Chapter 3
Occupational Injury and Illness in Farmworkers in the Eastern United States

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3.1 Introduction

Few populations of workers in the United States (US) are so readily acknowledged to be socially and economically disadvantaged as the nation's migrant and seasonal farmworkers. Agriculture as a whole is a dangerous industry, with rates of occupational fatality and injury that are seven times the national average (Bureau of Labor Statistics 2018). Migrant and seasonal farmworkers often face the worst working conditions within this dangerous industry.

Data on the degree to which the migrant and seasonal farmworker population experiences occupational injuries and illnesses are limited and generally inadequate. The traditional sources of such data simply do not provide reliable information for this population of workers. Injury logs used for reporting to the Occupational Safety and Health Administration (OSHA) and workers' compensation statistics are, at best, suspect with this group of workers. The problem of underreporting is substantial and leads to limited information being available to assess the issue of occupational illness and injury affecting workers in the eastern US (Azaroff et al. 2002).

Migrant and seasonal farmworkers are hired on a temporary basis, most without benefits or the protections other workers enjoy. Manual crop work often requires prolonged repetitive motion, lifting heavy weights, holding awkward postures for extended periods, exposure to toxic chemicals, and the use of sharp tools. These workers may be paid piece rate, which, under the pressure of the short harvest period, discourages adequate breaks and rest. Basic hydration and hygiene facilities are often not readily available at the work site. Workers' cultural and linguistic

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isolation and their uncertain legal status create extreme dependency upon the employer. This marked imbalance of power serves to enhance their susceptibility to occupational safety risks (Wilk 1988; Mobed et al. 1992). Given the organizational structure of these jobs, it is unlikely that OSHA reporting mechanisms will ever accurately reflect illness and injury rates.

Agricultural work exposes the worker to myriad occupational health challenges. Some of these are issues familiar to the occupational health practitioner: people being forced to fit the job, rather than vice versa, employers focused entirely upon short-term issues of production and costs, unhealthy rates of work, and unhealthy work conditions. Other occupational problems for Latinx farmworkers in the eastern US may be less familiar to occupational health professionals: agrochemical intoxications, heat stress, unusual working conditions, limited access to care, and linguistic and cultural differences. These are complex issues that would challenge most occupational health experts. Currently, these issues are routinely presented to practitioners who have expertise in primary care but may feel ill equipped to address these occupational challenges (Institute of Medicine 1988; Liebman and Harper 2001).

This chapter provides an overview of some of the more significant occupational health problems experienced by migrant and seasonal farmworkers as they cultivate and harvest large proportions of eastern states' overall agricultural production. Examined first are some of the problems that may occur commonly in a number of locations and with many commodities. Subsequent discussion of selected specific commodities illustrates how each can present unique challenges that require the health professional to have some understanding of the specific work process. Throughout the chapter, limited comments on treatment and prevention are provided. Recommendations on steps to improve the understanding and prevention of occupational health problems in farmworkers in the eastern US are provided at the end of this chapter.

3.1.1 The Role of Culture in Farmworker Occupational Injury

Farmers have their own culture as do Latinx farmworkers (see Sect. 2.4.2). The farmer-farmworker interaction represents the intersection of these distinct cultures, readily understood by neither the health professional nor outside observer. Farmers combine a remarkably high tolerance for risk (Sorensen et al. 2008) with an optimistic bias (Weinstein 1988), leading them to believe that most things will work out in the end. They generally place greater priority on efficient production than on personal safety, and they see most safety measures as contributing little to their efficiency and productivity. At the same time, farmers express considerable concern regarding the safety of spouses, children, and employees. This attitude reflects decisions to undertake the riskiest tasks personally and in the resultant elevated rates of injuries to farmers compared to employees on small family farms (Pratt et al. 1992).

The farmer's high tolerance of risk, denial of susceptibility, and skepticism regarding safety measures may contribute significantly to the woes encountered by

some farmworkers. The exposure of these workers to hazards, such as heat, chemicals, and falls, often reflects the farmers' personal approach to risk and prevention (Sorensen et al. 2008). Farmworkers' beliefs and values may exacerbate the potential for occupational injury. Their beliefs about the role of fate and supernatural factors in their health and safety, their recognition of their limited power relative to their employers, their expectation that work will be physically demanding, and their financial need to keep their jobs and maximize income may lead them to continue working in the face of imminent pain, injury, and illness (Faucett et al. 2001; Arcury et al. 2012).

3.1.2 Data on Farmworker Occupational Illness and Injury

Occupational injury and illness data are often incomplete for agriculture. In the case of farmworkers, this problem is compounded. Papers in the literature are limited, particularly when one focuses upon the experience of workers in the eastern US. Published rates are virtually nonexistent; for most of this work, there are significant questions regarding both numerators and denominators.

3.1.2.1 Numerator Problems

Many farmworkers are not particularly interested in being studied (Earle-Richardson et al. 1998). When they are injured, they have limited access to health care and, for financial, social, and legal reasons, may avoid interactions with the medical establishment. Many workers are just as likely to use home remedies or seek treatment from healers within their community (Arcury et al. 2016a, b). Certainly, those who are undocumented experience increasingly powerful disincentives to seek medical care or to participate in any research projects. This population can be hard to access, and much of the literature relies upon sampling that is little better than convenience sampling, with all of its attendant biases. Several methodologies have been developed that represent an improvement (Arcury et al. 2003a, b; Earle-Richardson et al. 2008; Scribani et al. 2013), but these continue to have limitations. The camp sampling methods used in North Carolina can suffer if some camps are not identified or are not sampled for reasons that might inject unrecognized biases (e.g., the camp owner does allow researchers access). The selection of those within the camp to sample can result in data that are not fully representative. The review of medical charts from migrant clinics and emergency rooms is labor intensive and presumes that those seeking care at these sites are representative of all farmworkers in the region. Problems can arise with accurate recognition, diagnosis, and sufficient documentation in the notes to enable identification of an occupationally related injury or illness in subsequent chart reviews. All of these issues lead to some uncertainty regarding the number of adverse health events actually being experienced by farmworkers in the eastern US.

Further complicating matters is the migratory nature of some of this work force. Does a musculoskeletal injury in a Pennsylvania orchard worker relate to orchard work? Might this injury actually relate to cucumber work done previously in North Carolina? In some cases, an injury may have occurred in one work setting but be further exacerbated by different work in a different location.

3.1.2.2 Denominator Problems

Although figures are quoted repeatedly throughout the literature and throughout this book, there is no clear understanding of how many farmworkers are employed in the eastern US or elsewhere in the country. Previous literature referred to estimates produced by the Health Resources and Services Administration (HRSA 1990), but the most recent substantial enumeration was done in 2000 and had a number of significant design flaws. Alternate estimates have been based upon the Larson's minimum labor demand methodology (Larson and Plascencia 1993; Larson 2000). Using figures relating the number of worker hours required to produce a given amount of a commodity product, Larson was able to estimate the total number of workers required in each state to account for its reported agricultural production of a series of different labor-intensive commodities.

Each state currently makes various estimates of the number of migrant farmworkers employed in the state. In New York, estimates are now made by both the Department of Agriculture and Markets and the Department of Labor. The traditional estimates made by the Department of Labor rely upon mandatory reporting by farms employing more than five workers or contractors employing any number of workers. Comparison of these figures with those derived using Larson's methodology shows considerable divergence, with Larson's minimum labor calculations estimating nearly twice as many workers (Earle-Richardson et al. 2005). Efforts based upon accumulating counts from various farmworker advocacy and support organizations have proven equally difficult (Borjan et al. 2008). These examples of the underlying uncertainty regarding the number of workers illustrate the challenges in any efforts aimed at establishing rates of injuries or illnesses in farmworkers.

The general absence of reliable numerator and denominator figures represents a substantial challenge to establishing priorities for intervention. Subsequently, this problem will also complicate the assessment of the effect of any interventions that are implemented. Assessment of long-term outcomes of either exposures or interventions is substantially challenged by the transient nature of this workforce.

3.2 Access to Optimal Health Care

Roughly 80% of America's 12 million undocumented residents are Latinx. An estimated 1–3 million of these undocumented residents work in agriculture. Like other immigrants, they have worse access to health care and worse health outcomes than

other people in the US (Martinez-Donate et al. 2017). Among the contributing factors are low rates of health insurance coverage (Ortega et al. 2015). Employer-provided insurance is unlikely for those who work on smaller operations (<50 full-time equivalents) or who work for less than 120 days. For the roughly 1% of US farms obligated to provide insurance, the fines for failure to do so might be less than the cost of premiums, so insurance still might not be provided (Ahearn et al. 2015).

While the future of the 2010 Patient Protection and Affordable Care Act (ACA) remains politically uncertain, it is important to review ways in which this legislation affected health insurance coverage for farmworkers in the US. The act aimed to assure coverage for more than half of the 20% of America's uninsured population by (1) expanding Medicaid, (2) requiring coverage ("individual mandate") and awarding tax credits to make insurance purchased on the health insurance exchanges more affordable (Ahearn et al. 2015), and (3) increasing funding provided to the US Health Resources and Services Administration (HRSA) for its system of federally qualified health centers (Henry J. Kaiser and Family Foundation 2013). These approaches did succeed in substantially improving rates of insurance coverage but generally have had limited impact upon many farmworkers.

Medicaid expansion mainly assists US citizens and those legally residing in the US for greater than 5 years (Ahearn et al. 2015). Additionally, a number of the states opting out of the Medicaid expansion are those that employ substantial numbers of farmworkers.

