

## Review Article

# Occupational Health Outcomes for Workers in the Agriculture, Forestry and Fishing Sector: Implications for Immigrant Workers in the Southeastern US

Sara A. Quandt, PhD,<sup>1,2\*</sup> Kristen L. Kucera, PhD,<sup>3</sup> Courtney Haynes, MS,<sup>4</sup>  
Bradley G. Klein, PhD,<sup>5</sup> Ricky Langley, MD,<sup>6</sup> Michael Agnew, PhD,<sup>4</sup>  
Jeffrey L. Levin, MD,<sup>7</sup> Timothy Howard, PhD,<sup>2,8</sup> and Maury A. Nussbaum, PhD<sup>4</sup>

**Background** *Workers in the Agriculture, Forestry, and Fisheries (AgFF) sector experience exposures directly related to the work itself, as well as the physical environment in which the work occurs. Health outcomes vary from immediate to delayed, and from acute to chronic.*

**Methods** *We reviewed existing literature on the health outcomes of work in the AgFF sector and identified areas where further research is needed to understand the impact of these exposures on immigrant Latino workers in the southeastern US.*

**Results** *Outcomes related to specific body systems (e.g., musculoskeletal, respiratory) as well as particular exposure sources (e.g., pesticides, noise) were reviewed. The most extensive evidence exists for agriculture, with a particular focus on chemical exposures. Little research in the southeastern US has examined health outcomes of exposures of immigrant workers in forestry or fisheries.*

**Conclusion** *As the AgFF labor force includes a growing number of Latino immigrants, more research is needed to characterize a broad range of exposures and health outcomes experienced by this population, particularly in forestry and fisheries.* Am. J. Ind. Med. © 2013 Wiley Periodicals, Inc.

**KEY WORDS:** *immigrant; agriculture*

<sup>1</sup>Department of Epidemiology and Prevention, Division of Public Health Sciences, Wake Forest School of Medicine, Winston-Salem, North Carolina

<sup>2</sup>Center for Worker Health, Wake Forest School of Medicine, Winston-Salem, North Carolina

<sup>3</sup>Division of Occupational and Environmental Medicine, Department of Community and Family Medicine, Duke University, Durham, North Carolina

<sup>4</sup>Department of Industrial and Systems Engineering, School of Biomedical Engineering and Sciences, Virginia Tech, Blacksburg, Virginia

<sup>5</sup>Department of Biomedical Sciences and Pathobiology, Virginia-Maryland College of Veterinary Medicine, Virginia Tech, Blacksburg, Virginia

<sup>6</sup>Division of Public Health, North Carolina Department of Health and Human Services, Raleigh, North Carolina

<sup>7</sup>Department of Occupational Health Sciences, University of Texas Health Science Center at Tyler, Tyler, Texas

<sup>8</sup>Center for Genomics and Personalized Medicine Research, Wake Forest School of Medicine, Winston-Salem, North Carolina

Contract grant sponsor: National Institute for Occupational Safety and Health; Contract grant number: R13-OH 009744.

Disclosure Statement: The authors report no conflicts of interests.

\*Correspondence to: Sara A. Quandt, PhD, Department of Epidemiology and Prevention, Division of Public Health Sciences, Wake Forest School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157. E-mail: squandt@wakehealth.edu

Accepted 17 January 2013

DOI 10.1002/ajim.22170. Published online in Wiley Online Library (wileyonlinelibrary.com).

## INTRODUCTION

The southeastern United States (US) has a long tradition of production in the Agriculture, Forestry, and Fishing (AgFF) sector, which is among the largest industrial sectors and employed over 1.2 million workers in 2010 [BLS, 2012a]. Immigrant labor accounts for about 37% of the AgFF workforce [AFL-CIO, 2005]. In 2010, this sector reported the highest rate of fatal work injuries [27.9/100,000 workers], and an incidence rate for nonfatal injury of 4.5 per 100 workers, compared to 2.2 in mining and 3.9 in construction [BLS, 2011, 2012b].

The last several decades have seen a substantial increase in the proportion of immigrant Latino labor in this sector in the Southeast. Over the five years preceding the 2000 census, the southern US received more domestic Latino migrants and international Latino immigrants than any other region in the country [US Census Bureau, 2003]. This new labor force includes immigrants who have established permanent residence in the US and work either year-round or seasonally in AgFF jobs, as well as migrants who move from place to place for their jobs. The latter include immigrants who move within the US and those who move back and forth across international borders for work. Within all these categories, only some of the workers have appropriate documents to be in the US (e.g., proof of citizenship, permanent resident alien work permits, or H-2A or H-2B temporary worker visas). This results in difficulty in accurately determining the number of immigrant Latino workers in the southeastern US, as discussed by Arcury et al. [2013].

The health outcomes from work in the AgFF sector arise from a complex set of exposures created in the workplace. These include: exposures related to the work environment that are generated by the industries themselves, including the machinery, tools, and chemicals used; conditions produced by these exposures, such as noise or airborne particulates; and industry products, including crops, livestock, fish, and timber. Such exposures occur within the context of the natural environment, which itself creates exposures relevant to health outcomes, such as weather, soil, water, plants, animals, and insects. How workers experience these exposures depends on contextual factors of the industry and the worksites [Grzywacz et al., 2013], with examples that range from external contextual factors (e.g., market prices and laws) to employer-specific factors (e.g., pace of work, provision of safety gear) to task-specific factors (e.g., repetition, worker control). Health outcomes from this range of exposures can vary in the time of occurrence from immediate to delayed, and in duration from acute to chronic.

This article addresses each of three industries—agriculture, forestry, and fisheries. For each industry, eight specific types of outcomes are addressed, including those

related to specific body systems and others related to particular exposure sources (e.g., animals, noise). Each section presents a review of what is known about the particular health outcome or exposure source for the three industries in the US in the *general worker population* and then for *immigrant workers within the southeastern US* in particular. Where evidence is lacking, we extrapolate from research in other populations. Finally, we summarize findings and highlight major areas for future research.

## AGRICULTURE

### General Worker Population

#### *Acute trauma*

Major mechanisms of traumatic injury and death in agriculture include falls, being struck by falling or rolling objects, crush injuries, assault by animals, and being run over or otherwise injured by machinery such as tractors, combines, and augers [Coury et al., 1999; Hard et al., 2002; Myers and Hendricks, 2010]. Commonly reported traumatic injuries on US farms are broken bones, cuts, and lacerations [Mariger et al., 2009; Goldcamp, 2010], with the most often injured body parts being hands, shoulders, back, and chest [Goldcamp, 2010]. Eye injuries account for 8.2% of all injuries in the agriculture sector [Gerberich et al., 1993]. These range from blunt trauma to perforation to complete enucleation and have been caused by debris from sharpening or using tools, chemical burns, and butting with an animal horn [Saari and Aine, 1984; CDC, 1995; Mackiewicz et al., 2005; Sprince et al., 2008]. Burns, dislocations, and spinal damage are less frequent but important farming-related injuries [Mariger et al., 2009].

Work involving livestock is the second-leading cause of nonfatal injuries on farms. In 1995, the greatest number of agriculture-related injuries (43.3%) occurred in beef, hog, or sheep operations [Myers, 2001a]. Contact with livestock is more likely to result in fractures and crushing injuries than other sources of injuries on farms. Risk factors for animal-related injuries include age (both young and old), hearing loss, arthritis, male sex, working with older farm equipment, living on beef farms, and taking prescription medications [Stallones, 1990; Brison and Lawrence, 1992; Zhou and Roseman, 1994; Layde et al., 1996; Sprince et al., 2003].

Aquaculture has trauma risks unique to the aquatic environment [Myers, 2010]. Aquaculture workers are at risk for stings, bites, and pinching injuries [Erondu and Anyanwu, 2005]. Wet or icy surfaces pose the risk of slips and falls [Moreau and Neis, 2009], and operating a skiff, maintaining cages, or feeding animals place workers at risk of falling into water where hypothermia or drowning

may occur [MacGregor, 2004]. Operating heavy machinery poses other risks such as entanglement, tripping, and being struck by snapping cables. Collisions of forklifts with pedestrians and falling materials [Moreau and Neis, 2009] and tractor rollovers have also been reported [Cole et al., 2009]. Use of heavy equipment (trucks and ATVs) on sea ice during harvesting presents additional drowning risk if the vehicles fall through the ice [Moreau and Neis, 2009]. Electrocutation is a risk when using power tools near water [Cole et al., 2009; Moreau and Neis, 2009]. Additionally, replacing the nets around aquaculture pens requires workers to use SCUBA equipment and risk becoming entangled under the water [MacGregor, 2004].

### ***Musculoskeletal disorders***

Low back disorders are common musculoskeletal injuries, particularly due to working in stooped postures [Fathallah et al., 2008] and repeated exposures to vibrations and jarring motions while operating mechanical equipment [Hostens and Ramon, 2003; Mayton et al., 2008]. Crop harvesting imposes prolonged and repetitive stooping and often results in low back, hand, and wrist pain [Fathallah, 2010], sprains and strains [Amshoff and Reed, 2005], and ligament tears [Goldcamp, 2010]. Farmworkers' exposure to repetition, high forces and loads, and sustained postures [Fathallah, 2010] can lead to chronic low back pain, degeneration of the spine, and deficits in postural stability [Mayton et al., 2008].

Dairy farm work entails routine and strenuous tasks [Innes and Walsh, 2010] associated with arthritis of the hips and knees [Kirkhorn and Schenker, 2002], increased risk for knee osteoarthritis in women [Holmberg et al., 2004], and musculoskeletal discomfort in the back, torso, shoulders, neck, and head [Innes and Walsh, 2010]. In aquaculture, musculoskeletal injuries occur due to repetitive lifting or hand feeding, lifting of heavy cages or bags of feed, prolonged non-neutral postures at workstations, and tractor use [Moreau and Neis, 2009; Cole et al., 2009; Nonnenmann et al., 2010]. These general risks can be exacerbated by exposure to extremely cold work environments [Cole et al., 2009; Moreau and Neis, 2009].

### ***Chemicals***

Potential sources of hazardous chemicals in agriculture include pesticides, fertilizers, organic solvents, metals, sterilization compounds, gasses from confined animal wastes and silos, and plant residues [Keifer et al., 2010]. Farmworkers face routine pesticide exposures from: planting; harvesting; food and water contamination; mixing, loading, and applying pesticides; maintenance of mixing and application equipment; spills, spray drift, and runoff;

and casual contact through drift and surface residues [Das et al., 2001; Kasner et al., 2012].

Pesticide exposure can cause dizziness, confusion, abnormal skin sensations, contact dermatitis, irritation of the eyes, blurred vision, muscle twitching, increased bronchial and salivary secretions, chest tightness, diarrhea and other gastrointestinal problems, vomiting, convulsions, and even death in cases of acute exposure [Krieger, 2001; Frank et al., 2004; Costa et al., 2008]. The EPA estimates 10,000–20,000 pesticide poisonings occur among hired US agricultural workers yearly [NIOSH, 2010]. While poisonings comprise a relatively small portion of total agricultural worker occupational illness [Litchfield, 1999; Kasner et al., 2012], this is likely underestimated due to inadequate state surveillance programs, lack of physician training to recognize poisonings, lack of health insurance among farmworkers, and worker reluctance to report poisonings [Das et al., 2001; McCauley et al., 2006].

Agrochemical exposure also has been linked to diverse chronic conditions, including: dermatological sensitivity; respiratory disease including lung fibrosis and chronic bronchitis [Eduard et al., 2009]; asthma-like syndromes [Koksal et al., 2003]; non-Hodgkins lymphoma [Chiu and Blair, 2009]; neurological symptoms [Kamel et al., 2005, 2007a]; neurobehavioral dysfunction [Alavanja et al., 2004; Keifer and Firestone, 2007; Costa et al., 2008; Colosio et al., 2009]; and chronic nervous system effects such as neurodegenerative disease [Frank et al., 2004; Sharp et al., 1986; Dreier and Kordysh, 2006], including Parkinson's disease [Dick et al., 2007; Kamel et al., 2007b; Bronstein et al., 2009; Costello et al., 2009; Tanner et al., 2011]. Further, chronic exposure to agrochemicals has been linked to cancers, including leukemia, prostate cancer, multiple myeloma, soft tissue sarcoma, prostate cancer, gastric cancer, and lung and cervical cancer [Dreier and Kordysh, 2006; Mahajan et al., 2006; Andreotti et al., 2009; Blair and Freeman, 2009; Chiu and Blair, 2009; Delancey et al., 2009; Koutros et al., 2009; Lynch et al., 2009; Bonner et al., 2010]. Diesel exhaust and solvent-related activities are associated with "wheeze" [Hoppin et al., 2004] and prostate cancer [Richardson et al., 2008; Parent et al., 2009]. Farmworkers also can be exposed to heavy metals such as arsenic and lead from several agrochemicals and from grinding or welding metal [Quandt et al., 2010b]. Such exposures have been linked in other populations with cancer, reproductive problems, and neuropsychological and cognitive effects [Tsai et al., 2003; Mahata et al., 2004; Wright et al., 2006; Shih et al., 2007; Weuve et al., 2009]. Occupational pesticide exposure is associated with adverse reproductive outcomes [Hanke and Jurewicz, 2004; Farr et al., 2006; Perry, 2008; Rosas and Eskenazi, 2008; Jurewicz et al., 2009; Van Maele-Fabry et al., 2010; Sathyanarayana et al., 2010].

Aquaculture chemicals include pesticides, spawning hormones, and anesthetics, some of which are listed as hazards by NIOSH [2005]. Concern over the health effects of aquaculture chemicals has focused more on the food consumer than on the producers [Erundu and Anyanwu, 2005; Cole et al., 2009]. Very limited epidemiological evidence exists regarding aquaculture workers' exposure or health outcomes resulting from such exposures.

