Juvenile Asthma in the U.S. Relate Asthma Incidence to Body Mass Index

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Abstract: Asthma is one of the most common chronic diseases among humans, juveniles. Obesity, as many studies suggest, is related to the development of asthma. This research study intends to identify the strength of correlation between BMI and asthma in different gender and ethnic groups and explore whether the incidence of asthma increases with higher BMI. Here, researchers first divided the data collected from the National Health and Nutrition Examination Survey into two groups by the variable _Have_Asthma_. T-tests for the difference in means were then employed to show that the average BMIs for the two groups differ in a statistically significant way. Quantile analyses were also used to compare the proportion of people having asthma in each BMI quantile. To quantify the strength of correlation, a bootstrap confidence interval was built and logistic regression models for the data from 2015 to 2016, and 2017 to 2018. To avoid the collinearity between gender and BMI, the researchers also built separate logistic models for each gender. The authors concluded that juveniles with higher BMI have a higher risk of getting asthma. Male juveniles have an overall higher risk of getting asthma than female juveniles. Non-Hispanic black juveniles are more likely to have asthma than Mexican American juveniles and non-Hispanic white juveniles.

1 INTRODUCTION

Asthma, a prevalent and variable disease, can range in severity from mild, with few obvious symptoms, to severe, which is characterized by acute or subacute progressive exacerbations of asthma symptoms (Lloyd, Price and Brown 2007, Mukherjee et al 2016). There is a large amount of epidemiological evidence showing that obesity is one of the most influential factors of asthma (Forno 2020). However, few studies are targeting specific age groups, especially juveniles (under 18 years old). Bidirectional Mendelian randomized studies in children and adults have shown an association between genetic risk score for obesity and subsequent development of asthma, but not between asthma genes and subsequent obesity (Chen, Fan, Huang, Liou and Lee 2019, Xu, Gilliland and Conti 2019). In addition, studies have shown that weight loss can significantly improve asthma symptoms and lung function (Okoniewski, Lu and Forno 2019). Similarly, some studies have found that obese asthma patients are difficult to manage, with poor lung function and weak response to asthma medication (Boulet and Franssen, Dixon, Shade, Cohen et al 2006). As juvenile asthma and obesity are becoming pressing public health issues around the globe, investigating the strength of correlation between BMI and asthma in the under-age population may benefit the prevention and prognosis of juvenile asthma. Based on the literature review, researchers in this study hypothesized that the incidence of asthma increases with higher BMI among juveniles. T-tests, quantile analyses, bootstrap confidence intervals, and logistic regression models were employed to identify and quantify the correlation between BMI and asthma incidence among juveniles grouped by different ethnicities and genders.

2 METHODS

2.1 Data Source and Screening

Our data set was downloaded from the National Health and Nutrition Examination Survey. The

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researchers merged the 2015-2016 data frame and 2017-2018 data frame, getting a sample size of 19225. Then select all rows that have a value of age less than 18, yielding a subset that has 7377 individuals. Next, screening the data, excluding individuals that have a missing value in the columns of Age, Sex, Ethnicity, Have Asthma, and BMI. The final complete data frame includes 5666 individuals.

Welch's T-tests

To avoid ambiguity and ensure enough data, Non-Hispanic White, Non-Hispanic Black, and Mexican American ethnicities were selected for further study. To control variables, the whole data was subsetted based on _Ethnicity_ (Mexican American, non-Hispanic whites, and non-Hispanic black) and _Gender_ (Male and Female). Six subgroups (e.g. Male+Mexican American) were then obtained. Each subgroup was further split by the categorical variable _Have_Asthma_ into two groups, which are the individuals that have asthma and the individuals that do not have asthma. Two sample t-tests were then conducted to compare the average BMI of asthma patients and people without asthma in each subgroup. Welch's t-test was chosen because the two samples compared have different sample sizes.

