


# Risk Factors and Treatment Types for Asthma Severity Among Adult Patients

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**Objective:** The aim of this study was to identify the risk factors and treatment types for asthma severity among adult patients by applying a retrospective study design.

**Materials and Methods:** The symptoms of asthma and corresponding medication prescription were addressed by descriptive statistics, and an ordinal logistic regression model was applied to identify the risk factors of asthma severity based on the data obtained from chronic follow-up of 422 adult asthma patients from September 11, 2012, to July 8, 2016, at the University of Gondar Teaching Hospital (UOGTH).

**Results:** From 422 study units, the more commonly presenting asthma symptoms were coughing and wheezing expressed by 52.13% and 50.9%, respectively. For the treatment type given to the patients, oxygen and prednisolone were highly distributed drugs to the patients in chronic illness, medication and follow-up clinic of the University of Gondar Teaching Hospital (UOGTH) which were expressed by 73.5% and 35.5%, respectively. The proportional odd logit model was used to analyse asthma severity in patients; patients who were female (OR=1.68), a rural resident (OR=1.56), regular physical exercise (OR=2.39), allergen to pet (OR=3.17), had asthma in childhood (OR=2.27), had a family history (OR=1.89), and had depression (OR=2.31) were more likely to increase asthma severity than others, and patients who were in case with regular cooker, dry season was less likely to increase asthma severity.

**Conclusion:** Generally, the study presented the most common asthma symptoms and treatment types correspondingly. The study also showed that demographic, environmental, genetic, and health-related factors have a significant effect on asthma severity.

**Keywords:** asthma severity, risk factors, symptom, medication, ordinal logistic regression

## Introduction

Asthma is a common and potentially serious chronic disease that can be controlled, but not cured and it causes symptoms such as wheezing, shortness of breath, chest tightness and cough that vary over time in their occurrence, frequency and intensity. Symptoms are associated with variable expiratory airflow that means; difficulty breathing air out of the lungs due to bronchoconstriction (airway narrowing), airway wall thickening, increased mucus, symptoms may be triggered or worsened by factors such as viral infections, allergens, tobacco smoke, exercise, and stress. It is a major cause of school absence; work absence and healthcare expenditure on asthma are very high.<sup>1</sup>

Asthma imposes a large burden on the individual and on health care systems. Currently, asthma prevalence is approximately 10%-13% globally. Unexplained temporal and geographical variations in asthma prevalence have also been reported

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with asthma prevalence increased over the past few decades and higher asthma prevalence in Western nations.<sup>2</sup>

According to the World Health Organization survey report, the mean prevalence of asthma was 8.2% and 5.2% in poor countries and middle-income countries, respectively. In Africa suggested that greater than 50 million individuals have asthma.<sup>3</sup> The disease is more prevalent in developed countries with the highest rate seen in Australia (21.5%), Sweden (20.2%), United Kingdom (18.2%), Canada (14.1%), and the United States of America (10.9%).<sup>3,4</sup> Although not comparable with high-income countries, many low and middle-income countries are showing an increase in prevalence, increasing the overall world burden of asthma.<sup>5</sup>

In Africa problems, including those arising from the over-utilization of health services, lack of trained staff and diagnostic apparatus, and non-availability and unaffordability of inhaled medications have hindered efforts to improve the management of asthma.<sup>6,7</sup> Some of the African countries are shown to have high asthma prevalence, for example, South Africa (8.1%), Nigeria (7–18%), and Egypt (9.4%).<sup>8</sup> With respect to asthma prevalence in Ethiopia nationwide data addressing the adult population is lacking. Community-based studies done in Jimma reported a 4.9% prevalence of asthma. Other studies indicated 10.7% and 16.2% of the 12-month self-reported prevalence of wheezing in school children in Addis Ababa and Gondar, respectively.<sup>9,10</sup> Assessment of severity is essential to guide initial doses of medications and the frequency of subsequent medical review.<sup>11,12</sup> The severity of asthma varies within and between individuals and is judged according to symptoms and medication requirements. Chronic bronchial asthma is classified as intermittent or persistent asthma. The successful management of patients with asthma includes four essential components: routine assessment and monitoring, patient education to create a partnership between clinician and patient, controlling environmental factors and co-morbid conditions that contribute to asthma severity and pharmacological therapy.<sup>12,13</sup>

There are no many enough studies that have been done with patterns of prescription medication and risk factors for asthma severity in Ethiopia.

## General Objective

To identifying risk factors and treatment types for asthma severity among adult patients attending in chronic illness, medication and follow-up clinic of UOGTH.

## Specific Objectives

- To identify the major symptoms of asthma and asthma treatment types.
- To assess demographic, environmental, genetic and health-related factors.
- To compare the general ordered model and ordinal logistic regression model.

## Materials and Methods

### Study Design

In this study, we used a retrospective study design.

