for different risk factors and their community prevalence were based on the available literature. The corresponding risk factor for asthma hospitalization was ‘current smoking’, for which an odds ratio of 1.86 and 34% of clinical asthma patients were exposed to this risk factor.[13] The case-to-control ratio was 1:3. The calculated sample size was 111 cases and 333 controls. After adding 5% for nonresponse, the total required sample size was 116 cases and 350 controls.

Assessment of risk factors

An interviewer-administered questionnaire (IAQ) was designed to obtain information on potential risk factors for hospitalization due to exacerbated asthma.

As the initial step in developing the questionnaire, a detailed literature review was performed to identify potential risk factors, and a conceptual framework was developed. Questions in the IAQ were developed to cover all relevant risk areas. Where appropriate, the questions used in previous studies were adapted to suit local conditions.[10,14] Relevant risk areas required to be covered by the IAQ were identified with the help of a panel of experts in the field of asthma management.

Factors assessed in each section of the questionnaire were broadly grouped into sociodemographic factors, factors related to the patient’s past medical history and drug history, family-related risk factors,

lifestyle-related risk factors, occupation-related risk factors, environmental risk factors, factors related to the level of asthma symptom control, factors related to the asthma treatment regimen, and asthma comorbidities.

The structured IAQ was pretested among 10 cases and 10 controls before the commencement of the study. The face and content validity of the questionnaire was assessed. Four pre-intern medical officers were selected and trained as data collectors. Informed written consent was obtained prior to the administration of the questionnaire. Steps were taken to minimize disturbances to the routine work of the wards and the clinics.

Information on medical conditions and long-term medication use was verified with the medical records of the participants. The status of tobacco smoking was assessed according to the Centers for Disease Control (CDC) classification (never smoker, current smoker, former smoker). Lifetime smoking exposure was defined according to the pack-year value.[15] Exposure to secondhand smoke was assessed by inquiring about household member smoking inside the household at present or during the past year.

The level of asthma symptom control was assessed using four questions to identify different levels of asthma control (well controlled, partially controlled, or uncontrolled) based on the Global Initiative for Asthma (GINA) guidelines on the management of asthma.[16] The asthma management step was decided based on the current asthma treatment regimen of the participants. The patients were categorized into five treatment steps (steps 1, 2, 3, 4, and 5) according to the asthma management guidelines of the GINA.[16] The asthma treatment step for each participant was reviewed and reconfirmed by a consultant respiratory physician. Asthmatics who were on treatment steps 1, 2 and 3 were amalgamated as ‘on low-dose steroids’, and those who were on treatment steps 4 and 5 were amalgamated as ‘on high-dose steroids’. Generalized obesity was categorized based on body mass index (BMI) according to the World Health Organization (WHO) definitions for adult Asians.[17] A BMI of 25 kg/m2 or more was considered to indicate obesity.

Data analysis

Analysis of the data was performed using the Statistical Package for Social Sciences software (version 20). Bivariate analysis was performed to assess the association between each potential risk factor and hospitalization for asthma. The significance of these associations was tested by using the chi-square test, as each variable was converted to a categorical variable. Multiple logistic regression (MLR) analysis was performed to identify the independent risk factors for hospitalization due to exacerbated asthma after adjustment for all confounders. The variables that showed a significant association ($p < 0.05$) in the bivariate analysis and had a cell count 10 or more in the exposed group were included in the MLR model. Of the 20 variables that showed significant associations in the bivariate analysis, only 15 variables were included in the MLR model, as five variables (long-term use of aspirin, long-term use of ACE inhibitors, current smoking status, occupational exposure to solvents, and use of > 200 doses of relievers per month) were excluded from the analysis because they had cell counts less than 10 in the exposed group. The MLR model was estimated by performing a stepwise backward logistic regression method. The

goodness of fit of the model was assessed by the Hosmer and Lameshow test, which supported the model (p = 0.19).

Ethical approval to carry out the study was obtained from the Ethics Review Committee of the Faculty of Medicine, University of Colombo, Sri Lanka.

Results

The study sample consisted of 116 asthma patients who were currently hospitalized due to exacerbation (cases) and 350 controls diagnosed with asthma without any hospitalization due to exacerbation during the past year. The response rate of both the cases and controls was 95%.

