Risk Factors of Asthma among Michigan Adult Population: Analysis of BRFSS 2018 data

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ABSTRACT

Studies in the past have explored asthma prevalence in the United States using national survey data. However, there are limited literatures specific to Michigan that have studied the association between asthma and various predictors. Using a secondary dataset from the 2018 Behavioral Risk Factor Surveillance System, we attempt to calculate the current asthma prevalence, understand various associations and identify risk factors of asthma among adults in Michigan. A total of 10,245 cases were analyzed to meet the objectives of the study. The current asthma prevalence was calculated to be 11.2%. In the univariate analysis, asthma was found to be significantly associated with the various demographic, socio-economic and health-related predictors under study. In the final model, we found female sex, age-group (18-24), below high school education, income in the $15,000-25,000 range, inability to work, obesity (BMI≥3000), borderline diabetes and presence of COPD as the potential risk factors of asthma.

BACKGROUND

In general terms, the Center for Disease Control and Prevention (CDC) defines asthma as a disease that affects lungs. It is one of the most common long-term diseases of children, but adults can have asthma, too. CDC identifies that asthma causes repeated episodes of wheezing, breathlessness, chest tightness, and nighttime or early morning coughing. Both incidence and prevalence of asthma have been increasing in the United States. Current asthma prevalence increased from 7.3% in 2001 to about 7.9% in 2017 [1]. Michigan has higher asthma prevalence rates than the national average. Based on 2016 Behavioral Risk Factor Survey (BRFSS), an estimated 10.9% of Michigan adults had current asthma [2]. Current asthma is defined as the proportion of adults who reported that they still had asthma during the survey period. Although asthma cannot be cured, it can be managed by avoiding things that trigger asthma attacks and receiving appropriate medical care. In this regard, this study attempts to identify demographic, socio-economic and health-related risk factors of asthma.

BRFSS is administered and supported by CDC and field operations are managed by state health departments in all the states in the US and participating US territories. It is a telephone survey designed to collect data on health-related risk behaviors, chronic health conditions, health care access, and use of preventive services form the noninstitutionalized adult population (≥18 years) residing in the United States [3]. This study utilizes the BRFSS 2018 data for Michigan to study prevalence of current asthma and identify the risk factors of asthma among Michigan adult population.

METHODOLOGY

BRFSS has been conducting both landline telephone and cellular telephone-based surveys since 2011. All the responses are self-reported. The respondents are randomly selected adult in a household for the landline telephone survey. For the cellular-telephone survey, those who answer the cellular telephones residing in a private residence of college housing were included. States conduct the interviews and data are transmitted to CDC [3]. A total of 437,436 responses was collected during BRFSS 2018 [4]. This study extracted the data from Michigan respondents for the necessary analysis. Among the 10,322 respondents from Michigan, we excluded cases that were missing for the outcome variable (current asthma) resulting to a sample of 10,245 respondents for this study. From the BRFSS survey, an individual would be considered to have a current asthma if he/she responded "Yes" to the question: "Do you still have asthma?". It should be obvious that this question was asked to those respondents who were ever told (by a doctor, nurse or other health professional) that they had an asthma.

Selection of Variables

The present study attempted to identify statistically significant risk factors of asthma among several factors/variables considered to be related to asthma. These variables were selected based on past studies and categorized into three categories: i) Demographic: gender, age-group, place of residence ii) Socio-economic: education, income, employment, veteran status and iii) Health-related: physical exercises, smoking and drinking habits, body mass index (BMI), diabetes, and chronic obstructive pulmonary disease (COPD).

Statistical Analysis

Descriptive statistics in tabular form have been used to present the background characteristics of the respondents. BRFSS developed weights for the survey and the current study uses those weights for all statistical analysis. Weights are computed using iterative proportional fitting (or "raking") methodology. Potential bias resulting from selection probabilities and noncoverage among segments of the population can be reduced through weighting [3]. As a result, weighting makes sample more representative of the entire population.

Inferential statistics such as Chi-square tests and Independent samples t-test have been used as univariate analysis methods to study the association of outcome variable with various factors. Factors found significant in univariate analysis were entered in the final model. The multivariable logistic regression model was developed to identify potential risk factors for asthma. P-values less than 0.05 were considered statistically significant in the final model. All analyses were performed using SAS 9.4.

RESULTS

A total of 10,245 samples were considered for analysis in this study. Table 1 presents the distribution of survey respondents in various demographic/socio-economic groups.

