Review Article

Gender in Occupational Health Research of Farmworkers: A Systematic Review

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Background Farmwork is one of the most hazardous occupations for men and women. Research suggests sex/gender shapes hazardous workplace exposures and outcomes for farmworkers. This paper reviews the occupational health literature on farmworkers, assessing how gender is treated and interpreted in exposure-outcome studies.

Methods The paper evaluates peer-reviewed articles on men and women farmworkers’ health published between 2000 and 2012 in PubMed or SCOPUS. Articles were identified and analyzed for approaches toward sampling, data analysis, and use of exposure indicators in relation to sex/gender.

Results 18% of articles reported on and interpreted sex/gender differences in health outcomes and exposures. Sex/gender dynamics often shaped health outcomes, yet adequate data was not collected on established sex/gender risk factors relating to study outcomes.

Conclusion Research can better incorporate sex/gender analysis into design, analytical and interpretive approaches to better explore its mediation of health outcomes in light of emerging calls to mainstream gender research.

INTRODUCTION

Researchers have argued the occupational health literature has inadequately accounted for gender in the formative, implementation, and analytical stages of study [Niedhammer et al., 2000; Messing et al., 2003; Coen and Banister, 2012]. They suggested as recourse the adoption of gender-sensitive research strategies, which addresses men’s and women’s health problems by identifying physiological, ergonomic and socio-cultural gender characteristics that shape study outcomes [Messing and Mager Stellman, 2006]. This research produces better empirical understandings of health and results in tangible outputs that equitably serve men and women.

In mainstream discourse, agriculture has been conceptualized as a male space [Peter, 2000; Brandth, 2002; Saugeres, 2002], yet women compose about 43% of the labor force in developing countries and at least 20% in developed economies [FAO, 2011b]. Despite this reality, occupational health literature addressing farmworkers has not focused on the instrumentality of gender in shaping health outcomes.

Research suggests that gender is elemental in constructing exposures in and outside the workplace that determine health. A recent report by the Canadian Institute for Health Research defines gender as “socially constructed roles, relationships, behaviours, relative power, and other traits that
societies ascribe to women and men;” while sex is characterized by “biological and physiological characteristics that distinguish females from males” [CIHR, 2010]. In this article, sex and/or gender (abbreviated herein as ‘sex/gender’) is used because of the inseparability of the two concepts in women’s and men’s lived experience. Sex/gender has been found as a determinant for agricultural work in task assignment, work hours, pay, workplace conditions and exposure to other occupational and non-occupational risks [Stallones and Beseler, 2004; Arcury and Quandt, 2007; Villarejo and McCurdy, 2008].

These differences are highly variable based on the context in which a farm industry is situated. Men on farms are generally disproportionately represented in land ownership and labor [Deere and Leon, 2001; Doss et al., 2013], while certain tasks (i.e. machine operation) are also overwhelmingly men-dominant [Brandth, 2006]. There is also evidence that women farm homemakers (often referred to in the literature as “farmer spouses”) frequently engage in farm tasks from field irrigation to driving tractors [Reed et al., 1999; FAO, 2011b]. Meanwhile, women in sub-Saharan Africa and in Asia take on more prominent roles in agricultural labor, as in Nigeria where women perform between 60%-90% of agricultural tasks – from land clearing, tilling, planting and maintenance, harvesting, food processing, transportation and marketing [Lawanson, 2008].

Indicators and Outcomes in Agricultural Research

The types of occupational morbidity in agriculture vary widely, from debilitating physical injuries to chemical poisonings and fungal, bacterial and viral illness [ILO, 2003]. Some health problems result from acute events, as when worker fall from heights or are bitten by snakes, while others like cancer may develop over prolonged periods of time [Quandt et al., 2013]. The variety of hazards and health problems prevalent in agricultural work suggests a complex occupational practice and environment—inclusive of ecosystems, farm and health technologies, individual physiology and psychology and the social context indigenous to each farming industry.

The literature has detailed the social, economic and occupational conditions that have made agricultural work among the most hazardous in the world [ILO, 2003; Wang et al., 2011; Shipp et al., 2013; Zheng et al., 2013]. Many workers are migrant and/or casually employed reflecting relative disadvantage compared to other occupational groups—in terms of pay, legal protections, housing, medical coverage and access to other resources [Arcury and Quandt, 2007]. These issues all feature as frequent indicators for assessing the determinants of agricultural worker health.