2.2 Quantile Analysis

Different from the previous subdivision, this time the data was subgrouped by each gender and each ethnicity separately, yielding five subgroups in total, which were used to conduct quantile analysis. The sample sizes of the five ethnic groups are 1678(Non-Hispanic White), 1086(Mexican American), 1312(Non-Hispanic Black), 1000(Other Race), and 589(Other Hispanic). The sample sizes of the two gender groups are 2842 (male) and 2823(female).
Q1 (First 25%), Q2(First 25%-50%), Q3(50%-75%), Q4(Last 25%).

2.3 Model Building

A statistical comparison is made between two classified sets. A preliminary hypothesis was made by directly comparing the number of people who have asthma in Q1-Q4. Case resampling will then be utilized to obtain a 95% bootstrap confidence interval for the correlation between BMI and asthma. Logistic regression models were then built to explore the correlation between asthma and other selected variables.

3 RESULTS

Welch's t-test for the Mexican American male group shows that the average BMIs of people with and without asthma are 20.81 and 22.84, respectively. The other t-test for the Mexican American female group showed that the average BMIs of people with and without asthma were 20.63 and 23.15, respectively. The p-values were both less than 0.05, indicating the differences in means were statistically significant (Figure 1).

Sample Subgroups	Have Asthma	Welch's T-tests	
		Mean (BMI)	P-value
Mexican American Male	Yes	20.81	0.014
	No	22.84	
Mexican American Female	Yes	20.63	0.0086
	No	23.15	
Non-Hispanic White Male	Yes	19.07	0.0018
	No	20.61	
Non-Hispanic White Female	Yes	19.11	7.98E-07
	No	21.73	
Non-Hispanic Black Male	Yes	19.38	0.0274
	No	20.62	
Non-Hispanic Black Female	Yes	20.76	0.1416
	No	21.7	

Figure 1: T-test Result for Mexican American Samples.

Welch's t-test for the non-Hispanic white male group showed that the average BMIs of people with and without asthma were 19.06 and 20.61, respectively. The other t-test for the non-Hispanic white female group showed that the average BMIs of people with and without asthma were 19.11 and 21.73, respectively. The p-values were both less than 0.05, indicating the differences in means were statistically significant.

Welch's t-test for the non-Hispanic black male group showed that the average BMIs of people with and without asthma were 19.38 and 20.62, respectively. The p-value was less than 0.05, indicating the difference in means was statistically significant. The other t-test for the non-Hispanic black female group showed that the average BMIs of people with and without asthma were 20.76 and 21.70, respectively. The p-values were greater than 0.05, indicating that the difference in means was not statistically significant.

The BMI-based distribution quantile analyzed for each gender group were in Figures 4 and 5. In general, our male sample had a higher overall asthma incidence (18.0%) than the female sample (13.5%). Though the male sample had a higher proportion of asthma population in all quantiles, there was not much difference between the two samples in the fourth quantile (23.7% vs. 21.2%), revealing the fact that the incidence of asthma was nearly the same for males and females with high BMI. In short, the incidence of asthma increased with higher BMI for both genders, and male juveniles were more likely to get asthma than female juveniles did (figure 2).

