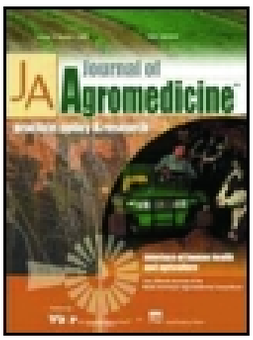

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Respiratory Disease in Agricultural Workers: Mortality and Morbidity Statistics

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ABSTRACT. To quantify the respiratory disease burden among agricultural workers, we examined the 1988–1998 National Center for Health Statistics (NCHS) "Multiple Cause of Death Data" and the 1988–1994 Third National Health and Nutrition Examination Survey data (NHANES III). Proportionate mortality ratios (PMRs) were determined for 11 respiratory conditions among 6 agricultural groups: crop farm workers, livestock farm workers, farm managers, landscape and horticultural workers, forestry workers, and fishery workers. Prevalence ratios (PRs) were determined for 12 respiratory conditions among 3 agricultural groups: farm workers, farm managers, and other agricultural workers. Disease categories groups were based on the 9th *International Classification of Diseases* and the agricultural groups on the NCHS or NHANES III industry and occupation codes, respectively. *Crop farm workers* and *livestock farm workers* had significantly elevated mortality for several respiratory conditions, with mortality for hypersensitivity pneumonitis being 10 and 50 times higher than expected. *Landscape and horticultural workers* had significantly elevated mortality for abscess of the lung and mediastinum and chronic airways obstruction. *Forestry workers* had significantly elevated mortality for pulmonary tuberculosis, chronic airways obstruction, and pneumonia. Prevalence of wheeze was elevated for female *farm workers,* shortness of breath was elevated for *farm workers* who had ever smoked, and hay fever was elevated for black, non-Hispanic *farm workers*. Prevalence of asthma was elevated for *other agricultural workers* who had ever smoked. *Farm workers* had a PR of 173 for obstructive respiratory abnormality. Continued improvement in occupational health surveillance systems for agriculture is essential to help guide prevention efforts for respiratory disease.

KEYWORDS. Agriculture, respiratory system disorders, mortality rates, morbidity rates

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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.

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INTRODUCTION

In 2002, the agricultural industry employed approximately 3.5 million workers.[1,2] Studies have demonstrated an increased risk for respiratory diseases among agricultural workers.[3–5] However, there has been limited national surveillance information regarding respiratory health outcomes in this industry. In 2007, the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC), published a surveillance report titled *Respiratory Disease in Agriculture: Mortality and Morbidity Statistics (RDAg)*[6] in which the respiratory disease outcomes among agricultural workers were quantified and research needs identified. Here, we present the summary information from the *RDAg* report.

METHODS

Two National Center for Health Statistics (NCHS) data files were analyzed—the 1988–1998 multiple cause-of-death data and the Third National Health and Nutrition Examination Survey (NHANES III, 1988–1994) data. Information on decedents' usual industry and occupation that complies with NCHS-established quality criteria was available in the NCHS multiple cause-of-death data for a subset of 24 states* for some years in the 1988–1998 period. Results for the NCHS mortality data were reported for six agricultural groups: *crop farm workers, livestock farm workers, farm managers, landscape and horticultural workers, forestry workers,* and *fishery workers*.[6] Results for the NHANES III morbidity data were reported for three agricultural groups: farm workers, farm managers, and other agricultural workers.[6] Agricultural groups for both data files were identified based on industry and occupation codes from the 1990 US Bureau of Census.[7] For detail on the agricultural group selection see appendices E and G of the *RDAg* report.[6]

The NCHS multiple cause-of-death data for persons aged 15 years or older were analyzed to determine proportionate mortality ratios (PMRs) for 11 respiratory conditions, including tuberculosis, influenza, and asthma. Respiratory diseases and conditions were identified and grouped using the 9th revision of the *International Classification of Diseases* (ICD-9).[8] The number of deaths for each respiratory condition included those coded as either the underlying or contributing cause of death.

The NHANES III data were restricted to persons aged 17 years or older and analyzed to determine prevalence ratios (PRs) for 12 respiratory conditions and the prevalence of obstructive respiratory abnormalities. An obstructive respiratory abnormality was defined as a forced expiratory volume in one second divided by a forced vital capacity (FEV_1/FVC) ratio below the lower limit of normal based on prediction equations from NHANES III data.[9]

PMRs and PRs were considered to be significant at the statistical level of $p < 0.05$. Data on non-agricultural workers were used for comparison purposes. Both outcome measures, PMRs and PRs, were adjusted for age, sex, and race/ethnicity; PRs were also adjusted for smoking status. The 95% confidence limits were determined by using the methods described by Bailar and Ederer.[10]

RESULTS

The following are highlights of the mortality and morbidity results:

Mortality (Tables 1 and 2)

- *Crop farm workers* had significantly elevated mortality for hypersensitivity pneumonitis (PMR more than 10 times higher than expected), blastomycotic infection, tuberculosis, histoplasmosis, acute respiratory infections of multiple or unspecified sites, influenza, bronchitis,

*Alaska, Colorado, Georgia, Hawaii, Idaho, Indiana, Kansas, Kentucky, Maine, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Washington, West Virginia, Wisconsin.