### **Dust and particulates**

Dust and particulate matter contribute to pulmonary conditions. Dust and particulate matter can carry contaminants such as allergens (e.g., animal dander, antigenic proteins from crops), organic (e.g., animal feces particles, crop and insect fragments), and inorganic (e.g., earth from tilling) matter [Schenker, 2000]. Agricultural workers in animal confinement facilities are particularly at risk for dust and particulate exposure [Iversen et al., 2000; Von Essen et al., 2010]. Workers in swine confinement facilities have a two- to three-fold increased risk of developing respiratory symptoms [Radon et al., 2000]. More generally, farmworkers face higher rates of rhinitis [Siracusa et al., 2000], acute and chronic bronchitis [Zejsda et al., 1993], asthma-like syndrome [Bongers et al., 1987; Haglind and Rylander, 1987], and organic dust toxic syndrome [Vogelzang et al., 1999]. Symptoms appear to be linked to task and time of the growing season [Mirabelli et al., 2010a].

### **Weather**

Farm work involves prolonged exposure to weather-related risks. From 1995 to 2002, 129 work-related deaths in the US were due to lightning strikes. Agriculture had the highest number of fatalities and the second highest fatality rate [Adekoya and Nolte, 2005]. Sun exposure increases risks for sunburn and skin/lip cancer [Blair and Freeman, 2009]. From 1992 to 2006, AgFF workers, especially crop workers, had heat-related death rates substantially higher than other US workers [Luginbuhl et al., 2008].

### **Infections and envenomations due to animals**

Agricultural workers are at risk of acquiring zoonotic infections from disturbing the soil or working with animals. Zoonotic infections account for 61% of infections in humans [Taylor et al., 2001] and may be acquired from aerosols, direct contact with an infected animal, or through infection transmitted by substances such as bedding. Infections associated with livestock and wild mammals are caused by bacteria (e.g., *E. colibacillosis* and Lyme disease), viruses (e.g., foot and mouth disease and influenza),

parasites (e.g., giardiasis, mange, and trichinosis), fungi (e.g. ringworm), and prions (e.g., bovine spongiform encephalopathy). A recently recognized fish pathogen, *Streptococcus iniae*, can cause skin infections and even endocarditis among fresh fish aquaculture workers [CDC, 1996; Weinstein et al., 1997]. Envenomation can occur when agricultural workers encounter venomous animals; and farmworkers have relatively high rates of nonfatal insect and spider injuries and illnesses [Drudi, 2000].

### **Noise**

Agricultural crops are often planted and harvested using heavy machinery, which can involve substantial noise exposure. While OSHA has mandated exposure limits and requirements for hearing conservation programs in several industry sectors, agriculture is not included among these. Roughly 10% of US farmers are exposed to noise that exceeds OSHA thresholds, and it is estimated that 25% and 50% of farmers at age 30 and 50, respectively, have noise-induced hearing loss [Karlovlch et al., 1988; Rein, 1992]. Only 30% of farmers report using hearing protection more than half the time [Carpenter et al., 2002; Schenker et al., 2002].

### **Immigrant Workers**

#### **Acute trauma**

AgFF is among the top four industrial sectors in the US in terms of reported work-related deaths for Hispanic workers; and between 2003 and 2006, foreign-born Hispanic workers experienced 2.4 more fatalities per 100,000 workers compared to native-born Hispanic workers [Cierpich et al., 2008]. Limited data exist on traumatic injuries among immigrants in the southeastern US, and these data may be underestimates. North Carolina and Georgia experienced a large increase in the numbers of immigrant workers between 1990 and 2000 [AFL-CIO, 2005], the majority of whom were Latinos in North Carolina [Arcury and Marin, 2009]. From 1992 to 2006, three southeastern states were among those indicated as having the highest number of fatalities (Florida) or the highest fatality rates (South Carolina and Georgia) for Hispanic workers [Cierpich et al., 2008].

Traumatic eye injuries among Latino farmworkers occur at rates exceeding those for overall US crop production [Quandt et al., 2012]. Specifically, eye injuries may result from hydraulic fluid from ruptured hydraulic lines in old machinery; airborne and loose soil; contact with plants when harvesting; chemical exposure; and being sprayed in the face by automated irrigation systems in the field [Lacey et al., 2007; Quandt et al., 2012]. Many of these workers (70–81%) have not been properly trained to

use eye protection and underestimate risks of eye injury [Verma et al., 2011].

### ***Musculoskeletal disorders***

Sprains and strains are frequently reported among Hispanic orchard workers [Salazar et al., 2005]. A majority of immigrant nursery (55%) and vineyard (48%) workers in the western US reported musculoskeletal pain, with back pain being the most common symptom [Brumitt et al., 2011; Faucett et al., 2001]. It is likely that such injuries are underreported [Dembe, 1999; Cooper et al., 2006; Castaneda, 2009]. At least five southeastern states (Florida, Georgia, North Carolina, South Carolina, and Virginia) are involved heavily in fruit and vegetable production [Arcury and Marin, 2009], so back, neck, and upper and lower extremity pain, as well as sprains and broken bones may occur at similar rates.

### ***Chemical exposures***

In North Carolina, urinary metabolites of immigrant Latino farmworkers indicate exposure to multiple agrochemicals as well as elevated levels of lead and arsenic [Arcury et al., 2009a, b; Quandt et al., 2010a, b]. Many farmworkers had repeated detections in subsequent sampling. Children also are exposed to multiple pesticides due to chemical contamination of farmworker residences [Quandt et al., 2004; Arcury et al., 2005, 2007].

Because agencies do not commonly assess immigration status [Calvert, 2010], characterization of acute pesticide poisoning in Latino immigrant farmworkers often relies on retrospective interview data from workers recruited near the worksite or at farmworker aid organizations. Among California Hispanic farmworkers, 7% reported previous chemical poisoning, 7–12% of workers had been sprayed or experienced drift, and 6–10% were told to taste unwashed grapes, which was significantly associated with gastrointestinal pain and diarrhea [Villarejo and McCurdy, 2008]. Pesticide contact among Latino farmworkers is associated with irritated eyes and skin, blurry vision, and headaches [McCurdy et al., 2003; Villarejo et al., 2010]. Specific crops and pesticides have been associated with particular cancers among Latino farmworkers in California [Mills et al., 2009]. Agrochemical exposure also has been linked with adverse neurobehavioral outcomes among Latino farmworkers and their children [Reidy et al., 1992; Kamel et al., 2003; Rohlman et al., 2005, 2007]. Among Latino women, maternal exposures to pesticides are associated with adverse reproductive outcomes including decreased fecundability, increased rate of autism spectrum disorders, neurodevelopmental delays, decreased child IQ, and abnormal perinatal reflexes [Young et al., 2005; Eskenazi et al., 2006; Roberts et al., 2007; Harley et al., 2008; Bouchard et al., 2011].

### ***Dust and particulates***

No data could be found for health effects of dust or particulates among immigrant agricultural workers in the US.

### ***Weather***

From 1995 to 2000, 41 out of 129 occupational fatalities from lightning strikes occurred to Latino workers, with a fatality rate among these workers four times higher than among non-Hispanic Whites [Adekoya and Nolte, 2005]. Of the 28 reported heat-related fatalities among US crop workers in 2003–2006, 20 were foreign-born workers [Luginbuhl et al., 2008]. In a 2009 survey of Latino farmworkers in North Carolina, 94% reported they had worked in extreme heat in US agriculture, and 40% of those reported having experienced symptoms consistent with heat-related illness [Mirabelli et al., 2010b]. Among immigrant farmworkers in North Carolina, changes in work activities and work hours during hot weather are associated with a lower prevalence of heat-related illness in H-2A but not non-H-2A workers [Mirabelli et al., 2010b]. Latino farmworkers in California reported common personal sun protection behaviors such as always wearing a hat, a long-sleeved shirt, or a collared shirt [Salas et al., 2005]. Use of sunglasses or sunscreen or limiting sun exposure are much less common protective measures [Quandt et al., 2001; Salas et al., 2005; Luque et al., 2007].

### ***Infections and envenomations due to animals***

Latino farmworkers in North Carolina report a high prevalence of superficial fungal skin infections [Krejci-Manwaring et al., 2006; Arcury et al., 2007]. No data could be found on envenomation among immigrant agricultural workers in the US.

### ***Noise exposure***

In a cross-sectional survey of migrant and seasonal farmworkers, more than half reported some hearing loss; and few reported using hearing protection [Rabinowitz et al., 2005].

## **FORESTRY**

### **General Worker Population**

#### ***Acute trauma***

In the logging process, falls and being struck by or against an object are the primary causes of injury [Wang et al., 2003; Mujuru et al., 2006]. Falls and crush injuries

can occur when body parts are pinned between logs or equipment [Wolf and Dempsey, 1978], while struck by injuries can result from falling trees or kickback from power saws, branches, or rolling logs. Logging injuries include traumatic brain injuries; fractures of the spine, skull, and legs; and eye injuries [Vayrynen, 1983; Saari and Aine, 1984; Johnson et al., 2002]. Mechanized operations, overall, seem to result in a lower injury risk than for comparable manual tasks [Laflamme and Cloutier, 1988]. Smaller, less mechanized forestry operations are likely to sustain more crush injuries from splitting tools and cuts from blades and chain saws [Lindroos et al., 2008].

### ***Musculoskeletal disorders***

Forestry workers' risk factors are related to trade-specific tool use. Manual tree planting requires prolonged and repetitive non-neutral postures. Planters in Ontario reported feeling the greatest pain in their wrists and feet; back pain was the most consistently reported symptom, and pain scores for almost all areas of the body increased significantly over the course of a single planting season [Slot and Dumas, 2010]. Chain saw operators experience greater nerve damage compared with forestry workers who primarily do heavy lifting tasks [Bovenzi et al., 2000], and the severity of nerve damage is related to cumulative vibration exposure. Exposure to cold conditions can further increase the risk of conditions such as vibration-induced white finger [Bovenzi et al., 1998; Bovenzi, 2010].

### ***Chemicals***

Forestry workers are exposed to chemicals including fertilizers, pesticides, lubricants, diesel and gasoline fuels, and their emissions [Athanasias, 2000; USNLM, 2010]. Fewer types of pesticides are used in forestry than in agriculture, with herbicides being predominant [Michael, 2000; Oregon Department of Forestry, 2009].

Pesticide exposure is reported among Canadian tree planters; more limited evidence of herbicide exposure is reported among Swedish and US seedling handlers [Lavy et al., 1992; Robinson et al., 1993; Elfman et al., 2009]. Although forest herbicide sprayers demonstrate less effect of exposure than agricultural sprayers [Frank et al., 1985; Knopp and Glass, 1991], pine foresters have greater exposure than potato harvesters working with the same fungicide (dithiocarbamate) [Kurtio and Savolainen, 1990]. In forestry, chemical hazards do not appear to be a significant source of acute injury [Helmkamp and Derk, 1999; Navarro et al., 2004; Elfman et al., 2009].

Compared to agriculture, less attention has been paid to the effects of long-term low-level exposure to forestry chemicals. An increased risk of non-Hodgkins lymphoma

was found in Swedish forest care workers [Wiklund and Holm, 1986; Wiklund et al., 1988]. Evidence is mixed for an increased risk of non-Hodgkins lymphoma associated with phenoxy herbicides in North American forestry workers [Green, 1991].

### ***Dust and particulates***

Most studies on respiratory effects in the forestry industry have been conducted in Europe and Canada. Approximately 2.0% of European workers are exposed to inhalable wood dust [Blot et al., 1997]. Most of these workers are in the construction and furniture industries, with a much smaller percentage (9%) in the combined sawmilling and forestry industries [Kauppinen et al., 2006]. Such exposure increases cancer, primarily nasal, risk [Blot et al., 1997].

### ***Weather***

Forestry involves high levels of physical exertion. Heavy protective equipment, along with exposure to heat and sun, can lead to dehydration and increased risk of heat illness [Wästerlund, 1998]. Among Japanese forestry workers, fewer years of experience and heat were among factors associated with increased risk of heat stroke symptoms [Maeda et al., 2006]. However, compared to other causes, deaths attributable to heat in this industry are relatively low (<1%), with 14 deaths from environmental heat in the US from 1992 to 2001 [Buckley et al., 2008].

Although forestry is often conducted in regions where exposure to cold and severe weather is also common, the physical nature of forestry/logging work may provide some protection from cold-related injury and hypothermia [Conway and Husberg, 1999]. Lightning strike also is a hazard for forestry workers. From 1992 to 2001, of 200 deaths in the industry attributed to "Exposure to Harmful Substances and Environments", 7 were attributed to lightning [Buckley et al., 2008].

### ***Infections and envenomations due to animals***

As in agriculture, forestry workers are at risk of acquiring zoonotic infections from disturbing the soil or from contact with animals. Forestry workers are at risk of stings from sawflies, wasps, bees, and ants, especially when nests or mounds are disturbed [Copertaro et al., 2006]. Up to 3–4% of people stung are at risk of developing an anaphylactic reaction [Giannandrea et al., 2003; Inorvaia et al., 2004]. This can be fatal if not treated immediately, and is a challenge for forestry workers in remote locations. Encounters with snakes in forests are not unusual. In the US, copperheads, cottonmouths, coral

snakes, and rattlesnakes are venomous species of concern. While rarely fatal, bites can lead to prolonged disability.