	Q1 (N=727)	Q2 (N=705)	Q3 (N=715)	Q4 (N=695)	Overall (N=2842)
Age					
Mean (SD)	6.15 (2.96)	7.06 (4.00)	10.7 (4.30)	12.7 (3.38)	9.14 (4.56)
Median [Min, Max]	6.00 [2.00, 16.0]	7.00 [2.00, 17.0]	11.0 [2.00, 17.0]	13.0 [2.00, 17.0]	9.00 [2.00, 17.0]
Ethnicity					
Mexican American	87 (12.0%)	104 (14.8%)	125 (17.5%)	166 (23.9%)	482 (17.0%)
Non-Hispanic Black	191 (26.3%)	163 (23.1%)	174 (24.3%)	140 (20.1%)	668 (23.5%)
Non-Hispanic White	232 (31.9%)	227 (32.2%)	217 (30.3%)	187 (26.9%)	863 (30.4%)
Other Hispanic	61 (8.4%)	79 (11.2%)	86 (12.0%)	84 (12.1%)	310 (10.9%)
Other Race	156 (21.5%)	132 (18.7%)	113 (15.8%)	118 (17.0%)	519 (18.3%)
Have.Asthma					
No	634 (87.2%)	595 (84.4%)	569 (79.6%)	530 (76.3%)	2328 (81.9%)
Yes	93 (12.8%)	108 (15.3%)	145 (20.3%)	165 (23.7%)	511 (18.0%)
DK	0 (0%)	2 (0.3%)	1 (0.1%)	0 (0%)	3 (0.1%)
BMI					
Mean (SD)	15.1 (0.699)	17.0 (0.567)	19.9 (1.18)	27.5 (5.17)	19.8 (5.39)
Median [Min, Max]	15.2 [12.2, 16.0]	16.9 [16.1, 18.0]	19.8 [18.1, 22.0]	25.8 [22.1, 50.2]	18.0 [12.2, 50.2]

Figure 2: Total Male Samples .

	Q1 (N=752)	Q2 (N=671)	Q3 (N=702)	Q4 (N=698)	Overall (N=2823)
Age					
Mean (SD)	5.76 (2.79)	6.93 (3.86)	10.8 (4.02)	13.0 (3.05)	9.09 (4.53)
Median [Min, Max]	5.00 [2.00, 17.0]	7.00 [2.00, 17.0]	11.0 [2.00, 17.0]	13.0 [5.00, 17.0]	9.00 [2.00, 17.0]
Ethnicity					
Mexican American	135 (18.0%)	122 (18.2%)	162 (23.1%)	185 (26.5%)	604 (21.4%)
Non-Hispanic Black	149 (19.8%)	170 (25.3%)	134 (19.1%)	191 (27.4%)	644 (22.8%)
Non-Hispanic White	240 (31.9%)	211 (31.4%)	195 (27.8%)	169 (24.2%)	815 (28.9%)
Other Hispanic	57 (7.6%)	60 (8.9%)	90 (12.8%)	72 (10.3%)	279 (9.9%)
Other Race	171 (22.7%)	108 (16.1%)	121 (17.2%)	81 (11.6%)	481 (17.0%)
Have.Asthma					
No	693 (92.2%)	598 (89.1%)	599 (85.3%)	550 (78.8%)	2440 (86.4%)
Refused	1 (0.1%)	0 (0%)	0 (0%)	0 (0%)	1 (0.0%)
Yes	58 (7.7%)	72 (10.7%)	103 (14.7%)	148 (21.2%)	381 (13.5%)
DK	0 (0%)	1 (0.1%)	0 (0%)	0 (0%)	1 (0.0%)
BMI					
Mean (SD)	15.0 (0.804)	17.1 (0.639)	20.3 (1.27)	28.0 (4.96)	20.0 (5.56)
Median [Min, Max]	15.2 [11.5, 16.1]	17.1 [16.2, 18.3]	20.2 [18.4, 22.7]	26.4 [22.8, 51.3]	18.3 [11.5, 51.3]

Figure 3: Total Female Samples.

In all four BMI quantiles, the Non-Hispanic Black sample exhibits a higher asthma incidence rate than the other two ethnic groups. In the Non-Hispanic Black sample, all the quantiles except Q1 had an asthma incidence rate higher than 20% (Figure 3).