### Study Area

The study was conducted at the University of Gondar Teaching Hospital, Amhara region Northwest Ethiopia which is 738 km from Addis Ababa. It has a latitude and longitude of 12°36'N 37°28'E, respectively, with an elevation of 2160 meters above sea level. The University of Gondar hospital is a 400-bed University hospital, which acts as the referral center for four district hospitals in the area. It has a range of specialties including pediatrics, surgery, gynecology, psychiatry, HIV care, and an outpatient clinic. Within its 400 staff, it employs 50 doctors, 150 nursing staff, three pharmacists, 90 care staff and 25 laboratory scientists. This staff serves a population of four million across the region. As a University hospital, it plays an important role in teaching medical and nursing students. This hospital provides different inpatient and outpatient services to the population in the surrounding area of Gondar town and the nearby districts and zones.

### Source and Study Population

The source populations were all patients attending to chronic illness, medication and follow-up clinic of UOGTH.

### Inclusion Criterion

All asthmatic patients whose ages were greater than or equal to 18 years in chronic illness, medication and follow-up clinic and who were starting follow-up before July 8, 2016, for asthma treatment at the University of Gondar teaching hospital (UOGTH) were included in the study.

### Exclusion Criterion

Asthmatic patients whose ages were less than 18 years, patients lost from follow-up medication or clinic and

pregnant ladies (due to the effects of pregnancy on asthma) were excluded from this study.

### Sample Size Selection Procedures

The three criteria to determine the appropriate sample size are the level of precision, level of confidence or risk, and degree of variability in the attributes being measured. The prevalence of asthma in Jimma town (Ethiopia) was 4.9%.<sup>10</sup> Therefore, the required sample size is 448 but 422 patients were actively participated in the study period, due to lost follow-up in the data collection time.

### Data Collection Procedure

The data were collected by developed structured questionnaires and guidelines from Self-report, direct observation, interview, and chart review of Asthmatic patients during the checkup and follow-up of patients.

The researcher has included six professional nurses from chronic illness medication and follow-up Clinics as data collectors after they took appropriate training on how to fill the structured questionnaires and guidelines.

## Variables Considered in the Study

### The Dependent Variable

In this study, the response or dependent variable is the ordinal response variable that can be influenced by independent variables and which is called “severity levels of asthma”. Severity levels of asthma can be classified as mild, moderate, severe asthma that shows some degree of deference which indicates characteristics of ordinal variables.<sup>9,10</sup>

### The Independent Variables

The independent variables are variables that are presumed to affect or determine a dependent variable. The variables that are considered in the study are expected to be the factors that influence the severity levels of asthma. The choices of those variables are guided by different literature as the determinant factors for asthma severity.<sup>9,10</sup>

### Logistic Regression Model

The logistic model, as a non-linear regression model, is a special case of the generalized linear model where the assumptions of normality and constant variance of residuals are not satisfied. This model is a statistical technique for predicting the probability of an event, given a set of predictor variables. The procedure is more sophisticated than the linear regression procedure.

Logistic regression is used to predict the probability of the dependent variable on the basis of independent variables

and to determine the effect of the independent variables on the dependent; to rank the relative importance of independents; to assess interaction effects, and to understand the impact of covariate control variables. The impact of predictor variables is usually explained in terms of odds ratios and hence the name logistic regression also called the log-odds function. This model applies maximum likelihood estimation after transforming the dependent into a logit variable.<sup>14</sup>

## Results

The data were analyzed using the STATA version 12 software.

### Descriptive Statistics on Severity and Risk Factors

From a total of 448 respondents, 422 were included in the final analysis. From total units in the study, 130 (30.8%) severe, 132 (31.28%) moderate, and 160 (37.91%) were mild asthmatic patients, respectively.

Table 1 shows that patients who were severely asthmatics 27.51% were female and 33.48% male. Those who were moderate asthmatic 28.04% were females and 33.91% were male. Percentage distributions of those who are mild asthmatic (44.44%, 32.62%) were female and male, respectively. For patients who are severely asthmatic, 27.78% were rural residents, 33.48% were urban residents. Of the patients who were moderate asthmatic 30.81% were rural, 31.7% are urban residents. Of the patients who are mild asthmatic 41.41% were rural, and 34.82% were urban residents.

Table 2 also shows that the percentage distribution of asthma severity levels by different environmental factors.

Out of total adult patients who were severely asthmatic 32.02%, 24.24% were registered in the dry season and

**Table 1** Percentage Distribution of Asthma Severity Level by the Levels of Demographic Factors

Demographic Factors				
Factors	Category	Severity Levels (%)		
		Severe	Moderate	Mild
Sex	Female	52(27.5)	53(28.1)	84(44.4)
	Male	78(33.5)	79(33.9)	76(32.6)
Residence	Rural	55(27.8)	61(30.8)	82(41.4)
	Urban	75(33.5)	71(31.7)	78(34.8)
Education	Illiterate	63(31.5)	57(28.5)	80(40)
	Literate	67(30.2)	75(33.8)	80(36)