The occupational factors typically studied include work hours, task assignment, workplace conditions, off-farm employment and exposure to other occupational hazards. Task assignment and work responsibilities have been identified as a conspicuously gendered practice. Without reasonable physiological or social justifications, women are regularly excluded from many tasks, affecting their health and men’s as well. For example, women rarely benefit from the perks of higher paying and more secure jobs as machine operators, but are also excluded from the higher risk of injury associated with these jobs [Xiao et al., 2013]. Meanwhile, the men-dominated task of machine operation is a major source of occupational injury. The ability of occupational health research to attend to sex/gender differences, both in health outcomes and the factors that shape their presentation, has staggering implications for the agricultural workforce.

Objective

This paper reviews the occupational health literature on farmworkers, assessing how gender is treated and interpreted in exposure-outcome studies of agricultural workers.

METHODS

Criteria for Considering Studies for This Review

Types of studies

Reviewed articles were limited to quantitative studies on farmworkers’ health published in peer-reviewed journals between January 1, 2000 and December 31, 2012. They assessed health outcomes (such as injuries, mortality, pesticide poisoning, dermatitis, respiratory, neurological functioning), employing either cross-sectional, case-control or longitudinal epidemiological designs and were published in English. Articles reporting only descriptive analyses were excluded from the review.

This review focuses on studies of workers in crop-producing agricultural industries, including work related to harvesting, seeding, planting, farm maintenance, cultivation, picking, and sorting. Articles exclusively on animal-product farming were excluded. No restrictions were made on the country or region of study.

Types of participants

Articles were included that analyzed data for men and women workers actively or once engaged in agricultural work. Studies were not excluded if they collected data on non-agricultural working populations, as in comparative studies or studies including farmers’ spouses. Study participants encompassed a diverse labor force: farm owners and their spouses, contract workers, seasonal workers, day-laborers, migrant workers and small-scale farmers who own
or rent the land where they produce. Among these were boys and girls and adult workers on part- or full-time schedules.

Search Methods for Identification of Studies

Electronic searches

This review drew articles from the SCOPUS and PubMed archival databases. These databases were chosen because of their expansive indexing of journals publishing epidemiological studies in medical and occupational health fields. The search included a wide range of terms covering key concepts of occupational health and agricultural work. Table I includes the strings used in PubMed and SCOPUS tailored to their search protocols.

Data Collection and Analysis

Selection of studies

Articles were first identified and screened through SCOPUS and then through PubMed, with duplicates found and removed. Articles were excluded at the abstract level that did not address crop-related farm work, if they had exclusively men or women samples (since these do not identify gender differences in exposures/outcomes) or if health was not the primary study outcome.

A standardized procedure was developed to assess the inclusion and exclusion of full-text articles and to categorize them based on their approaches towards sex/gender in research design, statistical analysis, and interpretation.

Data extraction and management

The extraction and management protocol for categorizing data drawn from each reviewed article followed a standardized procedure obtaining the following information: (1) year of publication; (2) country of publication; (3) study participants: number, men/women proportion; (4) methods: study design (prospective/retrospective or cross-sectional), data collection/data source; (5) study outcomes: findings on health outcomes by gender; (6) exposure assessment: indicators of exposure to any work hazards, task assessment (none; yes, without sex/gender differentiation; yes, with sex/gender differentiation), actual exposure measurements.

Data analysis

Studios were assessed for their sampling strategy, data analysis approach and the use of exposure indicators in

| TABLE I. Search Criteria |
|--------------------------|
| **Search engine**        |
| **SCOPUS**               |
| Search criteria 2000–2012|
| TITLE-ABS-KEY-AUTH((men OR male) AND (women OR female) AND (hygiene OR occupational health OR occupational injury OR occupational illness OR occupational disease) AND (farm OR agriculture)) AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "re");) AND (LIMIT-TO(LANGUAGE, "English");) AND (LIMIT-TO(SRCTYPE, "j");) AND (LIMIT-TO(PUBYEAR, 2012) OR LIMIT-TO(PUBYEAR, 2011) OR LIMIT-TO(PUBYEAR, 2010) OR LIMIT-TO(PUBYEAR, 2009) OR LIMIT-TO(PUBYEAR, 2008) OR LIMIT-TO(PUBYEAR, 2007) OR LIMIT-TO(PUBYEAR, 2006) OR LIMIT-TO(PUBYEAR, 2005) OR LIMIT-TO(PUBYEAR, 2004) OR LIMIT-TO(PUBYEAR, 2003) OR LIMIT-TO(PUBYEAR, 2002) OR LIMIT-TO(PUBYEAR, 2001) OR LIMIT-TO(PUBYEAR, 2000)) AND (LIMIT-TO(LANGUAGE, "English") AND (LIMIT-TO(SRCTYPE, "j");)) |
| **PubMed**               |
| (men OR male) AND (women OR female) AND (hygiene OR occupational health OR occupational injury OR occupational illness OR occupational disease) AND (farm OR agriculture) NOT methodological ("2000/01/01"[Date - Publication]: "2012/12/31"[Date - Publication]) |
| Filters: Humans; English |
relation to outcomes. The following protocol outlines issues emphasized within each study component:

