

# Asthma diagnosis and learning disabilities among children in the United States

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A – Study Design, B – Data Collection, C – Statistical Analysis, D – Data Interpretation, E – Manuscript Preparation, F – Literature Search, G – Funds Collection

**Summary Background.** This study intends to investigate the impact of socio-economic factors on children with asthma, as well as the impact of these factors on their academic performance.

**Objectives.** This work aims at studying asthma and learning disabilities in the United States during the years 2009–2018 and to find not only statistically significant indicators for asthma but also a possible link between asthma and learning disabilities.

**Material and methods.** The statistical methods used to extract the results of this work are the chi-square test and One-way Analysis of Variance (ANOVA) in order to check the statistical significance of asthma with regard to the socio-economic factors of patients. Additionally, a multiple logistic regression analysis was used with the odds ratio (OR) to find statistically significant prognostic factors for both asthma and learning disabilities.

**Results.** As specified by multiple logistic regression analysis, males who have neither a mother nor father have a higher risk of developing both asthma and learning disabilities, while Black or African Americans are three times more at risk for the occurrence of these types of diseases. In addition, parents' education and family income proved to also be prognostic risks for both asthma and learning disabilities.

**Conclusions.** The results of this work explain the significance of deprivation (of family and financial support) as the main prognostic risk factor for asthma. Moreover, the same factor proved to be the main prognostic risk factor for learning disabilities as for asthma, which implies a possible association between asthma and learning disabilities.

**Key words:** prognosis, asthma, learning disabilities, socio-economic factors.

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## Background

Asthma is a chronic inflammatory disease of the respiratory system that can cause an intermittent reduction of airflow to/from the lungs, resulting in dyspnea, chest tightness and cough [1]. Asthma ranks not only as the sixteenth most leading cause of Years Lived with Disability (YLD) but also the twenty-third leading cause of premature mortality, with an estimated 10.5 million Years of Life Lost (YLL) due to premature death in 2016 worldwide [2]. An increased trend of asthma was reported during the decade 2001–2010 [3]. This was due to both asthma related quality of life and pediatric management practices, as well as changes in the prevalence of the main risk factors for asthma, several of which are associated with socio-economic development [4–6].

Regarding asthma etiology, it is thought to be caused by interactions between genetic susceptibility and environmental exposure [7, 8], while important risk factors are age, race, family income and diet [3]. More specifically, the age of 5 years is considered the age of the most common occurrence of this disease, while black males have the most frequent incidence of asthma [3, 9]. Socio-economic Status (SES) plays a key role in the incidence rate and mortality from asthma [10]. Children coming from a low socio-economic status have a higher incidence rate of asthma compared to their peers coming from a high SES [11–17]. This is most likely due to different behavior in medical care, as well as higher levels of asthma-related stressors leading to uncontrolled asthma [14, 17].

Prior studies have reported an increased risk of learning disabilities in children with asthma [18, 19]. More specifically, it

has been found that asthma is associated with poor executive function of children, i.e. the management of cognitive processing [20, 21], which in turn affects their learning performance [22, 23].

This work studies asthma and learning disabilities in US during the years 2009–2018 with a view to find statistically significant indicators for asthma and a possible association between asthma and learning disabilities.

## Material and methods

The data used in this work originates from the National Health Interview Survey (NHIS) dataset [24] and covers the period 2009–2018. The number of children with asthma studied was 64,427. The statistical methods used to derive the results of this work were the chi-square test and One-way Analysis of Variance (ANOVA) for categorical continuous variables, respectively, in order to check the statistical significance of asthma in relation to the socio-economic characteristics of patients, such as gender, age, race, family structure, parents' education, family income, poverty status, health insurance coverage, place of residence and origin. Factors that ascertain the incidence of asthma were evaluated by using multiple logistic regression analysis. To better estimate the predictors of asthma, data concerning children with a new diagnosis of asthma compared to a matched cohort group of children without asthma was used. More specifically, the control group of children was made up of the target population without asthma with the same socio-economic characteristics as the group of asthmatic children. The data was weighted before analyzed. Predictors were presented using the



OR and 95% confidence intervals, and  $p < 0.05$  was regarded as statistically significant. The study was conducted using the IBMSPSS 25 software package for Windows.

