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## Respirator Use Among US Farm Operators With Asthma: Results From the 2011 Farm and Ranch Safety Survey

Megan L. Casey and Jacek M. Mazurek

Surveillance Branch, Respiratory Health Division, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Morgantown, West Virginia, USA

### Abstract

**Objective**—The purpose of this study was to estimate the national prevalence of respirator use among farm operators with farm work–related asthma and factors associated with respirator use.

**Methods**—The authors examined the 2011 Farm and Ranch Safety Survey, a national survey collected from 11,210 actively farming farm operators in the United States. Adjusted prevalence ratios (aPORs) of respirator use were calculated by demographic characteristics, farm characteristics, asthma characteristics, and selected exposures and hazards.

**Results**—Among the estimated 2.2 million farm operators in 2011, 35.7% reported using a respirator in the past 12 months. Respirator use was significantly ( $P < .05$ ) associated with age, marital status, sex, smoking status, farm value of sales, farm type, farm acreage, and geographic region. Operators who work with pesticides were 3.5 times more likely to use respirator than those who did not work with pesticides ( $P < .0001$ ). Among those with current asthma, 60.8% of operators with farm work–related asthma used respirators compared with 44.4% of operators with non–farm work–related asthma ( $P = .03$ ). Farm operators with farm work–related asthma who had an asthma attack at work were 11.3 times more likely to report respirator use than those who did not have an asthma attack at work ( $P = .03$ ).

**Conclusions**—Personal protective equipment, including respirators, is an approach to reducing respiratory exposures in agricultural settings, in particular among those with farm work–related asthma. Education for respirator use and evaluation for respirator tolerance should be considered.

### Keywords

Farm operator; occupational exposure; respirator; work-related asthma

### Introduction

In 2011, there were an estimated 2.2 million primary farm operators in the United States.<sup>1</sup> Primary farm operators are those who run a farm and make day-to-day management decisions<sup>2</sup> and may be exposed to organic and inorganic dusts, microbial agents, diesel

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CONTACT: Surveillance Branch, Respiratory Health Division, National Institute for Occupational Safety and Health, Mailstop HG-900, 1095 Willowdale Road, Morgantown, WV 26505, USA., ydg7@cdc.gov.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

exhausts, ammonia, pesticides, and other toxins.<sup>3</sup> These respiratory agents can cause de novo or exacerbate existing asthma. A subset of asthma caused or exacerbated by exposure to specific substances in the workplace is termed “work-related asthma.”<sup>4</sup> Work-related asthma has a substantial impact on individuals, as they experience more frequent asthma symptoms, activity limitation, and asthma attacks than those with non-work-related asthma.<sup>5</sup> An estimated 5.1% of farm operators had current asthma in 2011, with 15.4% being told by a clinician that their asthma was related to their work on the farm. Among operators with farm work-related asthma, 54.8% had an asthma attack in the past 12 months, and 33.3% had an asthma attack that occurred while working on the farm.<sup>1</sup>

Treatment for work-related asthma includes ceasing exposure by eliminating or substituting the causative agent.<sup>4</sup> When eliminating or substituting the causative agent from the workplace is not possible, the worker may need to be removed from a worksite. When worker removal from the worksite is not possible, engineering controls are often implemented to reduce exposure.<sup>6</sup> These controls can include enclosing tractor cabs and ventilating confined areas.<sup>7-9</sup> Due to the diversity of exposures and physical demands of farm work, engineering controls are not always possible. Therefore, personal protective equipment (PPE), notably respirators, is still an important means to reducing respiratory exposures.<sup>10,11</sup>

A 2012 systematic review by the European Respiratory Society found that respirators can reduce respiratory symptoms in persons with work-related asthma during short-term exposures but do not provide complete protection.<sup>12</sup> Similar conclusions were drawn from other reviews of work-related asthma management by the Agency for Healthcare Research and Quality and the British Occupational Health Research Foundation.<sup>13,14</sup> Overall, studies of respirator effectiveness for work-related asthma are few. In one study, 26 farmers with occupational asthma were challenged with a 1-hour exposure to dusts found in agriculture with and without air purifying respirators. Eleven of the 26 farmers experienced no breathing difficulties when using a respirator, and 15 reported a reduction in their respiratory complaints. The authors concluded that although respirator use reduced the development of bronchial obstruction, it did not provide complete protection.<sup>15</sup> Lack of complete protection among respirators has been attributed to filter and face-seal leaks.<sup>16-18</sup>