Table 1: Demographic and Socio-economic characteristics of the survey participants (Sample size=10,245)

Variable	Unweighted Frequency ($n^{\#}$)	Weighted %

Gender		
Male	4818	48.8
Female	5422	51.2
Age group (years)		
18-24	810	12.7
25-34	1218	16.1
35-44	1237	14.9
45-54	1625	16.3
55-64	2121	17.9
65 and above	3234	22.1
Education		
Below High School	482	10.2
High School	2630	29.3
Attended college/technical school	3164	34.9
Graduated from college/technical school	3935	25.6
Annual Income		
Below $15,000	738	7.2
$15,000 - $25,000	1249	12.7
$25,000 - $35,000	834	7.9
$35,000 - $50,000	1214	11.6
$ 50,000 or more	4425	41.9
Don't know/Not Sure/Missing	1785	18.6
Employment Status		
Employed for wages	4309	46.2
Self-employed	835	8.9
Out of work for 1 year or more	191	2.2
Out of work for less than 1 year	223	2.6
A homemaker	484	5.6
A student	379	5.6
Retired	2920	20.8
Unable to work	787	8.1
Residence		
Urban counties	9377	92.4
Rural counties	868	7.6
Veteran (Active duty in US Armed Forces)		
Yes	1069	9.2
No	9138	90.8

[#]n may not equal to 10,245 for some variables due to missing values.

The sample comprised of slightly more females than males. Regarding age-groups, the maximum number of respondents were aged 65 and above. Since education attained by the patients could possibly help manage asthma symptoms, we studied the distribution of respondents by education level. More than one-third of the respondents had at least attended college/technical school. Nearly 7% of the respondents had income below $15,000 while nearly 42% had $50,000 or more. Regarding employment status, nearly half of the total respondents were employed for wages during the survey time. Literatures suggested that asthma may also be associated with where an individual resides. Majority (92.4%) of the survey respondents reported to have been living in urban counties.

Nearly 10% of the respondents were identified as veteran meaning that they had served in the US Armed Forces.

Table 2: Health-related characteristics of the survey participants (Sample size=10,245)

Variable	Unweighted Frequency (n[#])	Weighted %
Doing physical activity/exercise (past 30 days)		
Yes	7838	76.3
No	2395	23.7
Current Smokers		
Yes	1645	18.8
No	8233	81.2
Smoked at least 100 cigarettes		
Yes	4497	45.3
No	5386	54.7
Drinks on single occasion (past 30 days) *	6.18 ± 0.25	
BMI Categories		
Underweight (<1850)	154	1.8
Normal Weight (1850-2499)	2862	30.7
Overweight (2500-2999)	3406	34.6
Obese (3000 or above)	3101	32.9
Diabetes history		
Yes	1346	12.4
No	8690	85.9
Pre-diabetes/Borderline	196	1.7
COPD history		
Yes	951	8.5
No	9241	91.5

[#]n may not equal to 10,245 for some variables due to missing values. * Number of drinks expressed as Mean ± S.D

During survey time, it was found that 76.3% of the respondents were doing some form of the physical activity since the last 30 days. Nearly one-fifth of them were smokers while nearly one-half smoked at least 100 cigarettes in their life. The average number of drinks taken by survey participants in the last 30 days was just above 6. Nearly equal proportions of them were in the normal weight, overweight and obese categories. Along with the asthma, the self-reported diabetes prevalence in the sample was 12.4%. We also found that 8.5% of the respondents had a COPD history. Like asthma, COPD is an obstructive pulmonary disease [5].

Current asthma prevalence among the Michigan adult population was calculated to be 11.2%.

Association of current asthma prevalence with variables under study

Before developing the final model, it is required to identify variables that are significantly associated with the outcome). We performed Chi-square test for categorical variables and independent samples t-test for continuous variables to study this association. The final model was developed with all significant variables from the univariate analysis.

Table 3: Association between current asthma and demographic/socio-economic characteristics