An opinion from the bioethics committee was not necessary for this work.

## Results

To test the zero hypotheses that the mean of the children in the United States with asthma did not differ in accordance with their socio-economic characteristics, the chi-square test and One-way Analysis of Variance (ANOVA) were used. As shown in Table 1, there is a statistically significant difference in the number of asthmatic children in relation to gender and age, and this occurs mainly in males (57.4%) in the age group of 5–11 (43.9%), while the most common origin and race was white

(69.6%) compared to Hispanic or Latino (42.9%). The parents' education found to be statistically significant was "More than a high school diploma" (66.3%). The poverty status found to be statistically significant was "not poor" (48.4%), with a family income of \$35,000 or more (37.6%). Health insurance coverage considered statistically significant was private (45.7%). In addition, the current health status that most asthmatic children had was "Excellent or very good" (67.7%). Moreover, most asthmatic children had both a mother and father as the family structure (57.3%). Finally, the region with the most frequent occurrence of asthma was the South (39.1%), with a population size of one million or more (54.4%).

Table 2 represents the multiple logistic regression analysis and Odds Ratios with the aim of finding the predictors for the incidence rate of asthma.

Characteristics of children with asthma: United States 2009–2018		Number of patients	Percentages	<i>p</i>
Gender	<b>Male</b>	36,999	57.4%	0.000
	Female	27,428	42.6%	
Age	3–4	10,139	15.7%	0.000
	<b>5–11</b>	28,291	43.9%	
	12–17	25,996	40.4%	
Race	<b>White</b>	41,273	69.6%	0.000
	Black or African American	15,944	26.9%	
	Asian	2,076	3.5%	
Origin	Hispanic or Latino	14,295	12.2%	0.000
	Mexican or Mexican American	8,182	7.0%	
	<b>Not Hispanic or Latino</b>	50,132	42.9%	
	White. Single race	29,378	25.1%	
	Black or African American. Single race	14,902	12.7%	
Parent's education	Less than a high school diploma	7,386	12.0%	0.000
	High school diploma	13,269	21.6%	
	<b>More than a high school diploma</b>	40,674	66.3%	
Family income	Less than \$35,000	24,083	24.9%	0.000
	<b>\$35,000 or more</b>	36,351	37.6%	
	\$35,000–\$49,999	7,698	8.0%	
	\$50,000–\$74,999	8,890	9.2%	
	\$75,000–\$99,999	6,434	6.6%	
	\$100,000 or more	13,328	13.8%	
Poverty status	Poor	16,753	27.4%	0.000
	Near poor	14,814	24.2%	
	<b>Not poor</b>	29,600	48.4%	
Health insurance coverage	Private	30,444	47.4%	0.000
	<b>Medicaid</b>	29,354	45.7%	
	Other coverage	1,379	2.1%	
	Uninsured	2,998	4.7%	
Current health status	<b>Excellent or very good</b>	43,619	67.7%	0.000
	Good	16,177	25.1%	
	Fair or poor	4,624	7.2%	
Family structure	<b>Mother and father</b>	36,900	57.3%	0.000
	Mother, no father	22,459	34.9%	
	Father, no mother	2,081	3.2%	
	Neither mother nor father	2,988	4.6%	
Place of residence (MSA: Metropolitan Statistical Area)	<b>Large MSA (population size 1 million or more)</b>	35,080	54.4%	0.000
	Small MSA (less than 1 million)	19,989	31.0%	
	Not in MSA	9,359	14.5%	
Region	Northeast	11,806	18.3%	0.000
	Midwest	14,304	22.2%	
	<b>South</b>	25,165	39.1%	
	West	13,151	20.4%	

