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Self-reported hay fever diagnosis and associations with sociodemographic characteristics among adults and children in the United States

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Abstract

Background: Hay fever (allergic rhinitis) is a common condition that causes unpleasant respiratory symptoms. The objective of this cross-sectional study is to examine the trends of hay fever self-reported diagnosis among adults and children in the United States from 2013 to 2018 and its associations with sociodemographic characteristics. Survey data from the National Health Interview (NHIS) were used to identify children and adults with hay fever. Chi-square tests were used to evaluate the group differences by sociodemographic characteristics within each year examined. Trends in self-reported hay fever as well as trends for each sociodemographic characteristic over the study period were charted.

Results: All sociodemographic characteristics examined in both adults and children showed statistically significant group differences. Females were the highest risk sex group among adults while males were the highest risk sex group among children. Hay fever was more likely to be found among those with two or more races, non-Hispanics, those with higher education level and wealth, and residents from the western United States.

Conclusions: The findings of this study can help identify subpopulations at higher risk of hay fever, which can aid in developing targeted interventions to help individuals experiencing hay fever alleviate their symptoms and improve their quality of life.

Keywords: Hay fever, National Health Interview Survey data, Sociodemographic, Adults, Children

Background

Hay fever, or allergic rhinitis, is a respiratory condition signified by symptoms such as runny nose, sneezing, and itchy soft palate and may be accompanied with irritability and fatigue. In the United States, the prevalence of hay fever is 17%, and constitutes 1 in 40 doctors' visits, proving it to be a common menace to the health of the United States' population (US Department of Health and Human Services 1991). Hay fever affects an individual's ability to

carry out daily and professional functions and poses a significant burden on the economy (Schatz 2007). Indirect costs associated with the productivity loss among children and adults were estimated to be 13 million dollars and 32 billion, respectively (Malone et al. 1997). Additionally, symptom days have a negative impact on one's mental health state and health-related quality of life (Schatz 2007). Children with hay fever, regardless of socioeconomic level, were reported to have higher peer issues, conduct issues, hyperactivity levels, and emotional obstacles compared with children not experiencing hay fever (Hammer-Helmich et al. 2016)

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In a cornerstone piece of research in the field of epidemiology, Strachan examined whether social, economic, and perennial risk factors were associated with hay fever among a national sample of 17,414 children in Britain, all of whom were born in the same week of March 1958, until age 23. This study coined the term Hygiene Hypothesis of hay fever. The Hygiene Hypothesis states that there is a correlation between increased allergic diseases and decreased microbial exposure. This study concluded that younger children in a larger household could be more exposed to infectious agents of their older siblings, protecting them against those infectious agents that produce hay fever (Strachan 1989). However, the Hygiene Hypothesis was refined by Rook et al. (2013) and proposed Old Friends (OF) Mechanism. Evidence from studies supports the recent OF hypothesis and emphasis that some pathogens or microbes stated as “old friends” may assist the immune system to develop a milieu against any form of allergic disease.

The existing literature provides conflicting evidence regarding the association between high-/low-income countries and the prevalence of hay fever. It was reported that among industrialized nations the spike in hay fever may be attributed to smaller family size (Harris 2020). Another study indicated that the prevalence of severe hay fever is higher in low-income countries than high-income countries in all age groups of children except 13–14 years (Zivkovic et al. 2012).

Some studies evaluated risk factors for hay fever in the United States. Male sex, parental history of allergy, and asthma significantly predicted allergic and asthmatic symptoms among El Paso resident children (Svendson et al. 2009). Nathan et al. cited that hay fever was significantly higher among the respondents in the age groups of 18–34 and 35–49 years as compared to the other age groups (Nathan et al. 1997). In the US, the highest prevalence was reported from the West South-Central region, while the lowest prevalence was reported from the West North Central Region (Nathan et al. 1997).

To date, no studies have examined the sociodemographic factors of both children and adults in a time period as recent as 2013–2018 using National Health Interview Survey (NHIS) data. Therefore, this study aimed to determine the rate of self-reported hay fever diagnosis among children and adults and to identify the sociodemographic variables associated with it, using NHIS data from 2013–2018.