**Table 2** Percentage Distribution of Asthma Severity Level by the Levels of Environmental and Behavioral Factors

Environmental Factors				
Factors	Category	Severity Levels (%)		
		Severe	Moderate	Mild
Season register	Dry	114(32)	111(31.2)	131(36.8)
	Rainy	16(24.2)	21(31.8)	29(43.9)
Smoking habit	Smoker	42(33.6)	37(29.6)	46(36.8)
	Non-Smoker	88(29.6)	95(31.9)	114(38.4)
Exercise (regular)	Yes	37(25.2)	37(25.2)	73(49.7)
	No	93(33.8)	95(34.6)	87(31.6)
Cooking habit	Yes	60(35.9)	59(35.3)	48(28.7)
	No	70(27.4)	73(28.6)	12(43.9)
Allergens to pollen	Yes	60(31.4)	55(28.8)	76(39.8)
	No	70(30.3)	77(33.3)	84(36.4)
Allergens to pet	Yes	16(18.4)	21(24.1)	50(57.5)
	No	114(34)	111(33.1)	110(32.8)
Allergens to dust	Yes	53(29.4)	54(30)	73(40.6)
	No	77(31.8)	78(32.2)	87(35.9)

rainy season, respectively. Of those moderate asthmatic patients 31.18%, 31.82% were registered during the dry and rainy season, respectively. And from mild asthmatic patients 40%, 36.04% were registered in a dry and rainy season, respectively. Of patients who had a habit of regular physical exercise 25.17%, 25.17%, 49.66% are severe, moderate, and mild asthmatic patients, respectively. And from the total study unit who had a regular cooking trend 35.93%, 35.33%, 28.74 were severe, moderate, mild asthmatic, respectively. Of the total study unit who are living with an allergen to pet 18.39%, 24.14%, and 57.47% were severe, moderate, mild asthmatic, respectively.

Similarly, **Table 3** shows that the percentage distribution of asthma severity level by the levels of different genetic and health-related factors. From the study unit who had depression, 21.64%, 24.63%, 53.73% were severe, moderate, and mild asthmatic, respectively. Of the total study unit who had asthma in childhood stage, 22.22%, 26.39%, 51.39% were severe, moderate, and mild asthmatic, respectively. Patients who had asthma in their family 23.71%, 25.77%, 50.52% were severe, moderate, and mild, respectively.

**Table 4** shows that the percentage distribution of asthma symptom seen in adult asthmatic patients are coughing (52.8%), wheezing (50.9%), dyspnea (44.55%), chest pain (25.59%), limited daily activity (8.77%), and rhinitis (5.21%).

**Table 3** Percentage Distribution of Asthma Severity Level by the Levels of Genetic and Health-Related Factors

Genetic and Health-Related Factors				
Factors	Category	Severity Levels (%)		
		Severe	Moderate	Mild
Depression	Yes	29(21.6)	33(24.6)	72(53.7)
	No	101(35.1)	99(34.4)	88(30.6)
Asthma in childhood	Yes	32(22.2)	38(26.4)	74(51.4)
	No	98(35.3)	94(33.8)	86(30.9)
Stress	Yes	56(29.5)	58(30.5)	76(40)
	No	74(31.9)	74(31.9)	84(36.2)
Family history	Yes	23(23.7)	25(25.8)	49(50.5)
	No	107(32.9)	107(32.9)	111(34.2)
Co-morbid illness	Yes	60(31.3)	58(30.2)	74(38.5)
	No	70(30.4)	74(32.2)	86(37.7)
Respiratory infection	Yes	66(31.4)	66(31.4)	78(37.1)
	No	64(30.1)	66(31.2)	82(38.7)
Body mass index of patients	Under weight	10(29.4)	11(32.4)	13(38.2)
	Normal	88(33.2)	88(33.2)	89(33.6)
	Over weight	26(24.1)	28(25.9)	54(50)
	Obese	6(40)	5(33.3)	4(26.7)

**Table 4** Percentage Distribution of Asthma Symptoms Seen Among Adult Patients in the Chronic Illness, Medication and Follow-Up Clinic of UOGTH

Symptom	Number of Patients	Percentage (%)
Cough	220	52.1
Wheezing	215	50.9
Dyspnea	188	44.5
Chest pain	108	25.6
Limits daily activity	37	8.8
Rhinitis	22	5.2

Note: Percentage value for **Tables 5** and **6** are calculated based on multiple responses of cases.

**Table 7** shows that highly distributed treatment to asthmatic patients is oxygen (O<sub>2</sub>) and prednisolone. From 422 patients, who received oxygen (O<sub>2</sub>) and prednisolone were 310 (73.5%) 150 (35.55%) respectively. The percentage distributions of beclomethasone, beclomethasone puff were equal which is expressed by 5.21%. Of all treatments distributed to asthmatic patients in a study unit, Salbutamol puff has a minimum percentage (4.74%) value.