	Q1 (N=331)	Q2 (N=332)	Q3 (N=326)	Q4 (N=323)	Overall (N=1312)
Age					
Mean (SD)	5.76 (2.90)	6.79 (3.69)	11.1 (4.11)	12.9 (3.15)	9.09 (4.56)
Median [Min, Max]	5.00 [2.00, 15.0]	6.00 [2.00, 17.0]	12.0 [2.00, 17.0]	13.0 [2.00, 17.0]	9.00 [2.00, 17.0]
Gender					
Female	140 (42.3%)	163 (49.1%)	147 (45.1%)	194 (60.1%)	644 (49.1%)
Male	191 (57.7%)	169 (50.9%)	179 (54.9%)	129 (39.9%)	668 (50.9%)
Have.Asthma					
No	276 (83.4%)	259 (78.0%)	258 (79.1%)	237 (73.4%)	1030 (78.5%)
Refused	1 (0.3%)	0 (0%)	0 (0%)	0 (0%)	1 (0.1%)
Yes	54 (16.3%)	71 (21.4%)	68 (20.9%)	86 (26.6%)	279 (21.3%)
DK	0 (0%)	2 (0.6%)	0 (0%)	0 (0%)	2 (0.2%)
BMI					
Mean (SD)	15.1 (0.725)	17.0 (0.619)	20.1 (1.29)	29.2 (6.04)	20.3 (6.24)
Median [Min, Max]	15.2 [12.2, 16.0]	16.9 [16.1, 18.1]	20.0 [18.2, 22.5]	27.3 [22.6, 50.6]	18.1 [12.2, 50.6]

Figure 4: Non-Hispanic Black Samples.

The 95% bootstrap confidence interval is (0.09507, 0.10764), indicating that 95% of the time the population correlation between BMI and asthma fell within the range of 0.095 and 0.107. In the univariable logistic regression model (Figure 4), the p-value was smaller than 0.05, suggesting that it is significantly associated with asthma status. In the multivariable logistic regression model (Figure 5), variables that were significantly associated with asthma include sex, age, BMI, and Mexican American. The rest of the variables had an insignificant association with asthma. Researchers in this study found that sex had the lowest p-value, indicating a strong association between gender and the probability of having asthma. The positive coefficient of this predictor suggested that with all other variables being equal, males were more likely to have asthma. Being male increased the log odds by 0.3474. The accuracy of this model showed 0.82. The dataset was then split into two subsets by gender. P-values in logistic regression models for males and females, respectively, were both less than 0.05.

Variable	Logistic Regression Analysis Estimate	Standard Error	P value	Multivariable Logistic Regression Analysis Estimate	Standard Error	P value
BMI (kg/m^2)	0.0478	0.0059	<0.001	0.0292	0.0074	<0.001
Age (Years)				0.0447	0.0098	<0.001
Sex						
Male				0.3474	0.0747	<0.001
Race						
Mexican American				-0.3793	0.1429	0.00794
Non-Hispanic White				-0.2418	0.1306	0.06417
Non-Hispanic Black				0.2452	0.1290	0.05745
Other Race				-0.2736	0.1440	0.05741

Figure 5: Univariable and Multivariable logistic regression analysis, NHANES, 2015-2016,2017- 2018(5,666)

Figure 6 was created to help explain the results from the logistic regression. From the graph, it was obvious to see that people who did not have asthma were significantly higher than people who have asthma in the low to medium range of BMI from 15-25. Although there were fewer data within the range from 25-30 compared with the range from 15-25, it was still clear to see that the people with asthma occupy a larger proportion of the whole.

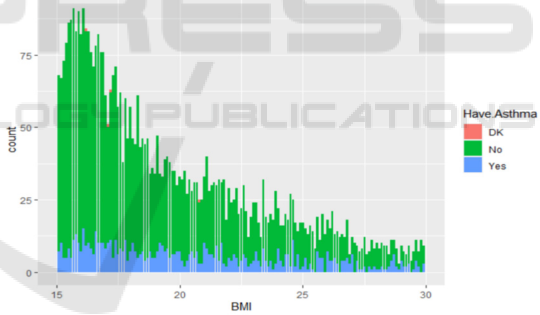

Figure 6: Distribution of asthma outcomes on the range of BMI.