Forestry workers are at increased risk of infection from several tick-borne diseases. In some countries, 20–30% of forestry workers are seropositive for Lyme disease [Buczek et al., 2009]. Other such diseases reported in forestry workers include tick-borne relapsing fever, Colorado tick fever, Rocky Mountain spotted fever, ehrlichiosis, babesiosis, and tularemia [Covert and Langley, 2002; Cisak et al., 2005]. Workers also may be at risk of viruses transmitted by mosquitoes such as eastern equine encephalitis, western equine encephalitis, and St Louis encephalitis [APHA, 2008]. Finally, workers may face exposure to rabies or other infections if approached by wild animals.

### **Noise exposure**

During 1997–1998, the logging industry in Washington State had the highest rate of hearing loss claims reported to workers' compensation at 70 claims per 1,000 worker years, twice as high as the rate for road construction [Daniell et al., 2002]. Logging tasks associated with excessive noise levels include the use of chokers and chain saws [Neitzel and Yost, 2002].

### **Immigrant Workers**

The immigrant worker population in forestry is large and expanding [McDaniel and Casanova, 2003]. Between 1996 and 2001, the southeastern US led the country in the number of H-2B visas requested [McDaniel and Casanova, 2003]. With over 100,000 H-2B visas issued, this is a fairly well-documented immigrant worker population. Smaller contractors, however, are more likely to employ undocumented immigrants. H-2B workers in the US move among contract sites as dictated by their employer. This presents a challenge for reporting immigrant worker population or injury rates in specific states because employers do not necessarily employ workers in the state in which their H-2B visas were issued [Sarathy and Casanova, 2008].

### **Acute trauma**

No evidence could be found documenting traumatic injuries among immigrant workers specifically in the forestry sector. However, some data exist for the overall forestry industry in the southeastern US. In Alabama, where forestry operations are largely mechanized, struck by and crush/run over injuries were responsible for the vast majority of fatalities during 1988–1997 [Bordas et al., 2001].

### **Musculoskeletal disorders**

Although no data were found on immigrant forestry workers specifically, there is reason to believe that

musculoskeletal injury is a significant health problem. H-2B guest workers make up 100% of work crews for the three largest tree-planting contractors in the southeastern US [McDaniel and Casanova, 2005]. Tree planting is a highly repetitive process requiring long hours in stooped postures and repeated use of small hand tools [McDaniel and Casanova, 2003].

### **Other health outcomes**

No data could be found regarding the effects of chemicals, dust and particulates, weather, infections or envenomations due to animals, or noise exposures on immigrant workers in forestry.

## **FISHERIES**

### **General Worker Population**

#### **Acute trauma**

Some exposures differ by region, but particular risks exist for all fish industry workers. Vessel casualties resulting from sinking, capsizing, fires, explosions, or collisions are substantial [Drudi, 1998; Jensen et al., 2005; Perez-Labajos et al., 2009; Lincoln and Lucas, 2010]. Between 2000 and 2009, over half of commercial fishing fatalities were a result of vessel disasters [Lincoln and Lucas, 2010]. Common hazards include falling overboard after becoming entangled in gear, slipping or tripping on deck, losing balance, or being washed overboard by large waves [Drudi, 1998; Thomas et al., 2001; Lucas and Lincoln, 2007; Lincoln and Lucas, 2010]. A majority of deaths after falling overboard occur when a crew member is working alone on deck [Lucas and Lincoln, 2007].

Fishing gear use and maintenance cause the greatest number of injuries and the most severe injuries such as broken bones and joint dislocations [Torner et al., 1995; Jensen et al., 2005, 2006; Chauvin and Le Bouar, 2007]. More specific causes of injury include entrapment of upper limbs in ropes, cables, or chains; lacerations, bruises, and fractures from breaking or snapping of cables; fractures and other injuries subsequent to falls on the deck or between deck levels; crush or head injuries caused by loaded nets or boxes falling onto the worker; entanglement in the winch drum, tripping over the winch cable, or the sudden snapping of the winch cable [Norrish and Cryer, 1990; MacGregor, 2004]; ocular and facial penetration due to fishing hooks, lures, and weights [Erisen et al., 2001; Alfaro et al., 2005]; cervical spine injury from harpoons [Mouzopoulos and Tzurbakis, 2009]; and forcible amputation due to entanglement in nets and lines [Nagesh and Rastogi, 2007].

Trawl doors used in trawl fishing are large and heavy and pose considerable crush risk if a limb or body becomes pinched between a trawl door and the vessel [MacGregor, 2004]. Seine fishing involves the use of large booms and a skiff, increasing the chances of a “struck by” injury or falling into the water. Seining also carries the additional risk of being performed mostly at night under low lighting conditions [MacGregor, 2004]. Long lining, salmon trolling, and crab fishing present a high risk for eye injuries from flying hooks on gear, the use of metal flashers with hooks, and the frequency of tossing the catch into storage, respectively [AMSEA, 1999]. Eye injuries can result from fish spitting out hooks or by workers touching their face after handling the catch [AMSEA, 1999].

The fish catch itself also exposes crew members to pricks, pinches, cuts, bites, and stings from various species of aquatic animals [MacGregor, 2004]. Although rare, fish can bite or stab with their spines, which can lead to severe injuries such as lacerations, amputations, and puncture wounds. These penetrating wounds can also become infected [Marshall et al., 2004]. Once the catch is on the boat, injuries can occur from large fish “flopping” on deck. Among commercial workers in the southeastern US, 20% of hand injuries were due to contact with finfish, shellfish, or other sea animals [Kucera et al., 2008].

### ***Musculoskeletal disorders***

Fishing exposes workers to heavy loads, forceful exertions, non-neutral postures, repetitive tasks, and working in moving environments [Fulmer and Buchholz, 2002; Duncan et al., 2010]. Common musculoskeletal injuries include strains to muscles and injured tendons [Torner et al., 1995; Chauvin and Le Bouar, 2007]. In lobstering, as an example, where multiple traps are continuously set out rather than a single large net, the speed and high frequency of work poses a risk for strain injury [Fulmer and Buchholz, 2002].

### ***Chemicals***

Principal acute chemical hazards in fisheries are exposure to toxic gases and asphyxiation from catch decomposition. Studies of Danish fishing vessels have found high concentrations of several potentially poisonous gases (hydrogen sulfide, carbon dioxide, ammonia, and methylamines), as well as low oxygen concentrations. Exposure to toxic gases accounts for 1 in 25 fishing deaths among Danish workers and 1.7% of fatalities among Alaskan workers [Dalgaard et al., 1972; Thomas et al., 2001; Laursen et al., 2008]. Chemical exposure can also result in burns [Lawrie et al., 2003] and allergic and respiratory reactions [Atkinson et al., 1993; Madsen et al., 2004].

Fishing industry workers also have extensive exposure to diesel and gasoline powered engines and exhaust [Kirrane et al., 2007]. The use of diesel fuel in pesticide dips for traps may also place workers at risk of long-term exposure to unburned diesel fume vapors [Barre and Van Vleet, 1994].

### ***Dust and particulates***

Fishery workers are exposed to aeroallergens produced during processing and canning, which places them at risk of pulmonary disease. The primary pulmonary condition observed is termed “occupational asthma” [Lucas et al., 2010]. Risk factors include exposure to aerosols from arthropods, such as shrimp, crab, and lobster, during fishing or processing [Malo and Cartier, 1993; Ortega et al., 2001]. Predisposition toward developing allergic reactions (atopy) is a risk factor for the development of occupational asthma in fishery workers [Gautrin et al., 2010]. There is considerable variation in the prevalence estimates of asthma (2–36%), due largely to varying definitions of the condition [Jeebhay and Cartier, 2010].

### ***Weather***

Natural environment hazards for fishing industry workers are similar to those in agriculture and forestry, but with the added factor of performing work on a moving vessel. Severe weather compounds the effects of physical demands due to boat motions [Petersen et al., 1989; Torner et al., 1988, 1994] and increases the risk of falls on deck or overboard. Working in cold waters places laborers at risk for cold-related mortality [Drudi, 1998] and morbidity [Conway and Husberg, 1999]. The combination of wet and windy environments with cold weather contributes to conditions such as frostbite, trench foot, and hypothermia. In a person-overboard situation, workers are at risk of drowning as well as hypothermia. From 1990 to 1999, 186 out of 217 fishing industry worker deaths were due to drowning or death from hypothermia as a result of vessel-related events and falls overboard [Conway et al., 2002].

### ***Infections and envenomations due to animals***

Workers in the fishing industry are at risk of envenomations, infections, and allergic reactions due to marine life [Burke, 1997; Ortega et al., 2001]. Venomous aquatic animals include catfish, zebra fish, scorpion fish, stingrays, jellyfish, and the Portuguese man of war [Burke, 1997], with jellyfish being the most common source of injury [Brown, 2005]. Fishing industry workers risk envenomation when handling fish or when removing jellyfish that

have become entangled in fishing nets. Although serious injury and death can occur, most stings in US waters cause only minor injury [Brown, 2005].

Fishing industry workers with open wounds from punctures or stings are subsequently at risk of acquiring a number of infections from the aquatic environment, usually by the bacteria *Staphylococcus* and *Streptococcus* [Lehane and Rawlin, 2000]. The widespread bacterium *Erysipelothrix rhusiopathiae* causes skin dermatitis (also referred to as fish poison, crab poison, or shrimp pickers disease) and can, rarely, cause endocarditis [APHA, 2008]. The bacterium *Edwardsiella tarda* can cause skin abscesses and serious life threatening infections [Hargreaves and Lucey, 1990; Slaven et al., 2001]. *Mycobacterium marinum* enters open skin and slowly grows into a warty-like lesion that can spread along the lymph channels and invade tendons, bones, and joints [Burke, 1997]. Gastroenteritis as well as serious wound infections may result from the bacterium *Aeromonas hydrophila*. Resulting wound infections can lead to muscle destruction and a particularly deadly form of gangrene, gas gangrene [Fulghum and Linton, 1978]. Various species of halophilic *Vibrio* organisms can also cause gastroenteritis, wound infections, and septicemia [Blake et al., 1979; Burke, 1997; APHA, 2008]. The bacteria *Vibrio parahaemolyticus*, *Vibrio damsela*, and *Vibrio vulnificus* can cause tissue inflammation and gas gangrene, which can lead to septic shock. Contact with certain algae, dinoflagellate organisms (red tides), bryozoans, and even fish slime can cause allergic reactions such as contact dermatitis in workers [Burke, 1997].

### **Noise exposure**

Fishing industry workers often work on vessels with diesel engines and other equipment used to pull in gear and remove and process the catch. Workers often spend several consecutive days on a boat and can thus be exposed to excessive noise both during and outside of their work shifts. In a case study of Massachusetts fishing vessels, two of three vessels had noise levels close to US Coast Guard threshold values [Fulmer and Buchholz, 2002]. Catch processing vessels have high work-shift and 24-hr exposure levels.

## **Immigrant Workers**

### **Acute trauma**

Little information could be found on immigrant workers in the fishing industry. It is likely that immigrant workers would experience similar types of traumatic injuries as native-born workers, but the extent to which cultural or language barriers create additional occupational risks for

immigrant workers remains unclear. Previous research with Texas Gulf Coast commercial fishermen noted over half (52%) spoke little or no English, highlighting the importance of delivering safety training in their native language [Carruth et al., 2010; Levin et al., 2010]. Although the immigrant worker population in fishing is poorly documented, there is some evidence regarding injuries specific to the types of fishing done in the southeastern US. In North Carolina, between 1977 and 1991, the fishing industry reported the highest rate of fatalities due to environmental working conditions compared to other industries [Loomis et al., 1997]. Also in North Carolina, a high prevalence of penetrating wounds occurs among small scale fin-fishing and crabbing crews, affecting primarily the hands, wrists, and fingers, and mainly attributable to contact with fish or marine animals [Marshall et al., 2004]. Hand injuries among commercial fishing industry workers in the southeastern US are related to maintenance work on the vessel and to using more than one type of fishing gear [Kucera et al., 2008].

### **Musculoskeletal disorders**

Evidence of risks specific to the immigrant worker population in fishing could not be found. However, some studies have assessed the musculoskeletal impact of commercial fishing in North Carolina, and these are likely representative of risks for fishing industry workers in the southeastern US. Low back symptoms are the most commonly reported among commercial fishers in North Carolina, followed by symptoms in the hands, wrists, and shoulders; and rates of musculoskeletal symptom onset among workers with no prior symptoms are highest for the lower back and shoulders [Lipscomb et al., 2004]. The rate of onset varies with hours spent fishing daily [Lipscomb et al., 2004; Kucera et al., 2009]. Among North Carolina fin-fishing and crabbing crews, 25% of injuries are strains and sprains, especially of the back and shoulders, and caused mostly by hauling gear and vessel loading or unloading [Marshall et al., 2004].

### **Chemicals**

In an Alaskan study of injury aboard fishing vessels, toxicity from chemical, liquid, or gas was noted in 0.74% of non-fatal incidents, and burns comprised 5.3% of non-fatal injuries. Immigrant workers made up 5% of the non-fatal injury group [Thomas et al., 2001].

### **Dust and particulates**

In the southern US, Latinos are a large part of the workforce in the crab processing industry [Selby et al., 2001]. However, no studies could be found on rates of

occupational asthma, as seen elsewhere from aerosolized proteins from these crustaceans [Ortega et al., 2001].

### **Weather**

No previous studies could be found documenting weather-related events among immigrant workers in the fishing industry. A review of medical examiner death certificates in North Carolina from 1977 to 1991 found that 41 out of 2,524 work-related deaths were due to natural environmental conditions; relative to all industries, fishing, agriculture, agricultural services, and logging occupied four out of the top five highest rates in this cause of death category [Loomis et al., 1997]. Though cold-related mortality and morbidity for this industry is highest among northern states such as Alaska [CDC, 1993; Conway and Husberg, 1999], risks may also be elevated in milder climates having rapid temperature changes, such as North Carolina [Fallico et al., 2005], where poor or extreme weather conditions often are combined with inadequate protective clothing and exposure to water and wind [Butts, 1994; Beaman et al., 2000].