**Table 8** shows that of patients with severe asthma got oral salbutamol are 22 (44%) and oxygen 84 (27.1%), beclomethasone puff 8 (57.14%), prednisolone 36 (24%), albutamol 10

**Table 5** Results of Maximum Likelihood and Odds Ratio Estimates for Model I

Parameter	Estimate	SE	Wald Chisq		P-value	95% CI	
						LB	UB
Constant 1	2.53	1.249	–	–	–	1.08	8.16
Constant 2	4.12	1.26	–	–	–	5.21	18.54
Logage	1.385	0.715	1.94	1.39	0.053	0.98	16.12
Female sex	0.472	0.203	2.33	1.6	0.020	1.08	2.38
Rural Residence	0.537	0.211	2.54	1.71	0.011	1.13	2.59
Dry season of first registration	–0.643	0.272	–2.37	0.526	0.018	0.32	0.91
Non-smoker	0.035	0.216	0.16	1.04	0.871	0.68	1.58
Regular physical exercise	0.830	0.216	3.83	2.29	<0.001	1.52	3.50
Regular cooking habit	–0.535	0.204	–2.62	0.585	0.009	0.39	0.87
Illiterate educational level	0.137	0.215	0.64	1.15	0.525	0.75	1.75
Asthma in childhood	0.841	0.215	3.91	2.32	<0.001	1.52	3.53
Pollen allergy	0.101	0.229	0.44	1.11	0.659	0.71	1.74
Pet allergy	1.088	0.261	4.17	2.97	<0.001	1.78	4.95
Dust allergy	0.011	0.228	0.05	1.01	0.963	0.65	1.58
Co-morbid illness	0.103	0.199	0.51	1.11	0.608	0.75	1.64
Depression	0.805	0.221	3.66	2.22	<0.001	1.45	3.44
Family history on asthma	0.651	0.243	2.68	1.92	0.007	1.19	3.09
Stress	0.193	0.203	0.95	1.21	0.340	0.82	1.80
Underweight BMI	0.339	0.366	0.93	1.40	0.355	0.69	2.89
Normal BMI	0.325	0.243	1.34	1.38	0.181	0.86	2.23
Overweight BMI	–0.785	0.539	–1.46	0.456	0.146	0.16	1.31
Respiratory infections	–0.081	0.197	–0.40	0.923	0.686	0.63	1.36

**Abbreviations:** SE, standard error; chisq, chi-square; Exp<sup>B</sup>, exponential of parameter (B); CI, confidence interval; LB, lower limit; UB, upper limit; Cut, cut point/constant; Logage, log transformation for age for respondent.

**Table 6** Results of Maximum Likelihood and Odds Ratio Estimates for Model II

Parameters'	Estimates	S.E	Wald Chisq	D.F	p-value		95% CI	
							LB	UB
Constant 1	0.021	0.310	–	–	–	–	1.02	1.87
Constant 2	1.58	0.320	–	–	–	–	2.59	9.01
Female sex	0.519	0.194	2.67	1	0.008	1.68	1.15	2.46
Rural Residence	0.563	0.195	2.88	1	0.004	1.76	1.21	2.58
Dry season of first registration	–0.596	0.265	–2.25	1	0.025	0.55	0.33	0.93
Regular physical exercise	0.873	0.208	4.20	1	<0.001	2.39	1.57	3.60
Regular cooking habit	–0.477	0.194	–2.46	1	0.014	0.62	0.42	0.91
Asthma in childhood	0.818	0.207	3.95	1	<0.001	2.27	1.51	3.42
Pet allergy	1.15	0.253	4.59	1	<0.001	3.17	1.91	5.21
Depression	0.835	0.216	3.86	1	<0.001	2.31	1.51	3.51
Family history on asthma	0.635	0.234	2.71	1	0.007	1.89	1.19	2.97

**Abbreviations:** SE, standard error; DF, degree of freedom; Exp<sup>B</sup>, exponential of parameter (B); CI, confidence interval; LB, lower limit; UB, upper limit; Cut, cut point/constant.

(16.95%), oral salmentrol 5 (11.36%), theophedrine 10 (29.41%), salbutamol puff 7(35%), dexamethasone 9 (29.03%), and beclomethasone 9 (40.91%).

Those with moderate asthmatic patients, oral salbutamol were 13 (26%) and oxygen 98 (31.61%), beclomethasone puff 2 (14.29%), prednisolone 29 (19.33%), albutamol 25

**Table 7** Percentage Distribution of Treatments for Adult Asthmatic Patients at the Chronic Illness, Medication and Follow-Up Clinic of UOGTH

Treatment Types	Number of Patients	Percentage
Oxygen(O <sub>2</sub> )	310	73.5
Prednisolone	150	35.5
Abetamol	59	13.9
Oral Salbutamol	50	11.8
Oral Salmentrol	44	10.4
Theophedrine	34	8.1
Dexamethasone	31	7.4
Beclomethasone	22	5.2
Beclomethasone puff	22	5.2
Salbutamol puff	20	4.7