Variables	Active Asthma		Chi-Square #	P-Value
	Yes	No		
Gender				
Male	377 (8.3) *	4441 (91.7)	47.652	<0.0001
Female	706 (13.9)	4716 (86.1)		
Age group (years)				
18-24	107 (14.0)	703 (86.0)	15.2	0.0095
25-34	132 (10.6)	1086 (89.4)		
35-44	139 (11.8)	1098 (88.2)		
45-54	193 (12.7)	1432 (87.3)		
55-64	239 (11.0)	1882 (89.0)		
65 and above	273 (8.8)	2961 (91.2)		
Education				
Below High School	84 (17.3)	398 (82.7)	30.574	<0.0001
High School	285 (10.6)	2345 (89.4)		
Attended college/technical school	386 (12.1)	2778 (87.9)		
Graduated from college/technical school	322 (7.9)	3613 (92.1)		
Annual Income				
Below $15,000	129 (18.7)	609 (81.3)	62.945	<0.0001
$15,000 - $25,000	188 (15.6)	1061 (84.4)		
$25,000 - $35,000	96 (13.3)	738 (86.7)		
$35,000 - $50,000	109 (9.0)	1105 (91.0)		
$ 50,000 or more	345 (7.9)	4080 (92.1)		
Don't know/Not Sure/Missing	216 (13.3)	1569 (86.7)		
Employment Status				
Employed for wages	406 (9.5)	3903 (90.5)	80.126	<0.0001
Self-employed	71 (9.0)	764 (91.0)		
Out of work for 1 year or more	32 (15.4)	159 (84.6)		
Out of work for less than 1 year	32 (16.1)	191 (83.9)		
A homemaker	49 (12.1)	435 (87.9)		
A student	45 (12.7)	334 (87.3)		
Retired	244 (8.7)	2676 (91.3)		
Unable to work	188 (24.5)	599 (75.5)		
Residence				
Urban counties	989 (11.1)	8388 (88.9)	0.968	0.3252
Rural counties	94 (12.9)	774 (87.1)		
Veteran (Active duty in US Armed Forces)				
Yes	72 (7.2)	997 (92.8)	15.261	<0.0001
No	1006 (11.6)	8132 (88.4)		

** Figures in the parenthesis represent percentages.*
 # Reported values are Rao-Scott F adjusted Chi-square statistic obtained using PROC SURVEYFREQ procedure.

The prevalence of asthma was significantly different across the groups considered. Each of the factors: gender, age-group, education, annual income, employment status was significantly associated with asthma. More females (13.9%) had an active asthma compared to males (8.3%). Regarding age-groups, the youngest group (18-24 years) had the highest rate. People who did not complete high school reported the largest prevalence of the disease (17.3%). Asthma rates were different among respondents in different income and employment status groups. Place of residence: urban vs rural counties had no significant association with the outcome. This is in similar line to previous finding by Frazier et.al [6]. Asthma was also found to be significantly associated with someone being a veteran. Recent study by Rivera et.al. [7] also found US military service members deployed in Iraq and Afghanistan had higher rates of new-onset asthma than those who did not deploy.

Table 4: Association between current asthma and health-related characteristics

Variables	Active Asthma		Chi-Square	P-Value
	Yes	No		
Doing physical activity/exercise (past 30 days)				
Yes	743 (10.1)	7095 (89.9)	19.016	<0.0001
No	337 (14.6)	2058 (85.4)		
Current Smokers				
Yes	812 (10.7)	7421 (89.3)		
No	228 (13.4)	1417 (86.6)	5.519	0.0633
Don't know/Refused/Missing	43 (10.9)	324 (89.1)		
Smoked at least 100 cigarettes				
Yes	505 (11.7)	3992 (88.3)	0.976	0.3232
No	535 (10.8)	4851(89.2)		
Drinks on single occasion (past 30 days)	7.3 ± 16.4	5.5 ± 12.9	-2.42	0.0156
BMI Categories				
Underweight (<1850)	21 (9.9)	133 (90.1)		
Normal Weight (1850-2499)	225 (9.0)	2637 (91.0)	41.116	<0.0001
Overweight (2500-2999)	315 (9.2)	3091 (90.8)		
Obese (3000 or above)	428 (15.0)	2673 (85.0)		
Diabetes history				
Yes	201 (15.1)	1145 (84.9)		
No	864 (10.7)	7826 (89.3)	15.125	0.0005
Pre-diabetes/Borderline	15 (7.5)	181 (92.5)		
COPD history				
Yes	304 (33.7)	647 (66.3)	115.819	<0.0001
No	765 (9.0)	8476 (91.0)		

Physical activities/exercises were found to be associated with asthma. Those who reported not doing any exercises had higher prevalence rates. Although it is recommended that people with asthma should get regular exercise, it can also trigger asthma symptoms. The association between asthma and smoking has not been clearly understood yet. In similar direction to previous studies, we found no significant relationship between asthma and current smokers as well as those who smoked at least 100 cigarettes in their lifetime. Possibly this was due to the cross-sectional nature of the survey. Drinking habit was found significantly associated and the average number of drinks was higher for those who developed asthma.

Body Mass Index was another characteristic significantly related to asthma which is a well-established result [8,9]. Respondents with normal weight had the lowest asthma incidence (9%) while the obese had the highest rate (15%). Obesity has been found to be associated significantly with the development of asthma, worsening asthma symptoms and poor asthma control.