Methods

Data source

This cross-sectional study utilizes frequency tables from NHIS data on hay fever for both adults and children in 2013, 2014, 2015, 2016, 2017, and 2018 (NHIS Adult

Table 2013a; NHIS Child Table 2013b; NHIS Adult Table 2014a; NHIS Child Table 2014b; NHIS Adult Table 2015a; NHIS Child Table 2015b; NHIS Adult Table 2016a; NHIS Child Table 2016b; NHIS Adult Table 2017a; NHIS Child Table 2017b; NHIS Adult Table 2018a; NHIS Child Table 2018b). NHIS is one of the major data collection programs of The National Center for Health Statistics (NCHS) a division of Center for Disease Control and Prevention (CDC). It consists of a cross-sectional household interview survey that monitors the health of the civilian noninstitutionalized population of the US and gives comprehensive information pertinent to various health topics (NHIS 2019). Survey data for children are collected from a parent or a responsible adult family member residing in the household while adult data are self-reported. From 2013 to 2018, the questions asked pertaining to child hay fever were as follows: “During the past 12 months, has {child’s name} had any of the following conditions? Hay fever? Any kind of respiratory allergy? Any kind of food or digestive allergy? Eczema or any kind of skin allergy?” (NHIS Child Table 2013a; NHIS Child Table 2014a; NHIS Child Table 2015a; NHIS Child Table 2016a; NHIS Child Table 2017a; NHIS Child Table 2018a). NHIS data are released by the CDC and report the annual total frequency of cases for hay fever along with its demographic factors including race, age, sex, region, and economic factors such as health insurance, family income, and poverty status.

Adults who responded to the survey stating that they were given a diagnosis on any of the respiratory conditions like hay fever, sinusitis, and bronchitis were included in the NHIS table of selected respiratory diseases for the year of their survey (NHIS Adult Table 2013b; NHIS Adult Table 2014b; NHIS Adult Table 2015b; NHIS Adult Table 2016b; NHIS Adult Table 2017b; NHIS Adult Table 2018b). Children whose parents responded to the survey stating that they had hay fever were included in NHIS frequency table category for child hay fever for the year of their response (NHIS Child Table 2013a; NHIS Child Table 2014a; NHIS Child Table 2015a; NHIS Child Table 2016a; NHIS Child Table 2017a; NHIS Child Table 2018a).

The sociodemographic variables used in this study included race; age; sex; health insurance coverage (private, Medicaid, Other, Uninsured, Medicare and Medicaid, Medicare Advantage, and Medicare only); poverty status (poor, near poor, and not poor); region of the United States (northeast, mid-west, south, and west); and employment status (full-time, part-time, not employed but has worked previously, and not employed and has never worked); education level for ages above 25 years (less than high school diploma, high school diploma or GED, some college, and bachelor’s degree or higher).

Among the parent-reported hay fever cases for children, the education level of parents was one of the covariates.

The IRB recognizes that the analysis of de-identified, publicly available data does not constitute human subjects research as defined at 45 CFR 46.102 and that it does not require IRB review. The IRB no longer requires the registration or review of studies involving the analysis of public use data sets unless a project merges multiple data sets and in so doing enables the identification of individuals whose data are analyzed.

Statistical analysis

Using frequency values for each year, the total frequency (in thousands) of hay fever each year was recorded. Within each subcategory, age-adjusted percentages of the general population were recorded from the NHIS tables for each year.

Chi-square tests

Chi-square tests were used to examine group differences among the respondents with hay fever within each year by different sociodemographic variables like sex, age group, race, employment status, health insurance, poverty status, region, and education. All statistical analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC, USA) at an a priori significance level of 0.05. Analysis was performed separately for adults and children.

Additionally, this study evaluated the trend of hay fever. Several graphs were depicted with the year plotted against the total number of hay fever cases and all the sociodemographic variables.