The majority (33%, n = 36) of cases were recruited from District General Hospital (DGH) Negombo, 27% (n = 29) were from DGH Gampaha, 22% (n = 24) were from Teaching Hospital (TH) Ragama, and 18% (n = 21) were from the National Hospital for Respiratory Diseases (NHRD) Welisara. The majority (30%, n = 100) of the controls were recruited from the NHRD Welisara, 25% (n = 83) from the TH Ragama, 23% (n = 77) from the DGH Negombo and 22% (n = 73) from the DGH Gampaha.

The sociodemographic characteristics of the study participants are shown in Table 1. The majority of patients were aged 60–79 years, both among cases (60.9%) and controls (51.7%). The majority of the patients (59.1%, n = 65) and controls (68.2%, n = 227) were females. Only 1.8% (n = 2) of the cases and 1.8% (n = 6) of the controls had received university or higher education. Among cases, 5.5% (n = 6) had a monthly income less than 5,000 rupees; however, among the controls, only 4.5% had a monthly income less than 5,000 rupees (n = 15). (Table 1). The other baseline characteristics of the study participants are shown in Table 2.

Table 1
Sociodemographic characteristics of the cases and controls.

Demographic and socioeconomic characteristics	Cases (n = 110)		Controls (n = 333)	
	Number	Percent	Number	Percent
Age group (years)				
20–39	10	9.1	6	1.8
40–59	24	21.8	154	46.2
60–79	67	60.9	172	51.7
≥ 80	9	8.2	1	0.3
Sex				
Male	45	40.9	106	31.8
Female	65	59.1	227	68.2
Ethnicity				
Sinhala	98	89.1	312	93.7
Tamil	6	5.5	16	4.8
Muslim	6	5.5	5	1.5
Religion				
Buddhist	75	68.2	218	65.5
Hindu	5	4.5	9	2.7
Islam	5	4.5	6	1.8
Catholic/Christian	25	22.7	100	30.0
Highest Educational level				
No formal education	8	7.3	22	6.6
Grade 1–10	60	54.5	202	60.7
G.C.E. O/L* completed	31	28.2	45	13.5
Grade 11–12	2	1.8	24	7.2
G.C.E. A/L** completed	7	6.4	34	10.2

*General Certificate of Education Ordinary Level; ** General Certificate of Education Advanced Level

Demographic and socioeconomic characteristics	Cases (n = 110)		Controls (n = 333)	
	Number	Percent	Number	Percent
Age group (years)				
University or higher education	2	1.8	6	1.8
Monthly Income (Rupees)				
< 5,000	6	5.5	10	3.0
5,001–10,000	21	19.1	60	18.0
10,001–20,000	43	39.1	82	24.6
20,001–40,000	28	25.4	137	41.1
> 40,000	12	10.9	44	13.2
*General Certificate of Education Ordinary Level; ** General Certificate of Education Advanced Level				

Table 2
Baseline characteristics of the cases and controls.

Baseline characteristics	Cases (n = 110)		Controls (n = 333)	
	Number	Percent	Number	Percent
Having Diabetes Mellitus				
Yes	32	29.1	58	17.4
No	78	70.9	275	82.6
Having symptomatic GORD				
Yes	36	32.7	59	17.7
No	74	67.3	274	82.3
Long term use of aspirin				
Yes	7	6.4	5	1.5
No	103	93.6	328	98.5
Long term use of ACE inhibitors				
Yes	9	8.2	5	1.5
No	101	91.8	328	98.5
First degree relative with asthma				
Yes	62	56.4	140	42.0
No	48	43.6	193	58.0
Smoking status				
Never smoker	81	73.6	295	88.6
current smoker	6	5.5	3	0.9
former smoker	23	20.9	35	10.5
Pack years of smoking				
≥ 20 pack years	10	9.1	10	3.0
< 20 pack years	100	90.9	323	97.0
Occupational exposure to solvents				
Yes	5	4.5	2	0.6