1. Sampling strategy: studies were assessed whether they recruited a sufficient number of women participants to study sex/gender differences and if clear consideration was given to sampling strategy.
2. Data analysis: articles were evaluated for their analytical treatment of the study population (i.e., use of sex/gender stratification; use of sex/gender as a covariate).
3. Exposure assessment methods: studies were assessed for the type of exposure assessment carried out in relation to study outcomes and how sex/gender was considered in exposure assessment.
4. Sex/gender differences in outcomes: how did men and women farmers differentially experience health outcomes.
5. Interpretation of sex/gender findings: did articles hypothesize, explain, or discuss why there may have been sex/gender differences or similarities in outcomes.

RESULTS

Results of the Search

The search initially found a total of 1983 articles: 682 articles in SCOPUS and 1,301 articles in PubMed, with 186 duplicates identified and removed. Upon first screening, 710 articles were selected: 315 articles through SCOPUS and 395 through PubMed.

These 710 articles were then reviewed as full-texts, 457 of which were excluded for not meeting the basic inclusion criteria (did not study a health outcome, were not specific to farmer populations and crop-production; were not epidemiological studies or only reporting descriptive analyses).

Excluded Studies

The overwhelming majority of excluded studies were eliminated because of vagueness surrounding the participants’ work status as farmers in the study. These studies had samples in rural areas said to largely work in agriculture, yet did not collect information to identify the workers as farmers or non-farmers. Several studies were not explicit whether participants were livestock or crop farmers, while a number of other studies identified women in their samples as only ‘farmer spouses,’ making no qualification of their participation in farming activities. Research that identified farmer spouses as engaging in farm work were included if meeting the other criteria.

The final screening yielded 253 articles for full-text review, with only 45 (18%) analyzing associations between risk factors and the primary health outcome and discussing findings on sex/gender differences or similarities in outcomes. In the remaining 208 articles that were excluded, 72 articles pooled men and women together in the analysis, and 136 articles used sex/gender as a covariate in their statistical models without providing hypotheses, explanations, or discussion of sex/gender differences or similarities in research outcomes.
incidence of skin ailments in Vietnam [Trang et al., 2007]. Tobacco sickness in India [Parikh et al., 2005] and respiratory symptoms in Sweden [Lembke et al., 2004], green melanoma in 9 European countries [Behrens et al., 2012], incidence in the US [Mills et al., 2005], risk of uveal US [Bell et al., 2006] (3) lymphohematopoietic cancers et al., 2005; Ruder et al., 2009], (2) pesticide exposure in the control studies included: (1) glioma cases in the US [Lee et al., 2002; Holmberg et al., 2004; Carlson et al., 2005; Marcum et al., 2011], in Finland [Virtanen et al., 2003], and in South Korea [Lee et al., 2012], (2) cancer survival among Latino farmers in California [Dodge et al., 2007], pesticide poisoning in the US [Calvert et al., 2008; Kasner et al., 2012], (3) Parkinson’s disease in Denmark [Tuchsen and Jensen, 2000] and (4) hearing loss in the US [Humann et al., 2012]. The case-control studies included: (1) glioma cases in the US [Lee et al., 2005; Ruder et al., 2009], (2) pesticide exposure in the US [Bell et al., 2006] (3) lymphohematopoietic cancers incidence in the US [Mills et al., 2005], (4) risk of uveal melanoma in 9 European countries [Behrens et al., 2012], (5) incidence of osteoarthritis in Sweden [Holmberg et al., 2004], respiratory symptoms in Sweden [Lembke et al., 2004], green tobacco sickness in India [Parikh et al., 2005] and (6) incidence of skin ailments in Vietnam [Trang et al., 2007].