Results

The results of Chi-square tests determining if there were significant group differences in hay fever by each covariate for 2013–2018 are summarized in Tables 1, 2 and 3.

Additional file 1: Fig. S1 illustrates the trends in the rate of hay fever for US adults from 2013 to 2018 that were recorded by frequency in thousands and charted over the study period. Diagnosis among adults remained relatively constant aside from a decrease in diagnosis in 2016. Unlike adult self-reported diagnosis, reports of child hay fever show an overall slight decrease from 2013 to 2018 (Additional file 1: Fig. S2).

Among the adult cohort, women were more likely to report having hay fever than men across all years ($P < 0.0001$ for each year) (Fig. 1). On the contrary, among children, males were more likely to be reported to have hay fever than females. ($P < 0.001$ for each year) (Fig. 2).

There were significant differences among age groups observed with the highest percentage of people with hay fever in the population in the adult age category of

45–64 years (Additional file 1: Fig. S3; Table 1) and the child age category of 12–17 years (Additional file 1: Fig. S4; Table 3) ($P < 0.0001$). Among both adults and children, non-Hispanics were more likely to report hay fever diagnosis than Hispanics ($P < 0.0001$).

Among adults, 2013 results showed that those that belonged to the racial category of American Indian or Alaska Native were more likely to report hay fever diagnosis, while every other year showed those with two or more races as most likely to report hay fever diagnosis ($P < 0.0001$). Children with two or more races showed the highest likelihood of reported hay fever diagnosis among all years observed ($P < 0.0001$).

Significant group differences in the proportions of employment and poverty status were exhibited among all respondents in every year examined ($P < 0.0001$). Aside from 2016, adults who were not employed but employed previously were more likely to report hay fever diagnosis than other adults. (Additional file 1: Fig. S5; Table 1). In 2016, adults who were employed part-time were more likely to report hay fever diagnosis. Among both adults and children, those who were classified as “not poor” were more likely to report hay fever diagnosis ($P < 0.0001$).

For health insurance among both adults under 65 and adults 65 and older, significant differences were observed between categories in all years evaluated ($P < 0.0001$). Among adults under 65, respondents in 2014 who had private health insurance were more likely to report hay fever diagnosis (Additional file 1: Fig. S6; Table 1). However, for every other year evaluated, adults under 65 with health insurance in the “other” category showed a higher likelihood of reporting hay fever diagnosis than those covered under private insurance, Medicaid, and those that were uninsured.

Among adults 65 and up as well as children, the insurance category with the highest percentage of reported hay fever diagnosis varied from year to year even though differences between such categories were statistically significant.

Differences between US regions’ percentages of hay fever diagnosis were statistically significant for every year evaluated among adults and children ($P < 0.001$) except for 2013 among children ($P = 0.260$). The south showed the highest percentage of hay fever diagnosis in all years evaluated among adults (Additional file 1: Fig. S8; Table 1). In children, the West, Northeast, and Midwest showed the highest rate of hay fever diagnosis in 2013, while the south alone showed the highest percentage of hay fever diagnosis from 2013 to 2018 (Additional file 1: Fig. S9; Table 3). This may point towards further research on pollution, agricultural factors, or access to diagnosis

Table 1 Adult self-reported diagnosis of hay fever from 2013 to 2018 by frequency (in thousands)