### **Other health outcomes**

No data were found on animal-related infections and envenomations or noise among immigrant fishery workers.

## **PSYCHOSOCIAL EXPOSURES AND OUTCOMES**

AgFF industries share characteristics that can lead to distress and subsequent adverse mental health effects on workers in these industries. Forestry and fishing can involve separation from family and social supports. For agriculture, this condition exists for immigrant workers, but not for resident farming populations. All are industries where uncontrollable environmental conditions regularly affect the ability of workers to make a living. These include natural conditions such as storms, droughts, and crop and livestock disease, as well as human-caused disasters such as fires or chemical contamination. Existing literature suggests that workers in these industries respond to such stressors with increased levels of distress, including depression, anxiety, and symptoms of post-traumatic stress syndrome [Picou, 1992; Palinkas et al., 1993; Freeman et al., 2008; Sartore et al., 2008; Taylor et al., 2008; Caldwell and Boyd, 2009].

Immigrant workers in the AgFF sector experience work conditions that are frequently dangerous, monotonous, and unpleasant. Many live in poor and unsanitary conditions [Arcury et al., 2012a, b]. They are socially marginalized, and subject to discrimination and threats due to their immigrant status. Many are separated from

kin and both socially and physically isolated from the larger US society [Grzywacz et al., 2006]. These conditions are potent threats to mental health. Studies of immigrant workers in the southeastern US have found that categories of stressors experienced include legality and logistics, social isolation, work conditions, family, and substance abuse by others [Grzywacz et al., 2007, 2010; Hiott et al., 2008].

The largest body of research on workers in the AgFF sector in the southeastern US has focused on farmworkers. The farmworker population in this region has become predominantly Latino in only the last few decades. In contrast to the farmworker population elsewhere in the country, which consists largely of family groups, in the southeastern US agricultural workers include many single men or men unaccompanied by their families. Evidence from studies on farmworkers throughout the US suggests that poor mental health among farmworkers is relatively common [e.g., Magaña and Hovey, 2003]. A psychiatric survey among California workers found that one in five met lifetime criteria for at least one psychiatric disorder, with anxiety disorder, substance abuse, and mood disorder being the most common [Alderete et al., 2000]. Mexican folk illnesses such as *nervios* [nerves] and *susto* [fright] also have been reported at high frequencies [Mines et al., 2001; Weigel et al., 2007].

In the southeastern US, a substantial number of male farmworkers show indications of alcohol abuse [Kim-Godwin and Fox, 2009]. Binge drinking has been reported by 27% of farmworkers, with 38% showing signs of alcohol dependence. Anxiety and depression at levels resulting in impairment affect farmworkers at rates of 18% and 42%, respectively [Grzywacz et al., 2007; Hiott et al., 2008]. These levels are substantially higher than those reported among farmworkers in California [Alderete et al., 2000]. Depressive symptoms in North Carolina tend to be highest early and late in the agricultural season [Grzywacz et al., 2010]. Few data exist for the southeastern US on folk illnesses, though Baer and Penzell [1993] found that 20% of workers reported *susto* after exposure to pesticides.

## **FUTURE RESEARCH NEEDS FOR IMMIGRANT AgFF WORKERS IN THE SOUTHEASTERN US**

The AgFF sector is among the largest employers in the US as a whole, and the southeastern US specifically. Work in this sector involves exposure to a broad range of risk factors for a broad range of adverse health outcomes. This sector also employs a large, and in some cases increasing, number of minority immigrant workers. Though evidence to date is quite limited, these workers appear to have a disproportionate burden of occupational morbidity and mortality. This review demonstrates the uneven nature

**TABLE I.** Summary of Existing Literature on Occupational Health and Safety in the Agriculture, Forestry, and Fisheries Sector, for Workers in the US in General, Immigrant Workers Anywhere in the US, and Immigrant Workers in the Southeastern US, by Industry

Outcomes or exposures	Agriculture			Forestry			Fisheries		
	US <sup>a</sup>	US immigrant	SEUS immigrant	US <sup>a</sup>	US immigrant	SEUS immigrant	US <sup>a</sup>	US immigrant	SEUS immigrant
	Acute trauma	***	***	**	***	—	—	***	—
Musculoskeletal disorders	***	***	**	***	—	—	***	—	—
Chemicals	***	***	**	***	—	—	***	**	—
Dust and particulates	***	—	—	***	—	—	***	—	—
Weather	***	***	**	***	—	—	***	—	—
Infections and envenomations due to animals	***	—	—	***	—	—	***	—	—
Noise	***	**	—	***	—	—	***	—	—
Psychosocial	***	***	**	***	—	—	***	—	—

—, No studies available; \*\*\*, multiple studies available; \*\*, limited studies available.

<sup>a</sup>Includes studies in any worker population in the US or from comparable industries in other countries.

of occupational health research in this sector. In general, the literature is most extensive for agriculture, covering all the outcomes or exposures included in this review (Table I). The literature for forestry and fisheries is, overall, much sparser. Some topics have little or no research; and risk factors presented are speculative, based on the nature of exposures. The literature for immigrant workers in the US is most robust for agriculture, though several exposures have not been studied among immigrants. Almost no research has been conducted on occupational health of immigrant labor in forestry and fisheries in the US. Research on occupational health among immigrant workers in the southeastern US is limited to agriculture. Much of this has been conducted in North Carolina and focuses on chemical exposures, heat, and psychosocial factors. The uneven nature of the research suggests several areas where further study of health and safety of immigrant workers in the US as a whole and the southeastern US, in particular, is needed.

## Acute Trauma and Musculoskeletal Disorders

Due to the prevalence of documented H-2B guest workers, the forestry industry arguably has the greatest potential for in-depth injury risk analysis for immigrant workers in the southeastern US. Musculoskeletal injury analysis may be the most relevant given the high number of immigrants performing highly repetitive tree-planting work. However, because of the difficulty of obtaining H-2B visas, there may still be a fairly large population of undocumented workers, especially among smaller forestry contractors that need to be accounted for when determining injury risk.

The need for more research on immigrant workers is most evident in the fishing industry. The literature is lacking regarding the number of immigrant workers employed in fishing in any region of the US, and no data could be found that are specific to the southeastern region. An immediate research need is to identify the proportion of immigrant fishermen in the US, their distribution among the various types of fishing, their occupational roles, and their injury rates. As with prior research in agriculture, such evidence will help identify how immigrant workers are contributing to overall occupational injuries reported in the fishing industry and may distinguish injury risks that are disproportionately high for immigrant workers.

Determining injury rates of immigrant workers with disabilities may also be of interest. Xiang et al. [2010] reported that, for forms of disability, immigrants are more likely to be employed than US-born adults with an equivalent disability. Additionally, AgFF, along with most other industries, employs a similar percentage of immigrants with and without disabilities.

## Chemicals

More work should be directed at quantitative assessment of chemical exposures to pesticides for immigrant workers in the southeastern US region, other than North Carolina, to determine if there are geographic differences. More work should be devoted to analyses of health outcomes (e.g., psychiatric disorders, neurodegenerative disease) and to identifying common combinations of pesticide exposures. Genetic variants for susceptibility to pesticide-induced pathology in workers should be further explored. The consequences of long-term exposure to hazardous non-pesticide chemicals, and their interaction with

pesticides, should not be ignored in farmworkers or forestry workers.

## Weather

Recent US deaths during heat waves in 2005, 2007, and 2008 have brought attention to the safety of agricultural workers. Weather-related injuries, such as heat illness, hypothermia, and struck-by-lightning are amenable to intervention in this industry given appropriate information and work practices (e.g., appropriate clothing, work organization). California and Washington have enacted state legislation requiring employers to take steps to prevent heat illness among outdoor employees [Washington Department of Labor and Industries, 2008; California Department of Industrial Relations, 2010]. Despite regulation, it is unclear whether employers abide by the regulations or whether they are enforceable [Burke, 2008; Rural Migration News, 2009]. Studies of intervention diffusion and effectiveness are an area for future research.

Immigrants present a particular challenge and emphasize the importance of safety messages being provided in both English and Spanish native languages and in a format that will reach the most workers (e.g., lay providers, tailgate talks). Heat safety interventions currently being implemented include programs such as Project Fresco, a bilingual educational program delivered to Texas farmworkers door-to-door by lay health workers [Gonzales, 2010]. Future studies can provide needed information about immigrant workers in forestry and fishing.

## Noise

Given the difficulty of monitoring and enforcing noise levels in traditional industrial settings, and the fact that employees reported wearing hearing protection only 62% of the time when exposed to noise [Daniell et al., 2006], the AgFF sector presents a particular challenge for intervening where oversight is more limited. Intervention effectiveness and compliance present areas for fruitful research. Future studies among immigrant populations are needed in forestry and fishing.

## Infections and Envenomations Due to Animals

Updated national surveys of animal-related injuries on farms are needed. Rates of injuries from farm animals differ by race and region of country, and studies are needed to determine factors responsible for these differences. National serosurveys of zoonotic diseases that are not currently reportable need to be undertaken to determine the prevalence in various populations. The frequency of domestic and wild animals kept in migrant camps needs to be assessed and the use of rabies vaccination in dogs and

cats in these camps determined. Work is needed to determine factors that influence the use of insect repellants in agriculture and forestry workers. The frequency of contact with wild animals has not been well studied in forestry workers.

The frequency of occupational allergy to shellfish needs to be determined in fishing industry workers and shellfish processing workers in the southeastern US. Surveys of health care providers among coastal communities on the risks of unusual infections that can result from marine water or fish contact need to be implemented and educational programs designed.

## Psychosocial Exposures

The dearth of mental health research in forestry and fishing in the southeastern US calls for future research. Both are sectors where the risk factors created by immigrant status and social and physical isolation are likely to be substantial. The sectors include exceedingly dangerous jobs that can be made more dangerous by inattention due to mental illness. Although farmworker research exists, it is largely limited to North Carolina, with a focus on men. Broader foci including other areas in the southeastern US and on women is needed. In addition, research on interactions with specific exposures (e.g., organophosphorus pesticides) known to be associated with mental illness [Stallones and Beseler, 2002] is needed. Finally, studies of mental health issues such as suicide that have been demonstrated to occur at higher than expected rates among farmworkers [Hovey and Magaña, 2003] should be conducted in the southeastern US.

## RECOMMENDATIONS

Addressing the burden of occupational health and safety among immigrant workers in the southeastern US will require new efforts on several fronts. Based on the current review, the following are recommended as near-term research needs and directions.

- Obtain improved estimates of the population and distribution of immigrant workers in the diverse jobs comprising the AgFF sector.
- Compile improved estimates of morbidity and mortality rates among immigrant workers in the AgFF sector.
- Identify specific jobs and/or work tasks that involve substantial exposures of immigrant workers to diverse categories of risk factors.
- Continue to identify the relationships between exposures and health outcomes among immigrant workers.
- Document and describe specific challenges involved in controlling risk factor exposures among immigrant workers.

- Develop and test intervention methods tailored to immigrant workers in AgFF.

Progress on these can be anticipated to contribute to substantial improvements in the occupational health of immigrant workers.