Diabetes has been established as a significant risk factor, Ehrlich et.al [10] and our study also revealed that respondents with diabetes had higher asthma rates. Similarly, asthma incidence was higher among respondents with COPD history than those without it (33.7% vs 9%).
Now, we select predictors for the multivariable analysis. From univariate analysis, we pick variables with p-values less than 0.20 because a traditional level (such as 0.05) often fails to identify variables known to be important [11].

Checking multicollinearity among the predictors

One important requirement for the multivariable logistic regression is that there should be no multicollinearity among the predictors. We refer to the values of variance inflation factors to detect the presence of multicollinearity.

Table 5: Collinearity statistics among predictors

	Collinearity statistics	
	Tolerance	VIF
Gender	0.919	1.088
Age group (years)	0.786	1.273
Education	0.915	1.093
Annual Income	0.983	1.017
Employment Status	0.824	1.214
Veteran (Active duty in US Armed Forces)	0.892	1.122
Doing physical activity/exercise (past 30 days)	0.951	1.051
Current Smokers	0.961	1.041
Drinks on single occasion (past 30 days)	0.959	1.043
BMI Categories	0.950	1.052
Diabetes history	0.939	1.065
COPD history	0.985	1.015

VIFs greater than 10 pose serious threat of multicollinearity. In our model, low values of VIFs were noted so we can proceed with all predictors for the multivariable logistic regression.

Finding of the multivariable logistic regression model

Our dependent (outcome) variable is the presence of current asthma in which the event is denoted by 1 and non-event is 2. We developed the model below considering all the predictors discussed above.

Table 6: Multivariable logistic regression output

Variables	B (Coefficients)	SE	OR	P-value	95% CI for OR	
					Lower	Upper
Gender						
Male	-0.5927	0.1411	0.55	<0.0001	0.42	0.73
Female (Ref.)					1	
Age group (years)						
18-24	0.9326	0.3134	2.54	0.0029	1.37	4.69
25-34	0.2355	0.3178	1.26	0.4588	0.67	2.36
35-44	0.306	0.2855	1.36	0.2838	0.78	2.38
45-54	0.2632	0.2765	1.3	0.3411	0.76	2.24
55-64	0.0358	0.2408	1.03	0.8817	0.65	1.66
65 and above (Ref.)					1	
Education						
Below High School (Ref.)					1	
High School	-0.9098	0.3341	0.4	0.0065	0.21	0.78
Attended college/technical school	-0.4872	0.3342	0.61	0.145	0.32	1.18
Graduated from college/technical school	-0.6333	0.3411	0.53	0.0634	0.27	1.04
Annual Income						
Below $15,000	-0.1092	0.3389	0.86	0.7473	0.46	1.74
$15,000 - $25,000	0.5077	0.2115	1.66	0.0164	1.09	2.52
$25,000 - $35,000	0.2815	0.2491	1.33	0.2585	0.81	2.16
$35,000 - $50,000	-0.0545	0.2263	0.95	0.8096	0.61	1.47
$ 50,000 or more (Ref.)					1	
Don't know/Not Sure/Missing	-0.0147	0.2174	0.99	0.9463	0.64	1.51
Employment Status						
Employed for wages	0.0538	0.2572	1.06	0.8344	0.64	1.75
Self-employed	0.2572	0.2959	1.3	0.3848	0.72	2.31
Out of work for 1 year or more	0.5838	0.4569	1.79	0.2014	0.73	4.39
Out of work for less than 1 year	0.487	0.4398	1.63	0.2682	0.69	3.86
A homemaker	0.361	0.333	1.43	0.2784	0.74	2.76
A student	0.3882	0.4095	1.45	0.3433	0.66	3.29
Retired (Ref.)					1	
Unable to work	0.9203	0.341	2.51	0.007	1.29	4.9

Veteran (Active duty in US Armed Forces)						
Yes	0.0541	0.2497	1.06	0.8286	0.64	1.72
No (Ref.)					1	
Doing physical activity/exercise (past 30 days)						
Yes	-0.0058	0.1707	0.99	0.9729	0.71	1.39
No (Ref.)					1	
Current Smokers						
Yes	-0.3589	0.1961	0.7	0.0672	0.48	1.03
No (Ref.)					1	
Don't know/Refused/Missing	0.7528	0.5782	2.12	0.193	0.68	6.6
Drinks on single occasion (past 30 days)	0.00623	0.00424	1.006	0.1422	0.99	1.02
BMI Categories						
Underweight (<1850)	-0.2139	0.4621	0.81	0.6435	0.33	1.99
Normal Weight (1850-2499) (Ref.)					1	
Overweight (2500-2999)	0.2429	0.1743	1.28	0.1634	0.91	1.79
Obese (3000 or above)	0.5979	0.1783	1.82	0.0008	1.28	2.58
Diabetes history						
Yes	0.1164	0.2183	1.12	0.5939	0.73	1.72
No (Ref.)					1	
Pre-diabetes/Borderline	-4.0958	1.0479	0.02	<.0001	0.002	0.13
COPD history						
Yes	1.571	0.2004	4.81	<.0001	3.25	7.13
No (Ref.)					1	