Year	2013	2014	2015	2016	2017	2018
Total adult survey respondents	237,394	239,688	242,501	245,142	246,657	249,456
Total cases	18,638 (7.6)	19,089 (7.7)	19,976 (7.9)	16,042 (6.2)	19,883 (7.7)	19,174 (7.3)
Sex						
Male	7811 (6.6)	7824 (6.6)	7704 (6.3)	6601 (5.4)	8428 (6.8)	7980 (6.4)
Female	10,827 (8.5)	11,265 (8.7)	12,272 (9.4)	9441 (7.1)	11,455 (8.5)	11,193 (8.3)
Missing values						1
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Age group (years)						
18–44	6341 (5.7)	6315 (5.6)	6602 (5.9)	5003 (4.4)	6048 (5.3)	5778 (5.0)
45–64	8848 (10.8)	8985 (10.9)	9245 (11.1)	7411 (8.9)	9204 (11.0)	8986 (10.8)
65–74	2123 (8.5)	2392 (9.1)	2723 (10.0)	2451 (8.6)	3016 (10.3)	3018 (9.8)
75 and over	1326 (7.3)	1397 (7.5)	1405 (7.3)	1177 (6.0)	1614 (8.0)	1392 (6.8)
Missing values			1		1	
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Race						
White	15,766 (8.0)	15,851 (8.0)	16,809 (8.4)	13,017 (6.4)	16,589 (8.2)	15,483 (7.6)
Black or African American	1535 (5.3)	1818 (6.0)	1822 (6.0)	1532 (5.0)	1490 (4.8)	1729 (5.5)
American Indian or Alaska Native	204 (10.6)	165 (8.1)	120 (5.0)	167 (6.9)	139 (*)	238 (8.5)
Asian	769 (5.9)	785 (5.8)	835 (6.0)	874 (5.9)	1112 (7.1)	1116 (6.9)
Native Hawaiian or Other Pacific Islander	*(*)	*(9.0)	*(*)	*(*)	*(*)	*(*)
Two or more races	355 (9.5)	447 (12.0)	362 (9.9)	442 (9.9)	532 (11.4)	581 (10.5)
Missing values	9	23	28	177	21	27
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Hispanic or Latino Origin:						
Hispanic or Latino origin	2012 (6.1)	1957 (5.8)	730 (4.6)	1764 (4.7)	1995 (5.4)	1589 (4.3)
Not Hispanic or Latino	16,626 (7.9)	17,132 (8.0)	18,246 (8.5)	14,278 (6.5)	17,888 (8.1)	17,585 (8.0)
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Employment status						
Full-time	8925 (7.1)	9042 (7.5)	9509 (7.6)	7153 (5.6)	9227 (6.8)	9086 (9.6)
Part-time	1690 (7.1)	2070 (7.8)	2054 (8.2)	2013 (7.3)	1980 (7.9)	2073 (11.3)
Not employed but has worked previously	7166 (8.7)	7216 (8.3)	7440 (8.8)	5947 (6.4)	7900 (8.8)	7107 (13.4)
Not employed and has never worked	794 (5.8)	642 (5.0)	855 (6.2)	814 (6.7)	625 (5.1)	755 (9.7)
Missing values	63	119	118	115	151	153
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Health insurance coverage (Under 65)						
Private	10,502 (8.0)	10,938 (8.0)	11,901 (8.3)	9001 (6.3)	11,552 (8.0)	10,503 (7.2)
Medicaid	1723 (8.9)	1692 (7.4)	1731 (6.9)	1610 (5.8)	1919 (7.5)	1718 (7.0)
Other	949 (9.4)	893 (7.9)	990 (8.6)	868 (8.2)	879 (7.7)	1047(9.2)
Uninsured	1950 (5.2)	1740 (5.7)	1184 (4.9)	917 (4.2)	877 (3.8)	1466 (5.9)
Missing values	65	37	41	18	25	30
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Health insurance coverage (65 +)						
Private	1845 (8.4)	1859 (8.2)	1778 (9.0)	1541 (7.5)	1860 (9.1)	1847 (8.4)
Medicare and medicaid	197 (6.3)	314 (10.5)	288 (8.9)	312 (9.2)	378 (10.2)	256 (7.0)
Medicare advantage	N/A	N/A	1062 (8.9)	888 (7.3)	1331 (9.8)	1299 (9.8)
Medicare only	1132 (7.5)	1365 (8.7)	615 (7.6)	611 (7.2)	715 (8.4)	596 (7.3)
Other	261 (8.5)	232 (6.8)	353 (9.0)	250 (6.3)	347 (9.5)	394 (7.5)
Uninsured	0 (0)	*(9.0*)	*(*)	*(*)	*(*)	*(*)
Missing values	14	19	32	116	26	18