Baseline characteristics	Cases (n = 110)		Controls (n = 333)	
	Number	Percent	Number	Percent
Having Diabetes Mellitus				
No	105	95.5	331	99.4
Exposure to traffic				
Yes	98	89.1	255	76.6
No	12	10.9	78	23.4
Exposure to secondhand smoking				
Yes	25	22.7	48	14.4
No	85	77.3	285	85.6
Previous hospitalizations due to asthma exacerbation				
Yes	28	25.5	22	6.6
No	82	74.5	311	93.4
Ever intubated/given ICU care				
Yes	12	10.9	12	3.6
No	98	89.1	321	96.4
Level of asthma control				
Well controlled	12	10.9	107	32.1
Partially controlled	42	38.1	173	52.0
Uncontrolled	56	50.9	53	15.9
Asthma treatment step				
Step 1	4	3.6	17	5.1
Step 2	31	28.2	104	31.2
Step 3	27	24.5	144	43.2
Step 4	34	30.9	68	20.4
Step 5	14	12.7	0	0.0
Intake of > 200 doses of relievers per month				

Baseline characteristics	Cases (n = 110)		Controls (n = 333)	
	Number	Percent	Number	Percent
Having Diabetes Mellitus				
Yes	8	7.3	5	1.5
No	102	92.7	328	98.5
BMI category				
≥ 25 kg/m^2	62	56.4	122	37.0
< 25 kg/m^2	48	43.6	208	63.0

Bivariate analysis revealed that age more than 60 years, education up to GCE O/level or less, monthly income ≤ Rs 20,000, having diabetes mellitus, having symptomatic GORD, long-term use of aspirin, long-term use of ACE inhibitors, first degree relative to asthma, having ever smoked, being a current smoker, > 20 pack years smoked, occupational exposure to solvents, exposure to traffic, exposure to secondhand smoke, previous hospitalization due to asthma exacerbation, ever intubated/given ICU care, having uncontrolled asthma, receiving high-dose steroids, intake of > 200 doses of relievers per month and having a BMI > 25 kg/m2 were significantly ($p < 0.05$) associated with hospitalizations due to exacerbated asthma. (Table 3). Independent risk factors identified by multiple logistic regression are shown in Table 4. Independent risk factors for hospitalization due to exacerbations among adult asthma patients were age > 60 years, education up to the GCE O/level or less, diabetes mellitus, symptomatic GORD, ever smoking, traffic exposure, exposure to secondhand smoke, ever intubated/given ICU care, previous hospitalizations due to asthma exacerbation, uncontrolled asthma and a BMI > 25 kg/m2.

Table 3
Factors associated with hospitalization due to exacerbated asthma among adult asthma patients according to bivariate analysis (level of significance = 0.05)

Variable	Categories	Unadjusted OR	95% CI	P
Age group	≥ 60 years	2.0	1.3–3.2	0.002
Education level	≤ G.C.E. O/Level	2.1	1.1–4.2	0.025
Monthly income	≤ Rs 20,000	2.0	1.3–3.2	0.001
Having Diabetes Mellitus	Yes	1.9	1.1–3.2	0.008
Having symptomatic GORD	Yes	2.2	1.3–3.6	0.001
Use of Asprin	Yes	4.4	1.3–14.3	0.013
Use of ACE inhibitors	Yes	5.8	1.9–17.0	0.001
First degree relative with asthma	Yes	1.7	1.1–2.7	0.009
Ever smoked	Yes	2.7	1.6–4.7	< 0.001
Current smoker	Yes	6.3	1.5–25.8	0.003
Number of pack years smoked	≥ 20 pack years	3.2	1.3–7.9	0.008
Worked with solvents	Yes	7.8	1.5–41.2	0.012
Exposure to traffic	Yes	2.4	1.3–4.7	0.005
Exposure to secondhand smoke	Yes	1.7	1.0-2.9	0.040
Previous hospitalizations due to exacerbations	Yes	4.8	2.6–8.8	< 0.001
Ever intubated/given ICU care	Yes	3.2	1.4–7.5	0.003
Level of asthma control	Not controlled[1]	3.8	2.0-7.3	< 0.001
Asthma treatment step	On high dose steroids[2]	3.0	1.9–4.7	< 0.001
Takes > 200 doses of relievers per month	Yes	5.1	1.6–16.0	0.005
BMI category	≥ 25 kg/m^2	2.2	1.4–3.4	< 0.001

[1] *'partly controlled' and 'uncontrolled' were amalgamated as 'not controlled'.*

[2] *asthma treatment steps 4 and 5 were combined as 'on high-dose steroids.'*

Table 4
Risk factors for hospitalization due to exacerbated asthma according to the multiple logistic regression model for adult asthma