TABLE 1. Mortality: Significantly Elevated Proportionate Mortality Ratios (PMRs[§]) by Agricultural Group, Selected States,* 1988–1999[†‡]

Disease (ICD-9 Code)	Number of Deaths	PMR	95% Confidence Interval	
			LCL	UCL
Crop Farm Workers				
Hypersensitivity pneumonitis (495)	23	1,228	777	1,844
Blastomycotic infection (116)	14	245	134	411
Miliary tuberculosis (018)	35	196	136	273
Histoplasmosis (115)	27	183	120	266
Acute upper respiratory infections of multiple or unspecified sites (465)	87	160	129	197
Pulmonary tuberculosis (011)	437	152	138	167
Influenza (487)	232	142	125	162
Bronchitis, not specified as acute or chronic (490)	269	134	119	151
Abscess of lung and mediastinum (513)	153	120	102	141
Other bacterial pneumonia (482)	955	120	113	128
Acute bronchitis and bronchiolitis (466)	126	117	103	133
Pulmonary congestion and hypostasis (514)	1,830	113	108	118
Asthma (495)	813	111	104	119
Pneumonia, organism unspecified (486)	23,135	109	107	111
Livestock Farm Workers				
Hypersensitivity pneumonitis (495)	31	5,563	3,779	7,904
Other respiratory tuberculosis (012)	5	675	218	1,577
Tuberculosis of meninges and central nervous system (013)	5	546	177	1,246
Asthma (493)	276	150	133	169
Influenza (487)	73	150	119	189
Landscape and Horticulture Workers				
Abscess of lung and mediastinum (513)	13	190	101	325
Chronic airway obstruction, nec (496)	624	111	103	120
Forestry Workers				
Pulmonary tuberculosis (011)	41	143	104	194
Chronic airway obstruction, nec (496)	1,890	127	122	133
Pneumonia, organism unspecified (486)	1,564	117	111	123
Fishery Workers				
Chronic airway obstruction, nec (496)	455	116	106	127

*AL, CO, GA, HI, ID, IN, KS, KY, ME, NV, NH, NJ, NM, NC, OH, OK, RI, SC, TN, UT, VT, WA, WV, WI.
[†]Data from National Institute for Occupational Safety and Health (NIOSH): *Respiratory Disease in Agricultural Workers: Mortality and Morbidity Statistics*.
[‡]nec indicates not elsewhere classified; ICD, *International Classification of Diseases*; LCL, lower confidence limit; UCL upper confidence limit.
[§]PMRs are adjusted for age, sex, and race.

abscess of the lung and mediastinum, pneumonia, pulmonary congestion and hypostasis, and asthma.

- *Livestock farm workers* had significantly elevated mortality for hypersensitivity pneumonitis (PMR more than 50 times higher than expected), tuberculosis, asthma, and influenza.
- *Landscape and horticultural workers* had significantly elevated mortality for abscess of the lung and mediastinum and chronic airways obstruction.
- *Forestry workers* had significantly elevated mortality for tuberculosis, chronic airways obstruction, and pneumonia.
- *Fishery workers* had significantly elevated mortality for chronic airways obstruction.

Morbidity

- The agricultural group *farm workers* had elevated prevalence of phlegm production

TABLE 2. Mortality: Agricultural Worker Groups with Significantly Elevated Proportionate Mortality Ratios (PMRs) by Disease*†‡

Disease (ICD-9 Code)	Crop Farm Workers	Livestock Farm Workers	Landscape and Horticulture Workers	Forestry Workers	Fishery Workers
Pulmonary tuberculosis (011)	√			√	
Pneumonia, organism unspecified (486)	√			√	
Influenza (487)	√	√			
Asthma (493)	√	√			
Hypersensitivity pneumonitis (495)	√	√			
Chronic airway obstruction, nec (496)			√	√	√
Abscess of lung and mediastinum (513)	√		√		

*nec indicates not elsewhere classified.
†*Crop farm workers* had 8 and *livestock farm workers* had 2 other respiratory diseases or disease categories with significantly elevated PMRs. See Table 1. PMRs are adjusted for age, sex, and race, US residents age 15 and over, selected states, 1988–1998. PMRs are significantly different from 100 ($p < 0.05$).
‡National Institute for Occupational Safety and Health (NIOSH): *Respiratory Disease in Agricultural Workers: Mortality and Morbidity Statistics*.

compared with all non-agricultural workers. Prevalence of wheeze was elevated for female *farm workers*, shortness of breath was elevated for *farm workers* who had ever smoked, and hay fever was elevated for black, non-Hispanic *farm workers* (Table 3).