Table 1 (continued)

Year	2013	2014	2015	2016	2017	2018
<i>P</i> value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Poverty status						
Poor	1916 (6.9)	2046 (7.0)	1877 (6.9)	1704 (6.2)	2013 (7.6)	1653 (7.0)
Near poor	2401 (6.3)	3027 (7.2)	2807 (6.6)	2141 (5.3)	2455 (6.1)	2460 (6.0)
Not poor	13,024 (8.4)	13,219 (8.3)	14,506 (8.6)	11,511 (6.6)	14,328 (8.0)	14,131 (7.7)
Missing values	1297	797	786	686	1087	930
<i>P</i> value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Region						
Northeast	3336 (7.7)	3328 (7.6)	3194 (7.3)	2609 (5.4)	3399 (7.1)	3706 (7.9)
Midwest	3810 (7.0)	3894 (7.0)	4101 (7.3)	3019 (5.3)	3831 (6.7)	3553 (6.1)
South	6343 (6.9)	6674 (7.1)	6999 (7.4)	5252 (5.7)	6544 (6.9)	6362 (6.5)
West	5149 (9.3)	5193 (9.4)	5681 (10.0)	5162 (8.6)	6109 (10.3)	5553 (9.2)
<i>P</i> value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Table 2 Education level of adults over 25 years reporting hay fever diagnosis by frequency (in thousands)

Year	2013	2014	2015	2016	2017	2018
Education level for ages 25+:						
Less than a high school diploma	1828 (6.5)	1665 (5.6)	1343 (4.9)	1448 (5.1)	1624 (6.1)	1361 (5.0)
High school diploma or GED some college	3780 (6.8)	3943 (7.2)	3195 (5.9)	2928 (5.2)	3497 (6.4)	3337 (6.1)
Bachelor's degree or higher	5473 (8.9)	5685 (9.1)	6351 (9.9)	4462 (6.9)	5554 (8.6)	5433 (8.3)
<i>P</i> value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

*Estimates are considered unreliable. Data preceded by an asterisk have a relative standard error (RSE) greater than 30% and less than or equal to 50% and should be used with caution. Data not shown have an RSE greater than 50% (according to the CDC)

in the West that could lead to higher rates of hay fever diagnosis in adults and children.

Furthermore, the percentage of hay fever diagnosis among adults with a bachelor's degree or higher was significantly higher than other education levels in every year examined ($P < 0.0001$). Among the parent-reported hay fever cases, the percentage of hay fever diagnosis in the population of children with parents of high school education level or higher was significantly higher than other education levels in each year evaluated ($P < 0.0001$ for each year).

Discussion

Findings of this study revealed statistically significant group differences in the hay fever diagnosis within each year (2013–2018) by all sociodemographic characteristics. This study showed an increased rate of hay fever in children for the oldest age group (12–17 years), indicating possible correspondence with Strachan's Hygiene Hypothesis (Strachan 1989). Since older children presented higher frequency of hay fever, younger siblings exposed to germs from older siblings may be less affected by the condition, possibly providing an