Predictor variable	β	SE (β)	Adjusted OR	95% CI		Significance
				Lower	Upper	
Age ≥ 60 years	0.755	0.286	2.1	1.2	3.7	0.008
Educated ≤ G.C.E. O/Level	0.814	0.348	2.2	1.1	4.4	0.019
Having Diabetes Mellitus	0.720	0.312	2.0	1.1	3.7	0.021
Having symptomatic GORD	1.233	0.318	3.4	1.8	6.4	< 0.001
Ever smoked	0.889	0.328	2.4	1.2	4.6	0.007
Exposure to traffic	1.189	0.284	3.2	1.8	5.7	< 0.001
Exposure to secondhand smoke	0.754	0.268	2.1	1.2	3.5	0.005
Ever intubated/given ICU care	1.262	0.420	3.5	1.5	8.0	0.003
Previous hospitalizations due to exacerbations	1.710	0.369	5.5	2.6	11.4	< 0.001
Uncontrolled asthma	1.243	0.371	3.4	1.6	7.1	0.001
BMI ≥ 25 kg/m^2	0.866	0.268	2.3	1.4	4.0	0.001
Constant	-5.884	0.670				

Discussion

Multiple studies have evaluated risk factors for hospitalization due to exacerbated asthma in the developed world. To our knowledge, this is the first study to evaluate risk factors for hospitalization due to exacerbations among Sri Lankan asthma patients.

We identified smoking and obesity as modifiable risk factors for asthma-related hospitalizations. These findings are supported by several previous studies [13,18, 19, 20, 21] highlighting the need to address these risk factors in asthma patients during follow-up care.

The presence of diabetes mellitus and symptomatic GORD as comorbidities was associated with an increased risk of asthma-related hospitalizations, which was in line with the findings of several previous studies.[9,22,23] These findings indicate the importance of maintaining good control of diabetes and GORD symptoms among asthma patients to prevent asthma-related hospitalizations.

Older age groups were at greater risk of asthma-related hospitalizations in the present study. Several studies have reported that older asthma patients utilize more healthcare, including more emergency care treatment and hospitalizations. [4,24] Even though sex was not revealed to be a risk factor for asthma-related hospitalizations in the present study, a previous systematic review identified female sex as a significant predictor of repeated hospital visits in asthmatic children.[5]

We reported that low educational attainment was a significant risk factor for asthma-related hospitalization, which was in line with the findings of several previous studies.[25,26] Previous studies have demonstrated a greater risk of adverse asthma outcomes among individuals in low-income groups [27,28,] which might be related to their poor living conditions and underutilization of health care services. We found a similar association only in our unadjusted analysis. However, individuals tend to under or overestimate their income levels depending on the situation, and the self-reported average monthly income of our participants might not reflect their actual economic status. Although family history plays a part in the presence, severity, and triggers of asthma[29,] it was not a significant risk factor for asthma-related hospitalizations in the present study.

We found that exposure to traffic and secondhand smoke in relation to the household environment increased the risk of hospitalization due to exacerbation in asthma patients. These findings are supported by several previous studies.[30,31] Since we used a questionnaire to assess these environmental exposures, overreporting or underreporting are potential limitations.

Previous hospitalizations due to exacerbations and ever intubated or given ICU care were significant risk factors for asthma-related hospitalizations in the present study, which is in line with the findings of several previous studies.[4,7,32] We reported that poor asthma control was a significant risk factor for asthma-related hospitalizations. Several studies have also identified the ‘level of asthma control’ as a significant contributor to asthma-related health care utilization.[33,34]

One limitation of our study is the use of long recall periods in assessing several risk factors, such as occupational hazards, selected long-term illnesses and lifetime smoking status. The absence of previous hospitalizations due to exacerbations among controls during the past year was confirmed by checking the clinic records in addition to the history given by the patient. Even though the possibility of false identification of controls by this method is unlikely, this cannot be ruled out. We could not evaluate the associations between certain occupational exposures and long-term use of medications for asthma hospitalizations due to the small number of positive participants.

Conclusions

The management of modifiable risk factors such as smoking and obesity and the treatment of comorbid conditions such as diabetes and symptomatic GORD should be integrated with the clinical management of asthma patients. We recommend addressing these modifiable risk factors and comorbid conditions

as a primary preventive measure for asthma-related hospitalizations. Asthma care providers could use these findings on risk factors to flag high-risk asthma patients for the delivery of specialized care.