Workers who handle pesticides are required to use PPE, including respiratory protection, according to the specifications on the pesticides' label.<sup>19</sup> A study by Hoppin et al. found that certain pesticides were associated with allergic asthma and that pesticide exposure events were associated with both allergic and nonallergic asthma.<sup>20</sup> Additionally, Henneberger et al. suggested that use of selected pesticides might be a risk factor for asthma exacerbation among adult pesticide applicators with active allergic asthma.<sup>21</sup> Estimates from the 2006 Farm and Ranch Safety Survey showed that among farm operators who worked with pesticides, only one in five used respirators. Among all farm operators, 37.2% used a respirator, and respirator use occurred most frequently when working in a dusty environment.<sup>22</sup> Even among agricultural crop production practices that require respirator use through a respiratory protection program, high rates of program inadequacies suggest widespread problems with respiratory protection programs in agricultural settings.<sup>23</sup>

The National Occupational Research Agenda (NORA) is a program coordinated by the National Institute for Occupational Safety and Health (NIOSH) to stimulate innovative research and improve workplace practices in occupational safety and health.<sup>24</sup> The NORA objectives for the US agriculture, forestry, and fishing industries focuses on surveillance; vulnerable populations; and outreach, communication, and partnerships.<sup>25</sup> The goals for the surveillance objective seek to “describe: the nature, extent, and economic burden of occupational illnesses, injuries and fatalities; occupational hazards; and worker populations at risk for adverse health outcomes.” This study examined the 2011 Farm and Ranch Safety Survey data to estimate the national prevalence of respirator use among farm operators with farm work–related asthma and factors associated with respirator use.<sup>26</sup>

## Methods

In 2011, the US Department of Agriculture’s National Agricultural Statistics Service (NASS) conducted the Farm and Ranch Safety Survey on behalf of NIOSH.<sup>26</sup> From a sample of 25,000 farm operations selected for a random telephone survey, a total of 11,210 (44.8%) active farm operations were surveyed.<sup>26</sup> Respondents were the primary farm operator or the operator’s spouse; children were not permitted to act as a proxy for the farm operator. The adjusted survey response rate, excluding noncontacts, was 70.8%.

## Definitions

Operators were considered to have current asthma if they had ever been told by a doctor, nurse, or other health professional that they had asthma and if they still have asthma. Those with current asthma were further asked whether a doctor, nurse, or other health professional ever told them that their asthma was related to their work on the farm. If the answer was “yes,” operators were considered to have farm work–related asthma. Respirator use was assessed by asking if the operators have used a respirator or dust mask on the farm or ranch in the past 12 months. Farm exposures and hazards were identified using responses to questions asking if the farm operator performed specific job duties or the presence or absence of a hazard on the farm. Detailed questions used to define exposures and hazards are listed in Table 1.

## Statistical analysis

We used SAS software version 9.3 (SAS Institute, Cary, NC) for statistical analyses. Sample weights were used to account for unequal selection probabilities, unit nonresponse, and post-stratification. Farms were stratified within US Census regions and post-stratified by the value of sales (<\$10,000, \$10,000–\$99,000, \$100,000) following the NASS sampling methodology. Proportions with corresponding 95% confidence intervals (CIs) were estimated. Due to small number of observations, some categories had to be collapsed for analysis. The Rao-Scott chi-square test of independence was used to test the differences in bivariate proportions. Variables associated with respirator use at  $P < .25$ , were included in a multivariate logistic regression model. Using backward selection, variables were sequentially removed from the model until all beta coefficients were significant at  $\alpha = .05$ . In the final model, prevalence odds ratios (PORs) were adjusted for age, sex, region,

farm type, and value of sales. Estimates with a relative standard error that was >30% were considered unstable and were not reported.

## Results

Demographic characteristics of primary farm operators and farm operators with asthma have been previously described.<sup>1</sup> Briefly, of the estimated 2.2 million primary farm operators in 2011, 94.7% were over 40 years old, 83.7% were males, 83.5% were married or living with a partner, and 60.3% were nonsmokers.<sup>1</sup> Asthma prevalence among farm operators in 2011 was 5.1%, and the proportion of farm operators with asthma who were told that their asthma is farm work related was 15.4%.