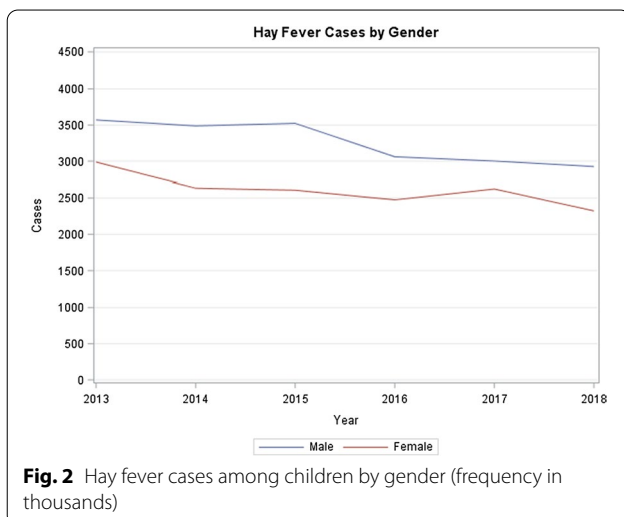
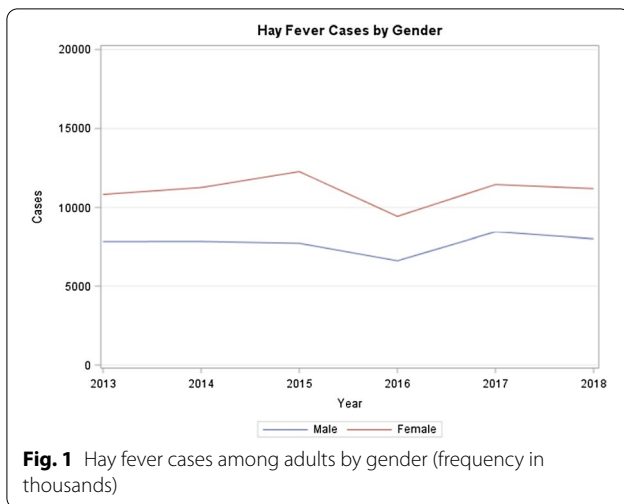
explanation for such results (Strachan 1989). Lewis, et al. found a negative correlation between low birth order and hay fever among children in the United Kingdom, which may contribute to lower hay fever levels among younger children in this study (Lewis and Britton 1998). However, proper evaluation of this similarity in the United States requires research estimating the association between number/age of siblings and hay fever on a national scale. Among the adults, the rate of hay fever was highest in the age group of 45–64 years. This is consistent with another study cited that the highest prevalence of hay fever among the age groups of 18–34 and 35–49 years (Nathan et al. 1997). Owens et al. analyzed hay fever from childhood to adulthood among an Australian cohort and found an increased prevalence from 7% at age 6 to 44% at age 24 (Owens et al. 2018).

This study showed a higher proportion of female adults and male children had hay fever, while Owens et al. found no significant difference between sexes (Owens et al. 2018). Previous studies, however, conducted in the US and UK among children found male sex to be a risk factor (Svendson et al. 2009; Lewis and Britton 1998). This study's result of higher adult female

Table 3 Parent-reported cases of hay fever among children from 2013 to 2018 by frequency (in thousands)