Sample, Design, and Exposure Assessment

Sample sizes varied dramatically in this diverse literature: at the low end, a study of the neurological effects of pesticides in Brazil ran extensive testing batteries with 66 youth [Eckerman et al., 2007] while the research with the largest sample analyzed data from 267,479 US farmers’ death certificates, comparing proportionate mortality of crop and livestock farmers [Lee et al., 2002]. The majority of studies, however, ranged between 600 and 8,000 participants, with some injury/mortality and cancer research drawing larger samples from regional surveillance databases.

Among the 45 reviewed papers, studies recruited fewer women participants than men. Seven papers included less than 15% of women in their sample and most papers (n = 24, 53%) included between 15% and 40% of women in their sample. Fourteen studies recruited more than 40% women to their studies [McCurdy et al., 2003; Holmberg et al., 2004; Carlson et al., 2005; Faria et al., 2005; Lee et al., 2005; Eckerman et al., 2007; Trang et al., 2007; Cha et al., 2009; Marcum et al., 2011; Moisan et al., 2011; Behrens et al., 2012; Humann et al., 2012; Liu et al., 2012; Peraza et al., 2012]. The low number of women in some studies was sometimes with good justification. For example, 11 studies reliant on the use of hospitalization records and death certificates included between 4% and 37% women in their sample, representing the only available records for extraction.

Ten studies relied on one variable to measure occupational exposure, while 26 studies report on 2 to 4 variables and the 9 remaining studies assessed five or more. Studies assessed exposure in a variety of places: at the home, in the workplace, and using aggregate-level geographic data. In total, 12 studies (27%) analyzed data on tasks, while the remaining did not collect or analyze this data. A number of studies (n = 4) identified risk factors for health outcomes using estimated exposure at the aggregate level based on a geographically limited area. The studies employing this method utilized area-level pesticide-use information to determine the relationship between exposure and cancer or Parkinson’s [Mills et al., 2005; Dodge et al., 2007; Lee et al., 2008; Moisan et al., 2011].

There is no uniform approach to capturing work task or exposure information, yielding a diverse taxonomy of classifications used in the papers under review. The most frequent means of assessing occupational exposure were by job title, with a number of studies (n = 11) relying primarily on this indicator to assess occupational risk for health outcomes [Tuchsen and Jensen, 2000; Lee et al., 2002; Holmberg et al., 2004; Lembke et al., 2004; Mills et al., 2005; Parikh et al., 2005; Dodge et al., 2007; Alterman et al., 2008; Bretveld et al., 2008; Cha et al., 2009; Moisan et al., 2011]. Crop type was also used as a surrogate measure of potential occupational exposures. Studies of chronic illnesses were the most frequent to rely on this approach, estimating regional pesticide use by the types of crops grown in an area and its hectarage [Mills et al., 2005; Dodge et al., 2007; Moisan et al., 2011]. A number of studies (n = 11, 24%) attempted to quantify incident rates based on exposure-time estimates, 3 of which studied pesticide-related illnesses [Bell et al., 2006; Calvert et al., 2008; Kasner et al., 2012] and another 3 that studied injuries among farmworkers [McCurdy et al., 2003; Stallones and Beseler, 2003; Marcum et al., 2011].

Sex/Gender Differences in Outcomes

The 45 reviewed studies reported differences in terms of exposure and outcomes between men and women
| Author/Year/Country | Outcomes | Study design & sampling | Exposures | Data analysis | Health outcome |
|---------------------|----------|-------------------------|-----------|--------------|----------------|
| Studies             |          |                         | Occupational exposure indicators | No | No | Gender stratification |
|                     |          |                         | Task assessment | Exposure duration or frequency | findings by gender |
|                     |          |                         | Gender treatment |                          | Men: livestock farmers had higher mortality rate for cancer of pancreas, prostate, brain, non-Hodgkin's lymphoma, multiple myeloma, and Parkinson’s. |
| Lee et al./2002/US | Fatalities | Cross-sectional/Death certificates | 267,479 farm fatalities/4% women | Job title | No | No | Men: crop farmers had higher mortality from cancer of lip, skin, multiple myeloma and chronic lymphoid leukemia. |
| Locker et al./2002/Canada | Injuries from farm machines | Cross-sectional/Hospital records | 2,333 cases/11% women | Machine type; mechanism of injury; agricultural season | No | No | Ratio of men to women injuries was highest in winter. |
| Alexe et al./2003/Greece | All cause injury | Cross-sectional/Hospital records/Questionnaires | 4,326 injuries/31% women | Mechanism of injury; time of injury during the day | No | No | Injuries from PTO (power take-off) mechanisms and harvest equipment were 10 times higher in men than in women. |
| McCurdy et al./2003/US | All cause injury | Cohort/Questionnaire | 1,201 farm workers/51% women | Work tasks (i.e. hoeing, sorting, picking, tying, packing); crop type; employment type; payment type; years of work; weekly work hours | Yes (no gender differentiation) | Yes, full-time equivalent | Gender stratification | Men at higher risk of injury than women; worked at younger age, more hours/week; mostly involved in machine and irrigation tasks. |

