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Lifetime allergic rhinitis prevalence among U.S. primary farm operators: findings from the 2011 Farm and Ranch Safety survey

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Abstract

Purpose—Allergic rhinitis is associated with decreased quality of life, and reduced workplace performance and productivity. This study investigated the prevalence of lifetime allergic rhinitis and factors associated with allergic rhinitis among U.S. primary farm operators.

Methods—The 2011 Farm and Ranch Safety Survey data collected from 11,210 active farm operators were analyzed. Survey respondents were determined to have lifetime allergic rhinitis based on a “yes” response to the question: “Have you ever been told by a doctor, nurse, or other health professional that you had hay fever, seasonal allergies, or allergic rhinitis?” Data were weighted to produce nationally representative estimates.

Results—An estimated 30.8% of the 2.1 million active farm operators had lifetime allergic rhinitis in 2011. The allergic rhinitis prevalence varied by demographic and farm characteristics. Farm operators with allergic rhinitis were 1.38 (95% CI 1.22 to 1.56) times more likely to be exposed to pesticides compared with operators with no allergic rhinitis. The association with pesticide exposure for allergic rhinitis and current asthma, and allergic rhinitis alone was statistically significant and greater than that for current asthma alone.

Conclusion—Certain groups of farm operators may be at increased risk of allergic rhinitis. Studies should further investigate the association of allergic rhinitis with specific pesticide exposure.

Keywords

Allergic rhinitis; Asthma; Agriculture; Farming; Occupational exposure; Pesticide; Surveys and questionnaire

INTRODUCTION

Agricultural workers have been shown to have increased rates of respiratory symptoms and diseases due to respiratory irritants and allergens (Greskevitch et al. 2007; ATS 1998).

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Rhinitis is an upper airway inflammatory disorder characterized by nasal itching, congestion, rhinorrhea, sneezing, and posterior nasal drainage (Stevens and Grammer 2015). Allergic rhinitis, the most common form of rhinitis, is a hypersensitivity reaction mediated by immunoglobulin-E (IgE) response to high molecular weight and some low molecular weight agents, is categorized as seasonal (hay fever; occurring after exposure to outdoor aeroallergens, e.g., tree, grass, weed pollen) and perennial (occurring after exposure to indoor aeroallergens, e.g., dust mites, molds, animal allergens). Work-related rhinitis is characterized by intermittent or persistent symptoms caused by over 200 allergic or non-allergic factors in the workplace, and often coexists with work-related asthma (Cartier 2015; Stevens and Grammer 2015). Symptoms of work-related rhinitis improve when the patient is away from the work environment. Among farm workers, rhinitis has been associated with grain farming and handling, livestock breeding, feed manufacture and handling, dairy farming, and cotton, flax, and hemp processing. Agents from these agricultural processes associated with rhinitis include gram-negative bacterial endotoxins, thermophilic bacteria, fungi, arthropod parts, grain dust, silica and silicate dust, pollens, gases, and pesticides (Cartier 2015; Quirce and Bernstein 2011; ATS 1998).