Among farm operators, an estimated 35.7% reported to have used a respirator in the past 12 months. In the bivariate analysis, respirator use was significantly ( $P < .05$ ) associated with age, marital status, sex, smoking status, farm value of sales, farm type, farm acreage, and geographic region. The proportion of farm operators using respirators increased with increasing farm acreage and farm value of sales. Farm operators managing farms that grow crops were significantly more likely to use respirator than those managing livestock farms (39.1% vs. 32.5%;  $P < .0001$ ) (Table 1).

An estimated 40% of farm operators reported working with pesticides, and among those, 54.5% reported using a respirator. Operators who work with pesticides were 3.5 times more likely to use respirator than those who did not work with pesticides ( $P < .0001$ ). Respirator use was frequently reported among farm operators who have manure storage facilities on the farm (52.1%) or work on a farm that involves grain production (51.2%).

Farm operators working in grain production were 2 times ( $P < .0001$ ) more likely to wear a respirator than those who did not work in grain production (Table 1). An estimated 88.5% of farm operators reported having grain storage facilities on the farm, such as grain silos, bins, or trenches. Proportion of respirator users was significantly greater among farm operators reporting grain storage facilities compared with farm operators who did not have grain storage facilities (56.3% vs. 31.6%;  $P < .0001$ ).

Compared with farm operators with no asthma, those with current asthma were significantly more likely to use a respirator in the previous 12 months (46.8% vs. 35.2%;  $P = .0001$ ). Among those with current asthma, 60.8% of operators with farm work–related asthma used respirators, compared with 44.4% of operators with non–farm work–related asthma ( $P = .03$ ). No significant difference in respirator use was found for farm operators with current asthma who reported an asthma attack in the past 12 months and those that did not ( $P = .27$ ), nor between those who had an asthma attack at work in the past 12 months and those who did not ( $P = .13$ ) (Table 2). Operators with farm work–related asthma who had an asthma attack at work were 11.3 times more likely to report respirator use than those who did not have an asthma attack at work ( $P = .03$ ) (Table 3).

Prevalence of respirator use among primary farm operators by select characteristic and asthma status is shown in Table 4. The association of respirator use with pesticide exposure was strongest for farm operators who had farm work–related asthma (aPOR = 7.9) (Table 4).

Among farm operators who had exposure to pesticides in the past 12 months, 64.9% used some type of PPE the last time they handled pesticides. For those operators who used some form of PPE the last time they handled pesticides, 15.9% wore a respirator. Types of respirators used by farm operators who used PPE the last time they handled pesticides included filtering face pieces or dust masks (56.4%) and cartridge respirators (43.6%). No significant difference was found in the types of respirators used by those who have current asthma and those who do not have current asthma. Cartridge respirators were full-face (20.8%), half-face (72.2%) and air supplied respirators (7.1%).

## Discussion

This study found that nearly half of farm operators with asthma and nearly two thirds of operators with farm work–related asthma used some type of respiratory protection in the past year. The proportion who use respirators was higher among operators with farm work–related asthma than those with non–farm work–related asthma. This could be explained partially because work-related asthma is a more severe disease than non–work-related asthma.<sup>5</sup> Persons with work-related asthma may have more frequent encounters with health care providers, and it is possible that clinicians discuss the use of respirators more often with these operators than with operators who have asthma that is not related to work.<sup>5</sup>

The US Environmental Protection Agency (EPA) requires respirator use when handling certain pesticides according to the manufacturer’s instructions.<sup>19</sup> However, this survey did not specify the type of pesticide used when farm operators wore a respirator. For those operators who did wear some form of PPE the last time they handled pesticides, 15.9% wore a respirator. Conversely, among operators who handled pesticides anytime in the past 12 months, only half (54.4%) wore a respirator at some time in the last year. Moreover, farm operators with farm work–related asthma who handled pesticides were more likely to report respirator use than operators who did not handle pesticides. Thus, although some farm operators who work with pesticides may use a respirator, a substantial proportion may not be adequately protected.