Abbreviations

IAQ
Interviewer Administered Questionnaire
MLR
Multiple Logistic Regression
GCE O/L
General Certificate of Examination Ordinary Level
ICU
Intensive Care Unit
GORD
Gastroesophageal reflux disease
BMI
Body mass index
ROC
Receiver operator curve
CI
Confidence interval
OR
odds ratio
ETU
Emergency Treatment Unit
CDC
Centre for Disease Control
GINA
Global Initiative for Asthma
WHO
World Health Organization
DGH
District General Hospital
TH
Teaching Hospital
NHRD
National Hospital for Respiratory Diseases

Declarations

Ethics approval and consent to participate.

This study was approved by the Ethics Review Committee, Faculty of Medicine, University of Colombo, Sri Lanka. (Reference number: EC-17-148). Informed and written consent was obtained from all study participants before IAQ was administered. All personal information was kept in accordance with the password protection computer of the principal investigator and in compliance with the Helsinki declaration. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication.

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

All three authors declare no competing interests.

Funding

The corresponding author received a research allowance from the Education and Training Unit, Ministry of Health, Sri Lanka, during the initial stage of the study.

Authors' contributions

Dhanusha Harshinie Punyadasa led the study with input from Vindya Kumarapeli and Wijith Senaratne. Dhanusha Harshinie Punyadasa conducted the study and the analysis of the data with expert inputs from Vindya Kumarapeli and Wijith Senaratne. Dhanusha Harshinie Punyadasa drafted the initial manuscript with support from Vindya Kumarapeli and Wijith Senaratne. All the authors read and approved the final version of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no other authors meeting the criteria have been omitted.

Acknowledgments

We wish to thank the health administrators, clinicians of the selected hospitals, participants of the panel of experts, and the study participants for their support, contribution, and participation.

References

1. Global Asthma Network The Global Asthma Report 2018.Aukland, New Zealand: Global Asthma Network,2018. http://globalasthmareport.org/(accessed 12 May 2020)
2. Gunasekera KD, Amarasiri WADL, Undugodage UCM et al (2022) Prevalence of asthma and its symptoms in Sri Lankan adults. BMC Public Health 22(1):1–8

3. Medical Statistics Unit. Annual Health Bulletin 2020. Colombo: Ministry of Health (2020) https://www.health.gov.lk/moh_final/english/public/elfinder/files/publications/AHB/2023/Annual Health Bulletin 2020(accessed 20 Sep 2023)
4. Arrotta N, Hill J, Villa-Roel C, Dennett E, Harries M, Rowe BH (2018) Factors associated with hospital admission in adult patients with asthma exacerbations: A systematic review. Can Assoc Emerg Physicians' Annu Sci Meet. ; https://www.tandfonline.com/action/journalInformation?journalCode=ijas20https://doi.org
5. Ardura-Garcia C, Stolbrink M, Zaidi S, Cooper PJ, Blakey JD (2018) Predictors of repeated acute hospital attendance for asthma in children: A systematic review and meta-analysis. Pediatr Pulmonol. ;53(9)
6. Kang HR, Song HJ, Nam JH et al (2018) Risk factors for asthma exacerbation based on asthma severity: A nationwide population-based observational study in South Korea. BMJ Open 8:20825
7. Buelo A, McLean S, Julious S et al (2018) At-risk children with asthma (ARC): A systematic review. Thorax 73:813–824
8. Rajapakse SI, Amarasiri L, Yasaratne D, Warnasekara J, Agampodi S (2020) Prevalence, and factors associated with severe asthma among preschool children of rural Sri Lanka. In: ERS International Congress. https://erj.ersjournals.com/content/56/suppl_64/2607
9. Amarasiri LD, Pathmeswaran A, Janaka de Silva H, Ranasinha CD (2010) Prevalence of gastro-esophageal reflux disease symptoms and reflux-associated respiratory symptoms in asthma. MBC Pulmonary Medicine. ; 10:49. http://www.biomedcentral.com/1471-2466/10/49
10. Danansuriya MN, Rajapaksa LC, Weerasinghe A (2015) Genetic, familial, and environmental correlates of asthma among early adolescents in Sri Lanka: A case control study. World Allergy Organ J 8(1):19
11. Samarasinghe A, Arnold S, Welgama I, Saravanabavan N, Fonseka P (2022) Risk factors associated with childhood asthma in 5–11 years old children. World J Adv Res Rev. ;14(2). https://doi.org/10.30574/wjarr.2022.14.2.0452
12. Schlesselman JJ (1982) Case control studies: design, conduct, analysis: Vol. 24
13. Eisner MD, Iribarren C (2007) The influence of cigarette smoking on adult asthma outcomes. Nicotine Tob Res 9(1):53–56
14. Samarakoon YM, Gunawardena NS, Pathirana A (2018) Behavioral, familial, and comorbid illness risk factors for colorectal cancer: a case control study. Ceylon Med J. ;63(3)
15. CDC. Health behaviors of adults 2005–2007: United states. Vol. 10, Vital and health Statistics (2010) https://stacks.cdc.gov/view/cdc/5553
16. GINA. Global Strategy for Asthma Management and Prevention (2018 update) (2018) Available from: www.ginasthma.org
17. Nishida C, Barba C, Cavalli-Sforza T et al (2004) Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 363(9403):157–163