Allergic rhinitis is associated with decreased quality of life, and reduced workplace performance and productivity (Meltzer et al. 2012). In 2006, an estimated 30% of working adults with allergic rhinitis missed work due to their nasal allergies (Blaiss et al. 2007). According to the 1998 American Academy of Allergy, Asthma & Immunology task force on allergic disorders report, allergic rhinitis results in 3.5 million lost workdays (Kay 2000). Based on a 2001–2002 survey of 8,267 volunteer employees at 47 employer locations in the United States (US), Lamb et al. (2006) reported that 55% of employees had allergic rhinitis for an average of 52.5 days in the previous year. Moreover, allergic rhinitis was associated with an average 3.6 work days missed per year, and 2.3 hours of productivity loss per workday resulting in \$593 of total productivity losses per employee per year (the mean total productivity losses per employee for other conditions ranged from \$518 for high stress to \$40 for coronary heart disease) (Lamb et al. 2006). The 2005 medical spending in the US to treat allergic rhinitis was estimated at \$11.2 billion (Soni 2008). Additional costs include diagnosing and treatment of comorbid conditions (e.g., asthma, chronic sinusitis, upper respiratory infection, otitis media, hearing impairment, nasal polyposis) and emergency room visits (Blaiss et al. 2007; Meltzer et al. 2012; Schoenwetter et al. 2004). Finally, the use of sedating antihistamine medications to control allergy symptoms may increase risk of an acute, traumatic injury at work (Hanrahan and Paramore 2003). Hanrahan and Paramore (2003) found that similar proportions of individuals who self-diagnose allergic rhinitis and those with physician-diagnosed allergic rhinitis (despite the availability of prescription, non-sedating alternatives) rely on sedating antihistamine medications to control their disease symptoms.

The prevalence of allergic rhinitis in US adults is 14% on the basis of self-reported physician diagnoses and the presence of symptoms in the past year (Blaiss et al. 2007) and over 30% on the basis of self-reported nasal symptoms in the past year (Nathan et al. 2008). Although evidence suggests that farm workers may have reduced risk of asthma and allergy as a result of farming exposures in childhood (Braback et al. 2004; Kilpeläinen et al. 2000; Rennie et al. 2016) and continued exposure to the farming environment (Douwes et al. 2007), some

studies indicated an elevated prevalence of allergic rhinitis among certain farm workers compared with that of the general population (Chatzi et al. 2005; Greskevitch et al. 2007; Heutelbeck et al. 2007; Rimac et al. 2010; Riu et al. 2008; Siracusa et al. 2000; Slager et al. 2009, 2010; Smit et al. 2007). Within these studies allergic rhinitis prevalence among various agricultural workers ranges from 8% to 74%. To our knowledge, no studies examined the national prevalence of allergic rhinitis and factors associated with allergic rhinitis among US primary farm operators. To address this gap, we examined the 2011 US Farm and Ranch Safety Survey data (USDA 2016).

METHODS

Data source

In 2011, to better understand the magnitude and scope of hazardous exposures related to agricultural operations, NIOSH sponsored the Farm and Ranch Safety Survey. The survey was conducted by the US Department of Agriculture's National Agricultural Statistics Service (NASS)(USDA 2016). Methods used to implement the survey have been published previously (Mazurek et al. 2015). Briefly, a sample of 25,000 farm operations were selected for a random telephone survey. Of these, 7,497 (30.0%) could not be reached by telephone during the survey period and 1,190 (4.8%) were non-active farms; operators managing 5,103 (20.4%) operations refused to participate in the survey. A total of 11,210 (44.8%) active farm operations were surveyed. Data on agricultural exposures including crops, animal production exposures, farm maintenance activities, as well as demographic and medical information were provided by the primary farm operators (i.e., those who run the farm, making day-to-day management decisions) or their spouses. The adjusted survey response rate (calculated as a sum of completed interviews and non-active farms divided by the difference between total and the number of those who could not be reached by phone) was 70.8%.

Definitions

Survey respondents were determined to have lifetime allergic rhinitis based on a "yes" response to the question: "Have you ever been told by a doctor, nurse, or other health professional that you had hay fever, seasonal allergies, or allergic rhinitis?" Operators were determined to have current asthma if they had ever been told by a doctor, nurse, or other health professional that they had asthma and still have asthma. Information on respiratory symptoms was not collected.

Previously established definitions for classifying cigarette smoking were used. Respondents who reported smoking at least 100 cigarettes in their lifetimes and smoked cigarettes either every day or some days at the time of the survey were considered current smokers. Former smokers were those who smoked at least 100 cigarettes in their lifetime but are no longer smokers. Non-smokers included those who smoked fewer than 100 cigarettes in their lifetime.