Table 2. Statistically significant predictors of asthma in children using multivariate logistic regression					
Socio-economic characteristics of children: United States 2009–2018		Patients	Controls	OR (95%CI)	p
Gender	Male	36,999	339,740	1.32 (1.29–1.34)	0.000
	Female	27,428	332,440	1.0 (ref)	
Age	3–4	10,139	192,620	0.44 (0.43–0.46)	0.000
	5–11	28,291	258,945	0.93 (0.91–0.94)	
	12–17	25,996	221,701	1.0 (ref)	
Race	White	41,273	505,986	1.36 (1.30–1.42)	0.000
	Black or African American	15,944	92,617	2.87 (2.74–3.01)	
	Asian	2,076	34,665	1.0 (ref)	
Origin	Hispanic or Latino	14,295	163,857	0.50 (0.49–0.51)	0.000
	Mexican or Mexican American	8,182	111,476	0.42 (0.41–0.43)	
	Not Hispanic or Latino	50,132	509,413	0.56 (0.55–0.57)	
	White. Single race	29,378	360,328	0.46 (0.46–0.47)	
	Black or African American. Single race	14,902	85,791	1.0 (ref)	
Parent's education	Less than a high school diploma	7,386	77,344	1.06 (1.03–1.09)	0.000
	High school diploma	13,269	121,150	1.22 (1.19–1.24)	
	More than a high school diploma	40,674	452,985	1.0 (ref)	
Family income	Less than \$35,000	24,083	187,145	1.68 (1.64–1.72)	0.000
	\$35,000 or more	36,351	435,351	1.09 (1.07–1.11)	
	\$35,000–\$49,999	7,698	76,584	1.31 (1.27–1.35)	
	\$50,000–\$74,999	8,890	105,637	1.10 (1.07–1.13)	
	\$75,000–\$99,999	6,434	78,476	1.07 (1.04–1.10)	
	\$100,000 or more	13,328	174,654	1.0 (ref)	
Poverty status	Poor	16,753	127,161	1.62 (1.59–1.65)	0.000
	Near poor	14,814	143,080	1.27 (1.24–1.30)	
	Not poor	29,600	364,562	1.0 (ref)	
Health insurance coverage	Private	30,444	368,283	1.15 (1.11–1.19)	0.000
	Medicaid	29,354	241,965	1.69 (1.62–1.76)	
	Other coverage	1,379	18,626	1.03 (0.96–1.10)	
	Uninsured	2,998	41,836	1.0 (ref)	
Current health status	Excellent or very good	43,619	576,170	0.15 (0.14–0.15)	0.000
	Good	16,177	87,678	0.37 (0.35–0.38)	
	Fair or poor	4,624	9,311	1.0 (ref)	
Family structure	Neither mother nor father	2,988	19,793	1.95 (1.87–2.02)	0.000
	Mother, no father	22,459	152,297	1.90 (1.87–1.93)	
	Father, no mother	2,081	24,641	1.09 (1.04–1.14)	
	Mother and father	36,900	476,538	1.0 (ref)	
Place of residence (MSA: Metropolitan Statistical Area)	Large MSA (population size 1 million or more)	35,080	367,925	0.97 (0.95–0.99)	0.000
	Small MSA (less than 1 million)	19,989	209,851	0.97 (0.94–0.99)	
	Not in MSA	9,359	95,491	1.0 (ref)	
Region	Northeast	11,806	107,676	1.37 (1.34–1.41)	0.000
	Midwest	14,304	152,408	1.17 (1.14–1.20)	
	South	25,165	248,270	1.27 (1.24–1.29)	
	West	13,151	164,918	1.0 (ref)	

As can be seen in Table 2, all prognostic factors are statistically significant ( $p < 0.05$ ). Based on multiple logistic regression, the risk of asthma is significantly higher in males (OR 1.32), as well as in the age group of 12–17 (OR 1.0), Black or African American (OR 2.87) and “High school diploma” as parents’ educational status (OR 1.22). Moreover, those with a family income “less than \$35,000” are almost two times more at risk of developing asthma (OR 1.67). In addition, the risk of asthma is significantly higher with a poverty status of “poor” (OR 1.62) and with health insurance coverage indicated as “Medicaid” (OR 1.69). Children with neither mother nor father are two times more at risk of developing asthma (OR 1.95), while those with a current health status of “Fair or poor” are also at a higher risk. Finally, the risk of asthma is significantly higher in the “Northeast” region (OR 1.37) and place of residence listed as “not in a Metropolitan Statistical Area” (OR 1.0).