In this study, farm operators with farm work–related asthma who had an asthma attack at work used respirators more frequently than those who had an asthma attack that was not at work (aPOR = 11.3, 95% CI = 1.3–101.2;  $P = 0.03$ ). Due to the cross-sectional design of this study, we were not able to determine if respirators were ineffective at preventing asthma attacks at work or if farm operators chose to wear a respirator as a result of having an asthma attack at work. In addition, although respiratory devices may reduce exposure, several studies and systematic reviews have found that they may not provide complete protection. Asthma symptoms and attacks may still occur when a respirator is being used, even when sensitizers’ levels in the ambient air are very low.<sup>27</sup>

Some farm operators with asthma may have difficulty tolerating respirators. Respirators can add inspiratory and expiratory resistances that cause an increase in tidal volume and a decrease in respiratory rate and ventilation.<sup>28,29</sup> The Occupational Safety and Health Administration (OSHA) Technical Manual indicates that some individuals with respiratory conditions, such as asthma, may not be medically able to wear a respirator.<sup>30</sup> Guidance for

respirator medical evaluation indicates that although most people with asthma should be able to wear a respirator, a field evaluation and a physician's judgment may be necessary to assure safe respirator use and adequate protection.<sup>31</sup>

There are other limitations to this study. The data for the 2011 Farm and Ranch Safety Survey were self-reported either by the farm operator or their spouse. The information collected from the spouse may not accurately reflect the experience of the farm operator. There was no indicator variable available to the authors that specified whether the respondent was the farm operator or spouse. Moreover, because the survey asked respondents to recall events during the past 12 months, some events may not be recalled or recalled outside this period. Respirator use was not specifically defined in the survey, so responses to respirator use questions may reflect issues of adherence, regulations, and various respirator types. Both terms, respirator and dust mask, were used during the telephone interview. Cognitive testing of the questionnaire showed that respondents often associated the term respirator with a rubber face mask with cartridges or supplied air.<sup>19</sup> Respondents who used N-95 respirators responded "No" to the question about respirator use as they considered the N-95 respirator a dust mask. Consequently, the questionnaire was modified to include both terms. In addition, the survey question evaluating the types of respirators worn while working with pesticides considered a powered air supplying respirators as cartridge respirators. Since supplied air respirators use compressors or pressurized cylinders as a source of air, they are not considered to be cartridge respirators. For this reason, respondents who use powered air supplying respirators may have been incorrectly classified. The survey did not assess the type of pesticides used during respirator use. Also, no data were available to determine if operators were wearing dust masks or respirators while having an asthma attack and if the attack was due to inappropriate or inadequate respiratory protection. Asthma attacks were self-reported, and although some of these attacks likely had work-related triggers, non-work-related triggers could also be responsible. Physician diagnosed asthma and work-related asthma were self-reported in the survey. In addition, this survey was administered to farm operators working on active farm operations and may be subject to healthy worker bias; operators with severe asthma may have left the workforce. Thus, the results may be underestimating the population asthma prevalence. Finally, due to a small number of farm operators with farm work-related asthma some estimates could not be computed or were unreliable.

Farm operators with asthma should be educated on respirator use and evaluated for respirator tolerance as part of their asthma management plan.<sup>32</sup> The American Thoracic Society advises that the use of respirators requires workers to adhere to professional guidance that includes device selection, fit testing, maintenance, and user training.<sup>32</sup> Patients with asthma should be encouraged to discuss respirators with their clinician. Periodic assessment of asthma symptoms and lung function testing can help the clinician assess respirator efficacy and determine specific exposures that increase risk for adverse health effects. Respiratory symptoms and consistent decline in lung function after exposure to causative agents may indicate inadequate respiratory protection. However, repetitive demonstration that an exposure is not associated with lung function decline "can reassure the worker, physician, and management that adequate control is in place" according to the American Thoracic Society.<sup>32</sup>

Occupational risk factors should be considered during assessments of patients with asthma-like symptoms and those with existing asthma. However, only one in seven employed adults with asthma talks to their clinician about the possible role of work in their disease.<sup>33</sup> Clinician recognition of farm work–related respiratory symptoms and respirator education might allow for symptom improvement in farm operators with asthma by reducing exposure to the substances causing the illness. Education and evaluation for respirator tolerance should be considered when exposure or worker removal from the farm is not feasible. The findings and limitations of this study indicate a need for additional research. Future studies should address the specifics of respirator use, including respirator type, knowledge, proper use, and respiratory protection programs including questions with regard to medical fit testing. In addition, studies should also address questions regarding the type of pesticide used while wearing a respirator to better understand adherence to EPA guidance.

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Table 1

Estimated number and prevalence of farm operators who use respirators by characteristic.