Information on farm acreage and value of sales (i.e., the gross value of agricultural products sold from the operation for the year) was categorized by the NASS coders. Farms were

classified based on the largest source of revenue for the farm. Farm exposures and hazards were identified using responses to questions asking about specific job duties or the presence or absence of a specific hazard on the farm. Operators were considered to have a second job if they answered “yes” to the question: “Do you have a second job in addition to your farming to supplement the farm income?” Questions used to categorize farm operations and to define exposures are listed in Table 1.

Statistical analysis

We used SAS® software version 9.3 for Windows (SAS Institute Inc., Cary, NC) survey procedures for analyses. Data were weighted to account for unequal selection probabilities, unit non-response, and post-stratification. Survey weights calculated using farm counts published by NASS for calendar year 2011. To calculate the survey weights, farms were post-stratified within the nine U.S. Census regions by the farm operation’s gross value of sales (<\$10,000, \$10,000–\$99,999, \$100,000+). Prevalence and proportions with corresponding 95% confidence intervals (CIs) were estimated. The Rao-Scott chi-square test of independence was used to test the differences in the distribution of proportions. The multivariate logistic regression modeling to estimate prevalence odds ratios (PORs) for the associations between allergic rhinitis and age, sex, marital status, smoking status, second job, census region, farm acreage, value of sales, farm type, and farm exposures involved two steps. First, we developed a base model. Variables associated with allergic rhinitis in bivariable analyses at $P < 0.2$ (i.e., age, sex, second job, census region, farm acreage, and value of sales) were selected for the multivariable logistic regression model. The model was then reduced using a backward selection process. The least significant variable was removed and the model was refit until the resulting regression coefficients for remaining independent variables were significant at $P < 0.05$. The independent variables associated with allergic rhinitis in the base model included age (3 categories: 16–39, 40–64, e65 years), sex, US census region (Midwest, Northeast, South, West), and value of sales (3 categories: <\$10,000; \$10,000–\$99,000; and e\$100,000). Next, we assessed the associations between allergic rhinitis and exposures and asthma individually adjusting for base-model covariates. Finally, we examined whether the association between allergic rhinitis and farm exposures differed by current asthma status using multivariate logistic regression analysis. For this analysis we created a new variable with four distinct categories of allergic rhinitis and current asthma, i.e., 1) allergic rhinitis and current asthma, 2) allergic rhinitis alone, 3) current asthma alone, and 4) no allergic rhinitis and no current asthma (the referent group). All tests were two-sided with $P < 0.05$ considered significant.

RESULTS

Demographic characteristics of primary farm operators and current asthma prevalence have been previously reported (Mazurek et al. 2015). Briefly, of the estimated 2.2 million primary farm operators in 2011, most were over 40 years old (94.7%), males (83.7%), married or living with a partner (83.5%), and non-smokers (60.3%). An estimated 30.8% of farm operators had lifetime allergic rhinitis (Table 2) and 5.1% had current asthma. Current asthma was prevalent among 11.6% (95% CI 10.1 to 13.1%) of the operators with lifetime allergic rhinitis, and among 2.2% (95% CI 1.7 to 2.6%) of operators with no allergic rhinitis.

Conversely, of those with current asthma, 70.6% (95% CI 65.4 to 75.7%) had lifetime allergic rhinitis (Table 3).