## REFERENCES

- Adekoya N, Nolte KB. 2005. Struck-by-lightning deaths in the United States. *J Environ Health* 67(9):45–50.
- AFL-CIO. 2005. Immigrant workers at risk: the urgent need for improved workplace safety and health policies and programs. Washington, DC: American Federation of Labor–Congress of Industrial Organizations. Retrieved from: [http://www.aflcio.org/aboutus/labor-day/upload/immigrant\\_risk.pdf](http://www.aflcio.org/aboutus/labor-day/upload/immigrant_risk.pdf)
- Alavanja MC, Hoppin JA, Kamel F. 2004. Health effects of chronic pesticide exposure: cancer and neurotoxicity. *Annu Rev Public Health* 25:155–197.
- Alderete E, Vega WA, Kolody B, Aguilar-Gaxiola S. 2000. Lifetime prevalence of and risk factors for psychiatric disorders among Mexican migrant farmworkers in California. *Am J Public Health* 90:608–614.
- Alfaro DV, Jablon EP, Fontal MR, Villalba SJ, Morris RE, Grossman M, Roig-Melo E. 2005. Fishing-related ocular trauma. *Am J Ophthalmol* 139:488–492.
- Alaska Marine Safety Education Association [AMSEA]. 1999. Eye injuries. *Marine Safety Update* 15:1–4.
- Amshoff SK, Reed DB. 2005. Health, work, and safety of farmers ages 50 and older. *Geriatr Nurs* 26:304–308.
- Andreotti G, Freeman LE, Hou L, Coble J, Rusiecki J, Hoppin JA, Silverman DT, Alavanja MC. 2009. Agricultural pesticide use and pancreatic cancer risk in the Agricultural Health Study Cohort. *Int J Cancer* 124:2495–2500.
- American Public Health Association [APHA]. 2008. Control of Communicable Diseases Manual. Washington, DC: APHA.
- Arcury TA, Marin AJ. 2009. Latino/Hispanic farmworkers and farm work in the Eastern United States the context for health, safety, and justice. In: Arcury TA, Quandt SA, editors. Latino farmworkers in the Eastern United States health, safety, and justice. New York: Springer-Verlag, p 15–36.
- Arcury TA, Quandt SA, Rao P, Doran AM, Snively BM, Barr DB, Hoppin JA, Davis SW. 2005. Organophosphate exposure in farmworker family members in Western North Carolina and Virginia: case comparisons. *Hum Organ* 64:40–51.
- Arcury TA, Grzywacz JG, Barr DB, Tapia J, Chen H, Quandt SA. 2007. Pesticide urinary metabolite levels of children in eastern North Carolina farmworker households. *Environ Health Perspect* 115:1254–1260.
- Arcury TA, Grzywacz JG, Chen H, Vallejos QM, Galvan L, Whalley LE, Isom S, Barr DB, Quandt SA. 2009a. Variation across the agricultural season in organophosphorus pesticide urinary metabolite levels for Latino farmworkers in eastern North Carolina: project design and descriptive results. *Am J Ind Med* 52:539–550.
- Arcury TA, Grzywacz JG, Isom S, Whalley LE, Vallejos QM, Chen H, Galvan L, Barr DB, Quandt SA. 2009b. Seasonal variation in the measurement of urinary pesticide metabolites among Latino farmworkers in eastern North Carolina. *Int J Occup Environ Health* 15:339–350.
- Arcury TA, Weir M, Chen H, Summers P, Pelletier LE, Galván L, Bischoff WE, Mirabelli MC, Quandt SA. 2012a. Migrant farmworker housing regulation violations in North Carolina. *Am J Ind Med* 55:191–204.
- Arcury TA, Weir MM, Summers P, Chen H, Bailey M, Wiggins MF, Bischoff WE, Quandt SA. 2012b. Safety, security, hygiene and privacy in migrant farmworker housing. *New Solut* 22:153–173.
- Arcury TA, Grzywacz JG, Sidebottom J, Wiggins M. 2013. Report 1. Overview of immigrant worker occupational health and safety for the agriculture, forestry, and fishing (AgFF) sector in the southeastern United States. *Am J Ind Med* [In press, this issue].
- Athanassiadis D. 2000. Energy consumption and exhaust emissions in mechanized timber harvesting operations in Sweden. *Sci Total Environ* 255:135–143.
- Atkinson DA, Sim TC, Grant JA. 1993. Sodium metabisulfite and SO<sub>2</sub> release: an under-recognized hazard among shrimp fishermen. *Ann Allergy* 71:563–566.
- Baer RD, Penzell D. 1993. Research report: susto and pesticide poisoning among Florida farmworkers. *Cult Med Psychiatry* 17:321–327.
- Barre JS, Van Vleet ES. 1994. Leaching from stone crab traps dipped in fungitrol: diesel fuel preservative. *Bull Environ Contam Toxicol* 53:813–819.
- Beaman S, Boone C, Bowman S, Brown K, Burke J, Davis C, Eason A, Etheridge P, Evans L, Fulcher L, Jones H, McDaniel A, Monday A, Ohl C, Hayes D, Weist W, Dolzinger J, Peah C, Shay C, Smith S, Thomas A, Warren C, Wheaton L, Butts C, Cline S, Enright D, Howell E, McBride D, Reddington J, Wilson J, Zeringue E, McCormack N. 2000. Morbidity and mortality associated with Hurricane Floyd—North Carolina, September–October 1999. *MMWR Morb Mortal Wkly Rep* 42(17):369–372.
- Blair A, Freeman LB. 2009. Epidemiologic studies of cancer in agricultural populations: observations and future directions. *J Agromed* 14(2):125–131.
- Blake PA, Merson MH, Weaver RE, Hollis DG, Heublein PC. 1979. Disease caused by a marine *Vibrio*. Clinical characteristics and epidemiology. *N Engl J Med* 300:1–5.
- Blot WJ, Chow WH, McLaughlin JK. 1997. Wood dust and nasal cancer risk. A review of the evidence from North America. *J Occup Environ Med* 39:148–156.
- Bureau of Labor Statistics [BLS]. 2011. Census of fatal occupational injuries charts, 1992–2009 [revised data]. Washington, DC: Bureau of Labor Statistics, United States. Department of Labor. Retrieved July 29, 2011 from <http://www.bls.gov/iif/oshwc/cfoi/cfch0008.pdf>
- Bureau of Labor Statistics [BLS]. 2012a. Employment by major industry sector. Washington, DC: Department of Labor. Retrieved July 10, 2012 from [http://www.bls.gov/oco/emp/ep\\_table\\_201.htm](http://www.bls.gov/oco/emp/ep_table_201.htm)
- Bureau of Labor Statistics [BLS]. 2012b. Incidence rate and number of nonfatal injuries by industry and ownership, 2010. Washington, DC: Bureau of Labor Statistics, United States. Department of Labor. Retrieved July 10, 2012 from <http://www.bls.gov/iif/oshwc/osh/os/ostb2805.txt>
- Bongers P, Houthuijs D, Remijn B, Brouwer R, Biersteker K. 1987. Lung function and respiratory symptoms in pig farmers. *Br J Ind Med* 44:819–823.
- Bonner MR, Williams BA, Rusiecki JA, Blair A, Beane Freeman LE, Hoppin JA, Dosemeci M, Lubin J, Sandler DP, Alavanja MC. 2010. Occupational exposure to terbufos and the incidence of cancer in the Agricultural Health Study. *Cancer Causes Control* 21:871–877.

- Bordas RM, Davis GA, Hopkins BL, Thomas RE, Rummer RB. 2001. Documentation of hazards and safety perceptions for mechanized logging operations in east Central Alabama. *J Agric Safety Health* 7:113–123.
- Bouchard MF, Chevrier J, Harley KG, Kogut K, Vedar M, Calderon N, Trujillo C, Johnson C, Bradman A, Barr DB, Eskenazi B. 2011. Prenatal exposure to organophosphate pesticides and IQ in 7-year-old children. *Environ Health Perspect* 119:1189–1195.
- Bovenzi M. 2010. A longitudinal study of vibration white finger, cold response of digital arteries, and measures of daily vibration exposure. *Int Arch Occup Environ Health* 83:259–272.
- Bovenzi M, Alessandrini B, Mancini R, Cannavara M, Centi L. 1998. A prospective study of the cold response of digital vessels in forestry workers exposed to saw vibration [abstract only]. *Int Arch Occup Environ Health* 71:493–498.
- Bovenzi MF, Giannini F, Rossi S. 2000. Vibration-induced multifocal neuropathy in forestry workers: electrophysiological findings in relation to vibration exposure and finger circulation. *Int Arch Occup Environ Health* 73:519–527.
- Brison RJ, Lawrence CW. 1992. Non-fatal farm injuries on 117 Eastern Ontario beef and dairy farms: a one-year study. *Am J Ind Med* 21:623–636.
- Bronstein J, Carvey P, Chen H, Cory-Slechta D, DiMonte D, Duda J, English P, Goldman S, Grate S, Hansen J, Hoppin J, Jewell S, Kamel F, Koroshetz W, Langston JW, Logroschino G, Nelson L, Ravina B, Rocca W, Ross GW, Schettler T, Schwarzschild M, Scott B, Seegal R, Singleton A, Steenland K, Tanner CM, Van Den Eeden S, Weisskopf M. 2009. Meeting report: consensus statement-Parkinson's disease and the environment: collaborative on health and the environment and Parkinson's Action Network [CHE PAN] conference 26–28 June 2007. *Environ Health Perspect* 117:117–121.
- Brown TP. 2005. Diagnosis and management of injuries from dangerous marine life. *Med Gen Med* 28(3):5.
- Brumitt J, Reisch R, Krasnoselsky K, Welch A, Rutt R, Garside LI, McKay C. 2011. Self-reported musculoskeletal pain in Latino vineyard workers. *J Agromed* 16:72–80.
- Buckley JP, Sestito JP, Hunting KL. 2008. Fatalities in the landscape and horticultural services industry, 1992–2001. *Am J Ind Med* 51(9):701–713.
- Buczek A, Rudek A, Bartosik K, Szymanska J, Wojcik-Fatla A. 2009. Seroepidemiological study of Lyme borreliosis among forestry workers in southern Poland. *Ann Agric Environ Med* 16:257–261.
- Burke W. 1997. Skin diseases in fishermen. In: Langley R, Mclymore R, Meggs W, Roberson G, editors. *Safety and health in agriculture, forestry and fisheries*. Rockville, MD: Government Institutes, Inc. p 680–712.
- Burke G. 2008. More farm deaths in California heat. *USA Today*. Retrieved Feb 05, 2013, from [http://usatoday30.usatoday.com/news/nation/2008-08-20-3205167992\\_x.htm](http://usatoday30.usatoday.com/news/nation/2008-08-20-3205167992_x.htm)
- Butts JD. 1994. Current trends hypothermia-related deaths—North Carolina, November 1993–March 1994. *MMWR Morb Mortal Wkly Rep* 43(46):849, 855–856.
- Caldwell K, Boyd CP. 2009. Coping and resilience in farming families affected by drought. *Rural Remote Health* 9:1088.
- California Department of Industrial Relations. 2010. Heat illness prevention. Division of Occupational Safety and Health [DOSH]. Retrieved May 21, 2010, from <http://dir.ca.gov/dosh/heatillnessinfo.html>
- Calvert GM. 2010. Standardized variables for state surveillance of pesticide-related illness and injury: National Institute for Occupational Health and Safety [NIOSH]. Available at <http://www.cdc.gov/niosh/topics/pesticides/pdfs/standardizedVariableDocument.pdf>
- Carpenter WS, Lee BC, Gunderson PD, Stueland DT. 2002. Assessment of personal protective equipment use among Midwestern farmers. *Am J Ind Med* 42:236–247.
- Carruth AK, Levin JL, Gilmore K, Bui T, Gallardo G, Evert W, Sealey L. 2010. Cultural influences on safety and health education among Vietnamese fishermen. *J Agromed* 15(4):375–385.
- Castaneda H. 2009. Illegality as risk factor: a survey of unauthorized migrant patients in a Berlin clinic. *Soc Sci Med* 68:1552–1560.
- Centers for Disease Control and Prevention [CDC]. 1993. Commercial fishing fatalities—Alaska, 1991–1992. *MMWR Morb Mortal Wkly Rep* 42(18):350–351.
- Centers for Disease Control [CDC]. 1995. Eye injuries to agricultural workers—Minnesota, 1992–1993. *MMWR Wkly* 44:364–366.
- Centers for Disease Control [CDC]. 1996. Invasive infection with streptococcus iniae—Ontario, 1995–1996. *MMWR Morb Mortal Wkly Rep* 45:650–653.
- Cisak E, Chmielewska-Badora J, Zwoliński J, Wójcik-Fatla A, Polak J, Dutkiewicz J. 2005. Risk of tick-borne bacterial diseases among workers of Roztocze National Park (south-eastern Poland). *Ann Agric Environ Med* 12:127–132.
- Chauvin C, Le Bouar G. 2007. Occupational injury in the French sea fishing industry: a comparative study between the 1980s and today. *Accid Anal Prev* 39:79–85.
- Chiu BC, Blair A. 2009. Pesticides, chromosomal aberrations, and non-Hodgkin's lymphoma. *J Agromed* 14:250–255.
- Cierpich HL, Styles L, Harrison R, Davis L, Chester D, Lefkowitz D, Valiante D, Richardson S, Castillo D, Romano N, Baron S. 2008. Work-related injury deaths among Hispanics—United States 1992–2006. *MMWR Morb Mortal Wkly* 57:597–600.
- Cole DW, Cole R, Gaydos SJ, Gray J, Hyland G, Jacques ML, Powell-Dunford N, Sawhney C, Au WW. 2009. Aquaculture: environmental, toxicological, and health issues. *Int J Hyg Environ Health* 212:369–377.
- Colosio C, Tiramani M, Brambilla G, Colombi A, Moretto A. 2009. Neurobehavioural effects of pesticides with special focus on organophosphorus compounds: which is the real size of the problem? *Neurotoxicology* 30:1155–1161.
- Conway GA, Husberg BJ. 1999. Cold-related non-fatal injuries in Alaska. *Am J Ind Med* 36(Suppl 1):39–41.
- Conway GA, Lincoln JM, Hudson DS, Bensyl DM, Husberg BJ, Manwaring JC. 2002. Surveillance and prevention of occupational injuries in Alaska: a decade of progress, 1990–1999. Cincinnati, OH: Alaska Field Station, Division of Safety Research, NIOSH. p 49.
- Cooper SP, Burau KE, Frankowski R, Shipp E, Del Junco DJ, Whitworth RE, Sweeney AM, MacNaughton N, Weller NF, Hanis CL. 2006. A cohort study of injuries in migrant farm worker families in south Texas. *Ann Epidemiol* 16:313–320.
- Copertaro A, Pucci S, Bracci M, Barbaresi M. 2006. Hymenoptera stings in forestry department agents: evaluation of risk. *Med Lav* 97:676–681.
- Costa LG, Giordano G, Guizzetti M, Vitalone A. 2008. Neurotoxicity of pesticides: a brief review. *Front Biosci* 13:1240–1249.
- Costello S, Cockburn M, Bronstein J, Zhang X, Ritz B. 2009. Parkinson's disease and residential exposure to maneb and paraquat from agricultural applications in the central valley of California. *Am J Epidemiol* 169:919–926.