**Table 8** Percentage Distribution of Treatments Corresponding to Severity Level

Treatment Types	Severity Level (%)		
	Severe	Moderate	Mild
Oxygen(O <sub>2</sub> )	84(27.1)	98(31.6)	128(41.3)
Prednisolone	36(24)	29(19.3)	85(56.7)
Abetamol	10(16.9)	25(42.4)	24(40.7)
Oral Salbutamol	22(44)	13(26)	15(30)
Oral Salmentrol	5(11.4)	10(22.7)	29(65.9)
Theophedrine	10(29.4)	8(23.5)	16(47.1)
DexyclamethasoneDexamethasone	9(29.1)	10(32.3)	12(38.7)
Beclomethasone	9(40.9)	2(9)	11(50)
Beclomethasone puff	8(57.2)	2(14.3)	4(28.6)
Salbutamol puff	7(35)	4(20)	9(45)

(42.37%), oral salmentrol 10 (22.73%), theophedrine 8 (23.53%), dexamethasone 10 (32.26%), and beclomethasone 2 (9.02%), salbutamaol puff 4(20%).

Patients with mildasthma who took oral salbutamol were 15 (30%) and oxygen 128 (41.29%), beclomethasone puff 4 (28.57%), prednisolone 85 (56.67%), albutamol 24 (40.68%), oral salmentrol 29 (65.91%), theophedrine 16 (47.06%), salbutamol puff 9 (45%), dexamethasone 12 (38.71%), and beclomethasone 11 (50%).

Generally, the distribution of salmentrol drugs was low in patients with severe asthma. Beclomethasone puff drug was low in patients with moderate and mild asthma in chronic illness medication and follow-up clinic of UOGTH.

## Test of Model Selection

From [Table 9](#), the result of AIC suggests that the ordinal logistic model is reasonable for a model with low AIC (859.05) is the preferred model. Therefore, a cumulative consideration of the above tests confirmed that the ordinal

**Table 9** Comparison of General Ordered Model and Ordinal Logistic Regression Model Based on AIC and BIC Value

Information Criteria	Ologit	Gologit	Difference
Akaike information criteria (AIC)	859.05	882.08	-23.03
Bayesian information criteria (BIC)	948.04	1051.97	-103.93

logistic regression model is appropriate. Similarly, from [Table 9](#) BIC values of the ordinal logistic model and generalized ordered model are 948.04 and 1051.97, respectively. Similarly, the ordinal logistic regression has smaller BIC values; we again conclude that the ordinal logistic model is appropriate to fit the data.

## Overall Model Test

For the selected model, before proceeding to examine the individual coefficients, we checked an overall test of the null hypothesis that the location coefficients for all of the variables in the model are 0.

From the STATA output the Likelihood Ratio (LR) Chi-Square test that at least one of the predictor regression coefficients is not equal to zero in the model. The number in the parenthesis indicates the degrees of freedom of the Chi-Square distribution used to test the LR Chi-Square statistic and is defined by the number of predictors in the model. The LR Chi-Square statistic can be calculated by  $-2*(L(\text{null model}) - L(\text{fitted model})) = -2*((-461.66) - (-407.52)) = 108.26$ , where  $L(\text{null model})$  is from the log-likelihood with just the response variable in the model (Iteration 0) and  $L(\text{fitted model})$  is the log-likelihood from the final iteration (assuming the model converged) with all the parameters. Correspondingly the probability of getting LR test statistic (Prob > chi2) as extreme as, or more so, than the observed under the null hypothesis. In other words, this is the probability of obtaining this Chi-square statistic (108.26) if there is, in fact, no effect of the predictor variables. This p-value is compared to a specified 0.05 alpha level. The small p-value from the LR test, <0.001, would lead us to conclude that at least one of the regression coefficients in the model is not equal to zero.

## Model Fitting

From [Table 5](#) shows nine variables are statically insignificant, so the model can be revised (reduced) by excluding the insignificant variables. Of 18 variables considered in the study age, educational status, smoking habit, stress, pollen,

dust, co-morbid disease, body mass index, respiratory infection is statistically insignificant to the severity of asthma.

## The Goodness of Fit Test

It is useful to be able to judge whether the model fits the data. A useful quantity in judging the goodness of fit is the deviance. The full ordinal logistic regression model has a total of  $n$  parameters. The regression model with fewer variables has  $K$  independent variables and 2 intercepts. However, if the reduced model (model-II) is good, it should fit almost as well as the full ordinal logistic one. Thus, a model I is better if  $D >$ .

where  $h$  is the difference between the number of the parameter in the model I and model II.

In the case of the two fitted models, the full model (model-I) has 34 dummy variables with 2 intercepts which results in  $n = 38+2 = 40$  parameters. The reduced model (model-II) has 18 dummy variables and 2 intercepts which results in  $p=18+2=20$  parameters.