Characteristic	Estimated total population (in thousands)	Respirator use			Respirator use vs. no respirator use		
		Distribution %	95% CI*	Proportion of operators using respirators	95% CI*	aPOR <sup>*,†</sup>	Lower CI* P
Total	2,181	100.0		35.7	34.5–36.9		
<i>Demographic characteristics</i>							
Age group							
16–44	222	11.7	10.4–13.0	<b>40.0</b>	36.2–43.8	1.00 (Ref)	
45–74	1,642	80.0	78.4–81.7	<b>37.1</b>	35.7–38.5	0.9	0.8–1.1 .377
75+	267	8.2	7.1–9.4	<b>24.2</b>	21.0–27.3	<b>0.5</b>	<b>0.4–0.7</b> <.0001
Sex							
Male	1,823	89.4	88.0–90.7	<b>38.1</b>	36.7–39.4	<b>1.6</b>	<b>1.4–2.0</b> <.0001
Female	354	10.6	9.3–12.0	<b>23.4</b>	20.6–26.2	1.00 (Ref)	
Marital status							
Married or living with partner	1,786	87.1	85.7–88.4	<b>37.7</b>	36.3–39.0	<b>1.4</b>	<b>1.2–1.6</b> <.0001
Widowed, divorced, separated, single	370	12.9	11.6–14.3	<b>26.8</b>	24.2–29.4	1.00 (Ref)	
Smoking							
Current or former smoker	845	37.8	35.7–39.9	<b>34.0</b>	32.0–36.0	1.00 (Ref)	
Never smoker	1,281	62.2	60.1–64.3	<b>37.0</b>	35.4–38.5	1.1	1.0–1.3 .073
Second Job							
Yes	1,041	48.3	46.2–50.4	36.0	34.3–37.6	1.0	0.9–1.2 .544
No	1,114	51.7	49.6–53.8	35.5	33.6–37.3	1.00 (Ref)	
<i>Farm characteristics</i>							
Farm value of sales <sup>***</sup>							
<\$10,000	1,201	48.6	46.8–50.3	<b>31.4</b>	29.5–33.4	<b>0.4</b>	<b>0.4–0.5</b> <.0001
\$10,000–\$99,000	600	26.2	25.0–27.4	<b>34.1</b>	32.5–35.7	<b>0.5</b>	<b>0.5–0.6</b> <.0001
\$100,000	380	25.3	24.1–26.4	<b>51.6</b>	49.4–53.9	1.00 (Ref)	
Region <sup>§</sup>							
Northeast	142	5.9	5.5–6.3	<b>32.5</b>	30.6–34.5	1.00 (Ref)	
Midwest	796	35.6	34.0–37.3	<b>35.0</b>	33.0–37.1	1.0	0.9–1.1 .852

Characteristic	Estimated total population (in thousands)	Respirator use			Respirator use vs. no respirator use		
		Distribution %	95% CI*	Proportion of operators using respirators	95% CI*	aPOR <sup>†‡</sup>	Lower CI* P
South	916	42.1	40.4–43.9	35.7	33.5–37.9	1.3	1.2–1.5 <.0001
West	327	16.3	15.5–17.2	38.6	36.7–40.5	1.4	1.2–1.5 <.0001
Farm type <sup>†††</sup>							
Crops	1,068	53.3	51.2–55.4	39.1	37.3–40.8	1.4	1.3–1.6 <.0001
Livestock	1,113	46.7	44.6–48.8	32.5	30.8–34.2	1.00 (Ref)	
Farm size							
<101 acres	1,389	58.1	56.3–60.0	32.5	30.9–34.2	1.0	0.8–1.2 .776
101–999 acres	666	33.6	31.8–35.3	39.4	37.5–41.3	1.0	0.8–1.2 .876
1000 acres	126	8.3	7.4–9.1	51.1	47.3–54.9	1.00 (Ref)	
<i>Farm exposures and hazards</i>							
Bale hay <sup>††</sup>							
Yes	856	43.3	41.3–45.3	38.5	36.6–40.3	1.1	0.9–1.2 .348
No	1,273	56.7	54.7–58.7	33.8	32.2–35.4	1.00 (Ref)	
Manure storage <sup>**</sup>							
Yes	98	6.8	5.9–7.7	52.1	47.0–57.3	1.7	1.3–2.1 <.0001
No	2,017	93.2	92.3–94.1	34.9	33.6–36.1	1.00 (Ref)	
Grain production <sup>†††</sup>							
Yes	426	28.8	27.1–30.6	51.2	48.6–53.8	2.0	1.7–2.2 <.0001
No	1,689	71.2	69.4–72.9	31.8	30.4–33.1	1.00 (Ref)	
Animals <sup>§§</sup>							
Yes	1,426	65.7	63.7–67.7	34.8	33.3–36.3	0.9	0.8–1.1 .262
No	689	34.3	32.3–36.3	37.6	35.4–39.7	1.00 (Ref)	
Pesticides <sup>¶¶</sup>							
Yes	843	61.1	59.0–63.2	54.5	52.5–56.5	3.5	3.1–3.9 <.0001
No	1,263	38.9	36.8–41.0	23.1	21.7–24.6	1.00 (Ref)	