In bivariate analyses, lifetime allergic rhinitis was significantly ($P<0.05$) associated with age, sex, second job, farm value of sales, farm type, farm acreage and US census region (Table 2). After adjusting for other variables, the odds of allergic rhinitis were significantly higher among operators aged 16–39 years (32.6%; POR 1.37, 95% CI 1.05 to 1.79) and 40–64 years (32.3%; POR 1.25, 95% CI 1.10 to 1.42) than those aged ≥ 65 years (28.4%), among females than males (37.5% vs. 29.5%; POR 1.38, 95% CI 1.17 to 1.61), among those managing farms with value of sales $< \$10,000$ (33.9%; POR 1.47, 95% CI 1.27 to 1.70) and $\$10,000$ – $\$99,000$ (29.9%; POR 1.34; 95% CI 1.18 to 1.53) than those managing farms with value of sales $\geq \$100,000$ (22.7%), and among operators living on farms located in the South compared to the West (38.2% vs. 29.0%; POR 1.50, 95% CI 1.32 to 1.70). Compared with operators with no allergic rhinitis, farm operators with lifetime allergic rhinitis were 6.03 times (95% CI 4.62 to 7.88) more likely to have declared current asthma, 1.74 times (95% CI 1.11 to 2.72) more likely to have asthma diagnosed before the age of 18 years, and 1.38 times (95% CI 1.22 to 1.56) more likely to report pesticide exposure (Table 3).

Multivariate associations between lifetime allergic rhinitis, current asthma and farm exposures among operators are shown in Table 4. The magnitude of associations of lifetime allergic rhinitis and current asthma with the farm exposures was similar to associations of allergic rhinitis alone/current asthma alone with the farm exposures. A notable exception was the pesticide use exposure—the association for lifetime allergic rhinitis and current asthma, and allergic rhinitis alone was statistically significant and much greater than that for current asthma alone.

DISCUSSION

This study found that an estimated 30.8% of primary farm operators had a history of allergic rhinitis. A review of cross-sectional studies conducted in various working populations, showed that the prevalence of current rhinitis among swine confinement workers, farm workers, and grain handlers ranged from 8% to 65% (occupational rhinitis prevalence in these groups ranged from 18% to 64%) (Siracusa et al. 2000). Slager et al. found that 67% to 74% of Iowa and North Carolina pesticide applicators had current rhinitis (Slager et al. 2009, 2010). In a study of poultry workers in Croatia, 39% of worker reported nasal allergies (Rimac et al. 2010). The prevalence of self-reported allergic rhinitis among grape farmers was 45.8% (Chatzi et al. 2005), and among European greenhouse flower and ornamental plant growers was 31% (Riu et al. 2008). Lower prevalence of rhinitis has been reported among farmers and farm workers in East North Carolina (1.1%), and Dutch (7.6%) or Italian swine breeders (13.9%) (Akpinar-Elci et al. 2016; Brouwer et al. 1986; Galli et al. 2015). These differences can be explained, in part, by differences in study methods, e.g., use of information on either self-reported symptoms or physician diagnosis of rhinitis (Akpinar-Elci et al. 2016), symptoms and physician diagnosis of hay fever (Slager et al. 2009, 2010), or combining questionnaire data with results of allergy test results or specific IgE blood levels (Chatzi et al. 2005; Galli et al. 2015; Rimac et al. 2010).

In this study 34.5% of primary farm operators who applied pesticides in the 12 months prior to the interview had a history of allergic rhinitis. Although this is lower than the rhinitis prevalence reported among workers in other settings, the positive association between pesticide application and lifetime allergic rhinitis in this study corroborates previous reports (Akpinar-Elci et al. 2016; Chatzi et al. 2007; Slager et al. 2009, 2010; Ye et al. 2013). Although we did not evaluate the association of rhinitis with the use of specific pesticides, Slager et al. previously reported that exposure to petroleum oil, herbicides 2,4-dichlorophenoxyacetic acid (2,4-D) and glyphosate, the insecticide diazinon, and the fungicide benomyl were positively associated with current rhinitis (Slager et al. 2009, 2010). Similarly, in a study of grape farmers, exposures to paraquat and other bipyridyl herbicides were found to increase the risk of allergic rhinitis (Chatzi et al. 2007). Moreover, we found a positive association between pesticide application and comorbid asthma and lifetime allergic rhinitis (Table 4). The association was not significant for operators with current asthma alone. The combination of current asthma and lifetime allergic rhinitis and the findings in our study are similar to the combination of adult-onset asthma and allergy in a study by Hoppin et al. (2009).