(Continued)
| Author/Year/Country | Outcomes | Study design/ Data sources | Sample/% Women | Occupational exposure indicators | Task assessment | Exposure duration or frequency | Gender treatment | Health outcome |
|---------------------|----------|-----------------------------|----------------|----------------------------------|----------------|------------------------------|-----------------|---------------|
| Stallones & Beseler/2003/US | All cause injury | Cross-sectional/Questionnaire | 754 farm workers/40% women | Work tasks (farmstead material handling, crop production, farm maintenance, animal handling, transport); hours worked; farming season | Yes (with gender differentiation) | Yes, full-time equivalent | Gender stratification | Injury rates were similar for men and women. Men: high injury rate in farm-maintenance activities. Women: very high injury rate while doing other farm work; worked more hours on other farm work; men worked more hours on all other tasks. |
| Virtanen et al./2003/Finland | All cause injury | Cohort/Population consensus-Registry | 69,629 farmers/35% women 11,657 compensated injuries | Farm type; farm tasks; cause/event of injury | Yes (no gender differentiation) | No | Gender as covariate | Men had higher injury rates than women (OR = 1.74; 95%CI = 1.66-1.83). Women: more likely to have animal-related injuries. Men: More injuries with objects. |
| Dimich-Ward et al./2004/Canada | All cause injury/fatality | Cross-sectional/Death certificates; Hospital records | 716 fatalities: 9%/women 8,263 injury cases/ 17% women | Cause of injury/fatality: machinery, non-machinery | No | No | Gender stratification | Highest fatal injuries for men were roll-overs (32%) and for women were being run-over (45%); 50% of men fatalities among owners/operators, highest women-fatalities were children of owners/operators (30%). Higher fatality rates among older men than older women; more fracture injuries among women older than... | (Continued) |
| Author/Year/Country | Outcomes | Study design & sampling | Occupational exposure indicators | Task assessment | Exposure duration or frequency | Gender treatment | Health outcome |
|---------------------|----------|-------------------------|---------------------------------|----------------|-----------------------------|----------------|---------------|
| Simpson et al./2004/Canada | All cause injury/stress | Cross-sectional/Questionnaire | 361 farm cases/22% women | Employment history; work tasks—cultivating, harvesting, harrowing or disk ing, and heavy lifting | Yes (with gender differentiation) | No | Gender stratification was 13.3/100/year; 18% of men; more likely to use mechanical equipment at time of injury. Women: age standardized rates of injury, 3.8/100/year; 11% of women reported stressful lives; reporting stress and no off-farm employment led to more injuries than all other categories. The risk for farm injury increased with levels of stress for women (OR = 2.73) and men (OR = 1.61). |
| Carlson et al./2005/US | Tractor-related injuries | Cohort/Questionnaire | 16,537 farmers/48% women | Source of injury; mechanism of injury; activity at time of injury; hours worked per week | No | No | Gender as covariate Injury rate was higher among men (16.2 injury events per 1,000 persons per year) than among women (2.5). Men at higher risk of tractor injury (OR = 5.3; CI = 2.9, 9.9). |
| Pickett et al./2008/Canada | Head Trauma injury | Cross-sectional/Hospital records | 1,245 cases/26% women | Cause of injury—animal-/machine-related; fall, struck | No | No | Gender stratification Men are over twice as likely injured (18.6 event rate) compared to women (7.3 event rate). Women ages 10-19: animals led to most head injury. Men older than 60: machinery led to most head injury. |
| Rautiainen et al./2009/Finland | All cause injury | Cross-sectional/Registry-Insurance records | 93,550 farmers/37% women | Farm type; presence of animals; employment status; work activity during incident; cause of injury | No | No | Gender as covariate Men at higher risk of injury. |
| Author/Year/Country | Study design & sampling | Study design/ Data sources | Sample/% Women | Occupational exposure indicators | Exposure duration or frequency | Gender treatment | Health outcomes |
|---------------------|-------------------------|----------------------------|----------------|---------------------------------|-------------------------------|-----------------|----------------|
| Hendricks & Hendricks/2010/US | All cause injury | Cross-sectional/ Questionnaire | 79,809 farm youth cases/37% women | Source of injury (i.e. All-terrain vehicle, crop, livestock) | No | No | Gender stratification | Trend in injury rates declined for men but increased for women. |
| Marcum et al./2011/US | All cause injury | Cohort/ Questionnaire | 670 farmers in 2002, 536 in 2003, 477 in 2004, 454 in 2005/49% women | Farm tasks; time doing farm work past week | No | Time doing farm work past week | Gender as covariate | Men reported 80% of injuries and had four times the odds of injury (EOR = 3.94) as women. Most common reported farmwork injury was cuts for men and chemical reactions for women. |
| Van den Broucke & Coémont/2011/Belgium | All cause injury | Cross-sectional/ Questionnaire | 510 participants/ 20% female | Machine use; animal handling; fall prevention behavior; pesticide use; farm characteristics | Yes (no gender differentiation) | No | Gender as covariate | 3.6% of women and 6.8% of men reported injuries; 10.8% of women and 15.9% of men reported disease; women behaved safer than men with animal handling and fall prevention. |
| Lee et al./2012/South Korea | All cause injury/ fatality | Cohort/Census & worker compensation data | 219 fatalities/8% women | Cause of injury/ fatality | No | No | Gender stratification | Men (18/1,000 persons-years) were more likely to be injured than women (13/1,000 persons-years); Men also had higher mortality rates (38/100,000 persons-year) than women (9/100,000 person-years). Men: most common cause of deaths from machinery use (35.6%); 85 and older highest injury incidence. Women: most common cause of deaths from transport (23.5%); most common cause of injuries from falls (45.4%). Women between 60 and 64 had highest |