4 DISCUSSION

A study shows that treating obese asthma patients has become a challenge since these patients have worse lung function and are less responsive to asthma medications. For these patients, the best and easiest treatment is to lose weight. Significant weight loss can improve asthma symptoms, lung function, or the rate at which asthma worsens (Dhabuwala and Cannan 2000). It was shown that bariatric surgery had significant effects on asthma controls, which led to an approximately 60% reduction in having asthma exacerbation (Peters, Dixon and Forno 2018). Their research has proved that the incidence of asthma is highly related to obesity, and losing weight is the best way to suppress asthma attacks, which also supports our conclusion that weight gain increases the risk of getting asthma. Moreover, some dietary habits and nutrition they absorb are also risk factors that might have impacts on children (Peters, Dixon and Forno 2018). Lack of vitamin D is a risk factor for the development of asthma (Peters, Dixon and Forno 2018). Infant feeding also plays an important role in the development of asthma among children (Figure 7) (Miliku and Azad 2018). Breastfeeding had also been considered as a factor, children who had been breastfeeding while they were infants were associated with a lower risk of asthma (Yan, Liu, Zhu, Huang and Wang 2014). This is due to the fact that there exists components in breast milk that can protect against allergies (Figure 8) (Oddy 2017). Therefore, there are multiple facets in life associated with having asthma. Children are also expected to develop good habits and diet to prevent asthma. Asthma exacerbations can take place at any time, however, there is a seasonal pattern among children (Herman, Hannah, Moshe, Erez and Ran 2014) , it was shown that there is an increased risk during the autumn (Sears and Johnston 2007). However, our research also has some flaws. Our study used BMI as the only indicator of obesity and did not delve into some other features that are shared by those obese people but cannot be quantified by BMI. Another study also pointed out that although the BMI indicator is a measure of physical factors, it does not identify body composition, adipose tissue, or metabolic disturbance. The criteria represented by BMI are too broad to capture a specific understanding of the nature of the disease (Forno 2020).

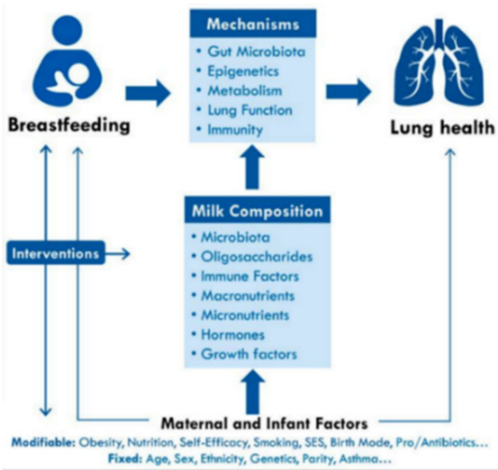

Figure 7: The impact of breastfeeding on lung health (Miliku and Azad 2018).

	Inducing	Protective
Antigens	sensitizing allergens	tolerizing allergens
Cytokines	IL-4 IL-5 IL-13	TGF-β soluble CD14
Immunoglobulins		s-IgA to ovalbumin
Polyunsaturated fatty acids	arachidonic acid C22:4n-6 C22:5n-6	eicosapentaenoic acid docosapentaenoic acid docosatetraenoic acid α-linoleic acid n-3 polyunsaturated fatty acids
Chemokines	RANTES IL-8	
Eosinophil-derived granular proteins	eosinophil cationic protein	
Polyamines		spermine spermidine

Figure 8: Factors that indues and protects against food allergies (Friedman and Zeiger 2005).