Tax-incentivized insurance on the exchanges is available (and required) for US citizens and legal residents exceeding Medicaid poverty limits. H-2A farmworkers actually have the responsibility to be covered and may utilize tax incentives for this coverage (Guild et al. 2016). Unfortunately, workers are not well-informed and rely mainly upon traditionally trusted sources and media for information (Arcury et al. 2017) on this complex process. The challenges of applying are greatly increased for a population without access to computers, command of the English language, and established bank accounts and credit.

Increased funding for HRSA community health centers is the only ACA benefit for more than half of all farmworkers who are undocumented (HRSA 2015a, b). Unfortunately, this advantage may be offset by the considerable swelling of the ranks of immigration officers across the East (Graybill 2012), which has substantially diminished many workers' willingness to undertake off-farm activities, including medical care (Baker and Chappelle 2012; Sexsmith 2017; Graybill 2012).

Despite these hurdles, access to appropriate health care remains an important issue. As will be noted in this and subsequent chapters, farmworkers are at risk for a number of specific health problems related to their work and living situations. Data from farmworkers in New York and Maine indicate that nearly 60% of workers obtain care from either a local emergency department or, more commonly, from a nearby migrant health facility (Earle-Richardson et al. 2008; Brower et al. 2009). Reviews of migrant clinic charts in New York and Pennsylvania demonstrated that more than 10% of all visits are related to occupational problems (and in some clinics, considerably more) (Earle-Richardson et al. 2003).

3.3 Common Occupational Health Problems

In recent years, clinical chart review data, questionnaire data, and combined survey/review data have provided greater insight on the most common occupational issues affecting eastern farmworkers.

The most extensive of the chart review reports described only problems identified as work-related during the clinic visit. Charts were reviewed in migrant clinics extending from Maine to western New York to the eastern shore of Maryland (Scribani et al. 2013). Over a 2-year period, 2520 injuries were identified—30.27 injuries per 10,000 worker weeks or 12.7 per 100 full-time equivalent (FTE) workers. These were overwhelmingly strain/sprain injuries (56%), followed by contact with natural irritants (20%), contact with chemicals (5%), struck by object injuries (4.5%), and falls (3.9%). Orchard crops and bush crops figured more prominently than ground crops, and rates varied considerably from region to region.

Other chart studies also included nonoccupational diagnoses but still documented frequent problems likely related to agricultural work. A study of over 1100 clinical records from farm clinics serving Georgia onion workers from 2009 to 2011 showed leading diagnoses of back pain (11.8%), hypertension (11.4%), musculoskeletal problems (11.3%), gastrointestinal disorders (8.6%), eye problems (7.2%), dermatitis or rash (7.0%), and tinea or fungal skin infections (5.6%) (Luque et al. 2012). As in other occupational settings, there was a suspicion that some musculoskeletal problems might relate in part to stress and depressive symptoms (Arcury et al. 2012). Similar work with clinician-reported diagnoses on over 6000 workers per year from 2003 to 2005 was reported from the New York State Department of Health in 2010 (Emmi et al. 2010). The leading diagnostic groups were infections, often skin, musculoskeletal problems, respiratory disease, hypertension, and diabetes.

These clinical findings are supported by other questionnaire-based data. The most studied source is the National Agricultural Workers Study (NAWS), which relies upon a series of English or Spanish interviews of workers (though the NAWS does not include H-2A workers) on randomly selected, consenting farm operations within randomly selected farm areas across the US. Recent work compared responses from 1999 and 2002–2004 (Period I) with data from 2008 to 2010 (Period II) (Tonozzi and Layne 2016). Injury rates declined by 33% over this period, though not for older workers. The types of injuries reported depended, in part, on the structure of the NAWS question but included sprain/strain 38.8% (Period I) and 50.3% (Period II), cut/laceration 21.2% and 21.1%, fracture/dislocation 12.5% and 12.3%, and bruise/contusion 2.8% and 5.0%. Interviews in North Carolina of Latinx youths (age 10–17 years) working with tobacco, berries, sweet potatoes, and other commodities documented musculoskeletal injury in 54% (commonly shoulder and wrist), trauma (frequently a laceration) in 61%, and dermatologic problems including sun burn and skin rash in 72% (Arcury et al. 2014a, b). Although many of the occupational hazards encountered by migrant farmworkers are universal issues affecting workers across commodities and across the eastern US, others are quite specific issues encountered only in a specific commodity.

3.3.1 Heat Stress

Few would seriously contest that climate change is impacting work conditions in eastern agriculture. The effects of climate change are most apparent in the Southeast (Kunkel et al. 2013a), but changes are also affecting the Mid-Atlantic and Northeast regions (Kunkel et al. 2013b). Recent clinical reports on both heat illness and fatality appear to reflect these climatic trends. Combined data from 9 southeastern states show 8315 occupational heat-related illness (HRI) emergency visits (6.5/100,000 workers) and 1051 inpatient hospitalizations (0.61/100,000) in the Southeast over the 2007–2011 period (Harduar Morano et al. 2015). A detailed review of 359 deaths (2000–2010) from the Census of Fatal Occupational Injuries (Bureau of Labor Statistics 2018) showed that agriculture had 35 times the heat-related fatality risk of all other industries. Forty percent of the fatalities occurred in ten states, half of these being located in the eastern US. Latinx workers had about three times the risk of non-Latinx workers. Males had much higher fatality rates than females, and age was only of minor importance (Gubernot et al. 2015). It appears that the combination of high heat plus humidity may contribute to the high rates of heat fatality in the southeastern states and that some of these events can be anticipated. Investigators in North Carolina reported that the number of emergency visits increased modestly for each degree of ambient temperature between 90° and 98 °F and by tenfold for each degree beyond 98° (Rhea et al. 2012).

Questionnaire data have also shown high rates of HRI symptoms among farmworkers in several southeastern states. Of 405 predominantly Latinx workers harvesting corn, peppers, tomatoes, and other crops in Georgia in June 2011, 34% experienced three or more symptoms of heat illness (Fleischer et al. 2013). Two cross-sectional surveys in North Carolina found 40% and 72% of those working in extreme heat experienced at least some symptoms of illness (Mirabelli et al. 2010; Kearney et al. 2016a, b). A more recent survey of a convenience sample of Florida farmworkers found that during the preceding work week 84% of workers noted at least 1 symptom of HRI, with 40% reporting 3 or more symptoms (Mutic et al. 2017). Of these, 46% experienced combinations of symptoms suggesting moderate or severe illness. These were more commonly experienced by female workers.

3.3.1.1 Work-Related Hyperthermia

Farmworkers acquire heat from the environment and from solar radiation but mainly from heat generated by strenuous muscular activity. A recent study of mainly male workers in California assessed a number of variables and found that workers' core temperatures rising above 38 °C correlated most strongly with ambient temperature and intensity of work (Vega-Arroyo et al. 2019). Hyperthermia occurs with the failure of various regulatory mechanisms that normally compensate for this heat loading.

The farmworker's primary defense against overheating is evaporative heat losses through perspiration from the skin surface. Peak sweating rates may be as high as 2 L/h (Bouchama and Knochel 2002). Determinants affecting evaporative cooling include clothing, sufficient fluid volume for both redistribution of blood flow to the skin and maximal sweat production, and the ambient relative humidity (Armstrong and Maresh 1991). As humidity increases, evaporation slows and cooling is impaired.

Over several weeks of acclimatization, a worker's fluid intake increases, kidney mechanisms shift toward fluid preservation, blood volume increases, maximal sweat production goes up, and clothing and heat avoidance behaviors become refined. Before acclimatization, the worker is more susceptible to the risk of hyperthermia (Bouchama and Knochel 2002). An analysis of 2012–2013 nonagricultural illness/fatalities investigated by OSHA found that nine of the 13 heat-related deaths occurred within the first 3 days on the job (Arbury et al. 2014).

Early indicators of HRI include dehydration related to excessive fluid losses and inadequate intake. Declining urine output and rising urine concentration are signs of inadequate hydration. Headache, dizziness, and muscle cramps, particularly affecting the calves and abdomen, are other early symptoms. Heat exhaustion is present when body temperature exceeds 38 °C; headache, muscle pain, and lightheadedness are likely. The onset of confusion, nausea, and vomiting at this stage is particularly onerous because it removes the potential for oral rehydration. Heat stroke is associated with hot, dry skin and confusion, convulsions, or coma (Bouchama and Knochel 2002). This can lead to damage of multiple organs and even death.

Treatment of heat stroke focuses upon cessation of muscular activity, cooling (removal of clothing and application of cooling packs), and support of organ-system function. Aggressive rehydration with intravenous fluids is of great importance, though the total volume depletion may be less than would be expected in many of these patients (Seraj et al. 1991). The risk of serious complications in these workers is considerable, and urgent medical evaluation is needed.

3.3.1.2 Prevention of Heat Injury

Hats and lightweight, loose-fitting, light-colored, breathable clothes are important. Ready access to clean water is essential. One-half to one liter of water per hour may be needed as the temperature increases from 80 to 90 °F. Voiding should be frequent with light-colored, dilute urine. Use of coffee or sugary soft drinks is ill-advised. One potentially unanticipated problem is the belief among some groups that hot-cold imbalance leads to illness (Flores 2000), causing some workers to drink insufficient volumes of water.

Supervisors must be aware of the effects of temperature and humidity. Short work breaks and use of shade are encouraged. They must recognize the greater sensitivity of those who have not undergone the 2–3 weeks of acclimatization. Recognition of early warning signs such as cramping, muscle pain, weakness, and lightheadedness should prompt immediate cessation of physical exertion, aggressive oral hydration, and removal to a cooler environment.