- Coury HJCG, Kumar S, Jones E. 1999. Farm related injuries and fatalities in Alberta. *Int J Ind Ergon* 23:539–547.
- Covert DJ, Langley RL. 2002. Infectious disease occurrence in forestry workers: a systematic review. *J Agromed* 8:95–111.
- Dalgaard JB, Dencker F, Fallentin B, Hansen P, Kaempe B, Steensberg J, Wilhardt P. 1972. Fatal poisoning and other health hazards connected with industrial fishing. *Br J Ind Med* 29:307–316.
- Daniell WE, Fulton-Kehoe D, Cohen M, Swan SS, Franklin GM. 2002. Increased reporting of occupational hearing loss: workers' compensation in Washington State, 1984–1998. *Am J Ind Med* 42:502–510.
- Daniell WE, Swan SS, McDaniel MM, Camp JE, Cohen MA, Stebbins JG. 2006. Noise exposure and hearing loss prevention programmes after 20 years of regulations in the United States. *Occup Environ Med* 63:43–51.
- Das R, Steege A, Baron S, Beckman J, Harrison R. 2001. Pesticide-related illness among migrant farm workers in the United States. *Int J Occup Environ Health* 7:303–312.
- Delancey JO, Alavanja MC, Coble J, Blair A, Hoppin JA, Austin HD, Beane Freeman LE. 2009. Occupational exposure to metribuzin and the incidence of cancer in the Agricultural Health Study. *Ann Epidemiol* 19:388–395.
- Dembe A. 1999. Social inequalities in occupational health and health care for work-related injuries and illnesses. *Int J Law Psychiatry* 22:567–579.
- Dick FD, De Palma G, Ahmadi A, Scott NW, Prescott GJ, Bennett J, Semple S, Dick S, Counsell C, Mozzoni P, Haites N, Wettinger SB, Mutti A, Otelea M, Seaton A, Soderkvist P, Felice A. 2007. Environmental risk factors for Parkinson's disease and parkinsonism: the Geoparkinson study. *Occup Environ Med* 64:666–672.
- Dreihier J, Kordysh E. 2006. Non-Hodgkin lymphoma and pesticide exposure: 25 years of research. *Acta Haematol* 116:153–164.
- Drudi D. 1998. Fishing for a living is dangerous work. In: US BLS, editors. *Compensation and working conditions*. Washington, DC: U.S. Bureau of Labor Statistics. p 3–7.
- Drudi D. 2000. Are animals occupational hazards? In: US BLS, editors. *Compensation and working conditions*. Washington, DC: U.S. Bureau of Labor Statistics. p 15–22.
- Duncan CA, MacKinnon SN, Albert WJ. 2010. Changes in thoracolumbar kinematics and centre of pressure when performing stationary tasks in moving environments. *Int J Ind Ergon* 40:648–654.
- Eduard W, Pearce N, Douwes J. 2009. Chronic bronchitis, COPD, and lung function in farmers: the role of biological agents. *Chest* 136:716–725.
- Elfman L, Hogstedt C, Engvall K, Lampa E, Lindh CH. 2009. Acute health effects on planters of conifer seedlings treated with insecticides. *Ann Occup Hyg* 53:383–390.
- Erisen L, Basut O, Coksun H, Hizalan I. 2001. An unusual penetrating facial injury due to a fishing-line sinker. *J Oral Maxillofac Surg* 59:945–947.
- Erondu ES, Anyanwu PE. 2005. Potential hazards and risks associated with the aquaculture industry. *Afr J Biotechnol* 4:1622–1627.
- Eskenazi B, Marks AR, Bradman A, Fenster L, Johnson C, Barr DB, Jewell NP. 2006. In utero exposure to dichlorodiphenyltrichloroethane [DDT] and dichlorodiphenyldichloroethylene [DDE] and neurodevelopment among young Mexican American children. *Pediatrics* 118:233–241.
- Fallico F, Nolte KB, Siciliano L, Yip F. 2005. Hypothermia-related deaths—United States, 2003–2004. *MMWR Morb Mortal Wkly* 54(7):173–175.
- Farr SL, Cai J, Savitz DA, Sandler DP, Hoppin JA, Cooper GS. 2006. Pesticide exposure and timing of menopause: the Agricultural Health Study. *Am J Epidemiol* 163:731–742.
- Fathallah FA. 2010. Musculoskeletal disorders in labor-intensive agriculture. *Appl Ergon* 41:738–743.
- Fathallah FA, Miller BJ, Miles JA. 2008. Low back disorders in agriculture and the role of stooped work: scope, potential interventions, and research needs. *J Agric Safety Health* 14:221–245.
- Faucett J, Meyers J, Tejada D, Janowitz I, Miles J, Kabashima J. 2001. Instrument to measure musculoskeletal symptoms among immigrant Hispanic farmworker: validation in the nursery industry. *J Agric Safety Health* 7:185–198.
- Frank R, Campbell RA, Sirons GJ. 1985. Forestry workers involved in aerial application of 2,4-dichlorophenoxyacetic acid [2,4-D]: exposure and urinary excretion. *Arch Environ Contam Toxicol* 14:427–435.
- Frank AL, McKnight R, Kirkhorn SR, Gunderson P. 2004. Issues of agricultural safety and health. *Annu Rev Public Health* 25:225–245.
- Freeman SA, Schwab CV, Jiang Q. 2008. Quantifying stressors among Iowa farmers. *J Agric Saf Health* 14:431–439.
- Fulghum DD, Linton WR. 1978. Fatal aeromonas hydrophila infection of the skin. *South Med J* 71:739–741.
- Fulmer S, Buchholz B. 2002. Ergonomic exposure case studies in Massachusetts fishing vessels. *Am J Ind Med* 42(Suppl 2):10–18.
- Gautrin D, Cartier A, Howse D, Horth-Susin L, Jong M, Swanson M, Lehrer S, Fox G, Neis B. 2010. Occupational asthma and allergy in snow crab processing in Newfoundland and Labrador. *Occup Environ Med* 67:17–23.
- Gerberich SG, Gibson RW, French LR. 1993. The Regional Rural Injury Study-I (RRIS-I): a population-based effort—a report to the CDC. Minneapolis, MN: University of Minnesota Regional Injury Prevention Research Center.
- Giannandrea F, Marini Bettolo P, D'Onofrio A, Riccardi F, Bernardini P. 2003. Systemic reactions to hymenoptera stings: epidemiologic study of 100 forestry department agents. *G Ital Med Lav Ergon* 25:26–27.
- Goldcamp EM. 2010. Work-related non-fatal injuries to adults on farms in the U.S., 2001 and 2004. *J Agric Safety Health* 16:41–51.
- Gonzales A. 2010. Project FRESCO: a fresh approach to farmworker heat and sun safety education. Ag Connections, NIOSH Centers for Agricultural Safety and Health Research, Education, and Prevention 5: 8.
- Green LM. 1991. A cohort mortality study of forestry workers exposed to phenoxy acid herbicides. *Br J Ind Med* 48:234–238.
- Grzywacz JG, Quandt SA, Early J, Tapia J, Graham CN, Arcury TA. 2006. Leaving family for work: ambivalence and mental health among Mexican migrant farmworker men. *J Immigr Minor Health* 8:85–97.
- Grzywacz JG, Quandt SA, Isom S, Arcury TA. 2007. Alcohol use among immigrant Latino farmworkers in North Carolina. *Am J Ind Med* 50:617–625.
- Grzywacz JG, Quandt SA, Chen H, Isom S, Kiang L, Vallejos Q, Arcury TA. 2010. Depressive symptoms among Latino farmworkers across the agricultural season: structural and situational influences. *Cultur Divers Ethnic Minor Psychol* 16:335–343.

- Grzywacz JG, Lipscomb HJ, Casanova V, Neis B, Fraser C, Monaghan P, Vallejos Q. 2013. Organization of work in agricultural, forestry and fishing sector in the US Southeast: implications for immigrant workers' occupational safety and health. [In press, this issue].
- Haglund P, Rylander R. 1987. Occupational exposure and lung function measurements among workers in swine confinement buildings. *J Occup Med* 29:904–907.
- Hanke W, Jurewicz J. 2004. The risk of adverse reproductive and developmental disorders due to occupational pesticide exposure: an overview of current epidemiological evidence. *Int J Occup Med Environ Health* 17:223–243.
- Hard DL, Myers JR, Gerberich SG. 2002. Traumatic injuries in agriculture. *J Agric Safety Health* 8:51–65.
- Hargreaves JE, Lucey DR. 1990. Life-threatening *Edwardsiella tarda* soft-tissue infection associated with catfish puncture wound. *J Infect Dis* 162:1416–1417.
- Harley KG, Marks AR, Bradman A, Barr DB, Eskenazi B. 2008. DDT exposure, work in agriculture, and time to pregnancy among farmworkers in California. *J Occup Environ Med* 50:1335–1342.
- Helmkamp JC, Derk SJ. 1999. Nonfatal logging-related injuries in West Virginia. *J Occup Environ Med* 41:967–972.
- Hiott AE, Grzywacz JG, Davis SW, Quandt SA, Arcury TA. 2008. Migrant farmworker stress: mental health implications. *J Rural Health* 24:32–39.
- Holmberg S, Thelin A, Thelin N. 2004. Is there an increased risk of knee osteoarthritis among farmers? A population-based case-control study. *Int Arch Occup Environ Health* 77:345–350.
- Hoppin JA, Umbach DM, London SJ, Alavanja MC, Sandler DP. 2004. Diesel exhaust, solvents, and other occupational exposures as risk factors for wheeze among farmers. *Am J Respir Crit Care Med* 169:1308–1313.
- Hostens I, Ramon H. 2003. Descriptive analysis of combine cabin vibrations and their effect on the human body. *J Sound Vib* 266:453–464.
- Hovey JD, Magaña CG. 2003. Suicide risk factors among Mexican migrant farmworker women in the midwest United States. *Arch Suicide Res* 7:107–121.
- Incorvaia C, Senna G, Mauro M, Bonadonna P, Marconi I, Asero R, Nitti F. 2004. Prevalence of allergic reactions to hymenoptera stings in northern Italy. *Eur Ann Allergy Clin Immunol* 36:372–374.
- Innes E, Walsh C. 2010. Musculoskeletal disorders in Australian dairy farming. *Work* 36:141–155.
- Iversen M, Kirychuk S, Drost H, Jacobson L. 2000. Human health effects of dust exposure in animal confinement buildings. *J Agric Saf Health* 6:283–288.
- Jeebhay MF, Cartier A. 2010. Seafood workers and respiratory disease: an update. *Curr Opin Allergy Clin Immunol* 10:104–113.
- Jensen OC, Stage S, Noer P. 2005. Classification and coding of commercial fishing injuries by work processes: an experience in the Danish fresh market fishing industry. *Am J Ind Med* 47:528–537.
- Jensen OC, Stage S, Noer P. 2006. Injury and time studies of working processes in fishing. *Saf Sci* 44:349–358.
- Johnson CM, Lagares-Garcia JA, Miller SL. 2002. When the bough breaks: a 10-year review of logging injuries treated at a rural trauma center in Pennsylvania. *Am Surg* 68:573–581.
- Jurewicz J, Hanke W, Radwan M, Bonde JP. 2009. Environmental factors and semen quality. *Int J Occup Med Environ Health* 22:305–329.
- Kamel F, Rowland AS, Park LP, Anger WK, Baird DD, Gladen BC, Moreno T, Stallone L, Sandler DP. 2003. Neurobehavioral performance and work experience in Florida farmworkers. *Environ Health Perspect* 111:1765–1772.
- Kamel F, Engel LS, Gladen BC, Hoppin JA, Alavanja MC, Sandler DP. 2005. Neurologic symptoms in licensed private pesticide applicators in the agricultural health study. *Environ Health Perspect* 113:877–882.
- Kamel F, Engel LS, Gladen BC, Hoppin JA, Alavanja MC, Sandler DP. 2007a. Neurologic symptoms in licensed pesticide applicators in the Agricultural Health Study. *Hum Exp Toxicol* 26:243–250.
- Kamel F, Tanner C, Umbach D, Hoppin J, Alavanja M, Blair A, Comyns K, Goldman S, Korell M, Langston J, Ross G, Sandler D. 2007b. Pesticide exposure and self-reported Parkinson's disease in the agricultural health study. *Am J Epidemiol* 165:364–374.
- Karlovich R, Wiley T, Tweed T, Jensen D. 1988. Hearing sensitivity in farmers. *Public Health Rep* 103:61–71.
- Kasner EJ, Keralis JM, Mehler L, Beckman J, Bonnar-Prado J, Lee SJ, Diebolt-Brown B, Mulay P, Lackovic M, Waltz J, Schwartz A, Mitchell Y, Moraga-McHaley S, Roisman R, Gergely R, Calvert GM. 2012. Gender differences in acute pesticide-related illnesses and injuries among farmworkers in the United States, 1998–2007. *Am J Ind Med* 55:571–583.
- Kauppinen T, Vincent R, Liukkonen T, Grzebyk M, Kauppinen A, Welling I, Arezes P, Black N, Bochmann F, Campelo F, Costa M, Elsigan G, Goerens R, Kikemenis A, Kromhout H, Miguel S, Mirabelli D, McEneaney R, Pesch B, Plato N, Schlünssen V, Schulze J, Sonntag R, Verougstraete V, De Vicente MA, Wolf J, Zimmermann M, Husgafvel-Pursiainen K, Savolainen K. 2006. Occupational exposure to inhalable wood dust in the member states of the European Union. *Ann Occup Hyg* 50:549–561.
- Keifer MC, Firestone J. 2007. Neurotoxicity of pesticides. *J Agromed* 12:17–25.
- Keifer M, Gasperini F, Robson M. 2010. Pesticides and other chemicals: minimizing worker exposures. *J Agromed* 15(3):264–274.
- Kim-Godwin YS, Fox JA. 2009. Gender differences in intimate partner violence and alcohol use among Latino-migrant and seasonal farmworkers in rural southeastern North Carolina. *J Community Health Nurs* 26:131–142.
- Kirkhorn SR, Schenker MB. 2002. Current health effects of agricultural work: respiratory disease, cancer, reproductive effects, musculoskeletal injuries, and pesticide-related illnesses. *J Agric Safety Health* 8:199–214.
- Kirrane E, Loomis D, Egeghy P, Nylander-French L. 2007. Personal exposure to benzene from fuel emissions among commercial fishers: comparison of two-stroke, four-stroke and diesel engines. *J Expo Sci Environ Epidemiol* 17:151–158.
- Knopp D, Glass S. 1991. Biological monitoring of 2,4-dichlorophenoxyacetic acid-exposed workers in agriculture and forestry. *Int Arch Occup Environ Health* 63:329–333.
- Koksal N, Hasanoglu HC, Gokirmak M, Yildirim Z, Gultek A. 2003. Apricot sulfurization: an occupation that induces an asthma-like syndrome in agricultural environments. *Am J Ind Med* 43:447–453.
- Koutros S, Lynch CF, Ma X, Lee WJ, Hoppin JA, Christensen CH, Andreotti G, Freeman LB, Rusiecki JA, Hou L, Sandler DP, Alavanja MC. 2009. Heterocyclic aromatic amine pesticide use and human cancer risk: results from the U.S. Agricultural Health Study. *Int J Cancer* 124:1206–1212.
- Krejci-Manwaring J, Schulz MR, Feldman SR, Vallejos QM, Quandt SA, Rapp SR, Arcury TA. 2006. Skin disease among Latino farmworkers in North Carolina. *J Agric Saf Health* 12(2):155–163.