To test the goodness of fit of model-II, we used the deviance to compare its goodness of fit with model-I.  $D = [-2 \log\text{-likelihood model-II}] - [-2 \log\text{-likelihood model-I}]$  with degrees of freedom equals to  $h = n - p = 40 - 20 = 20$ . From the STATA output of the last iteration for both model I and model II, the value of deviance is equal to  $2 \times (413.407 - 407.52) = 11.8$  that follows  $\chi^2(20)$  which is greater than from this critical value (11.8) and non-significant at the 5% level of significance. Thus, we can conclude that there is no statistical advantage that can be gained by considering the model-I. Therefore, model-II is selected as a better regression model to fit the data.

## Test of Parallel Line

One of the assumptions underlying ordinal logistic regression is that the relationship between each pair of outcome groups is the same. This can be tested by scores, likelihood ratio, Wald tests of proportional odds assumption, by comparing the model to a more general “non-proportional odds model” with effects  $\{\beta_j\}$ . This can be checked using the test of parallel lines in which the null hypothesis states that the slope coefficients in the model are the same across response categories. If we fail to reject the null hypothesis, we conclude that the assumption holds. The results are shown in Table 10, we can see that the Chi-square test statistic is not significant (Chi-square 12.37, P-value = 0.193) at the 5% level of significance. The same is true for the other methods of parallel assumption tests. Therefore, there is not enough evidence to reject the

null hypothesis for the final model. Thus, the proportional odds assumption appears to have held for the final model (see Table 10).

## Test of Multicollinearity

Multicollinearity happens when two or more predictors contain much of the same information. If predictor variables are related to each other, the interaction effect will be created which misleads model fitting. This problem can be checked by a multi-collinearity test, specifically variance inflation factor which is an indicator of how much of the inflation of the standard error could be caused by collinearity. This test is used to identify whether each predictor variable is independent of each other or not by using the variance inflation factor of cut point values for each predictor variable. If the variance inflation factor (VIF) value of each variable is between 1 and 10, those variables are taken as statistically independent to each other. Table 11 shows that the variance inflation factors (VIF) value for all predictors are between 1 and 10. Then, we conclude that the interaction effect was statistically insignificant for model fitting.

## Model Diagnosis Checking

After model fitting, the next important step in logistic regression, model building is to perform an analysis of residuals and diagnostics. That is, the adequacy of the fitted model is checked for possible presence and treatment of outliers and influential values. From diagnostic test results for detection of outliers and influential values are showed that the standardized residuals are within the interval of  $-3$  and  $+3$  which implies that no outlier is detected at the 0.05 significance level. The Cook's influence statistics ( $D_i$ ) less than one and the DFBETA's (all values less than  $2/\sqrt{n} = 0.097$ ) for model parameters including the constant term were all less than 0.097. Therefore, we conclude that the model is adequate.

**Table 10** Results for Test of Parallel Line Across a Responses Category

Methods	Chi <sup>2</sup>	DF	P>Chi <sup>2</sup>
Rant (Omnibus)	12.37	9	0.193
Score	9.437	9	0.398
Likelihood Ratio	8.636	9	0.472
Wald	10.88	9	0.28

**Abbreviations:** DF, degree of freedom; Chi<sup>2</sup>, chisq=chi-square; P, probability.

**Table 11** Test Independence for Predictor Variables

Model	Colinearity Statistics	
	Tolerance	VIF
Sex of patients	0.938	1.066
Residence of patients	0.837	1.195
season of register	0.945	1.058
Smoking habit of patients	0.931	1.074
Regular physical exercising habit	0.898	1.113
Regular cooking habit	0.934	1.071
Educational statuses	0.785	1.273
Asthma in childhood	0.940	1.064
Pollen allergy	0.717	1.395
Pet allergy	0.943	1.060
Dust allergy	0.710	1.408
Co-morbid illness	0.925	1.081
Depression on asthma	0.925	1.081
Family history of patients	0.936	1.068
Stress on asthma	0.898	1.113
Body mass index of patients	0.855	1.169
respiratory infection	0.944	1.060
Logage	0.812	1.232

**Abbreviations:** VIF, variance inflation factor; Logage, log transformation for age for respondent.

## Interpretation

From the results displayed in [Table 6](#) shows that sex, residence, season, regular physical exercise, regular cooking habit, asthma in childhood, allergy to pet, depression, family history are found to be significant predictors for asthma severity.

The estimated odds ratio (OR = 1.68) indicates that females are 1.68 times more likely to increase asthma severity than those who are male (reference). The 95% confidence interval also suggests that the odds of severe asthma for females are 1.15 times as low and 2.46 times as high as compared to those males.

The estimated odds ratio (OR = 1.76) indicates that asthmatic patients who were rural residents are 1.76 times more likely to increase the severity level of asthma than those asthmatic patients who were urban residents (reference). The 95% confidence interval also suggests that the odds of severe asthma are 1.21 times as low and 2.58 times as high as compared to those urban residents.

The estimated odds ratio (OR = 0.55) indicates that the odds of severe asthma (as opposed to moderate or mild) for the dry season are 45% lower than rainy season, as the odds of moderate or severe (as opposed to mild), by holding other variables constant. The odds with 95% confidence could be as low as 0.33 and as high as 0.93.