Standards for prevention of heat injury have recently been published by the National Institute for Occupational Safety and Health (NIOSH 2016a). These include recommendations for workplace limits and surveillance, instituting a system of medical monitoring for employees, work modifications, and worker training.

3.3.1.3 Other Heat Considerations

Over the past two decades, an epidemic of unexplained chronic kidney disease, Mesoamerican nephropathy, has been recognized in the highly agricultural lowlands of Central America, with El Salvador, Honduras, and Nicaragua experiencing some of the highest rates of death from kidney disease in the world (Ramirez-Rubio et al. 2013; Johnson et al. 2019). The affected young male agricultural workers do not have obvious risk factors such as hypertension or diabetes, and the current view is that Mesoamerican nephropathy may be multifactorial. Among the leading suspects are repeated bouts of dehydration related to demanding physical work in hot conditions, possibly combined with use of nonsteroidal analgesics or other medications, and exposure to pesticides or arsenic and other heavy metals (Wesseling et al. 2014).

3.3.2 Health Effects of Pesticide Exposure

Pesticides are substances or mixtures of substances intended for (1) preventing, destroying, repelling, or mitigating any pest; (2) use as a plant regulator, defoliant, or desiccant; or (3) use as a nitrogen stabilizer (US Environmental Protection Agency 2019a). Numerous agricultural pesticides of different classes (e.g., organophosphates, pyrethroids, neonicotinoids) are used to address diverse agricultural pests (e.g., insects, weeds, rodents).

Farmworkers are exposed to pesticides where they work; they and the members of their families are also exposed to pesticides where they live. Pesticides are toxicants that can have immediate effects on health (Roberts and Reigart 2013). Pesticide exposure has also been linked to increased long-term risk for diseases, including cancer, reproductive health problems, neurodegenerative diseases, and respiratory diseases. Few regulations protect farmworkers or their family members from pesticide exposure, making this exposure an environmental and occupational injustice.

3.3.2.1 The Ubiquity of Farmworker Pesticide Exposure

Farmworkers in the eastern US are exposed to high levels of a wide variety of pesticides. Analysis of pesticide urinary metabolites from samples collected four times at 1-month intervals from farmworkers in 2007 showed that these farmworkers had high doses of a variety of different pesticides, including organophosphate insecti-

cides, carbamate insecticides, pyrethroid insecticides, and herbicides (Arcury et al. 2009a, b). The detection and amount of each pesticide urinary metabolite varied across the agricultural season; for example, detection of the malathion pesticide urinary metabolite MDA increased from May to June and decreased in July and August, while detection for the chlorpyrifos pesticide urinary metabolite TCPy increased each month from May through June, July, and August (Arcury et al. 2009a, b). Finally, individual farmworkers were exposed to several different pesticides during the agricultural season, and they were often repeatedly exposed to the same pesticide. For example, the acephate pesticide urinary metabolite APE was detected at four different times for 15 of 196 farmworkers, while TCPy was detected four times for 20 of 196 farmworkers (Arcury et al. 2010). Data collected in North Carolina in 2010 (Raymer et al. 2014) and 2012 (Arcury et al. 2016a, b, 2018a, b) and in Florida in 2011 (Runkle et al. 2013) indicate that farmworker pesticide exposure continues. Research conducted in the western US indicates similar farmworker pesticide exposure (Coronado et al. 2006; Huen et al. 2012).

Farmworkers in the eastern US are exposed to pesticides in their homes. Quandt et al. (2004) documented the presence of an array of agricultural and residential pesticides in the homes of seasonal farmworkers in western North Carolina; for example, chlorpyrifos was found in 32 of the 41 houses, diazinon in 14, and oxyfluorfen in 10. Arcury et al. (2014a, b) reported that organophosphate insecticides were found in 166 of 176 migrant farmworker dwelling, and pyrethroid insecticides were found in 171 of these dwellings. As with pesticide urinary metabolites, research conducted in the western US also documented the presence of pesticides in farmworker dwellings (Bennett et al. 2019; Quirós-Alcalá et al. 2012).

3.3.2.2 The Health Effects of Farmworker Pesticide Exposure

Pesticides can have immediate acute and long-term chronic health effects. Pesticide health effects differ for adults and children (see Chap. 7 for effects on child health). The immediate health effects of pesticide exposure depend on the specific pesticide and the actual dose (Roberts and Reigart 2013). A very small dose of a pesticide may not result in any immediate sign or symptom. With increasing doses, pesticides can result in eye and skin irritation, dizziness, nausea, vomiting, and muscle ache. An extremely high pesticide dose can result in coma and death. All farmworkers and most other people in the US are regularly exposed to pesticides, but because the doses are small, they experience no immediate adverse effects (Centers for Disease Control and Prevention 2019).

Long-term effects can result from large doses of pesticides as well as from continuous small doses over extended periods. The Agricultural Health Study (2019a) has used a sample of 80,000 licensed pesticide applicators and their family members in Iowa and North Carolina to document the long-term adverse effects of pesticide exposure for those involved in agriculture. The size and longitudinal design (data collection began in 1994 and continues to the present) of the Agricultural Health Study has allowed the investigators to show that, in the long term, exposure

to different pesticides increases the risk for specific types of cancer, respiratory problems, and neurocognitive decline (Agricultural Health Study 2019b). Other research has documented that pesticide exposure can affect the reproductive health of men and women (Rao 2008), increases the risk of depression and suicide (Freire and Koifman 2013), and results in DNA damage (McCauley et al. 2008).

Insecticides including the organophosphates, carbamates, pyrethroids, and neonicotinoids, are all neurotoxicants. Research has emphasized the potential long-term neurocognitive effects of insecticide exposure, including increased risk for general cognitive decline, Parkinsonism, dementia, and amyotrophic lateral sclerosis (ALS) (Alavanja et al. 2004; Kamel et al. 2012; Baldi et al. 2003). The longitudinal data needed to document neurocognitive disease outcomes among farmworkers are not available. However, research in the eastern US provides indicators of the neurocognitive effects of pesticide exposure among farmworkers. This research has documented relatively high cholinesterase inhibition among farmworkers (Quandt et al. 2010, 2015). It has shown that farmworkers had decreased olfactory function for odor threshold compared to non-farmworker Latinx participants (Quandt et al. 2016, 2017a, b, c, d) and that postural control differed in comparing farmworkers with non-farmworker Latinx (Sunwook et al. 2016; Kim et al. 2018)

3.3.2.3 Reducing Pesticide Exposure

Farmworkers are commonly exposed to pesticides, and this pesticide exposure affects their immediate and long-term health. Preventing all pesticide exposure may be impossible, given the widespread use of pesticides in agriculture and across contemporary society. Processes to reduce pesticide use in agriculture, including organic agriculture and integrated pest management, are important. However, strong regulations are needed that limit the types of pesticides that are used. Recent political processes that stopped the US Environmental Protection Agency from banning the use of the organophosphate pesticide chlorpyrifos document the difficulty of regulating pesticides (Lipton 2017, 2018). Regulations are also needed to control how pesticides are used (e.g., to reduce drift), for the improvement of field sanitation procedures and for mandating that farm work be organized to reduce the level of pesticide exposure.

Current policies and procedures to protect farmworkers from pesticide exposure remain limited. Two federal regulations address the reduction of farmworker pesticide exposure: (1) the US Environmental Protection Agency (US EPA) Worker Protection Standard (WPS; Environmental Protection Agency 2019b) and (2) OSHA field sanitation and housing regulations. Some states have instituted additional regulations to document pesticide use (Yanga et al. 2018) and reduce pesticide exposure for farmworkers who apply pesticides (Hofmann et al. 2008, 2010; Weyrauch et al. 2005), but these are located on the West Coast.

The Worker Protection Standard was first implemented in 1994. It was revised after a protracted political struggle, with the revision only being fully implemented in 2019. As one US EPA representative stated in a presentation to farmworker advo-

cates and service providers in North Carolina, the revised Worker Protection Standard did not reflect the standards dictated by the current science, but what could be approved in the face of industry objections. The current Worker Protection Standard addresses three domains: information, protection, and mitigation. For information, the regulations require that farmworkers be trained annually and that they be provided access to information about pesticides applied where they work. The protection domain requires that workers be isolated from areas in which pesticides are being or have been recently applied and that necessary personal protective equipment be available. For example, a sign, such as Fig. 3.1, indicating that pesticides have been applied to an area should be posted until after the restricted entry interval has expired; the farmworker in Fig. 3.2 is wearing appropriate personal protective equipment for his work in applying herbicide from a backpack sprayer. The mitigation domain requires that decontamination supplies be available and that emergency assistance be provided in the case of pesticide exposure.

OSHA field sanitation and housing requirements are also very limited. The Occupational Safety and Health Act requires that all agricultural employers with 11 or more employees provide drinking water, toilet, and washing facilities for farmworkers while they are working in a field. A supply of cool, fresh water must be within 500 ft. of the working area. Toilet facilities must be located within 5 min travel time of the field. Hand-washing facilities should be provided and located near the toilets and within 5 min travel time of the field. Soap and individual towels should be supplied. Housing regulations, which apply only to housing for migrant

Fig. 3.1 Pesticide restricted entry interval sign (Photo by Thomas A. Arcury)

Fig. 3.2 Farmworker wearing appropriate personal protective equipment. Photo by Pesticide Safety Education Program of the Alabama Cooperative Extension System (Published with kind permission of © The Alabama Cooperative Extension System 2017. All Rights Reserved)

workers, are discussed in Chap. 2. These regulations address the number of bathing and laundry facilities provided for each worker.