This study showed that operators with lifetime allergic rhinitis have higher prevalence of current asthma than those with no allergic rhinitis. These results are corroborated by the previous reports on risk of asthma among patients with occupational rhinitis (Ameille et al. 2013; Karjalainen et al. 2003). For example, Karjalainen et al. (2003) followed patients with occupational rhinitis for asthma incidence and found that the relative risk (RR) of asthma was 4.8 (95% CI 4.3 to 5.4) compared with those with other occupational disease. The risk was highest among farmers (RR 6.8) and wood workers (RR 7.0).

This study is subject to limitations. First, we examined the prevalence of self-reported lifetime history of physician-diagnosed allergic rhinitis. The diagnosis was not validated with medical records. Also, no information on rhinitis symptoms, skin prick test results, and laboratory test results for total serum IgE or allergen-specific IgE antibodies were available. Thus, it is possible that our results are overestimates because of potential inclusion of operators with non-allergic rhinitis. Validity of self-reported allergic rhinitis remains unknown. Moreover, because Farm and Ranch Safety Survey is a cross-sectional survey, causality or the temporal relationship between allergic rhinitis and pesticide application could not be assessed. It is also possible that we underestimate the allergic rhinitis prevalence because the survey asked about lifetime rhinitis diagnosis and some operators might not recall it if it has been established in a distant past. Furthermore, it is not clear what proportion of operators with an allergic rhinitis diagnosis established in the past may no longer have any symptoms. However, a longitudinal prospective population-based study of children followed from birth to 26 years of age by Nissen et al. (2013) showed an increasing rate of sensitization to aeroallergens with increasing age and suggested the persistence of allergic diseases. In addition, our findings might be affected by the healthy worker survivor effect, i.e., when some workers with respiratory symptoms might avoid or leave certain jobs with work-related exposures that trigger their symptoms (Mouchetrou et al. 2012; Slager et al. 2009). For example, operators with allergies might avoid active participation in haying, manure store, grain or animal production implying potential reverse causation. Finally, our outcome and exposure results are based solely on questionnaire report by farm operator or

operator's spouse and required recall of certain variables such as farming exposure and past history of rhinitis diagnosis. Although proxy responses, particularly by spouses, have shown good agreement with self-reported responses (Weinfurt et al. 2002), no data were available to the investigators to assess potential bias.

This study is one of the few to investigate lifetime allergic rhinitis prevalence and associated pesticide exposure in a nationally representative population of farmer operators. Results showed a high prevalence of lifetime allergic rhinitis among farm operators relative to the general population and identified groups of farm operators at increased risk of allergic rhinitis. Work-related allergic rhinitis and asthma have common risk factors and agents associated with work-related respiratory diseases are continuously revised and new ones are reported. A table with a list of agents causing work-related asthma with key references is available on the Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST) web site at http://www.asthme.csst.qc.ca/document/Info_Med/IdCauses/Bernstein/AgentsAnglais.pdf. The US Association of Occupational and Environmental Clinics publishes a list of substances that meet criteria for causing work-related asthma by sensitization or acute irritant-induced asthma (<http://www.aoecdata.org/ExpCodeLookup.aspx>). Additional data are needed to evaluate rhinitis-associated socio-economic adverse effects in farm operators including quality of life reduction, number of work days lost, and reduced productivity. Also, researchers should further investigate the association of allergic rhinitis with specific pesticide exposure.