Note. Numbers in bold show a statistically significant difference between groups where  $P < .05$ .

\* CI = confidence interval; aPOR = adjusted prevalence odds ratio.

† aPOR was adjusted for age, sex, region, farm type, and value of sales.

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§ Northeast: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, Pennsylvania; Midwest: Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota; 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.

¶ Exposure to baling hay was defined with the question: "Do you/Does the Farm Operator bale hay or straw on the farm?"

\*\* Exposure to manure storage was defined using the question: "Do you/Does the Farm Operator have any manure storage facilities on the farm or ranch?"

†† Exposure to grain production was defined using 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 stand alone grain bins with a capacity of 5000 bushel or more (do you/does the Farm Operator) have on the farm or ranch?"; "(Do you/Does the Farm Operator) use trenches on the farm or ranch for grain or animal feed storage?"

§§ Exposure to animals was defined using the 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?"

¶¶ Exposure to pesticides was defined using the question: "In the past 12 months, (have you/has the farm operator) ever mixed, loaded, or applied pesticides on your farm?"

\*\*\* Farm value of sales comes from the USDA Census of Agriculture and reflects the gross value of agricultural products sold from the operation for the year.

††† Farm type was determined by whether crops or livestock accounted for the majority of the farm income.

Table 2

Estimated number and prevalence of farm operators who use respirators by asthma characteristics.

Asthma characteristic	Estimated total population (in thousands)	Respirator use			Respirator use vs. no respirator use			
		Distribution %	95% CI*	Proportion of operators using respirators	95% CI*	aPOR <sup>†</sup>	Lower CI*	P
Current asthma								
Yes	108	6.6	5.6–7.7	<b>46.8</b>	41.0–52.5	<b>1.7</b>	<b>1.4–2.1</b>	<b>&lt;.0001</b>
No	2,019	93.4	92.3–94.4	<b>35.2</b>	34.0–36.4	1.00 (Ref)		
Current farm work–related asthma								
Yes	16	19.9	13.3–26.6	<b>60.8</b>	48.0–73.6	1.8	1.0–3.5	.07
No	90	80.1	73.4–86.7	<b>44.4</b>	37.9–50.8	1.00 (Ref)		
Age of asthma diagnosis <sup>§</sup>								
Age 18 or Less	61	40.3	33.4–47.3	45.2	37.9–52.5	0.8	0.5–1.2	.343
Age 19+	89	59.7	52.7–66.6	45.7	39.4–52.1	1.00 (Ref)		
Asthma attack past 12 months								
Yes	55	54.7	46.5–62.9	49.8	41.6–58.0	1.3	0.8–2.2	.229
No	53	45.3	37.1–53.5	43.5	35.6–51.5	1.00 (Ref)		
Asthma attack past 12 months–at work								
Yes	20	43.1	32.1–54.1	57.9	45.3–70.4	1.9	0.9–3.8	.081
No	35	56.9	45.9–67.9	45.3	34.8–55.7	1.00 (Ref)		

Note. Numbers in bold show a statistically significant difference between groups where  $P < .05$ .

\* CI = confidence interval; aPOR = adjusted prevalence odds ratio.

<sup>†</sup> aPOR was adjusted for age, sex, region, farm type, and value of sales.

<sup>§</sup> Age of asthma diagnosis includes individuals who do not have current asthma but were diagnosed with asthma in the past.

Table 3

Report of asthma attack among farm operators with current farm work–related asthma and current non–farm work–related asthma.