Field sanitation and housing requirements are important to pesticide safety. Frequent hand-washing—particularly before eating and toileting—bathing immediately after finishing work, and wearing clean clothes each day all reduce the dose that results from pesticide exposure. Despite their importance, federal regulations requiring agricultural employers to provide toilets, drinking water, and hand-washing facilities to workers in the fields have only been in effect since 1987.

Implementation of the Worker Protection Standard and OSHA field sanitation and housing requirements is hampered by limited resources for enforcement. These regulations are generally administered by state rather than federal agencies, with funding for enforcement reliant on state budgets. In North Carolina, for example, enforcement of the Worker Protection Standard is the responsibility of the Department of Agriculture and Consumer Services, and enforcement of OSHA field sanitation and housing requirements is the responsibility of the Department of Labor. Each agency has 10 staff members for enforcement across the state's 100 counties and thousands of farms.

Neither set of regulations has been evaluated to address whether they reduce farmworker pesticide exposure. The Worker Protection Standard is limited to training and reacting to pesticide exposure events; it does little to change how pesticides are used or how farm work is organized. The Worker Protection Standard training may increase the knowledge farmworkers have about pesticides, but it is not clear if

it actually reduces exposure. Although the field sanitation requirements should make personal hygiene facilities available, the only evaluations of whether these requirements are actually enforced have not been positive (e.g., Arcury et al. 2001a, b). If the goal of these regulations is to reduce pesticide exposure, then an evaluation that tests whether they decrease farmworker pesticide exposure and dose is needed. Such an evaluation could test for individual exposure (e.g., monitoring cholinesterase inhibition or pesticide urinary metabolites) or environmental contamination (e.g., the presence of pesticides in the work environment and in housing).

3.3.3 Musculoskeletal Injuries and Illness

3.3.3.1 Musculoskeletal Injuries Affecting Farmworkers

The National Institute for Occupational Safety and Health defines musculoskeletal disorders (MSDs) as "injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs." Among these are "sprains, strains, tears; back pain; … carpal tunnel syndrome" and other problems occurring in response to "bending, climbing, crawling, reaching, twisting, overexertion, or repetitive motion" (NIOSH 2004). These disorders include a broad spectrum of problems that can be placed into three groups: (1) peripheral neuropathies arising from carpal and cubital tunnel syndromes, (2) tendonitis and epicondylitis, and (3) other musculoskeletal disorders, including strains and muscle pain, rotator cuff injuries, bursitis, and others (Morse et al. 2005). Major factors are excessive load, rapidly repeating motions, and sustained awkward postures—all common experiences for the farmworker. In most cases, these MSDs represent an accumulation of microtrauma for a worker who has insufficient opportunity to recover. Any activity requiring moderate or greater force, work cycles of 30 s or less, or consistently less recovery time than work time in a cycle places the worker at considerable risk of MSD (Latko et al. 1999; Stock 1991).

Work-related MSDs are among the most common problems affecting farmworkers. These MSDs account for half of all agricultural occupational injuries reported in the 2008–2010 NAWS (Tonozzi and Layne 2016). Data from North Carolina and several northeastern states describe musculoskeletal complaints affecting 39–56% of farmworkers (Arcury et al. 2012; Scribani et al. 2013). These problems are often chronic and of sufficient severity that in one report half of those affected had to modify their normal activities and a third had changed their jobs. Back, shoulders, neck, and upper extremities are most affected by the repetitive, work-related overloading of selected muscle groups. The median age for workers reporting MSD in the NAWS survey was 39 years. Migrant workers, those hired directly by farmers, working women, and possibly those with an underlying health condition had higher risk (Tonozzi and Layne 2016; Xiao et al. 2013).

In the Northeast, Scribani et al. (2013) conducted a systematic review of medical visits to migrant health facilities and emergency rooms across seven states to identify over 2500 occupational injury/illness cases occurring in 2001 and 2002. Strain/sprain injuries accounted for 56% of the total. Sixty percent of these affected the

back, trunk, and shoulders, with the remainder involving the extremities. The rates were significantly higher for bush crops and orchards than for ground crops.

Cross-sectional surveys have also found high rates of MSD. Arcury et al. (2012) collected information on musculoskeletal discomfort, working while injured, and depressive symptoms from a sample of randomly selected workers within randomly selected farmworker camps in North Carolina. Of the 300 tobacco workers studied, 39% reported musculoskeletal discomfort. Risk appeared to be higher for older workers, those performing loading and barning of tobacco, and those with depressive symptoms. In a convenience sample of 120 sweet potato workers in North Carolina, nearly 80% of respondents described "any pain," with back and shoulder being the regions of highest reported pain. Sixty percent of respondents described pain at level three or greater on a scale of six. Older workers reported more back and knee pain, while younger workers noted more shoulder pain (Kearney et al. 2016a, b).

Other commodities have been associated with different types of musculoskeletal risks. Data from wild blueberry rakers in Maine suggest that the tendonitis and epicondylitis pain is common. Harvesting some vegetables involves the combined motions of spinal flexion and extension, partial rotation of the trunk, and throwing the produce back over the shoulder. All of this is repeated several times a minute for long days with limited recovery time. Mushroom work often requires sustained difficult postures. Harvesting mushrooms exposes workers to highly repetitious movements at high rates of speed. Work with onions combines heavy loads and near-continuous stooping with intermittent heavy overhead loads.

3.3.3.2 Diagnosis and Treatment of Musculoskeletal Disorders

Diagnosis of musculoskeletal disorders is seldom challenging for the health professional who has even limited insight into the nature of the work being performed. Usually a few extra moments learning from the patient about the motions and forces associated with any repetitive tasks can readily explain the etiology of most musculoskeletal complaints. The intensity of the worker's symptoms generally correlates well with the intensity of the work. For some of these disorders, the role of underlying medical conditions such as diabetes, hypothyroidism, obesity, arthritis, and depression (Arcury et al. 2012) must be considered.

Musculoskeletal disorders are caused by overuse and are ideally treated with rest, anti-inflammatory agents, and, when appropriate, splinting, physical therapy, and gradual rehabilitation. Unfortunately, farmworkers are subject to considerable pressure, both internal and external, to continue to work at highly productive rates. Advice that they rest more and slow down is not helpful. Ready access to joint injections, splinting, physical therapy modalities, and rehabilitation is possible for some workers in America but not the farmworker population. Many farmworkers currently rely upon home remedies and over-the-counter anti-inflammatory agents while they continue injurious repetitive work activities. Reliance upon manipulative treatments offered by traditional healers (e.g., *sobadores*) appears to be common in some communities (Quandt et al. 2017a, b, c, d).

3.3.3.3 Musculoskeletal Disorder Solutions

One solution to physically demanding, highly repetitive agricultural work is increased mechanization. In commodities in which this approach has been taken, the small number of remaining workers may be exposed to a new set of mechanical hazards, while the majority of workers no longer have a job. Mechanization is feasible for major crops like apples, citrus, strawberries, leafy greens, and grapes (Seabrook 2019). Other commodities continue to rely upon manual labor based upon considerations of capital expenditures, terrain, availability of reliable workers, and various social and economic considerations. The challenge is to address those aspects of the work that are most demanding and most likely to induce musculoskeletal disorders.

Interventions, ranging from administrative changes to altered work procedures to redesign of commonly used tools, can reduce the hazard from physically demanding repetitive tasks (Fathallah 2010). Job redesign efforts in California reduced awkward postures, forceful thumb-finger pinches, and repetitive bending and twisting (Janowitz et al. 1998). Introduction of hourly 5-min rest breaks significantly decreased musculoskeletal disorder symptoms in California farmworkers (Faucett et al. 2007). Adoption of different tools and processes led to fewer MSD hazards among midwestern vegetable producers with production equal to or improved compared to baseline levels (Chapman et al. 2004). Community-based approaches can effectively combine the expertise of ergonomists and researchers with the expertise of the workers, farm owners, and cooperative extension personnel (Scharf et al. 1998; Hawkes et al. 2007). Process and tool redesign approaches can be considered and interventions can be systematically tested. With key contributions from northeastern farmworkers and their employers, this approach has led to successful redesign of the rake used for harvesting blueberries with attendant improved ergonomics, less pain, and higher productivity (May et al. 2008).

3.3.4 Skin Disease

3.3.4.1 Skin Disorders Affecting Farmworkers

Occupational dermatitis occurs much more commonly in production agriculture than in the general population of American workers (Bureau of Labor Statistics 2007). Rates are particularly high for the "crop production" category, especially greenhouse, nursery, floriculture, and fruit farming. Among farmworkers in the eastern US, this has been best studied in North Carolina, where more than half of the farmworkers described skin problems. Sunburn and fungal infection led the list, followed by acne, "skin rash," and "itching" reported by more than 40% (Vallejos et al. 2008). It appears that these problems may evolve over the course of the growing season, rising from nearly 25% early to 37% late in the season (Arcury et al. 2003a, b). Dermatological examination of residents of two camps in North Carolina

documented the presence of skin disease in 47 of 59 (80%) workers examined (Krejci-Manwaring et al. 2006).

Fungal infection of the skin, scalp, and nails is commonly reported. In the 47 cases noted above, fungal infections of the feet and nails accounted for 28 (nearly 60%) of the cases. These infections can be readily transmitted person-to-person, from animals, or from contaminated surfaces. The housing conditions and shared shower facilities in many migrant farmworker camps (Early et al. 2006) likely play a significant role in the persistence and spread of these problems.