(Continued)
| Author/Year/Country | Outcomes | Study design/Data sources | Sample/% Women | Occupational exposure indicators | Task assessment | Exposure duration or frequency | Gender stratification | Health outcome |
|---------------------|----------|---------------------------|----------------|---------------------------------|----------------|--------------------------------|----------------------|--------------|
| Lee et al./2005/US | Glioma-Brain Tumor | Case-control/Questionnaire | 251 farmer cases/498 controls/43% women | Type of herbicide/pesticide used; years of farm work; size of farm | No | No | Gender stratification | Associations between farm work and glioma found for men (OR = 3.9). More brain cancer among men farmers reporting use of insecticides (OR = 1.8), nitrosatable pesticides (OR = 1.9), or organophosphate (OR = 2.0). |
| Mills et al./2005/US | Lymphohematopoietic cancers | Case-control/Cancer registry; pesticide databank | 131 cases/28% women 655 controls/28% women | Estimated pesticide exposure by crop employment for cases and controls; crop type; geographic location | No | No | Gender stratification | Women: work in vegetables had increased risk for leukemia (OR = 4.01). Women: working with chemicals had higher risk (Malathion OR = 4.91; Mancozeb OR = 4.78; Chorothalonil OR = 4.78; Trifuralin OR = 4.51). |
| Dodge et al./2007/US | All Cancer Mortality | Cohort/Cancer registry | 1,186 Hispanic farm cases/178,718 Hispanic controls/51% women | Job title; regional farming exposure | No | No | Gender stratification | Cancer diagnosis mean age 65 for men, 54 for women. Cancer-specific survival worse in farmer men than non-farmer men; no difference observed for women. (Continued) |
| Author/ Year/ Country | Studies | Study design & sampling | Exposure assessment | Data analysis | Health outcome |
|----------------------|---------|------------------------|---------------------|--------------|----------------|
| Lee et al./2008/ South Korea | All Cancer Mortality | Ecological study/ Death certificates; census data | Occupational exposure indicators: Regional farming exposure cumulatively estimated by many variables (i.e. number of farm households, farm size, crop type) | No | Greater farm exposure in men led to higher cancer mortality of esophagus, stomach, brain and leukemia, while in women led to higher cancer mortality of esophagus and stomach. |
| Ruder et al./ 2009/ US | Glioma-Brain Tumor | Case-control/ Questionnaire | Work tasks (pesticide/ fertilizer use, equipment use, farm maintenance); frequency task performed; PPE use; chemical use; crop types, hectarage, & years grown; work tools | Yes (with gender differentiation) | Women: greater risk of glioma on farms where milo grown (OR = 4.19) compared to men (OR = 2.15). Men: lower risk of glioma on farms growing corn, rye or soy beans. Pesticide applicators never washing face and hands immediately after applying had increased risk of glioma (women OR = 10.5; men OR = 2.71). |
| Behrens et al./ 2012/ Europe (9 countries) | Uveal melanoma | Case-control/ Questionnaire - Pathology reports | Crop type; farm tasks; pesticide mixing and/or application; PPE use; duration of pesticide exposure | No | No increased risk of uveal melanoma in men or women for pesticide exposure and occupational activities in farming. |
| Author/Year/Country | Outcomes | Study design/Data sources | Sample/% Women | Occupational exposure indicators | Task assessment | Exposure duration or frequency | Gender treatment | Findings by gender |
|---------------------|----------|---------------------------|----------------|---------------------------------|----------------|-------------------------------|----------------|------------------|
| Bell et al./2006/US  | High pesticide exposure event (HPEE) | Case-control/questionnaire | 369 pesticide applicators, spouses/17% women 738 controls/17% women | Work tasks, frequency engaged in pesticide application, type of pesticide, type of pesticide delivery method (i.e. vehicle, backpack, sprayer) | Yes (with gender differentiation) | Yes, cases analyzed for frequency of pesticide application | Gender stratification | Women applying pesticides over 6 days/year more likely to experience pesticide exposure event compared to 5 days/year (OR = 1.7); women wearing gloves and not storing pesticides at home less likely to experience pesticide exposure event. Men: increased application days per year, not removing work boots when entering home, and not wearing PPE increased the risk for a pesticide exposure event. |
| Calvert et al./2008/US | Acute pesticide poisoning | Cohort/Pesticide poisoning database | 3,271 farm worker cases/32% women 2,423 farm owner cases/29% women | Type of exposure to pesticide (i.e. drift, contact with treated surface); crop type; pesticide handling; use of PPE | Yes (with gender differentiation) | Yes, poisoning rates calculated based on estimated hours (full-time equivalent) | Gender stratification | Incidence rate of pesticide poisoning was twice as high for women farmers (141.8 per 100,000 FTE) than men farmers (74.7 per 100,000 FTE). Women handled pesticides less than. Women less likely to use PPE (27%) than men (40%). |