Figure 1 represents the trends in asthma and learning disabilities during the years 2009–2018 in the US. The occurrence of asthma decreased, while learning disabilities continued to increase from 2009 to 2018.

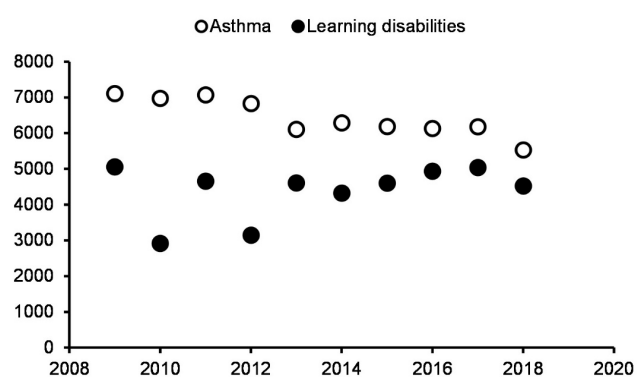


Figure 1. Trends in asthma and learning disabilities during 2009–2018 in the United States

With the purpose of finding a possible link between asthma and learning disabilities, a multivariate logistic regression analy-

sis was used for children with learning disabilities. As shown in Table 3, family structure and race play an essential role in the occurrence of learning disabilities. Black or African American children who have neither mother nor father have the highest risk for the occurrence of learning disabilities (OR 3.0 and 1.5, respectively). Family income, gender and parents' education are also prognostic risks for learning disabilities. More specifically, those with family income "less than \$35,000" (OR 2.3), males (OR 1.71) and "less than a high school diploma" indicated as parents' education status (OR 1.5) are at a higher risk for learning disabilities. Moreover, the risk of learning disabilities is significantly higher with age 12–17 (OR 1.0), as well as in those of Black or African American origin (OR 1.0). The risk of learning disabilities is significantly higher with a poverty status of "poor" (OR 2.0) and in those with health insurance coverage indicated as "Medicaid" (OR 1.8). Finally, the risk of learning disabilities is significantly higher with in the "Northeast" region (OR 1.3) and place of residence listed as "not in a Metropolitan Statistical

Area" (OR 1.0). Finally, the risk of learning disabilities is higher in those with a current health status of "Fair or poor" (OR 1.0).

## Discussion

Greater focus should be given to the prognostic factors that had the highest Odds Ratio. It should be pointed out that the socio-economic characteristic of asthmatic children with the highest risk is family structure, and more specifically, it was found that children with neither mother nor father have the highest risk of developing asthma (OR 1.95). Additionally, family income and parents' education play a key role in developing this type of disease. Children with family income "Less than \$35,000" and "High school diploma" indicated as parents' education are twice as likely to be at risk of having asthma (OR 1.68 and 1.22, respectively). Finally, race is a prognostic risk for this type of disease, as it was found that Black or African American males are at a higher risk of developing asthma (OR 2.87 and 1.32, respectively).