Six to twelve percent of skin disease noted in surveys of North Carolina farmworkers was related to contact dermatitis (Krejci-Manwaring et al. 2006; Arcury et al. 2008). In 2018, the federally funded migrant health programs reported roughly 18,000 contact dermatitis cases (HRSA 2015b), which could be in response to a primary irritant or to an allergic sensitizing agent. Irritant contact dermatitis (80% of all contact dermatitis) is a nonallergic reaction appearing within minutes of contact with a wide variety of irritating substances. The itchy eruptions affecting the upper extremity flexor surfaces of North Carolina tobacco workers, noted by Abraham et al. (2007), may well be examples of irritant-induced contact dermatitis. These reactions may occur to endogenous plant components or to chemicals that have been applied to the plants (Schuman and Dobson 1985).

Allergic contact dermatitis requires a period of 1–3 weeks for the initial sensitization. With subsequent contacts, dermatitis appears within hours or days. As most people do not react to the majority of sensitizers, allergic contact dermatitis is relatively uncommon. An exception to this is urushiol, the allergen found in poison ivy, oak, and sumac, to which a majority of the population reacts. This most certainly includes farmworkers who are likely to be exposed, while working in orchards and other sites. A systematic review of agricultural contact dermatitis cited pesticides, rubber products, disinfectants, and plant materials (notably tobacco) as leading causes but acknowledged that meaningful data from patch testing was only available for the first two of these (Irby et al. 2009).

The ultraviolet waves of the sun are a significant skin hazard. Phototoxic or photoallergic reactions to a sensitizing agent (topical or systemic) can cause itching, local redness, and blistering in sun-exposed workers. Antibiotics and other drugs, as well as a number of plant-derived compounds, can be responsible for these reactions. Typically, these occur on the sun-exposed surfaces of individuals with relatively limited pigment in their skin.

Solar radiation of ultraviolet light (UV) is clearly associated with skin cancers (Schmitt et al. 2011). The more common UVA rays penetrate more deeply and also prematurely age the skin. UVB rays are more superficial but have also been associated with skin cancer. The occurrence of premalignant and malignant skin lesions is fairly common in farmers. At public screening events in New York and Pennsylvania, roughly 25% of farmers are typically referred to a dermatologist for evaluation of a lesion (Evans and May, unpublished data). The vast majority of these prove to be premalignant changes such as actinic keratoses, generally appearing upon sun-exposed surfaces of the face, ears, or upper extremities. While there

is clearly a selection bias in these public screening events, the more systematic selection involved in the New York Farm Family Health and Hazard Survey yielded quite similar findings (May, unpublished data). Of the malignancies detected, two-thirds were basal cell cancers, and nearly all others were squamous cell cancers. It should be noted that these findings apply to a population composed largely of farmers of northern European ancestry. There are remarkably few data regarding the rates of these problems in eastern farmworkers, and this should be an area of future study.

3.3.4.2 Skin Disease Solutions

Clothing worn in the field can prevent some contact dermatitis problems. However, such clothing is also potentially contaminated, so it should be removed promptly at the end of the work day and laundered separately from other non-contaminated clothing. Using gloves when feasible for the job may be helpful in reducing some of the mechanical and chemical trauma to the skin. Daily showering and routine use of nonirritating cleansing agents are recommended.

Ideally, solar radiation should be avoided. The use of light, loose-fitting clothing and hats that shade the face and neck can do much to reduce skin damage from UVA and UVB light. Topical sun-blocking agents can substantially reduce exposure, but it is unlikely that most farmworkers will routinely apply sufficient amounts to make this an effective strategy.

3.3.5 Hearing Loss

3.3.5.1 Hearing Loss Occurring in Eastern Agriculture

Hearing loss, typically noise-induced, is very common among farm populations (Marvel et al. 1991; Gomez et al. 2001). Substantial noise has been documented around agricultural equipment in New York (Dennis and May 1995). Information on hearing loss for farmworkers in the eastern US is limited to one report focusing upon a self-selected group of 150 predominantly Mexican men (mean age 34 years) in Connecticut River Valley migrant camps (Rabinowitz et al. 2005). The majority were tobacco workers; smaller proportions worked in nurseries and fruit orchards. They were thoroughly evaluated with a survey questionnaire, tympanometry, and pure tone audiometry. Twelve percent of these workers met criteria for hearing impairment, and more than half showed evidence of deficits ($\geq$25 dB) at one or more frequencies. Subjectively, 35% complained of difficulty hearing or understanding speech. When compared with the findings of the 1982–1984 Hispanic Health and Nutrition Examination Survey, the farmworkers demonstrated consistently worse high-frequency perception in all age groups.

3.3.5.2 Causes of Hearing Loss in Farmworkers

The obvious cause of these findings (Rabinowitz et al. 2005) is exposure to hazardous noise (>80 dB) in the work environment, particularly as only 14% of workers, mainly nursery workers, reported using appropriate hearing protection. However, currently no data regarding the level of noise encountered by these workers are available, and it might be expected that, because of less exposure to farm machinery, their total noise exposures would be less than other agricultural workers. Baseline information on rates of hearing loss among workers in their native populations would be of interest. The effects of recreational noise, agrichemicals, and other toxin exposures need further investigation. A better understanding of other nonagricultural occupational exposures encountered by these workers might provide important insight into their increased levels of hearing loss. Further audiometric assessment of other migrant populations would be of considerable interest as would systematic area or personal noise sampling of the various work environments commonly encountered.

3.3.5.3 Hearing Loss Solutions

As in other prevention situations, engineering approaches to hearing loss are preferred. In agriculture, minor adjustments such as tightening a few screws to reduce metal vibration on machinery and replacing defective mufflers can do much to reduce ambient noise. However, the most apparent solution to this problem is provision of inexpensive hearing protection for workers and instruction on its proper use. Earmuffs can be put on and off easily, but they are bulky and can be misplaced. Therefore, earplugs are preferred by many workers. These should be available in any setting where background noise requires workers to raise their voices to be heard. Attention must be given to proper insertion techniques and to the cleanliness of the earplugs after repeated use. Care must be taken to avoid contamination with agrichemicals prior to insertion in the ear.

3.3.6 Eye Injury

3.3.6.1 Eye Injuries Affecting Eastern Farmworkers

The National Electronic Injury Surveillance System recorded 131,000 emergency room visits for occupational eye injuries in 2016 (NIOSH 2016b). Eye injuries have been reported in agriculture for many decades (Smith 1940). These certainly can affect farmworkers. Penetrating ocular injuries or other acute trauma can result from contact with plants, particularly in orchard work, or tasks such as the sharpening of a hoe. However, accurate recording of eye injury in agriculture is suspect. It is estimated that the Bureau of Labor Statistics captures less than a quarter of the actual

number of events (Lacey et al. 2007). Recent questionnaire data on eye injuries affecting a population of predominantly H-2A workers in North Carolina confirmed that a substantial number of these injuries go unreported. The self-reported lost work injury rate was three times that previously described, with the majority of these being penetrating injuries mostly from vegetation (Quandt et al. 2017a, b, c, d).

Exposure to agrichemicals poses some specific risks for workers. In one older study, nearly 20% of workers with a mean of 8 years of exposure to fenthion (organophosphate) were found to have macular changes (Misra et al. 1985). Data from pesticide applicators in North Carolina and Iowa suggest that several types of fungicide are related to retinal degeneration in both applicators and their wives (Kirrane et al. 2005). The most common specific agents were three dithiocarbamate compounds: maneb, mancozeb, and ziram. The Japanese literature describes a series of disorders ("Saku disease") related to organophosphate agents, which can be readily absorbed into the chambers of the eye following topical application, eventually reaching the cells of the retina (Boyes et al. 1994). Manifestations of these exposures range from problems at the level of the lens to pathologic changes in the retina (Dementi 1994).

3.3.6.2 Chronic Irritation of the Eyes

Most commonly, farmworkers experience problems with chronic conjunctivitis affecting the tissue covering the eye, or blepharitis, an inflammation affecting the margin of the lid. When North Carolina farmworkers from randomly selected housing sites were interviewed over the course of a growing season, they noted the presence of a number of eye symptoms. This predominantly Mexican group of 197 tobacco and cucumber workers experienced eye pain (40%), redness (43%), itching (25%), and blurred vision (13%). More than 98% of these workers wore no sunglasses while in the fields. Half stated that sunglasses interfered with their work and their ability to differentiate ripe from green leaves (Quandt et al. 2001a, b). Vegetable workers (and farm owners) in New York complain that the fine black soil of the region produces eye irritation. In a cohort of 120 of these workers, 67% described one or more of the of eye symptoms described in North Carolina: eye pain (29%), redness (49%), itching (43%), and blurred vision (43%) (Earle-Richardson et al. 2014).

3.3.6.3 Cataract and Pterygium

Although there are no reports on cataract rates in eastern farmworkers, their extensive exposure to solar UV radiation would be expected to result in elevated risk for the opacities of the lens. Another effect of solar radiation, combined with other sources of chronic irritation (wind, dust), is the development of pterygium. This wedge-shaped fleshy growth of conjunctival tissue extends across the surface of the eye, typically extending from the inner corner of the eye toward the pupil. These

may grow to be large enough to actually obscure vision, though this is rare. More commonly pterygia cause ongoing irritation and redness by interfering with the normal lubricating mechanism of the eye. In the only relevant study of this problem, digital photographs of 304 North Carolina farmworkers documented a 23% prevalence (10% bilateral) of this problem (Taylor et al. 2006). Treatment of these lesions may require surgery if it becomes so extensive as to obscure vision, though more often lubricating eye drops, possibly topical steroid drops, and sunglasses or protective UV-blocking glasses are recommended.