- Krieger RI, editor. 2001. Handbook of pesticide toxicology. 2nd edition. San Diego: Academic Press.
- Kucera KL, Loomis D, Marshall SW. 2008. A case crossover study of triggers for hand injuries in commercial fishing. *Occup Environ Med* 65:336–341.
- Kucera KL, Loomis D, Lipscomb HJ, Marshall SW, Mirka GA, Daniels JL. 2009. Ergonomic risk factors for low back pain in North Carolina crab pot and gill net commercial fishermen. *Am J Ind Med* 52:311–321.
- Kurtio P, Savolainen K. 1990. Ethylenethiourea in air and in urine as an indicator of exposure to ethylenedisithiocarbamate fungicides. *Scand J Work Environ Health* 16:203–207.
- Lacey SE, Forst LS, Petrea RE, Conroy LM. 2007. Eye injury in migrant farm workers and suggested hazard controls. *J Agric Saf Health* 13:259–274.
- Laflamme L, Cloutier E. 1988. Mechanization and risk of occupational accidents in the logging industry. *J Occup Accid* 10:191–198.
- Laursen LH, Hansen HL, Jensen OC. 2008. Fatal occupational accidents in Danish fishing vessels 1989–2005. *Int J Inj Contr Saf Promot* 15:109–117.
- Lavy TL, Cowell JE, Steinmetz JR, Massey JH. 1992. Conifer seedling nursery worker exposure to glyphosate. *Arch Environ Contam Toxicol* 22:6–13.
- Lawrie T, Matheson C, Murphy E, Ritchie L, Bond C. 2003. Medical emergencies at sea and injuries among Scottish fishermen. *Occup Med [Lond]* 53:159–164.
- Layde PM, Nordstrom DL, Stueland D, Wittman LB, Follen MA, Olson KA. 1996. Animal-related occupational injuries in farm residents. *J Agric Saf Health* 2:27–37.
- Lehane L, Rawlin GT. 2000. Topically acquired bacterial zoonoses from fish: a review. *Med J Aust* 173:256–259.
- Levin JL, Gilmore K, Shepherd S, Wickman A, Carruth A, Nalbone JT, Gallardo G, Nonnenmann MW. 2010. Factors influencing safety among a group of commercial fishermen along the Texas Gulf Coast. *J Agromed* 15(4):363–374.
- Lincoln JM, Lucas DL. 2010. Occupational fatalities in the United States commercial fishing industry, 2000–2009. *J Agromed* 15(4):343–350.
- Lindroos O, Aspman EW, Lidestav G, Neely G. 2008. Accidents in family forestry's firewood production. *Accid Anal Prev* 40:877–886.
- Lipscomb HJ, Loomis D, McDonald MA, Kucera K, Marshall S, Li L. 2004. Musculoskeletal symptoms among commercial fishers in North Carolina. *Appl Ergon* 35:417–426.
- Litchfield MH. 1999. Agricultural work related injury and ill-health and the economic cost. *Environ Sci Pollut Res Int* 6:175–182.
- Loomis DP, Richardson DB, Wolf SH, Runyan CW, Butts JD. 1997. Fatal occupational injuries in a southern state. *Am J Epidemiol* 145:1089–1099.
- Lucas DL, Lincoln JM. 2007. Fatal falls overboard on commercial fishing vessels in Alaska. *Am J Ind Med* 50:962–968.
- Lucas D, Lucas R, Boniface K, Jegaden D, Lodde B, Dewitte JA. 2010. Occupational asthma in the commercial fishing industry: a case series and review of the literature. *Int Marit Health* 61(1):13–16.
- Luginbuhl R, Jackson L, Castillo D, Loring K. 2008. Heat-related deaths among crop workers—United States, 1992–2006. *MMWR Morb Mortal Wkly* 57(24):649–653.
- Luque JS, Monaghan P, Contreras RB, August E, Baldwin JA, Bryant CA, McDermott RJ. 2007. Implementation evaluation of a culturally competent eye injury prevention program for citrus workers in a Florida migrant community. *Prog Community Health Partnersh* 1:359–369.
- Lynch SM, Mahajan R, Beane Freeman LE, Hoppin JA, Alavanja MC. 2009. Cancer incidence among pesticide applicators exposed to butylate in the Agricultural Health Study [AHS]. *Environ Res* 109:860–868.
- MacGregor D. 2004. Fishsafe: a handbook for commercial fishing and aquaculture. Yarmouth, Nova Scotia: Nova Scotia Fisheries Sector Council.
- Mackiewicz J, Machowicz-Matejko EM, Salaga-Pylak M, Piecyk-Sidor M, Zagorski Z. 2005. Work-related, penetrating eye injuries in rural environments. *Ann Agric Environ Med* 12:27–29.
- Madsen J, Sherson D, Kjoller H, Hansen I, Rasmussen K. 2004. Occupational asthma caused by sodium disulphite in Norwegian lobster fishing. *Occup Environ Med* 61:873–874.
- Maeda T, Kaneko S, Ohta M, Tanaka K, Sasaki A, Fukushima T. 2006. Risk factors for heatstroke among Japanese forestry workers. *J Occup Health* 48(4):223–229.
- Magaña CG, Hovey JD. 2003. Psychosocial stressors associated with Mexican migrant farmworkers in the midwest United States. *J Immigr Health* 5:75–86.
- Mahajan R, Blair A, Lynch CF, Schroeder P, Hoppin JA, Sandler DP, Alavanja MC. 2006. Fonofos exposure and cancer incidence in the agricultural health study. *Environ Health Perspect* 114:1838–1842.
- Mahata J, Chaki M, Ghosh P, Das LK, Baidya K, Ray K, Natarajan AT, Giri AK. 2004. Chromosomal aberrations in arsenic-exposed human populations: a review with special reference to a comprehensive study in West Bengal, India. *Cytogenet Genome Res* 104(1–4):359–364.
- Malo JL, Cartier A. 1993. Occupational reactions in the seafood industry. *Clin Rev Allergy* 11(2):223–240.
- Mariger SC, Grisso RD, Perumpral JV, Sorenson AW, Christensen NK, Miller RL. 2009. Virginia agricultural health and safety survey. *J Agric Safety Health* 15:37–47.
- Marshall SW, Kucera K, Loomis D, McDonald MA, Lipscomb HJ. 2004. Work related injuries in small scale commercial fishing. *Inj Prev* 10:217–221.
- Mayton AG, Kittusamy NK, Ambrose DH, Jobes CC, Legault ML. 2008. Jarring/jolting exposure and musculoskeletal symptoms among farm equipment operators. *Int J Ind Ergon* 38:758–766.
- McCauley LA, Anger WK, Keifer M, Langley R, Robson MG, Rohlman D. 2006. Studying health outcomes in farmworker populations exposed to pesticides. *Environ Health Perspect* 114:953–960.
- McCurdy SA, Samuels SJ, Carroll DJ, Beaumont JJ, Morrill LA. 2003. Agricultural injury in California migrant Hispanic farm workers. *Am J Ind Med* 44:225–235.
- McDaniel J, Casanova V. 2003. Pines in lines: tree planting, H2B guest workers, and rural poverty in Alabama. *South Rural Sociol* 19:73–96.
- McDaniel J, Casanova V. 2005. Forest management and the H2B guest worker program in the Southeastern United States: an assessment of contractors and their crews. *J For* 103:114–119.
- Michael JL. 2000. Pesticides used in forestry and their impacts on water quality. 53rd annual Southern Weed Science Society meeting Tulsa, Oklahoma: Southern Weed Science Society. p 81–91.

- Mills PK, Dodge J, Yang R. 2009. Cancer in migrant and seasonal hired farm workers. *J Agromed* 14:185–191.
- Mines R, Mullenax N, Saca L. 2001. The binational farmworker health survey. Davis: California Institute for Rural Studies. Available at: <http://www.cirsinc.org/Documents/Pub1001.2.pdf>
- Mirabelli MC, Hoppin JA, Chatterjee AB, Isom S, Grzywacz JG, Howard TD, Quandt SA, Vallejos QM, Arcury TA. 2010a. Job activities and respiratory symptoms among Latino farmworkers in North Carolina. *Arch Environ Occ Health* 39:468–471.
- Mirabelli MC, Quandt SA, Crain R, Grzywacz JG, Robinson EM, Vallejos QM, Arcury TA. 2010b. Symptoms of heat illness among Latino farmworkers in North Carolina. *Am J Prev Med* 39:468–471.
- Moreau DTR, Neis B. 2009. Occupational health and safety hazards in Atlantic Canadian aquaculture: laying the groundwork for prevention. *Mar Pol* 33:401–411.
- Mouzopoulos G, Tzurbakis M. 2009. Unusual cervical spine injury by fishing harpoon. *Eur J Emerg Med* 16:209–211.
- Mujuru P, Singla L, Helmkamp J, Bell J, Hu W. 2006. Evaluation of the burden of logging injuries using West Virginia Workers' Compensation claims data from 1996 to 2001. *Am J Ind Med* 49:1039–1045.
- Myers J. 2001. Injuries among farm workers in the United States 1995. Cincinnati, OH: US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH). Publication No. 2001-153.
- Myers JR. 2001b. Injuries among farm workers in the United States, 1995. NIOSH Pub. No. 2001-153.
- Myers ML. 2010. Review of occupational hazards associated with aquaculture. *J Agromed* 15:412–426.
- Myers JR, Hendricks KJ. 2010. Agricultural tractor overturn deaths: assessment of trends and risk factors. *Am J Ind Med* 53:662–672.
- Nagesh KR, Rastogi P. 2007. Amputation due to fishing net. *J Forensic Leg Med* 14:377–381.
- Navarro P, Neis B, MacDonald M, Lawson J. 2004. Newfoundland and Labrador Forestry Occupational Health and Safety Project: statistical report on forestry and forestry-related WHSCC claims, 1990–2002.
- Neitzel R, Yost M. 2002. Task-based assessment of occupational vibration and noise exposures in forestry workers. *AIHA J* 63:617–628.
- National Institute for Occupational Safety and Health. 2005. NIOSH pocket guide to chemical hazards: Center for Disease Control. Report # 2005-149. Available at: <http://www.cdc.gov/niosh/npg/> (Accessed July 13, 2010).
- National Institute for Occupational Safety and Health. 2010. Pesticide illness and injury surveillance. Available at: <http://www.cdc.gov/niosh/topics/pesticides/default.html> (Accessed July 13, 2010).
- Nonnenmann MW, Hussain A, Shirley M, Shepherd S, Gilmore K, Levin JL. 2010. Risk factors for musculoskeletal symptoms among crawfish farmers in Louisiana—a pilot study. *J Agromed* 15(4):386–393.
- Norrish AE, Cryer PC. 1990. Work related injury in New Zealand commercial fishermen. *Br J Ind Med* 47:726–732.
- Oregon Department of Forestry. 2009. Pesticide use in Oregon's forests. Available at: <http://www.oregon.gov/ODF/privateforests/pesticides.shtml> (Accessed July 13, 2010).
- Ortega HG, Darowalla F, Petsonk EL, Lewis D, Berardinelli S Jr, Jones W, Kreiss K, Weissman DN. 2001. Respiratory symptoms among crab processing workers in Alaska: epidemiological and environmental assessment. *Am J Ind Med* 39:598–607.
- Palinkas LA, Downs MA, Petterson JS, Russell J. 1993. Social, cultural, and psychological impacts of the Exxon Valdez oil spill. *Hum Org* 52:1–13.
- Parent M-E, Desy M, Siemiatycki J. 2009. Does exposure to agricultural chemicals increase the risk of prostate cancer among farmers? *McGill J Med* 12:70–77.
- Perez-Labajos CA, Blanco B, Azofra M, Achutegui JJ, Eguia E. 2009. Injury and loss concentration by sinkings in fishing fleets. *Saf Sci* 47:277–284.
- Perry MJ. 2008. Effects of environmental and occupational pesticide exposure on human sperm: a systematic review. *Hum Reprod Update* 14:233–242.
- Petersen I, Torner M, Hansson T, Zetterberg C, Kadefors R. 1989. The effect of ship motions on the musculo-skeletal system of fishermen. *Bull Inst Marit Trop Med Gdynia* 40(3/4):211–216.
- Picou S. 1992. Disruption and stress in an Alaskan fishing community: initial and continuing impacts of the Exxon Valdez oil spill. *Organ Environ* 6:235–257.
- Quandt SA, Elmore RC, Arcury TA, Norton D. 2001. Eye symptoms and use of eye protection among seasonal and migrant farmworkers. *South Med J* 94:603–607.
- Quandt SA, Arcury TA, Rao P, Snively BM, Camann DE, Doran AM, Yau AY, Hoppin JA, Jackson DS. 2004. Agricultural and residential pesticides in wipe samples from farmworker family residences in North Carolina and Virginia. *Environ Health Perspect* 112:382–387.
- Quandt SA, Chen H, Grzywacz JG, Vallejos QM, Galvan L, Arcury TA. 2010a. Cholinesterase depression and its association with pesticide exposure across the agricultural season among Latino Farmworkers in North Carolina. *Environ Health Perspect* 118:635–639.
- Quandt SA, Jones BT, Talton JW, Whalley LE, Galvan L, Vallejos QM, Grzywacz JG, Chen H, Pharr KE, Isom S, Arcury TA. 2010b. Heavy metals exposures among Mexican farmworkers in eastern North Carolina. *Environ Res* 110:83–88.
- Quandt SA, Schulz MR, Talton JW, Verma A, Arcury TA. 2012. Occupational eye injuries experienced by migrant farmworkers. *J Agromed* 17:63–69.
- Rabinowitz P, Sircar K, Tarabar S, Galusha D, Slade M. 2005. Hearing loss in migrant agricultural workers. *J Agromed* 10:9–17.
- Radon K, Garz S, Schottky A, Koops F, Hartung J, Szadkowski D, Nowak D. 2000. Lung function and work-related exposure in pig farmers with respiratory symptoms. *J Occup Environ Med* 42:814–820.
- Reidy TJ, Bowler RM, Rauch SS, Pedroza GI. 1992. Pesticide exposure and neuropsychological impairment in migrant farm workers. *Arch Clin Neuropsychol* 7:85–95.
- Rein BK. 1992. Health hazards in agriculture—an emerging issue. Farm safety fact sheet. Washington, DC: National Agriculture Safety Database [NASD], US Department of Agriculture Extension Service.
- Richardson DB, Terschuren C, Hoffmann W. 2008. Occupational risk factors for non-Hodgkin's lymphoma: a population-based case-control study in Northern Germany. *Am J Ind Med* 51:258–268.
- Roberts EM, English PB, Grether JK, Windham GC, Somberg L, Wolff C. 2007. Maternal residence near agricultural pesticide applications and autism spectrum disorders among children in the California Central Valley. *Environ Health Perspect* 115:1482–1489.