**Table 3. Multivariate logistic regression**

Learning disabilities in children		Children with LD	Controls	Odds ratio (95% CI)	p
Gender	<b>Male</b>	30,061	285,295	1.71 (1.67–1.74)	0.000
	Female	17,487	284,169	1.0 (ref)	
Age	3–4	2,420	80,824	0.28 (0.26–0.29)	0.000
	5–11	21,177	266,059	0.74 (0.72–0.75)	
	<b>12–17</b>	23,952	223,745	1.0 (ref)	
Race	White	35,111	424,057	2.5 (2.3–2.7)	0.000
	<b>Black or African American</b>	8,267	82,913	3.0 (2.8–3.2)	
	Asian	983	30,201	1.0 (ref)	
Origin	Hispanic or Latino	10,570	136,434	0.78 (0.75–0.8)	0.000
	Mexican or Mexican American	6,607	92,513	0.71 (0.69–0.74)	
	Not Hispanic or Latino	36,980	434,196	0.85 (0.83–0.88)	
	White. Single race	25,984	302,728	0.86 (0.84–0.88)	
	<b>Black or African American. Single race</b>	7,676	77,259	1.0 (ref)	
Parent's education	<b>Less than a high school diploma</b>	6,940	63,908	1.5 (1.4–1.5)	0.000
	High school diploma	10,157	101,156	1.4 (1.3–1.4)	
	More than a high school diploma	27,965	385,959	1.0 (ref)	
Family income	<b>Less than \$35,000</b>	19,318	153,275	2.3 (2.2–2.3)	0.000
	\$35,000 or more	25,353	373,386	1.23 (1.2–1.26)	
	\$35,000–\$49,999	5,531	64,804	1.6 (1.5–1.6)	
	\$50,000–\$74,999	6,975	88,497	1.3 (1.4–1.5)	
	\$75,000–\$99,999	4,388	66,734	1.2 (1.14–1.23)	
	\$100,000 or more	8,460	153,354	1.0 (ref)	
Poverty status	<b>Poor</b>	13,435	103,107	2.0 (2.0–2.1)	0.000
	Near poor	12,209	120,563	1.6 (1.6–1.7)	
	Not poor	19,864	313,776	1.0 (ref)	
Health insurance coverage	Private	19,597	320,083	0.9 (0.8–0.9)	0.000
	<b>Medicaid</b>	23,999	195,893	1.8 (1.7–1.9)	
	Other coverage	1,154	15,287	1.1 (1.0–1.2)	
	Uninsured	2,526	37,192	1.0 (ref)	
Current health status	Excellent or very good	29,937	485,316	0.11 (0.10–0.11)	0.000
	Good	13,196	77,331	0.30 (0.29–0.31)	
	<b>Fair or poor</b>	4,401	7,899	1.0 (ref)	
Family structure	<b>Neither mother nor father</b>	26,828	396,020	1.5 (1.4–1.6)	0.000
	Mother, no father	16,317	134,129	0.76 (0.72–0.8)	
	Father, no mother	2,006	22,620	1.3 (1.3–1.4)	
	Mother and father	2,396	17,866	1.0 (ref)	
Place of residence (MSA: Metropolitan Statistical Area)	Large MSA (population size 1 million or more)	24,738	313,870	0.75 (0.73–0.77)	0.000
	Small MSA (less than 1 million)	15,130	159,785	0.9 (0.8–0.9)	
	<b>Not in MSA</b>	7,681	73,310	1.0 (ref)	
Region	<b>Northeast</b>	8,895	92,041	1.3 (1.3–1.4)	0.000
	Midwest	10,835	128,938	1.1 (1.1–1.2)	
	South	17,719	211,029	1.1 (1.1–1.2)	
	West	10,102	138,623	1.0 (ref)	

It is also worth noting that the socio-economic characteristics of children with learning disabilities with the highest Odds Ratio were the same as those of asthmatic children. Deprivation of family and financial comfort were found to be the principal prognostic risk factor for both asthma and learning disabilities, which indicates a possible link between asthma and learning disabilities. It has also been found that not only deprivation but also the death of both mother and father plays a key role in the increased risk of developing these two diseases.

The importance of this study lies in the interaction of multiple socio-economic variables with asthma and learning disabilities, which reflects the complexity and multidimensional nature of deprivation, as well as the various roles of these dimensions during the course of one's life, which in turn reflects the longest gestation period for both asthma and learning disabilities. Deprivation has been linked to stress, which in turn influences human

behavior and health. More specifically, stressors in early life are responsible for the production of cortisol, a hormone that peaks in response to stressful experiences, and has not only immunological effects (hormonal disorders), but also social and behavioral problems (poor social skills and disruptive behaviors) [25–27].

## Conclusions

This paper has outlined that different socio-economic variables are associated with different asthma risks, while deprivation (of family and financial comfort) proved to be the primary prognostic risk factor for asthma. Moreover, the same factor proved to be the primary prognostic risk factor for learning disabilities, which implies a possible link between asthma and learning disabilities.

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