3.3.6.4 Eyesight and Eye Care

Good vision is important for safety in hazardous occupations such as farm work. Only a few studies have explored the visual acuity of farmworkers in the eastern US and the eye care they have received. Using interviews and Snellen charts with 289 farmworkers in North Carolina, Quandt et al. (2017a, b, c, d) assessed the previously reported high frequency of vision complaints (Quandt et al. 2008). Three-quarters had not had previous vision screening. Two-thirds described visual acuity that was only moderate or worse. Vision testing revealed normal distance vision in 98% and normal near vision in 93% of workers. It appears that farmworkers in the eastern US have generally excellent vision despite concerns to the contrary. It is also clear that routine eye care occurs infrequently if at all.

3.3.6.5 Eye Injury Solutions

Relying entirely upon protective equipment is not viewed as desirable in occupational health, but in this case, use of carefully selected protective glasses is the most realistic solution. Such eyewear should provide protection from both UVA and UVB rays, thus reducing risk of problems such as cataract and pterygium. These high-impact glasses should have side shields to limit the risk of foreign bodies and trauma from plants and also to reduce exposure of the conjunctiva and cornea to the effects of dust and wind. Unfortunately, the experience in the Midwest has been that workers resist use of protective glasses because of appearance, discomfort, perspiration and fogging, slowing work processes, and interference with vision (Forst et al. 2006). Less than 10% of North Carolina workers use protective glasses for many of the same concerns. Other major factors were lack of education—roughly three-quarters had not been trained and did not believe they had much risk—and failure of most employers (92%) to provide eye protection (Verma et al. 2011).

The experience with workers in New York who adopted use of safety glasses after distribution of eyewear and training by community health workers (Earle-Richardson et al. 2014) parallels that of Midwest farmworkers (Forst et al. 2004). Initially, New York vegetable workers experienced fogging and discomfort with some designs and problems seeing spoilage on lettuce leaves with dark lenses. But after some trial and error, they settled upon designs that were comfortable, socially

Fig. 3.3 Camp health aide demonstrates emergency use of eye wash in the fields (Photo by Jason Lind. Published with kind permission of © Jason Lind 2007. All Rights Reserved)

acceptable, and functional for their specific tasks. They were able to identify lens colors (yellow) that did not interfere with their work efficiency. As the wearing of protective glasses became a social norm, general acceptance increased substantially. Following early season trainings, the use of sunglasses or protective eyewear ("sometimes" or "always") was in the range of 90% (Earle-Richardson et al. 2014). In a study comparing workers on control and intervention farms, the use of small plastic vials of sterile saline solution for immediate eye irrigation/moisturizing combined with protective eyewear significantly reduced eye pain and redness (Earle-Richardson et al. 2014) (Fig. 3.3).

The training of respected workers to model behavior, distribute glasses, administer first aid, and provide peer-to-peer education increased utilization at 15 weeks of protective eyewear among intervention (11–27%) compared to control (2.4–2.6%) groups of Florida citrus workers (Monaghan et al. 2011).

A review from the Midwest encouraged redesign of tasks or selection of alternate tools in order to reduce the risk of eye injury (Lacey et al. 2007).

3.3.7 Transportation

3.3.7.1 Transportation Injuries Affecting Farmworkers

There is remarkably little in the scientific literature regarding transportation deaths in migrant farmworkers, particularly in the eastern US. This is surprising as motor vehicle incidents are the leading contributor to overall occupational fatality and

appear to be a significant source of fatality among migrant farmworkers (NIOSH 2003). A study of proportionate mortality in California among United Farm Workers members found a ratio of observed to expected deaths of 1.78 (95% confidence limits 1.61, 1.98) for transportation injuries, higher for passengers and pedestrians (Mills et al. 2006). In a 2001 report of farmworker deaths across 24 states, farmworkers from the Northeast and Southeast accounted for nearly 60% of the total. Of the injury-related deaths in the group, 53% were due to motor vehicles (Colt et al. 2001). The agriculture, forestry, and fishing sectors consistently have rates of highway fatalities that are second only to the transportation industry itself (MMWR 2004). Considerable confusion surrounds the interpretation of "transportation fatalities" and the distinction of "vehicle" vs. "machinery" in some of the published literature. Unfortunately, the Bureau of Labor Statistics has further confounded the situation by distributing tractor-related fatalities among the vehicle, machinery, and several other categories in the Census of Fatal Occupational Injuries (CFOI) statistics (Murphy and Yoder 1998). To compound the problems, the determination of when a highway collision is "occupational" is also arbitrary. The CFOI database excludes incidents involving the commute to or from work, unless traveling from a camp.

Farmworkers, particularly those born outside the US and whose English language skills are limited, are at risk on rural highways when they are going to and from work or traveling between fields. A study on farmworkers in California's Central Valley assessed driving behaviors by using both questionnaires and unobtrusive systematic observations of 126 vehicles being driven in Central Valley labor camps. This work documented an increased incidence of adverse outcomes (including revoked licenses, citations, and crashes) and unsafe driving behaviors among those licensed in Mexico and those driving without licenses. Among all drivers, 79% were licensed. Only 58% learned to drive in the US, and those who learned to drive in Mexico learned at an early age (20% between ages 8 and 14 years). Observed use of seat belts was 37%, and compliance with belting of passengers, children, and use of child seats was low (Stiles and Grieshop 1999), though this situation may have changed since 1999. In Steinhorst's study of Latinx farmworkers admitted to a North Carolina trauma center, 51% of injuries were related to motor vehicle crashes, though the vast majority of these were not work-related. Significant factors in the incidence and severity of these injuries included the low rates of seat belt and airbag usage (40%) and the high rates of positive blood alcohol levels (66%) (Steinhorst et al. 2006).

More information is available from the insurance industry, which identified "a dozen accidents that left 38 dead and nearly 200 injured" in 2015–2016 (Breed 2016). Key considerations in some Florida incidents were unsafe vehicles not registered with the Labor Department, lack of a commercial operator's license, worn tires, and inadequate insurance. The dependence of workers upon predatory *raiteros* (paid drivers who transport low-wage workers to their jobs) for necessary transportation places them at considerable risk. Enforcement of transportation regulations in the Migrant and Seasonal Agricultural Worker Protection Act has been limited at best (Breed 2016).

It is likely that the factors traditionally associated with fatal crashes (e.g., running off the road or failing to stay in the proper lane, driving over the speed limit or too fast for conditions, driver inattention, and driver drowsiness [MMWR 2004]) are involved in these farmworker crashes as well. These workers often have little recourse other than the use of old, poorly maintained vehicles that are often overcrowded. Poor understanding of traffic laws, unavailability of seatbelts or lack of seatbelt use, and, in some cases, the use of alcohol certainly contribute to the hazard. When incidents do occur, payment of medical costs, lost work, and even repatriation of remains often fall upon the farmworker and family.

3.3.7.2 Transportation Solutions

In situations where farmworkers are being transported by an employer or contractor, strict enforcement of licensing requirements for drivers, inspection and safety requirements for vehicles, and occupancy and seatbelt laws for passengers by local and state police is needed. Substantial fines from local traffic enforcement and from OSHA are entirely appropriate. Similar enforcement is appropriate for farmworkers driving personal vehicles, but educational interventions might also be used in an effort to reduce both crashes and problems with law enforcement. Undocumented farmworkers' inability to obtain drivers licenses may not restrict their driving but certainly restricts opportunities to train and regulate their driving. Licensing efforts in a number of states now aim to educate and enhance the driving skills of undocumented workers (Arnold 2019).

3.4 Commodity-Specific Occupational Illness and Injury

With the obvious exception of pesticide exposures (Sect. 3.3.2), the occupational health challenges described above are those that might generally be expected to affect farmworkers in nearly any agricultural setting. In addition to these universal problems, there are a number of exposures and health problems that are specific for a given commodity.

3.4.1 Orchard Work

Orchard fruits are major production commodities in much of the eastern US. Citrus production, which is largely limited to Florida, accounts for nearly 70% of the nation's total acreage of citrus orchards. Other significant orchard fruits include peaches (Georgia, South Carolina, Pennsylvania, New York), pears (Pennsylvania, New York), and apples (Pennsylvania, New York).

3.4.1.1 The Nature of Orchard Work

The vast majority of the manual labor associated with orchard production relates to the harvesting of the fruit. Some ergonomic exposures are associated with off-season pruning, and some potential exposures are related to application of pesticides and plant hormones prior to harvest. However, the number of workers exposed is far less than the number associated with harvest.

Orchard work is quite similar across commodities, with the main variation in the work relating to the size of the trees and the nature of the fruit. Some fruits are increasingly grown on dwarf trees, which reduce ladder work but may increase the amount of stoop work. The durability of the fruit also dictates some of the specific practices. Because apples bruise after any impact, they are harvested in buckets smaller than those for citrus. At about 45 lb., a full apple bucket weighs considerably less than a full citrus bag. The citrus worker can stand upright while dumping the bag of fruit, while the apple harvester must fully flex forward with a loaded bucket to release the apples from the bottom of the bucket into the apple bin.

Detailed ergonomic data are available on the harvesting process. A standardized time sampling technique demonstrated that New York apple harvesters spend 63% of their time with one or both arms extended above the head reaching for apples. Often this is with a nearly filled bucket on the shoulder. Buckets are at least partially loaded nearly 80% of the time. Nearly 10% of the time is spent with the spine acutely forward flexed over the edge of a bin as the buckets are emptied (Earle-Richardson et al. 2004).