Year	2013	2014	2015	2016	2017	2018
Total cases	6558 (8.9)	6124 (8.4)	6132 (8.4)	5536 (7.5)	5627 (7.6)	5248 (7.2)
Sex						
Male	3571 (9.5)	3488 (9.3)	3523 (9.4)	3060 (8.2)	3001 (8.0)	2925 (7.9)
Female	2987 (8.3)	2636 (7.4)	2609 (7.3)	2476 (6.9)	2626 (7.3)	2323 (6.4)
P value	<.0001	<.0001	<.0001	<.0001	0.0003	<.0001
Age group (years)						
0–4	840 (4.2)	669 (3.4)	858 (4.3)	587 (2.9)	659 (3.4)	623 (3.2)
5–11	2783 (9.7)	2550 (9.0)	2569 (8.9)	2288 (8.0)	2278 (7.9)	2054 (7.0)
12–17	2935 (11.9)	2905 (11.7)	2705 (10.9)	2661 (10.7)	2690 (10.8)	2571 (10.5)
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Race						
White	5047 (9.2)	4560 (8.4)	4573 (8.4)	4165 (7.7)	4430 (8.2)	3979 (7.4)
Black or African American	822 (7.6)	774 (7.1)	846 (7.9)	641 (6.1)	577 (5.3)	605 (5.7)
American Indian or Alaska Native	33 (3.9)	93 (10.0*)	46 (5.5)	*(*)	*(*)	*(*)
Asian						
Native Hawaiian or Other Pacific Islander	244 (6.7)	308 (8.4)	266 (6.9)	204 (5.3)	267 (6.2)	285 (6.9)
Missing values	*(*)	-(*)	*(*)	*(*)	*(*)	*(*)
Two or more races	407 (12.5)	389 (11.9)	397 (12.3)	419 (11.7)	332 (9.4)	349 (9.2)
Missing values	5		4	107		30
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Hispanic or Latino origin:						
Hispanic or Latino origin	1225 (7.0)	1202 (6.8)	1365 (7.6)	1139 (6.3)	878 (4.8)	1091 (5.9)
Not Hispanic or Latino	5333 (9.5)	4922 (8.8)	4766 (8.6)	4397 (7.9)	4749 (8.6)	4157 (7.6)
Missing values						
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Health insurance coverage						
Private	3865 (9.6)	3762 (9.4)	3681 (9.1)	3260 (8.1)	3817 (9.2)	3318 (8.0)
Medicaid or other public	2126 (7.9)	1862 (6.9)	2075 (7.5)	1818 (6.8)	1493 (5.7)	1503 (5.8)
Other	159 (8.4)	130 (7.4)	167 (11.2)	203 (10.4)	151 (6.5)	116 (5.1)
Uninsured	397 (7.9)	343 (8.2)	186 (5.4)	242 (6.1)	147 (3.4)	299 (7.6)
Missing values	11	27	23	13	19	12
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Parent's education level						
Less than a high school diploma	582 (6.5)	458 (5.3)	518 (6.4)	343 (4.5)	353 (4.6)	351 (5.0)
High school diploma or GED	903 (7.0)	834 (5.9)	743 (5.9)	746 (6.1)	557 (4.7)	590 (4.9)
More than high school	4834 (9.8)	4665 (9.7)	4644 (9.4)	4228 (8.4)	4522 (8.8)	4131 (8.0)
Missing values	239	167	227		195	176
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Poverty status						
Poor	1114 (7.5)	945 (6.1)	1027 (7.2)	912 (6.9)	736 (5.9)	616 (5.7)
Near poor	1173 (7.9)	1238 (7.7)	1182 (7.1)	940 (5.7)	988 (6.2)	1028 (6.7)
Not poor	3833 (9.9)	3780 (9.9)	3680 (9.4)	3409 (8.3)	3692 (8.7)	3417 (7.7)
Missing values	438	161	243	275	211	187
P value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Region						
Northeast	1043 (9.1)	728 (6.6)	962 (8.4)	886 (6.7)	969 (7.4)	701 (6.1)
Midwest	1520 (9.1)	1407 (8.5)	1371 (8.2)	1011 (6.4)	1239 (7.8)	1111 (7.3)
South	2418 (8.7)	2293 (8.2)	2203 (7.9)	2102 (7.9)	1810 (6.7)	1723 (6.1)
West	1576 (9.1)	1696 (9.6)	1596 (9.2)	1535 (8.8)	1609 (9.2)	1713 (9.1)
Missing values	1			2		
P value	0.260	<.0001	0.0003	<.0001	<.0001	<.0001

*Estimates are considered unreliable. Data preceded by an asterisk have a relative standard error (RSE) greater than 30% and less than or equal to 50% and should be used with caution. Data not shown have an RSE greater than 50% (according to the CDC)



than adult male rates of hay fever was comparable to other studies conducted using NHANES and NHIS (Salo et al. 2011; Pleis et al. 2006, 2009).

Among regions, the West consistently showed the highest percentage of respondents reporting hay fever diagnosis in both adults and children; However, Nathan et al. reported in their study that the Southern region had the most people reporting hay fever (Nathan et al. 1997). In light of these findings, future research should evaluate the association between environmental factors that may be specific to the southern or western regions and the prevalence of hay fever. Additionally, these regions should be compared to observe differences or similarities in diagnosis trends.