- Robinson DG, Trites DG, Banister EW. 1993. Physiological effects of work stress and pesticide exposure in tree planting by British Columbia silviculture workers. *Ergonomics* 36:951–961.
- Rohlman DS, Arcury TA, Quandt SA, Lasarev M, Rothlein J, Travers R, Tamulinas A, Scherer J, Early J, Marin A, Phillips J, McCauley L. 2005. Neurobehavioral performance in preschool children from agricultural and non-agricultural communities in Oregon and North Carolina. *Neurotoxicology* 26:589–598.
- Rohlman DS, Lasarev M, Anger WK, Scherer J, Stupfel J, McCauley L. 2007. Neurobehavioral performance of adult and adolescent agricultural workers. *Neurotoxicology* 28:374–380.
- Rosas LG, Eskenazi B. 2008. Pesticides and child neurodevelopment. *Curr Opin Pediatr* 20:191–197.
- Rural Migration News. 2009. California: heat, UFW, UI. Retrieved April 2010, from <http://migration.ucdavis.edu.rmn/commens.php?id=1481030>
- Saari KM, Aine E. 1984. Eye injuries in agriculture. *Acta Ophthalmol* 161:42–51.
- Salas R, Mayer J, Hoerster K. 2005. Sun-protective behaviors of California farm workers. *J Occup Environ Med* 47(12):1244–1249.
- Salazar MK, Keifer M, Negrete M, Estrada F, Snyder K. 2005. Occupational risk among orchard workers: a descriptive study. *Fam Community Health* 28:239–252.
- Sarathy B, Casanova V. 2008. Guest workers or unauthorized immigrants? The case of forest workers in the United States. *Policy Sci* 41:95–114.
- Sartore GM, Kelly B, Stain H, Albrecht G, Higginbotham N. 2008. Control, uncertainty, and expectations for the future: a qualitative study of the impact of drought on a rural Australian community. *Rural Remote Health* 8(3):950.
- Sathanarayanan S, Basso O, Karr CJ, Lozano P, Alavanja M, Sandler DP, Hoppin JA. 2010. Maternal pesticide use and birth weight in the agricultural health study. *J Agromed* 15:127–136.
- Schenker M. 2000. Exposures and health effects from inorganic agricultural dusts. *Environ Health Perspect* 108(Suppl 4):661–664.
- Schenker MB, Orenstein MR, Samuels SJ. 2002. Use of protective equipment among California farmers. *Am J Ind Med* 42:455–464.
- Selby E, Dixon D, Hapke H. 2001. A woman's place in the crab processing industry of Eastern Carolina. *Gender Place Culture* 88:229–253.
- Sharp DS, Eskenazi B, Harrison R, Callas P, Smith AH. 1986. Delayed health hazards of pesticide exposure. *Annu Rev Public Health* 7:441–471.
- Shih RA, Hu H, Weisskopf MG, Schwartz BS. 2007. Cumulative lead dose and cognitive function in adults: a review of studies that measured both blood lead and bone lead. *Environ Health Perspect* 115:483–492.
- Siracusa A, Desrosiers M, Marabini A. 2000. Epidemiology of occupational rhinitis: prevalence, aetiology and determinants. *Clin Exp Allergy* 30:1519–1534.
- Slaven EM, Lopez FA, Hart SM, Sanders CV. 2001. Myonecrosis caused by *Edwardsiella tarda*: a case report and case series of extra-intestinal *E. tarda* infections. *Clin Infect Dis* 32:1430–1433.
- Slot TR, Dumas GA. 2010. Musculoskeletal symptoms in tree planters in Ontario, Canada. *Work* 36:67–75.
- Sprince NL, Park H, Zwerling C, Lynch SF, Whitten PS, Thu K, Burmeister LF, Gillette PP, Alavanja MCR. 2003. Risk factors for animal-related injury among Iowa large-livestock farmers: a case-control study nested in the Agricultural Health Study. *J Rural Health* 19:165–173.
- Sprince NL, Zwerling C, Whitten PS, Lynch CF, Burmeister LF, Gillette PP, Thu K, Alavanja MCR. 2008. Farm activities associated with eye injuries in the Agricultural Health Study. *J Agromed* 13:17–22.
- Stallones L. 1990. Surveillance of fatal and non-fatal farm injuries in Kentucky. *Am J Ind Med* 18:223–234.
- Stallones L, Beseler C. 2002. Pesticide poisoning and depressive symptoms among farm residents. *Ann Epidemiol* 12:389–394.
- Tanner CM, Kamel F, Ross GW, Hoppin JA, Goldman SM, Korell M, Marras C, Bhudhikanok GS, Kasten M, Chade AR, Comyns K, Richards MB, Meng C, Priestley B, Fernandez HH, Cambi F, Umbach DM, Blair A, Sandler DP, Langston JW. 2011. Rotenone, paraquat, and Parkinson's disease. *Environ Health Perspect* 119(6):866–872.
- Taylor LH, Latham SM, Woolhouse MEJ. 2001. Risk factors for human disease emergence. *Phi Trans R Soc Lond B* 356:983–989.
- Taylor MR, Agho KE, Stevens GJ, Raphael B. 2008. Factors influencing psychological distress during a disease epidemic: data from Australia's first outbreak of equine influenza. *BMC Public Health* 3(8):347.
- Thomas TK, Lincoln JM, Husberg BJ, Conway GA. 2001. Is it safe on deck? Fatal and non-fatal workplace injuries among Alaskan commercial fishermen. *Am J Ind Med* 40:693–702.
- Torner M, Blide G, Eriksson H, Kadefors R, Karlsson R, Petersen I. 1988. Musculo-skeletal symptoms as related to working conditions among Swedish professional fishermen. *Appl Ergon* 19(3):191–201.
- Torner M, Almstrom C, Karlsson R, Kadefors R. 1994. Working on a moving surface—a biomechanical analysis of musculo-skeletal load due to ship motions in combination with work. *Ergonomics* 37(2):345–362.
- Torner M, Karlsson R, Saethre H, Kadefors R. 1995. Analysis of serious occupational accidents in Swedish fishery. *Saf Sci* 21:93–111.
- Tsai SY, Chou HY, The HW, Chen CM, Chen CJ. 2003. The effects of chronic arsenic exposure from drinking water on the neurobehavioral development in adolescence. *Neurotoxicology* 24:747–753.
- US Census Bureau. 2003. Census 2000. Migration by Race and Hispanic Origin for the Population 5 Years and Over for the United States, Regions, States, and Puerto Rico: 2000. Table I. Gross and Net Migration by Race and Hispanic Origin for the Population 5 Years and Over for the United States, Regions, and States: 2000. Available at: <http://www.census.gov/population/www/cen2000/briefs/phc-t25/tables/tab01.pdf> (Accessed July 27, 2011).
- United States National Library of Medicine. 2010. Tree farm and logging. Available at: [http://toxtown.nlm.nih.gov/text\\_version/locations.php?id=59](http://toxtown.nlm.nih.gov/text_version/locations.php?id=59) (Accessed July 13, 2010).
- Van Maele-Fabry G, Lantin AC, Hoet P, Lison D. 2010. Childhood leukaemia and parental occupational exposure to pesticides: a systematic review and meta-analysis. *Cancer Causes Control* 21:787–809.
- Vayrynen ST. 1983. Protection of the head and eyes in forestry work. *Scand J Work Environ Health* 9:204–207.
- Verma A, Schulz MR, Quandt SA, Robinson EN, Grzywacz JG, Chen H, Arcury TA. 2011. Eye health and safety among Latino farmworkers. *J Agromed* 16:143–152.
- Villarejo D, McCurdy SA. 2008. The California agricultural workers health survey. *J Agric Saf Health* 14:135–146.

- Villarejo D, McCurdy SA, Bade B, Samuels S, Lighthall D, Williams D III. 2010. The health of California's immigrant hired farmworkers. *Am J Ind Med* 53:387–397.
- Vogelzang PF, van der Gulden JW, Folgering H, van Schayck CP. 1999. Organic dust toxic syndrome in swine confinement farming. *Am J Ind Med* 35:332–334.
- Von Essen S, Moore G, Gibbs S, Larson KL. 2010. Respiratory issues in beef and pork production: recommendations from an expert panel. *J Agromed* 15(3):216–225.
- Wang J, Bell JL, Grushecky ST. 2003. Logging injuries for a 10-year period in Jilin Province of the People's Republic of China. *J Safety Res* 34:273–279.
- Washington Department of Labor and Industries. 2008. L&I files permanent rule on heat-related illness. Retrieved May 22, 2010, from <http://lni.wa.gov/safety/topics/atoz/heatstress/default.asp>
- Wästerlund DS. 1998. A review of heat stress research with application to forestry. *Appl Ergon* 29(3):179–183.
- Weigel MM, Armijos RX, Hall YP, Ramirez Y, Orozco R. 2007. The household food insecurity and health outcomes of U.S.-Mexico border migrant and seasonal farmworkers. *J Immigr Minor Health* 9:157–169.
- Weinstein MR, Litt M, Kertesz DA, Wyper P, Rose D, Coulter M, McGeer A, Facklam R, Ostach C, Willey BM, Borczyk A, Low DE. 1997. Invasive infections due to a fish pathogen, *Streptococcus iniae*. *N Engl J Med* 337:589–594.
- Weuve J, Korrick SA, Weisskopf MG, Ryan LM, Schwartz J, Nie H, Grodstein F, Hu H. 2009. Cumulative exposure to lead in relation to cognitive function in older women. *Environ Health Perspect* 117:574–580.
- Wiklund K, Holm LE. 1986. Soft tissue sarcoma risk in Swedish agricultural and forestry workers. *J Natl Cancer Inst* 76:229–234.
- Wiklund K, Lindefors BM, Holm LE. 1988. Risk of malignant lymphoma in Swedish agricultural and forestry workers. *Br J Ind Med* 45:19–24.
- Wolf CH, Dempsey GP. 1978. Logging injuries in Appalachia. Forest Service Research Paper NE-416. Forest Service, US Department of Agriculture.
- Wright RO, Amarasiwardena C, Woolf AD, Jim R, Bellinger DC. 2006. Neuropsychological correlates of hair arsenic, manganese, and cadmium levels in school-age children residing near a hazardous waste site. *Neurotoxicology* 27:210–216.
- Xiang H, Shi J, Wheeler K, Wilkins JR. 2010. Disability and employment among US working-age immigrants. *Am J Ind Med* 52:425–434.
- Young JG, Eskenazi B, Gladstone EA, Bradman A, Pedersen L, Johnson C, Barr DB, Furlong CE, Holland NT. 2005. Association between in utero organophosphate pesticide exposure and abnormal reflexes in neonates. *Neurotoxicology* 26:199–209.
- Zejda JE, Hurst TS, Rhodes CS, Barber EM, McDuffie HH, Dosman JA. 1993. Respiratory health of swine producers. Focus on young workers. *Chest* 103:702–709.
- Zhou C, Roseman JM. 1994. Agricultural injuries among a population-based sample of farm operators in Alabama. *Am J Ind Med* 25:385–402.