Unless dwarf trees are being harvested, the ladder is a major component of the job. Motivated in part by the piecework pay strategy, workers try to minimize the number of times the ladder is repositioned. Harvesters will place one foot off to the side of the ladder upon a convenient branch to extend their picking range without having to move the ladder. Often this involves repeated shifts of the bag or bucket from one hip to the other. Conditions in the orchard for the first half of each day tend to be wet from dew in the grass and trees, so footing on ladders and branches can be insecure. The demand for reaching highly placed fruit and for extending reach means that workers routinely use the top two steps of the ladder, thus reducing its stability and increasing their chances of falling (Salazar et al. 2005).

3.4.1.2 Occupational Health Problems Associated with Orchard Work

On the basis of review of charts from migrant health programs and from nearby emergency departments, a cohort of 303 work-related injuries affecting apple workers has been analyzed. Sixty percent of these related to musculoskeletal strain, 11% to contact with an irritant material, and 8% to falls. The most common medical diagnoses are shown in Fig. 3.4. These include musculoskeletal disorders from the repetitive motions, load bearing, acute flexion, and overhead work noted above. Eight percent of injuries relate to falls, probably a common occurrence that often does not result in a medical visit but can result in sprains, contusions, and broken

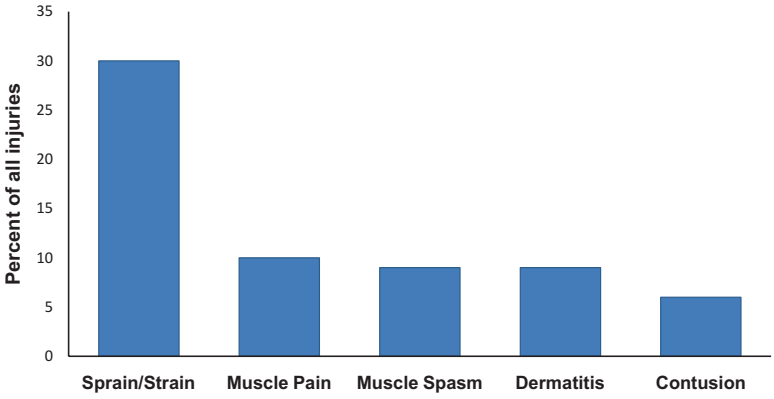

Fig. 3.4 Distribution of 303 injuries to orchard workers noted at New York and Pennsylvania migrant health program chart audits (Data from The New York Center for Agricultural Medicine and Health)

bones. These falls may relate to inadequate maintenance of ladders, wet and slippery footwear, overreaching, and inadequate attention to the proper placement of the ladder. A smaller number of eye injuries may follow trauma from vegetation in the trees and rebounding branches. This risk is present early in the season when a small number of workers are pruning and at harvest when a large number of workers are on the trees.

3.4.1.3 Orchard Work Injury Solutions

In the orchard, greater awareness of the safety challenges of the work might substantially reduce the risk of injury (Salazar et al. 2005). Some of the solutions here could relate to reengineering the job or the equipment. Other challenges might be addressed by administrative changes in the pay structure of the job.

For eye injuries, reliance upon protective equipment is perhaps the most direct approach to the issue. The use of polycarbonate lenses with side guards will greatly reduce the risk of eye trauma related to tree branches.

Falls from ladders are complex and related to the condition of both the ladder and the worker's footwear. Behaviors such as the setting of the ladder, the height ascended, the extent of reach beyond the ladder, and behaviors such as stepping onto adjacent branches and shifting a loaded bucket also are key determinants of risk. To reduce falls, each of these issues must be addressed. Unsafe ladders need to be retired. The positioning and use of ladders cannot be hurried. The use of piece-rate pay strategies encourages inappropriate haste and shortcuts, which may well heighten injury risk. More data on the unrecognized costs of piece-rate strategies could be effective in discussing this practice with farmers.

Mechanization efforts may address a number of the challenges of orchard picking. Mobile picking platforms afford a stable work surface for pickers as the

platform maneuvers around trees (Elkins et al. 2011). Mechanical means to elevate bins are also available. The major limitation of this approach relates to the layout of existing orchards and the size and shape of trees relative to optimum for the platform. Considerable progress has been made with robotic picking devices that may eventually obviate these barriers, while also displacing most of the hired workers (Silwal et al. 2017)

3.4.2 Tobacco Production

The termination of the USDA tobacco allotment program has caused substantial changes in tobacco production. Despite a 27% decline in US production, approximately 700 million pounds of tobacco are still produced annually. Although some states in the Northeast are involved in production, the majority of the nation's production occurs in the Southeast (Statista 2019).

3.4.2.1 The Nature of Tobacco Production Work

The process of tobacco production extends from setting the plants and early cultivation to curing and baling the harvested leaves toward the end of the season (Arcury and Quandt 2006). Over the middle third of the season, workers remove flowers ("topping" the plants) to direct the growth to the leaves, and they cultivate and harvest the earlier maturing leaves. Harvesting varies with the type of tobacco. Burley is harvested by the entire stalk, while flue-cured tobacco is harvested by the leaf ("primed"). This begins with the larger lower leaves that contain less nicotine. Typically, about three leaves are taken from the plant with each cycle of picking. As each is picked, it is placed with others in a stack held under the worker's arm. Toward the end of the season, the smaller "tip" leaves containing the highest concentrations of nicotine are taken. "Curing" the leaf begins as it is picked. For burley tobacco, several tobacco plants are attached to long wooden poles and lifted up four to five levels into the rafters of the barn for air curing. For flue-cured tobacco, curing involves packing the tobacco into "bulk barns" in which the heat and humidity are automatically controlled. Cured leaves are then retrieved from the different barns. For burley tobacco, the leaves are manually stripped from the stalks and baled; for flue-cured tobacco, the leaves are removed from the barns and baled.

3.4.2.2 Occupational Health Problems Associated with Tobacco Production

For a review of occupational health problems associated with tobacco production, see Arcury and Quandt (2006). Areas of potential hazard in this process include repetitive motion and sustained awkward postures, as ergonomic challenges are

associated with planting in the initial weeks of the season and with the harvest season for burley and for flue-cured in the early harvest when the lower leaves are being primed. A variety of potentially toxic chemicals are applied to tobacco over the course of the growing season, including insecticides and growth regulators. Heat and humidity are significant problems for workers throughout the most active portions of the season. For burley tobacco, potential hazards include lacerations from the "knives" used to cut the tobacco stalks and "spear points" put on sticks that allow impaling the stalks. Harvest is also associated with considerable dermal contact with the tobacco leaves. Using digital photography of the face, hands, arms, and feet to look specifically for skin rash, 304 systematically selected workers were followed at 3-week intervals through the season. More than 40% of participants reported symptoms of itch or skin rash, and the two were highly correlated. A dermatologist reviewed the photographs and noted traumatic skin lesions in 16.8% of workers and contact dermatitis in 12.2% (Arcury et al. 2008). For burley tobacco, the curing process requires considerable climbing on barn rafters, while holding poles with the attached leaves. Although there are no data available on fall rates associated with the suspending of leaves from barn rafters, there is clearly risk there.

Green tobacco sickness is a common occupational illness that results from tobacco work. It results from nicotine absorbed through the skin from plant leaves and nicotine-containing dew or rain saturating the workers' clothes (Gehlbach et al. 1975). Over the course of the season, roughly one-quarter of tobacco workers are likely to experience at least some of the symptoms of green tobacco sickness. These include nausea, vomiting, abdominal pain, diarrhea, dizziness, palpitations, and headache. Most commonly noted are headache, dizziness, vomiting, and nausea occurring in the evening or night following a day of working with tobacco (Arcury et al. 2001a, b). The illness is self-limited once continuous dermal absorption of nicotine is interrupted. Levels of the nicotine breakdown product, cotinine, in workers' saliva and incidence of green tobacco sickness symptoms increase across the course of the season, likely related to the progressively more intense dermal contact associated with the common methods of harvest (Quandt et al. 2001a, b). Work conditions associated with increased occurrence of symptoms and levels of salivary cotinine include harvesting, late season, and wet leaves (Arcury et al. 2003a, b). Other worker characteristics that have been associated with increased risk of green tobacco sickness include age, experience, nonoccupational exposure to nicotine, and type of tobacco work (Quandt et al. 2001a, b). Older, more experienced workers have fewer symptoms, likely reflecting both learned avoidance behaviors and some "healthy worker" effect. The 40% of Latinx farmworkers who smoke (Spangler et al. 2003) or use chewing tobacco have notably lower rates of green tobacco sickness symptoms (Arcury et al. 2001a, b). The presence of self-reported skin rash significantly increased the odds of green tobacco sickness (odds ratio, 3.30; 95% confidence interval 2.17, 5.02) (Arcury et al. 2008).

Shade tobacco, which is grown to produce wrapper leaves for cigars and is largely confined to New England, is not associated with symptoms of green tobacco sickness or measurable increases in salivary cotinine levels, perhaps because this tobacco is generally not harvested wet and, once picked, leaves are minimally handled by workers (Trapé-Cardoso et al. 2005).

Although tobacco workers do not seem to experience elevated rates of most respiratory symptoms, there is a relative increase in the rate of wheeze in workers engaged in topping, barning, and baling of tobacco (Mirabelli et al. 2011).