| Kachaiyaphum et al./2010/Thailand | Abnormal serum cholinesterase (SChE) levels | Cross-sectional/Questionnaire/Blood samples | 350 farmers/38% women | Type of work; duration of pesticide exposure; frequency pesticide use; cholinesterase level; PPE use; practices during and after spraying | No | No | Gender as covariate | Men more likely to develop abnormal serum cholinesterase levels than women (adjusted OR = 5.80) | (Continued)
| Author/Year/Country | Outcomes | Study design/ Data sources | Sample/ % Women | Study design/ Data sources | Sample/ % Women | Occupation exposure indicators | Task assessment | Exposure duration or frequency | Gender treatment | Findings by gender |
|---------------------|----------|-----------------------------|----------------|-----------------------------|----------------|-----------------------------|----------------|-----------------------------|----------------|------------------|
| Zhang et al./2011/China | Acute pesticide poisoning | Cross-sectional/Questionnaire | 910 applicators/39% women | Crop types, application methods; application time; PPE use | No | No | Gender as covariate | Higher proportion of women reported acute pesticide poisoning than men (13.1% vs. 6.1%, p < 0.001). Acute pesticide poisoning was 70% more likely to occur among women than men (AOR = 1.70, 95% CI:0.99–2.91). | |
| Kasner et al./2012/US | Acute pesticide poisoning | Cohort/Pesticide poisoning database | 2,534 cases of acute pesticide/illness and injury; 30% women | Pesticide exposure type (i.e. drift, contact with treated surface); crop type; pesticide handling; use of PPE | Yes (with gender differentiation) | Yes, poisoning rates calculated based on estimated hours (full-time equivalent) | Gender stratification | Incidence rate for women farmers nearly twice that of men (OR = 2.2); more women reported exposure due to off-target drift (60%) than men (55%), fungicides (39%) compared to 30%), and inorganic compounds (30% to 20%). More women had respiratory (42%) gastrointestinal (50%) and neurological problems (63%) compared to men (30%, 35%, and 50% respectively). Men reported greater exposure to cholinesterase inhibitors (36% compared to 30%). Exposed women more likely to work in small fruit crop production (46%) than men (21%). Exposed men more likely to work in tree fruit crop production (36%) than women (10%). Women: higher incidence rates among all age groups except youngest (15-17) and oldest (55-64); more likely to report illness or reaction when exposed. | |
| Author/Year/Country | Study design & sampling | Study design/ Data sources | Sample/% Women | Occupational exposure indicators | Task assessment | Exposure duration or frequency | Gender treatment | Data analysis | Health outcome |
|---------------------|-------------------------|-----------------------------|----------------|--------------------------------|----------------|-----------------------------|----------------|--------------|----------------|
| Tuchsen & Jensen/2000/Denmark | Parkinson’s disease | Cohort/Registry | 949 Parkinson’s cases/36% women | Job title | No | No | Gender stratification | Increased risk of Parkinson’s disease among men self-employed farmers. |
| Hwang et al./2001/US | Hearing loss | Cross-sectional/ Questionnaire | 1622 farmers/38% women | Use of noisy farm equipment; duration of use; average hours worked per day; work status on farm; farm type | No | Life-time exposure to noisy farm equipment (hours) | Gender as covariate | Men are at higher risk of hearing loss than women (R = 2.53; 95% CI = 1.98 – 3.23). Men had higher exposure to noisy farm equipment than women. |
| Kimbell-Dunn/2001/New Zealand | Respiratory symptoms | Cross-sectional/ Questionnaire | 1,706 farmers/24% women | Work exposures; chemical exposures; farm type | Yes (no gender differentiation) | No | Gender as covariate | Women had higher incidence of Dyspnea (OR = 1.7; 95% CI = 1.3 – 2.3) and lower incidence of chronic bronchitis (OR = 0.7; 95% CI = 1.5 – 1.03) than men. |
| Park et al./2001/US | Dermatitis | Cross-sectional/ Questionnaire | 638 farmers & spouses/40% women | Work tasks (i.e. pesticide application; animal work) and specific exposure agents (i.e. pesticides, cleaning items, detergents, food products); PPE use; health/safety training | Yes (with gender differentiation) | No | Gender stratification | 9.6% of men and 14.4% of women reported dermatitis. Rates of exposure to causal agents were lower among women. Men: history of allergy associated with higher risk. Women: higher education and exposure to petroleum products related to higher risk. |