For all but one year evaluated among adults and all years among children, those having two or more races

were most likely to report hay fever diagnosis. This differs from previous literature, which finds that white people are more likely to report hay fever diagnosis (Pleis et al. 2006, 2009; Salo et al. 2011). However, Chen et al. found Asian race to be a risk factor among Californian adults, raising questions on the validity of national trends in specific regions (Chen et al. 2002). On the contrary, Upperman et al. found hay fever was widespread among black people (Upperman et al. 2017). Further research is needed to ascertain such observed differences in racial groups' hay fever diagnosis on both a regional and national scale.

A trend of increasing diagnosis among non-Hispanics was consistent with the findings from other NHIS studies (Pleis et al. 2006, 2009; Upperman et al. 2017). Female sex was a risk factor among adults along with non-Hispanic white adults being more likely to experience hay fever than Hispanic adults in this study, which corresponds with previous literature (Pleis et al. 2006, 2009).

An upward trend in hay fever among adults with higher education levels, children whose parents presented higher education levels, and children and adults with non-poverty status are consistent with summary health statistics from the 2005 and 2007 NHIS and research by Salo et al., Uphoff et al., and Upperman et al. (Pleis et al. 2006, 2009; Salo et al. 2011; Uphoff et al. 2014; Upperman et al. 2017). Upperman examined that enhancing education and income were associated with an increase in hay fever prevalence (Upperman et al. 2017). Parker, et al., however, found that children experiencing higher levels of poverty were more likely to have hay fever levels affected by pollution, prompting inquiry into whether those with higher socioeconomic status are over-diagnosed or more able to access available resources for diagnosis (Parker et al. 2007). However, in Africa, lower socioeconomic status was associated with higher levels of hay fever among children, raising questions on whether higher socioeconomic status is associated with hay fever only in the United States (Georgy 2006). Future studies need to evaluate the association between accessibility to health care services and diagnosis, as the majority of the respondents had private insurance. Further research is needed to ascertain the correlation between health insurance for adults 65 and older and hay fever diagnosis as well as classify what insurance types in the "other" category and factors involving private insurance may lead to higher rates of hay fever diagnosis in adults under 65 and in children (Additional file 1: Fig. S7.).

This study has some limitations including recall bias. Underestimation or overestimation of hay fever may exist. Thus, reported frequencies may skew depending

on the reliability of reported data, possibly creating false significance of variables tested. Conclusions on whether certain sociodemographic factors cause hay fever cannot be drawn due to the cross-sectional design. And finally, these data do not include institutionalized individuals and are hence not generalizable for all the US population.

Conclusions

In conclusion, all sociodemographic variables tested in both adults and children showed statistically significant group differences. Risk factors observed over the study period were mostly similar among adults and children. Future studies should analyze the effect of socioeconomic status and health insurance coverage on the prevalence of hay fever. Additionally, more female adults than male adults and more male children than female children reporting hay fever require further inquiry, as does the difference in racial trends in this study from previous research. Furthermore, differences in national trends versus trends in California and El Paso prompt research into the applicability of nationally representative surveys on hay fever's epidemiology to specific regions (Chen et al. 2002; Svendsen et al. 2009).

Abbreviations

NHIS: National Health Interview; OF: Old friends; NCHS: National Center for Health Statistics; CDC: Center for Disease Control and Prevention.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s42269-022-00808-x>.

Additional file 1. File contains author information and supplementary figures documenting frequency trends over time in hay fever diagnosis overall and among varying age groups, employment statuses, health insurance coverages, and regions in the United States.

Acknowledgements

We would like to thank Pamela Blades for her valuable input and guidance throughout the project.

Author contributions

JZ was a major contributor in writing the manuscript. AM and ZM analyzed and interpreted the results. HC oversaw the study. All authors have read and approved the manuscript.

Funding

This study received no funding.

Availability of data and materials

Available on request.

Declarations

Ethics approval and consent to participate

Not applicable. The IRB recognizes that the analysis of de-identified, publicly available data does not constitute human subjects research as defined at 45 CFR 46.102 and that it does not require IRB review.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 29 October 2021 Accepted: 12 April 2022

Published online: 25 April 2022

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