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Table 1

Definitions of farm type and exposures

Measure	Definition
Farm type	
Crops	Farm operations with the largest source of revenue from grains, tobacco, cotton, vegetables, fruits or nuts, nursery or greenhouse, cutting Christmas trees, and other crops or hay.
Livestock	Farm operations with the largest source of revenue from swine, dairy, beef cattle, sheep or goats, equine, poultry, aquaculture, and other animals.
Farm Exposures and Hazards	
Bale hay	Defined as a “yes” response to the question: “Do you/Does the farm operator bale hay or straw on the farm?”
Manure storage	Defined as a “yes” response to the question: “Do you/Does the farm operator have any manure storage facilities on the farm or ranch?”
Grain production	Defined as a “one or more” response to the questions: “How many PTO-driven feed mixers or forage grinders (do you/does the farm operator) have?”, “How many silage blowers (do you/does the Farm Operator) have?”, “How many PTO-driven portable grain augers (do you/does the Farm Operator) have?”, “How many standalone grain bins with a capacity of 5000 bushel or more (do you/does the Farm Operator) have on the farm or ranch?”, or a “yes” response to the question “(Do you/Does the Farm Operator) use trenches on the farm or ranch for grain or animal feed storage?”
Animals	Defined as a “yes” response to any of these questions: “In the last 12 months (have you/has the farm operator) kept any large animals such as cattle, bison, horses, donkeys, ponies, mules or hogs?”, “(Do you/Does the farm operator have any beef cattle or bison on the farm or ranch?”, “(Do you/Does the farm operator have any dairy cattle on the farm or ranch?”, “(Do you/Does the farm operator have a dairy bull on the farm or ranch?”, “(Do you/Does the farm operator) have any horses or other equine such as ponies, mules, donkeys, or burros on the farm or ranch?”, “(Do you/Does the farm operator) have any hogs or pigs on the farm or ranch, whether owned by (you/them) or by someone else?”
Pesticide	Defined as a “yes” response to the question: “In the past 12 months, (have you/has the farm operator) ever mixed, loaded, or applied pesticides on your farm?”

Table 2

History of lifetime allergic rhinitis among farm operators, by select characteristic

Characteristics	Estimated population (in 1,000s)	Lifetime allergic rhinitis					
		Distribution		Prevalence		Association	
	% ^a	95%CI	% ^a	95%CI	POR ^b	95%CI	P-value
Total	2,181	100.0	30.8	(29.6 to 32.0)			
Demographics							
Age group (years.; mean=59.8)							
16–39	113	5.6	(4.5 to 6.7)	32.6	(27.3 to 37.8)	1.37	(1.05 to 1.79) 0.0198
40–64	1,270	62.5	(60.1 to 64.8)	32.3	(30.7 to 33.9)	1.25	(1.10 to 1.42) 0.0005
e65	749	32.0	(29.7 to 34.2)	28.4	(26.4 to 30.4)	Reference	
Sex							
Male	1,823	80.2	(78.2 to 82.2)	29.5	(28.2 to 30.8)	Reference	
Female	354	19.8	(17.8 to 21.8)	37.5	(34.2 to 40.8)	1.38	(1.17 to 1.61) 0.0001
Marital status							
Married or living with partner	1,802	83.5	(81.7 to 85.2)	30.8	(29.5 to 32.1)	1.10	(0.93 to 1.29) 0.26
Widowed, divorced, separated, single	355	16.5	(14.8 to 18.3)	30.9	(27.9 to 33.9)	Reference	
Smoking status							
Current	200	9.4	(7.9 to 10.8)	30.7	(26.6 to 34.9)	0.90	(0.73 to 1.11) 0.27
Former	645	30.6	(28.4 to 32.9)	31.2	(28.9 to 33.4)	1.03	(0.90 to 1.17) 0.32
Never	1,281	60.0	(57.6 to 62.4)	30.8	(29.2 to 32.3)	Reference	
Second job							
Yes	1,041	52.6	(50.2 to 55.0)	33.4	(31.6 to 35.2)	1.11	(0.97 to 1.27) 0.12
No	1,114	47.4	(45.0 to 49.8)	28.5	(26.9 to 30.1)	Reference	
Farm Characteristics							
Farm value of sales ^c							
<\$10,000	1,201	60.5	(58.7 to 62.2)	33.9	(31.9 to 35.8)	1.47	(1.27 to 1.70) <.0001
\$10,000–\$99,000	600	26.6	(25.3 to 28.0)	29.9	(28.5 to 31.4)	1.34	(1.18 to 1.53) 0.047