18. Polosa R, Russo C, Caponnetto P et al (2011) Greater severity of new onset asthma in allergic subjects who smoke: A 10-year longitudinal study. Respir Res 12(1):16
19. Taylor B, Mannino D, Brown C, Crocker D, Twum-Baah N, Holguin F (2008) Body mass index and asthma severity in the National Asthma Survey. Thorax 63(1):14–20
20. Dixon AE, Shade DM, Cohen RI, Skloot GS, Holbrook JT, Smith LJ (2006) Effect of obesity on clinical presentation and response to treatment in asthma. J Allergy Clin Immunol 43:553–558
21. Schatz M, Zeiger RS, Yang SJ et al (2015) Prospective study on the relationship of obesity to asthma impairment and risk. J Allergy Clin Immunol Pract 3(4):560–565
22. Wu TD, Brigham EP, Keet CA, Brown TT, Hansel NN, McCormack MC (2019) Association Between Prediabetes/Diabetes and Asthma Exacerbations in a Claims-Based Obese Asthma Cohort. J Allergy Clin Immunol Pract 7(6):1868–1873e5
23. Uppal P, Mohammed SA, Rajashekar S et al (2023) Type 2 Diabetes Mellitus and Asthma: Pathomechanisms of Their Association and Clinical Implications. Cureus. ;15(3)
24. Zein JG, Dweik RA, Comhair SA et al (2015) Asthma is more severe in older adults. PLoS ONE. ;10(7)
25. Maziak W, von Mutius E, Keil U, Hirsch T, Leupold WRP, Behrens TWS (2004) Predictors of health care utilization of children with asthma in the community. Pediatr Allergy Immunol 15:166–171
26. Cesaroni G, Farchi S, Davoli M, Forastiere F, Perucci CA (2003) Individual and are-based indicators of socioeconomic status and childhood asthma. Eur Respir J 22(4):619–624
27. McGrath RJ, Stransky ML, Seavey JW (2011) The impact of socioeconomic factors on asthma hospitalization rates by rural classification. J Community Health 36(3):495–503
28. Fleming L (2018) Asthma exacerbation prediction: recent insights. Curr Opin Allergy Clin Immunol. ;18(2)
29. Alem K, Gebeyehu S, Arega Y (2020) Risk Factors and Treatment Types for Asthma Severity Among Adult Patients. J Asthma Allergy 13:167–177
30. Delfino RJ, Wu J, Tjoa T, Gullesserian SK, Nickerson B, Gillen DL (2014) Asthma morbidity and ambient air pollution: effect modification by residential traffic-related air pollution. Epidemiol 25(1):48–57
31. Wang Z, May SM, Charoenlap S et al (2015) Effects of secondhand smoke exposure on asthma morbidity and health care utilization in children: a systematic review and meta-analysis. Ann Allergy Asthma Immunol 115(5):396–401e2
32. León JE, Islas DG, Gutierrez LS, Reyes JLM, Tejeda AO (2017) Risk factors for hospitalization and ICU admission for near-fatal asthma. Eur Respir J. ;50(10)
33. Gold LS, Thompson P, Salvi S, Faruqi RA, Sullivan SD (2013) Level of asthma control and health care utilization in Asia-Pacific countries. Respir Med. ;108(2)
34. Vollmer WM, Markson LE, O'Conner E, Frazier E, Berger M, Buist AS (2002) Association of Asthma Control with Health Care Utilization. Am J Respir Crit Care Med 165(2):195–199