- Black, non-Hispanics in the agricultural group *other agricultural workers* had elevated prevalence of pneumonia compared with all non-agricultural workers. Prevalence of asthma was elevated for *other agricultural workers* who had ever smoked (Table 3).
- *Farm workers* had a PR of 173 for obstructive respiratory abnormality.

TABLE 3. Morbidity: Significantly Elevated Prevalence Ratios (PRs†) by Agricultural Group, Sex, and Race/ethnicity*‡

Respiratory Condition	Prevalence Ratio
Farm Workers	
Hayfever (past year), Black, non-Hispanics	333
Phlegm (current)	133
Females	226
Ever smokers	156
Wheezing (apart from a cold), females	155
Wheezing (past year), females	146
Shortness of breath (current), ever smokers	130
Other Agricultural Workers	
Pneumonia (past year), black, non-Hispanics	496
Asthma (ever), ever smokers	225

*NHANES III Code 26; NHANES III Code 27.
†PRs are adjusted for age, sex, race, and smoking (except for smoking-specific analyses), US residents age 17 and over, 1988–1994. PRs are significantly different from 100 ($p < 0.05$).
‡Data from National Institute for Occupational Safety and Health (NIOSH): *Respiratory Disease in Agricultural Workers: Mortality and Morbidity Statistics*.

DISCUSSION

Farmers and other individuals involved in agriculture have potential inhalatory exposures to a very wide range of agents: inorganic dust from the soil, organic dust containing microorganisms, mycotoxins or allergens, decomposition gases, and pesticides that can result in varying degrees and types of lung responses including those described in the previous section.[11] Of all agricultural groups, *crop farm workers* had elevated PMRs for the greatest number of respiratory diseases. Mortality from hypersensitivity pneumonitis was more than 10- and 50-fold higher than expected based on the non-agricultural population for *crop farm workers* and *livestock farm workers*, respectively. *Crop farm*

workers also had significantly elevated PMRs for other respiratory conditions including miliary and pulmonary tuberculosis, asthma, influenza, blastomycotic infection, histoplasmosis, and acute upper respiratory infections of multiple or unspecified sites.

Findings of elevated PMRs for agricultural workers associated with pulmonary tuberculosis, hypersensitivity pneumonitis, and asthma are consistent with respiratory disease risks identified in NIOSH's health hazard evaluations, and case studies and medical surveys reported by other investigators.[11–23] A CDC survey from 1985–1989 estimated that the risk of tuberculosis in farm workers was 6-fold that of the general population.[13]A study of pulmonary tuberculosis deaths occurring between 1979 and 1990 from the National Mortality Surveillance database showed that farm workers were at about 2-fold increased risk.[15] Exposure to plant-derived materials, such as grain dust and cotton dust, can give rise to an asthma-like syndrome, as well as asthma, per se.[23–25] Crop production workers have been shown to develop asthma when sensitized to plant antigens and barn and storage mites.[26–28] Farmer's hypersensitivity pneumonitis is caused by animal proteins (ie, pigeon serum) and bacteria or fungi found in moldy hay, straw, or grain dust in the farm environment.[29] A study by Thorne indicated prevalence rates of asthma-like syndrome and asthma of 11% and 20% for livestock workers.[16] Livestock production workers have been shown to develop asthma when sensitized to animal-derived proteins.[30] Agricultural workers working with swine may be at risk of influenza because of their close contact with infected animals.[22] The *forestry and fishing* occupation had a prevalence of 42% for current smokers, which is the second highest prevalence reported for all occupations in the 2002 *World Report*.[31] This high smoking prevalence likely contributes to the significantly elevated mortality for chronic airways obstruction for these occupations.

Morbidity data showed agricultural workers had a substantially higher rate of obstructive respiratory abnormalities than non-agricultural workers. Chronic airways obstruction was the only respiratory disease where significantly elevated mortality was noted for three agricultural groups (*landscape and horticultural workers*, *forestry workers*, and *fishery workers*; Table 2). Both mortality and morbidity findings indicate that chronic airways obstruction is a risk for agricultural workers.

The findings are subject to some limitations. NCHS multiple cause-of-death data contain records of all deaths in the United States that are reported to state vital statistics offices. NHANES III is a cross-sectional household interview survey on the health of the civilian non-institutionalized population of the United States. Therefore, migrant and seasonal farm workers who are not US residents and whose deaths occur outside of the United States are not included in these data sources.

The PMRs in this report are derived from data reported by 24 states, which account for 32% of the US agricultural worker population and omit data from some of the major agricultural states (eg, California, Texas, and Florida). Therefore, they may not be representative of the mortality patterns for the whole country. In addition, they may fail to indicate risks for some agricultural operations and situations not, or poorly, represented in the 24 states.

The PMRs in this report have not been adjusted for smoking because of lack of these data. A decedent's or survey respondent's usual or current industry/occupation is not always indicative of the industry and occupation associated with the exposure that may be responsible for that individual's disease even when that disease is work related. As with all studies of death certificate data, this analysis is subject to disease misclassification errors.

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