The estimated odds ratio (OR =0.62) implies that the odds of severe asthma (as opposed to moderate or mild) for patients who were regular cooker are lower than those who are not by 38%, as the odds of severe or moderate asthma (as opposed to mild), by taking other variable effects constant.

The estimated odds ratio (OR = 2.39) indicates that patients who do physical exercises regularly are 2.39 times more likely to develop severe asthma than those who do not have. In the same way, patients who do physical exercises regularly are 2.39 times more likely to attain sever outcomes (to develop severe or moderate asthma) than those who do not have, holding other predictors constant. The odds with 95% confidence could be as low as 1.57 and as high as 3.60.

The log odds of severe asthma for patients who live with and allergen to pet are increased by 1.15. The estimated odds ratio (OR = 3.17) indicates that patients who live with and allergen to pet are 3.17 times more likely to develop severe asthma than those with none, by keeping other predictors constant.

The log odds of a severe outcome of asthma who were asthmatic patients in their childhood stage were increased by 0.6274. The estimated odds ratio (OR=2.27) shows that patients who were asthmatic in their childhood stage were 2.27 times more likely to develop severe asthma than those who were none by holding all other variable constant.

The increment to log odds of severe outcomes for patients who are asthmatic in their family is 0.635. The estimated odds ratio (OR=1.89) indicates that patients whose family were asthmatic are 1.89 times more likely to develop severe asthma than those no asthmatic in their family (reference group) by taking other predictor fixed.

The increment to log odds of severe outcome who were depressed patients were 0.835. The estimated odds ratio (OR=2.31) indicates that patients who had depressed were 2.31 times more likely to develop severe asthma than those nondepressed patients (reference group) by controlling another predictor as fixed.

## Discussion

From 422 patients included in the study, presenting asthma symptom seen in adult asthmatic patients treated with chronic illness, medication and follow-up clinic of University of Gondar Teaching Hospital (UOGTH) were coughing (52.8%), wheezing (50.9%), dyspnea (44.55%), chest pain (25.59%), limited daily activity (8.77%), and rhinitis (5.21%). It is a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role and this



chronic inflammatory disorder may cause airway hyper-responsiveness that leads to recurrent episodes of wheezing, breathlessness, chest tightness and coughing. This study finding is comparable to the study conducted in Ethiopia in 2015,<sup>15</sup> Uganda in 2012,<sup>6</sup> and Denmark on the major symptom and sign seen among those diagnosed with asthma. Similarly, from total units in the study, 130 (30.8%) severe, 132 (31.28%) moderate, and 160 (37.91%) mild asthmatic, respectively. This study finding is relatively comparable with the study conducted in Ethiopia 2015;<sup>15</sup> in this study, the results are shown us high percentage value in each asthma severity level as compared to the study conducted in Malaysian health and morbidity (MHM SUR II) in 1996. This may be due to the less understanding creation of possible causes of asthma severity.

The drug prescribed to patients in chronic follow-up clinics of the University of Gondar Teaching Hospital (UOGTH) is not based on the Global Initiative for Asthma Management and Prevention (GINA) standard. The prescription asthma treatment was low, for example, over 11.85 of the patients received oral salbutamol therapy instead of inhaled salbutamol. The reason may be the cost because inhaled steroid and beta<sub>2</sub> agonist are more expensive than oral salbutamol. The cost has been recognized as a factor in asthma medication use in many developing countries. The 73.5% of the patients received oxygen treatment. This finding may be due to less cost of oxygen drug. This result agreed with the study conducted in Uganda in 2012.<sup>6</sup> The 35.5% of the patients received Prednisolone. This drug highly recommended in GINA, this result is almost agreed with the Global Initiative for Asthma Management and Prevention (GINA) 2014.<sup>7,16</sup> The percentage coverage who received theophedrine drug was 8.06%. This result is relatively comparable with studies conducted in Ethiopian and India.<sup>7,17</sup> 7.35% of patients received dexamethasone.

This study has demonstrated that women, rural resident patients, patients who had a habit of regular physical exercise, patients who were asthmatic in childhood stage, patients who live with a pet, patients who had depression, patients who had asthma in their family have a greater risk of having severe asthma than were not. And patients in the dry season and patients who were regular cooks were less likely to develop severe asthma.

The study shows that there is a significant association between sex and asthma severity. Females had more often severe asthma than men. This is due to the fact that in females, there is a relative change in work activity which leads to more opportunities to develop severe asthma. This

result is comparable to the study conducted in England,<sup>18</sup> Sweden,<sup>19</sup> Indian,<sup>20</sup> and Columbia.<sup>16</sup> There is a significant difference in the asthma severity between urban and rural residential patients. This study showed that people living in rural areas were highly risked to develop severe asthma than people live in urban areas. The possible reason for the higher frequency of rural resident patients will be less understanding of factors of asthma than urban resident patients. This result is agreeing with the study conducted in India.<sup>20</sup>