In this study, it was proven that the positive correlation between BMI and asthma incidence is significant, probably because obesity may affect free air movement in the lungs and thus can have a severe impact on the respiratory system (Azizipour and Yosra et al 2018). However, we still cannot define a causation relationship between BMI and asthma incidence. One possibility people need to consider was that having asthma might also influence BMI through a confounding variable, which is exercise. Though the value of exercise as a treatment aid was emphasized by many studies, it is also pointed out that vigorous physical activity can trigger bronchial narrowing and may result in bronchospasm (McFadden and Illeen 1994). Rapid breathing may cause evaporation of mucosal surface water and an increase in osmolarity, resulting in mast-cell degranulation and contraction of airway smooth muscle (Anderson 1984). In general, exercise-induced asthma is seen more commonly among children and young adults because of their high levels of physical activity. Given the controversy of the pathogenesis of exercise-induced asthma, some physicians would advise asthma patients not to overexert themselves. Thus, asthma patients may on average have a lower level of physical activity than people without asthma, putting them at a higher risk of having higher BMI. In short, the authors can only reveal a positive correlation at present. Whether there is a causation relationship between BMI and asthma incidence is still an unsolved question that needs further research.

In an epidemiological related study, obese individuals with a BMI greater than 30kg/m2 had a 92% increased risk of asthma (Beuther and Sutherland 2007). This research supports our results sufficiently. In a separate article of the effect of obesity on the incidence of asthma, the authors noted that analysis of both adults and children showed there are no prominent differences between females and males, which is consistent with our findings as well (Julia st al 2015). Since BMI is a comprehensive measurement to evaluate an individual's body condition, to better study the relationship between obese condition and asthma, a more precise definition is needed. For example, to explore and reduce the risk of asthma in obese individuals, nutritional indicators can be used, which better describe the inner changes of obese patients. Studies have shown that dietary restriction in obese asthmatic patients can improve bronchial hyperresponsiveness, airway inflammation and other related diseases (Dixon et al 2011). In contrast, a high-fat diet can increase airway neutrophilia and impair bronchodilator recovery in obese asthmatics (Wood, Garg and Gibson 2011). Although the results cannot give strong evidence to demonstrate that BMI plays a decisive role in the prevalence of asthma, other studies reveal that an unusual high BMI (>25kg/m2) often indicates an individual is obese in most cases, and strict diet control is proved efficient to reduce the incidence of asthma. Therefore, our study can better suggest obese individuals reduce the risk of having asthma according to their BMI.

There are also some studies stating that girls with high BMI would have a higher risk of having asthma (Ulrik, Lophaven , Anderson, Sørensen and Baker 2018). However, in our study, the authors find that there is no significant difference in asthma incidence between boys and girls with high BMI. Apart from sex and BMI, there are also other risk factors, ethnicity is also considered as a risk factor of having asthma. This is consistent with the results of our study that the non-Hispanic Black set has a larger proportion of people having asthma than others. While many scientific research studies show that more physical exercise is needed, clinical trials should also be taken into action, as obese asthmatics have multiple consequences related to mechanical or physiologic effects, and immune or metabolic effects (Baffi and Cynthia et al 2015).

5 CONCLUSIONS

In conclusion, this study reveals a significant positive correlation between BMI and asthma incidence among juveniles no matter if they are male or female. Although the incidence of asthma is nearly the same for males and females with high BMI, male juveniles have an overall higher risk of getting asthma than female juveniles, probably because boys are more likely to have an inconsistent growth of their airway diameter and their lung volume in their early life (Fuseini, Hubaida and Dawn 2017). Additionally, other factors such as ethnicity also exert some influence on asthma outcomes. Non-Hispanic black juveniles are more likely to have asthma than Mexican American juveniles and non-Hispanic white juveniles as their weight increases. However, as mentioned previously, there are some limitations in this study. For example, BMI is the only indicator of obesity used in this study. Possible improvements can be made by including more obesity indicators and even other measurements of body condition. This study can provide a reference for future prevention and treatment of juvenile asthma. One of the takeaways is that obese juveniles should be aware of the importance of losing weight given our result that the risk of having asthma increases with higher BMI. Additionally, having balanced nutrition and a good eating habit is also a key to preventing asthma. Future research studies should also pay more attention to both asthma prediction and prevention. Developed to tackle asthma problems, personalized prediction models not only can prevent attacks but can also reduce attacks (Fleming 2018).

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