Characteristics	Lifetime allergic rhinitis											
	Distribution					Prevalence					Association	
	% <i>a</i>	95%CI	% <i>a</i>	95%CI	POR ^b	95%CI	% <i>a</i>	95%CI	POR ^b	95%CI	P-value	
e\$100,000	380	12.9	(11.9 to 13.9)	22.7	(20.9 to 24.5)	Reference						
Region ^d												
Midwest	796	28.4	(26.5 to 30.3)	24.1	(22.1 to 26.0)	0.81				(0.70 to 0.94)	<.0001	
Northeast	142	5.3	(4.9 to 5.7)	25.2	(23.3 to 27.1)	0.81				(0.71 to 0.93)	<.0001	
South	916	52.1	(50.2 to 54.1)	38.2	(36.0 to 40.4)	1.50				(1.32 to 1.70)	<.0001	
West	327	14.2	(13.2 to 15.1)	29.0	(27.2 to 30.8)	Reference						
Farm type												
Crops	1,068	53.7	(51.3 to 56.1)	32.2	(30.5 to 33.9)	0.96				(0.85 to 1.08)	0.51	
Livestock	1,113	46.3	(43.9 to 48.7)	29.4	(27.7 to 31.1)	Reference						
Farm size (acres)												
<101	1,389	67.5	(65.6 to 69.4)	32.7	(31.0 to 34.3)	0.83				(0.65 to 1.05)	0.11	
101–999	666	27.7	(25.9 to 29.5)	28.1	(26.3 to 29.8)	0.90				(0.72 to 1.11)	0.84	
e1000	126	4.7	(4.0 to 5.4)	25.1	(21.8 to 28.3)	Reference						
Farm Exposures and Hazards												
Bale hay												
Yes	856	38.2	(35.9 to 40.5)	29.2	(27.4 to 31.0)	0.95				(0.84 to 1.08)	0.43	
No	1,273	61.8	(59.5 to 64.1)	32.0	(30.3 to 33.6)	Reference						
Manure storage												
Yes	98	3.3	(2.6 to 4.1)	22.2	(17.8 to 26.6)	0.78				(0.59 to 1.02)	0.07	
No	2,017	96.7	(95.9 to 97.4)	31.3	(30.1 to 32.6)	Reference						
Grain production												
Yes	426	17.3	(15.6 to 19.0)	26.4	(24.1 to 28.8)	0.95				(0.81 to 1.10)	0.49	
No	1,689	82.7	(81.0 to 84.4)	32.1	(30.7 to 33.5)	Reference						
Animals												
Yes	1,426	69.7	(67.5 to 72.0)	31.9	(30.5 to 33.4)	1.04				(0.92 to 1.19)	0.53	
No	689	30.3	(28.0 to 32.5)	28.9	(26.7 to 31.0)	Reference						
Pesticides												

Characteristics	Lifetime allergic rhinitis									
	Estimated population (in 1,000s)		Distribution			Prevalence			Association	
			% ^a	95%CI	% ^a	95%CI	POR ^b	95%CI	P-value	
Yes	843	44.8	(42.3 to 47.2)	34.5	(32.6 to 36.5)	1.38	(1.22 to 1.56)		<.0001	
No	1,263	55.2	(52.8 to 57.7)	28.6	(27.0 to 30.1)	Reference				

Note: Numbers in bold show a statistically significant difference across levels of demographic or a statistically significant association.

^aWeighted to produce unbiased national estimates.