Asthma characteristic	Current asthma, farm work related				Current asthma, not farm work related			
	Proportion of operators who use respirators	aPOR Respirator vs. no respirator <sup>*,†</sup>	95% CI*	P	Proportion of operators who use respirators	aPOR Respirator vs. no respirator <sup>*,†</sup>	95% CI*	P
Asthma attack past 12 months								
Yes	58.3	0.8	0.3–2.5	.75	48.3	1.4	0.8–2.4	.19
No	63.7	1.00 (Ref)			40.3	1.00 (Ref)		
Asthma attack past 12 months—at work								
Yes	69.2	<b>11.3</b>	<b>1.3–101.2</b>	<b>.03</b>	54.9	1.6	0.7–3.7	.30
No	40.3	1.00 (Ref)			45.8	1.00 (Ref)		

Note. Numbers in bold show a statistically significant difference between groups where  $P < .05$ .

\* CI = confidence interval; aPOR = adjusted prevalence odds ratio.

<sup>†</sup> aPOR was adjusted for age, sex, region, farm type, and value of sales.

Table 4

Prevalence of respirator use among farm operators by characteristic and asthma status.

Characteristic	No asthma diagnosis			Current asthma, farm work related			Current asthma, not farm work related		
	Proportion of operators using respirators	aPOR respirator vs. no respirator* 95% CI*	Proportion of operators using respirators 95% CI*	Proportion of operators using respirators	aPOR respirator vs. no respirator**† 95% CI*	Proportion of operators using respirators	Proportion of operators using respirators	aPOR respirator vs. no respirator**† 95% CI*	Proportion of operators using respirators
<i>Demographic characteristics</i>									
Age group									
16–64	38.6	37.0–40.2	1.00 (Ref)	57.9	42.3–73.6	1.00 (Ref)	47.0	38.4–55.6	1.00 (Ref)
65+	28.5	26.5–30.5	0.6	69.7	52.0–87.4	2.0	41.1	31.8–50.4	0.7
Sex									
Male	37.3	36.0–38.7	1.7	***	1.4–2.0	***	48.7	41.4–56.0	1.5
Female	22.9	20.0–25.8	1.00 (Ref)	***	***	***	31.3	18.7–43.8	1.00 (Ref)
Marital status									
Married or living with partner	36.8	35.4–38.3	1.4	***	1.2–1.6	***	49.4	42.3–56.5	2.9
Widowed, divorced, separated, single	26.8	24.0–29.6	1.00 (Ref)	***	***	***	22.7	12.4–33.0	1.00 (Ref)
Smoking									
Current or former smoker	33.1	31.1–35.2	1.1	63.0	39.9–86.2	1.0	42.2	32.8–51.6	1.2
Never smoker	36.3	34.7–37.9	1.00 (Ref)	60.1	43.1–77.1	1.00 (Ref)	46.4	38.0–54.7	1.00 (Ref)
Second job									
Yes	34.8	33.0–36.7	1.1	63.0	42.7–83.4	1.4	45.0	35.4–54.7	0.9
No	35.2	33.5–37.0	1.00 (Ref)	58.5	41.7–75.3	1.00 (Ref)	43.8	35.6–52.0	1.00 (Ref)
<i>Farm characteristics</i>									
Farm value of sales									
<\$100,000	51.3	49.0–53.6	0.5	62.7	43.7–81.9	1.1	54.2	40.7–67.7	0.7
\$100,000	31.6	30.1–33.0	1.00 (Ref)	59.9	42.8–77.1	1.00 (Ref)	43.1	36.0–50.1	1.00 (Ref)
Region <sup>§</sup>									
Northeast	32.3	30.2–34.3	1.00 (Ref)	54.7	38.9–70.6	1.00 (Ref)	36.7	26.2–47.3	1.00 (Ref)
Midwest	34.4	32.3–36.5	1.0	55.2	25.8–84.7	0.9	44.6	32.5–56.6	1.3