Results of the multivariable logistic regression model show that males are less 45% less likely to develop asthma than females and the result is statistically significant. Regarding age groups, respondents in all age-groups had higher possibilities of getting asthma compared to the respondents aged 65 and above. However, statistical significance was established only for respondents in the 18-24 years age group. Asthma among young age-groups is the most common.

Education had a significant association with asthma in the univariate analysis. However, with other predictors considered, only those who attended high school had significantly low odds. Those who attended high school and above were less likely to develop asthma compared to those who did not complete high school.

Only some levels of income and employment status were found to be significant predictors of asthma. The study established that respondents in income categories between $15,000-$25,000 had significantly higher odds of getting asthma. This may be because they are unable to support themselves for medical help due to low income. People who were unable to work had higher risk of getting asthma. This could be the other way around: people developing asthma might have left their work. Due to the cross-sectional nature of the survey, this effect cannot be assessed properly.

Although the study showed that those who served in the US Armed Forces had slightly higher chances of getting asthma, the result was not found statistically significant. We already saw in the univariate analysis, the association of smoking with asthma is dubious. Due to the survey nature, it might be the case that respondents with asthma might have quitted smoking compared to those without asthma so, a clear understanding of the association is not established. Increase in the number of drinks slightly increased the risk of asthma, although not statistically significant.

The study showed that obese people were 82% more likely to get asthma than those in the normal weight groups. Several other studies have also established this association and thus obesity is an established risk factor of asthma [8,9].

Recent studies Baek et.al. [12] also claimed the association of diabetes with asthma. Our model showed that although people with diabetes had higher odds, however the result was not statistically significant. Those in the borderline diabetes group had 2% lower chances of getting the disease. COPD, on the other hand, was found to be a significant predictor. Respondents with COPD were nearly 5 times more likely to develop asthma than those without COPD.

Goodness of fit tests

All the goodness of fit tests suggest that the model is adequate. The Akaike Information Criterion, Schwarz Criterion and -2 log likelihood (lower the better) values indicate that the model with the selected covariates is superior to model with intercept only.

Table 7: Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	2425283.9	2189460.1
SC	2425297.1	2189894.8
-2 Log L	2425281.9	2189394.1

The overall logistic regression model was highly significant at the 5% level as indicated by the Likelihood ratio, Wald and Score tests (all p-values <0.0001) of the global null hypothesis that the model parameters are significant. Although we do not intend to make predictions from this model, it was noted that the Somer's D value (better if close to -1 or 1) was 0.407 and the area under the receiver operator characteristics (ROC) curve was 70.4%.

DISCUSSION

The study used data from a national survey to calculate current asthma rates among Michigan adult population. The major strength of this study is that it uses weights to make sample results more representative of the entire Michigan population. As the data were taken from telephonic interview, all results are self-reported by the respondents. One limitation from these kinds of study is that the survey respondents might not correctly recall all the information resulting to recall bias.

The results show that the prevalence of current asthma in Michigan was 11.2% in 2018. We found that males had lower prevalence of asthma (8.3% in males vs 13.9 in females, OR=0.55, 95%

CI:0.42,0.73). As DeMarco et.al.[13] suggests, this could be attributed partly to lower airway caliber in female. The lowest age group of respondents (18-24) years had significantly higher odds of getting asthma.

If income level and employment status were to be considered as an indicator of socio-economic status, this study found that the impact was not consistent among groups of income level and employment status. This was in contrary to previous studies by Hedlund et.al.[14] that mainly uses occupation as the base of classification. People doing regular exercises had lower asthma prevalence. Some dubious results were observed between the association of asthma and smoking. Further studies are required to understand the actual relationship. Asthma prevalence was higher among those in the overweight and obese groups. Again, this has been reported in multiple previous studies that obese patients tend to have worse asthma control and increased hospitalizations compared to lean patients with asthma. Although diabetes patients were found to have higher odds of getting asthma, the odds ratio was not statistically significant in the final model. Patients with COPD history were 5 times more likely to get asthma. Often, COPD and asthma has been misunderstood to be the same. However, significant differences prevail between the two as discussed in [5].

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