^bPOR, prevalence odds ratio; POR adjusted for age, sex, region, and value of sales

^cDefined by the USDA Census of Agriculture and reflects the gross value of agricultural products sold from the operation for the year.

^dMidwest: Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota; Northeast: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, Pennsylvania; South: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, Texas, West:Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, Alaska, California, Hawaii, Oregon, Washington

Table 3
 Estimated number and prevalence of farm operators with lifetime allergic rhinitis by asthma characteristics

Characteristics	Lifetime allergic rhinitis						
	Distribution		Proportion		Association		
	% ^a	95% CI	% ^a	95% CI	POR ^b	95% CI	P-value
Current asthma ^c							
Yes	108	11.6 (10.1 to 13.1)	70.6 (65.4 to 75.7)	6.03	(4.62 to 7.88)	<.0001	
No	2,019	88.4 (86.9 to 89.9)	28.7 (27.5 to 29.9)	Reference			
Farm work related asthma							
Yes	16	15.5 (11.1 to 20.0)	70.9 (57.9 to 83.9)	1.01	(0.50 to 2.05)	0.98	
No	90	84.5 (80.0 to 88.9)	70.0 (64.3 to 75.8)	Reference			
Age of asthma diagnosis ^d							
<18 years	59	46.7 (40.7 to 52.6)	74.8 (68.8 to 80.9)	1.74	(1.11 to 2.72)	0.02	
e18 years	81	53.3 (47.4 to 59.3)	62.0 (55.6 to 68.5)	Reference			
Asthma attack in the past 12 months ^e							
Yes	55	51.2 (44.5 to 58.0)	70.9 (63.4 to 78.4)	0.97	(0.59 to 1.59)	0.90	
No	53	48.8 (42.0 to 55.5)	70.2 (63.1 to 77.3)	Reference			
Asthma attack at work ^f							
Yes	20	39.1 (29.9 to 48.4)	75.4 (63.8 to 87.1)	1.39	(0.62 to 3.10)	0.42	
No	35	60.9 (51.6 to 70.1)	68.6 (58.8 to 78.4)	Reference			

Note: Numbers in bold show a statistically significant difference across groups or a statistically significant association. CI, confidence interval; POR, prevalence odds ratio

^aWeighted to produce unbiased national estimates.

^bPOR adjusted for age, sex, region, and value of sales

^cMissing information on current asthma for 280 respondents

^dIncludes individuals who do not have current asthma, but were diagnosed with asthma in the past

^eFor operators with current asthma

^fFor operators who reported an asthma attack in the past 12 months

Table 4

Logistic regression. Models with independent variables lifetime allergic rhinitis and current asthma, lifetime allergic rhinitis alone, or current asthma alone.

Dependent variable	Allergic rhinitis and current asthma		Allergic rhinitis alone		Current asthma alone	
	POR ^a	95%CI	POR ^a	95%CI	POR ^a	95%CI
Bale hay	0.89	(0.65 to 1.21)	0.96	(0.84 to 1.09)	0.85	(0.55 to 1.33)
Manure storage	1.28	(0.72 to 2.26)	0.71	(0.53 to 0.96)	0.91	(0.46 to 1.80)
Grain production	0.95	(0.67 to 1.35)	0.95	(0.81 to 1.11)	1.03	(0.63 to 1.70)
Animals	1.03	(0.75 to 1.42)	1.04	(0.91 to 1.19)	0.96	(0.60 to 1.54)
Pesticides	1.90	(1.42 to 2.54)	1.33	(1.17 to 1.51)	1.16	(0.73 to 1.84)

Note: Numbers in bold show a statistically significant association.

^aPrevalence ratios adjusted for age, sex, US census region, and value of sales. Prevalence ratios from the multivariable logistic regression model examining four disjoint categories of allergic rhinitis and current asthma (i.e., allergic rhinitis and current asthma, allergic rhinitis alone, current asthma alone, and no allergic rhinitis or current asthma as a referent category).