This study also showed that the dry season is less likely to increase asthma severity than the rainy season. Since asthma is a thickening of the airway wall problem, this airway wall may relax in the dry season. This result was agreed with the study conducted in China 2015, Uganda.<sup>6</sup> This study showed that patients who had regular cooking habits were less likely to develop severe asthma. This result contradicts the study conducted in China,<sup>2</sup> England.<sup>18</sup> This contradicted result may be due to the study methodology difference that they use. Patients who live with the allergen to pets are highly risked to increase asthma severity. A dog or cat quickly becomes a member of the family, and unfortunately, many allergic animal lovers find themselves facing the daily discomfort of persistent allergy symptoms and this allergy symptom may lead to increased severity of asthma. This result is comparable to the study conducted in Sweden,<sup>19</sup> Columbia.<sup>16</sup> Patients who had a habit to do regular physical exercise were highly risked for severe asthma in this study. This indicates an asthma type is exercise-induced which is exacerbated by regular physical exercise. This result is contradicting with the Global Initiative for Asthma Management and Prevention (GINA) 2014.<sup>16</sup>

In this study, the result showed that patients who had asthma in their family were highly risked to increase severity levels of asthma, suggesting that genetic factors play a central role in increasing asthma severity. This result agreed with the study in China<sup>2</sup> and India.<sup>20</sup> Patients who were asthmatic in the childhood stage were highly risked for severe asthma in this study. Reactivity to inhalant allergens may increase with age. This result is agreeing with the study conducted in China<sup>2</sup> and the Netherlands. Patients who were depressed were highly risked to develop severe asthma than among those who were not. Since depression is mental tiredness, this case psychological activity plays an active role in the genesis of asthma. This result is comparable with a study conducted in India,<sup>20</sup> and Columbia.<sup>16</sup>

## Limitation of the Study

One of the limitations of this study was all patients who were proposed to be included in the study were not coming to the clinic during the data collection time and hence the proposed number of respondents decrease. The main problem for the study is data incompleteness, especially for data related to age, season of the register and severity level. Shortage of appropriate equipment may violate real variable effect (like allergy test, infection test) in the study. The shortage of literature available nationally in Ethiopia limits the prior variable selection for asthma severity.

## Conclusions

Symptoms and types of treatments prescribed were identified. Eighteen predictors were selected for the study and Univariable ordinal logistic regression models were developed to assess the relationship between asthma severity and the selected variables. Based on the results, the multiple ordinal logistic regression analysis was applied to select the most important risk factors for asthma severity.

The study showed that demographic, environmental, genetic, and health-related factors have a significant effect on asthma severity. The study also showed that severe asthma is more likely for females as compared to those males. Rural resident patients were more likely to develop severe asthma than urban resident patients. And the dry season is less likely to asthma severity than the rainy season. Patients who had a habit of regular physical exercise, asthma in childhood, allergen to pet, depressed patients, patients who had asthma in their family history were more likely to develop severe asthma than were not. Patients who were regular cooks were less likely to develop severe asthma than non-cooker.

## Recommendations

Based on the study finding, the following issues should be considered and promoted for improving the prevention of asthma disease in the community. The medication prescribed for asthmatic patients in chronic illness, medication and follow-up clinic of the University of Gondar Teaching Hospital (UOGTH) were not based on the Global Initiative for Asthma Management and Prevention (GINA) guidelines. So, medication prescription should be based on the Global Initiative for Asthma Management and Prevention (GINA) guidelines on the quality-assured, affordable, essential asthma medicines.

The females were found to be positively related to the increment of asthma severity, showing that the respected organization should give priority for women to create an understanding of the work which leads to the asthma severity level increment.

In this study, rural area has a very significant impact on the increment of asthma severity. In this case, health extension workers, health centers and Hospital professionals have a positive impact on creating programs that focus on creating awareness about the facilitator of asthma severity.

Pets (cats, dogs, rodents and horses) have a statistically significant impact on the severity of asthma. So, the respected organization should actively participate in educating the community about animals and asthma relationships.

Health extension workers, health centers and Hospital professionals have a positive impact on prevention, management of asthma through patient education, counseling on the effects of family history on asthma, asthma in childhood, depression, and season.

Further research needs to be taken by including other factors that are not included in this study (like income, occupation, duration before diagnosed).

## Abbreviations

AIC, Akaike information criteria; BIC, Bayesian information criteria; BMI, body mass index; GINA, Global Initiative for Asthma Management and Prevention; ICS, inhaled corticosteroid; UOGTH, University of Gondar Teaching Hospital; WHO, World Health Organization; Ologit, ordinal logit.

## Ethical Approval and Consent to Participate

This study was approved by the ethical clearance review committee of the University of Gondar. The University of Gondar hospital administration also expressed their willingness after they were informed about the whole purpose of the research. Written consent was obtained from each study subject. Participants were told the objective of the study and their right to refuse to give an answer for the data collectors. Any information that was obtained during the study was kept confidential.

## Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and

interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All authors read and approved the final manuscript.

## Disclosure

The authors report no possible conflicts of interest in this work.

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