Characteristic	No asthma diagnosis			Current asthma, farm work related			Current asthma, not farm work related		
	Proportion of operators using respirators	aPOR vs. no respirator* 95% CI*	aPOR vs. no respirator* 95% CI*	Proportion of operators using respirators	aPOR vs. no respirator* 95% CI*	aPOR vs. no respirator* 95% CI*	Proportion of operators using respirators	aPOR vs. no respirator* 95% CI*	aPOR vs. no respirator* 95% CI*
South	35.2	32.9–37.4	<b>1.3</b>	71.6	1.1–1.5	1.1	42.8	31.4–54.2	1.5
West	37.6	35.6–39.6	<b>1.3</b>	52.8	1.2–1.5	1.0	49.7	41.0–58.5	1.9
Farm type									
Crops	<b>38.3</b>	36.5–40.1	<b>1.4</b>	55.3	1.3–1.6	0.7	47.8	38.3–57.3	1.4
Livestock	<b>32.0</b>	30.2–33.7	1.00 (Ref)	65.6		1.00 (Ref)	41.4	32.7–50.0	1.00 (Ref)
Farm size									
<101 acres	<b>31.8</b>	30.1–33.5	1.0	51.2	0.8–1.2	<b>0.1</b>	43.4	35.2–51.6	1.2
101–999	<b>39.1</b>	37.1–41.0	1.1	65.8	0.9–1.3	0.2	46.6	36.7–56.5	1.2
1000	<b>50.2</b>	46.2–54.2	1.00 (Ref)	79.7		1.00 (Ref)	46.6	24.6–68.7	1.00 (Ref)
<i>Farm exposures and hazards</i>									
Bale hay <sup>¶</sup>									
Yes	<b>37.8</b>	35.9–39.8	1.1	<b>59.6</b>	1.0–1.2	0.7	48.9	38.3–59.5	1.2
No	<b>33.2</b>	31.5–34.8	1.00 (Ref)	<b>61.8</b>		1.00 (Ref)	42.1	34.2–50.1	1.00 (Ref)
Manure storage <sup>**</sup>									
Yes	<b>51.4</b>	46.0–56.9	<b>1.6</b>	***	1.3–2.1		<b>69.7</b>	51.4–87.9	<b>3.1</b>
No	<b>34.3</b>	33.0–35.5	1.00 (Ref)	***			<b>43.1</b>	36.5–49.6	1.00 (Ref)
Grain production <sup>††</sup>									
Yes	<b>50.6</b>	47.9–53.3	<b>2.0</b>	<b>78.4</b>	1.7–2.3	<b>3.7</b>	<b>59.2</b>	47.2–71.3	1.8
No	<b>31.1</b>	29.7–32.5	1.00 (Ref)	<b>52.0</b>		1.00 (Ref)	<b>41.7</b>	34.6–48.8	1.00 (Ref)
Animals <sup>§§</sup>									
Yes	34.2	32.7–35.7	0.9	61.0	0.8–1.1	0.6	45.3	37.6–53.1	1.2
No	36.8	34.5–39.1	1.00 (Ref)	60.3		1.00 (Ref)	42.4	31.3–53.6	1.00 (Ref)
Pesticides <sup>¶¶</sup>									
Yes	<b>53.7</b>	51.6–55.8	<b>3.4</b>	<b>77.7</b>	3.0–3.9	<b>7.9</b>	<b>60.7</b>	51.3–70.2	<b>3.2</b>
No	<b>22.9</b>	21.4–24.3	1.00 (Ref)	<b>34.2</b>		1.00 (Ref)	<b>30.8</b>	23.0–38.6	1.00 (Ref)

Note. Numbers in bold show a statistically significant difference between groups where  $P < .05$ .



\* CI = confidence interval; aPOR = adjusted prevalence odds ratio.

<sup>†</sup> aPOR was adjusted for age, sex, region, farm type, and value of sales.

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

<sup>¶</sup> Exposure to baling hay was defined with the question: "Do you/Does the Farm Operator bale hay or straw on the farm?"

\*\* Exposure to manure storage was defined using the question: "Do you/Does the Farm Operator have any manure storage facilities on the farm or ranch?"

<sup>††</sup> Exposure to grain production was defined using 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 stand alone grain bins with a capacity of 5000 bushel or more (do you/does the Farm Operator) have on the farm or ranch?"; "(Do you/Does the Farm Operator) use trenches on the farm or ranch for grain or animal feed storage?"

<sup>§§</sup> Exposure to animals was defined using the 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?"

<sup>¶¶</sup> Exposure to pesticides was defined using the question: "In the past 12 months, (have you/has the farm operator) ever mixed, loaded, or applied pesticides on your farm?"

\*\*\* The coefficient of variation for these estimates was >30% and considered unstable.