3.4.2.3 Occupational Health Solutions in Tobacco Production

The use of water-repellent clothing can reduce the incidence of symptoms (Arcury et al. 2002), but this presents a potential hyperthermia problem. The use of gloves and changes in how the leaves are held after picking (i.e., not under the arm) can reduce skin injury and nicotine absorption. Changing out of wet clothing during the day or at the end of the day and showering immediately after work should reduce nicotine exposure as well.

3.4.3 Vegetables

Tomatoes, melons, beans, cucumbers, peppers, and cabbages are among the leading vegetable commodities in the eastern US. Each of these requires substantial input of farmworker labor. There can be no single description for vegetable work, but many commodities do share some similar tasks that can be associated with occupational health problems. Planting vegetables may involve seeding but often involves planting seedlings, while riding on the back of a slowly moving tractor. This work involves the ergonomic challenges of rapid, continually repeated movements, often in an awkward sustained posture. Depending upon the use of plastic mulch, more or less cultivating and thinning of seedlings may be required. In some situations this can be done mechanically, but, more often, it is done either manually or chemically, both of which can present potential occupational health problems for farmworkers. Harvest work usually involves the use of blades with associated risk of lacerations. Issues of posture and repetitive motions are likely to be prominent in harvest work as well. Farmworkers are at risk of skin and eye injuries related to sun and heat problems throughout most vegetable work.

The Northeast, Mid-Atlantic, and Southeast have substantial production of onions, potatoes, and sweet potatoes. The harvesting of these root crops may be ergonomically challenging with prolonged bending, stooping, and kneeling. Transfer of the produce from field to truck requires repeated lifting and heaving of substantial loads. Ergonomic assessments of packing house workers in New York identified the transferring and stacking 80 pound bags of onions as major risk factors for musculoskeletal injury. Sweet potato workers in North Carolina report frequent lifting and carrying of loaded baskets, typically lifting and dumping one every 2 min. Seventy-nine percent of these workers reported pain, most commonly in the back (especially lumbar region), shoulder, and knee. Of these, 60% ranked their pain level at three or higher on a scale of six (Kearney et al. 2016a, b).

3.4.4 Wild Blueberries

3.4.4.1 The Work of Harvesting Wild Blueberries

Blueberry production in many states centers upon bush fruit, while Maine blueberries are "wild," growing on scrubby plants no higher than 6–8 in. off the ground. The terrain is sometimes rocky and quite irregular. The wild berries are harvested in midsummer by "raking" with comblike metal rakes with an attached collecting box. These rakes come in varying widths and usually weigh 3.5–10 pounds. The traditional rake has a single, short, horizontally oriented central handle (Fig. 3.5) that requires repeated forceful motions of the wrist to engage the foliage with the rake and then pull directly up. Bending at the waist and working at a rate often exceeding 30 cycles per minute, the worker might pause only intermittently to empty the rake's collecting box. Considerable force is required to pull the rake up through the foliage.

3.4.4.2 Occupational Injury Associated with Wild Blueberry Work

Evidence from a variety of sources shows that the traditional approach to blueberry raking is associated with ergonomic challenges and related worker injuries (Tanaka et al. 1994; Estill and Tanaka 1998). Ergonomic problems affecting the elbows, shoulders, and particularly the back and wrist have been noted in association with blueberry raking (Millard et al. 1996). Chart review data from the Maine Migrant Health Program showed 86 clinic visits for complaints identified as related to blueberry raking. Sixty-five of these (76%) were musculoskeletal problems. Of these,

Fig. 3.5 The traditional center-handled rake used in harvesting of wild blueberries (Photo by New York Center for Agricultural Medicine and Health. Published with kind permission of © The New York Center for Agricultural Medicine and Health 2006. All Rights Reserved)

Fig. 3.6 A blueberry rake with 12 in. handle extensions (Photo by New York Center for Agricultural Medicine and Health. Published with kind permission of © The New York Center for Agricultural Medicine and Health 2006. All Rights Reserved)

38% related to back problems; 32% related to shoulder, wrist, and hand problems; and 18% related to knee problems (Hawkes et al. 2007). Twelve percent related to skin problems.

3.4.4.3 Solutions for Injuries in Wild Blueberry Work

Previously, a work team composed of farmworkers and farm owners worked to examine various alternative rake designs. A long-handled design (Fig. 3.6) was found to enhance productivity and was preferred by the workers, who noted less force required and less pain associated with harvest work (May et al. 2008). Video analyses of postures showed that the long-handle rake was associated with less squatting and less moderate to severe flexion of the torso (May et al. 2012). Currently, rake manufacturers are offering long-handle models and are selling inexpensive handle conversion kits for traditional rakes.

3.5 Personal Protection

For many of the occupational hazards described above, the most suitable solutions are redesign of the job, tools, or work organization. Institution of short rest periods, rotation of tasks, and changes in piece-rate pay strategies can do much to alleviate many of the problems experienced by farmworkers in the eastern US. Personal pro-

tective equipment is the least desirable "solution" to a hazard exposure because it depends on human behavior and so is likely to provide less than complete protection. However, the realities of the workplace make use of personal protective equipment a necessary option.

There are limited data regarding farmworkers' use of hearing protection. In a convenience sample of 150 Connecticut farmworkers, 10% of apple workers, 36% of nursery workers, and 7% of tobacco workers—14% of all workers tested—reported use of hearing protection (Rabinowitz et al. 2005). The challenges of eye protection are outlined above, with fewer than 10% of North Carolina workers using protective glasses and fewer than 10% of employers providing such protection (Verma et al. 2011). However, work from both New York and Florida suggests that making eyewear readily available, offering choices well suited for the work and the workers, training workers, and modeling the behavior can substantially enhance the use of protective glasses (Monaghan et al. 2011; Earle-Richardson et al. 2014).

There are limited data on respiratory protection despite common hazards of inhaled dust and chemicals. A cohort of 56 New York vegetable workers was assessed for respirator fit testing. Eleven of these workers (20%) described actual use of respirators on the job. Only one of the cohorts had previously undergone fit testing. These Latinx workers proved to be harder to fit with the commonly approved respirators, with only 41% achieving protection with a respirator that typically fits the vast majority of Anglo workers (Earle-Richardson et al. 2014). This combination of rarely undergoing fit testing and frequent misfits with usual respirators suggests that the majority of those farmworkers who are using an approved respirator is not protected by it. Recent changes in EPA regulations may increase the frequency and suitability of respirator use by farmworkers.

3.6 Conclusions

As agriculture evolves, shifts in commodities and modification of production methods will change some of the hazards experienced by Latinx farmworkers. Work in tobacco may decline, while work in other commodities is likely to increase. Severe acute injury and fatality may become more significant threats as farmworkers experience increased exposure to large animals and machinery. The more traditional, highly repetitive manual labor will remain in many commodities. Occupational health threats relating to heat, musculoskeletal injury, and injury to eyes, ears, and skin will continue to be challenges for this population of workers and for those providing support for them.

That people who perform difficult work and provide such a vital service to our society remain at the very bottom of America's economic and social order is a curious and unfortunate phenomenon. The social and economic inequities imposed on these workers certainly compound the occupational hazards inherent in their work. To some degree the problems experienced by farmworkers relate directly to the behaviors of some of their employers. However, on a larger scale, farmworkers

and farmers alike are victims of both economic policies and evolving market forces. The phenomenon of vertical integration (e.g., a firm marketing chicken meat owns the chicks, provides the feed and bedding, and controls the entire process, simply renting the farmer's space and labor) and the impact of competition from subsidized foreign producers are just two recent and powerful factors that threaten the existence of many farms. While some operations thrive, many chronically operate on very thin margins. It is easy and sometimes appropriate to view the farm owner as the cause of the farmworkers' problems, but this approach can be both incorrect and counterproductive. In many ways the producer shares the same concerns as the farmworker. They both want the farm to stay in business and provide employment. They want the workers to be productive and to avoid injuries. Most farm owners want their workers to stay through the season and return for the next. Many employers can be effective partners in seeking ways to keep their employees safe. The combined wisdom and experience of farmworkers and farm owners can be invaluable in devising solutions to the daunting problems described above. The challenge for the farmworker advocate is to seek just treatment for workers without squandering the possibilities for effective collaboration with farm owners.

3.7 Recommendations

A variety of initiatives would likely enhance our understanding of the causes and remedies for some of the occupational health challenges discussed above. These include the following:

- Rest periods have been recommended for both musculoskeletal and heat-related problems. Study the effects of regular short rest periods upon overall productivity for employers and personal income for workers.
- Conduct a true cost-benefit analysis of various pay strategies (e.g., piece-rate pay strategies), in terms of injuries, medical expenses, retention of work force, and overall productivity.
- Examine the impact on workers (social, economic, and health) of mechanization in orchard, berry, and vegetable work.
- Develop algorithms predicting a worker's heat injury risk and specifying supervisor interventions. These might include temperature, humidity, weeks on the job, age, and chronic health conditions.
- Collaboration with insurers, police, and departments of motor vehicles to develop reliable surveillance of transport incidents involving farmworkers.
- Study the impact of driver licenses for undocumented workers in states where such legislation has been effected.
- Improve surveillance of occupational illness and injury in farmworkers.
- Increase access to occupational health support and expertise for migrant clinicians.

- Examine social marketing and other approaches aimed at enhancing employers' provision of personal protection and workers' adoption of protection.
- Develop labor-management safety committee approaches to enhancing worker safety in agriculture.
- Assure adequate resources to federal and state agencies for development of interventions demonstrated to effectively reduce occupational injury and illness in farmworkers.

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