(Continued)
| Author/Year/Country | Outcomes | Study design & sampling | Sample/% Women | Occupational exposure indicators | Exposure duration or frequency | Gender treatment | Findings by gender |
|---------------------|----------|-------------------------|----------------|----------------------------------|-------------------------------|-----------------|-------------------|
| Melbostad & Eduard/2001/Norway | Respiratory and eye irritation | Cross-sectional/Questionnaire; personal exposure assessment | 8,482 farmers / 34% women 106 farmers tested / 19% women | Work tasks (i.e. farm handling, animal, manuring); ppm measures for tasks; number of years worked; weekly work hours | Yes (with gender differentiation) | No | Gender stratification | Prevalence of work-related irritation symptoms was 71% in men farmers compared to 56% in women farmers. |
| Holmberg et al./2004/Sweden | Osteoarthritis | Case-control/Questionnaire | 778 cases/57% women 695 controls/58% women | Job title; years of farm work | No | No | Gender stratification | Women who worked for 11-30 years in farming had an increased risk of osteoarthritis (OR = 2.1). Working on the farm and being overweight produced an increased risk of developing osteoarthritis in men (OR = 3.1) and women (OR = 4.4). |
| Lembke et al./2004/Sweden | Respiratory health | Case-control/questionnaire | 1,134 farmer cases /11% women 1,843 controls/51% women | Job title | No | No | Gender stratification | Prevalence of respiratory symptoms where generally higher among farmers compared to controls: 14% wheezing in women farmers compared to 12% in controls; high prevalence of asthma was found among young women farmers. 8% work-related wheeze in men farmers compared to 2% in controls; prevalence of asthma in men farmers increased by age. Men farmers had a higher prevalence of work-related wheeze than controls (OR =1.74). |
| Studies | Study design & sampling | Exposure assessment | Data analysis | Health outcome |
| --- | --- | --- | --- | --- |
| **Author/Year/Country** | Outcomes | Study design/ Data sources | Sample/% Women | Gender treatment findings by gender |
| Faria et al./2005/Brazil | Asthma and chronic respiratory disease | Cross-sectional/ Questionnaire | 1,379 farmers/ 45% women | Days per month of chemical exposure Gender as covariate | Women had higher incidence of asthma (OR = 1.51; 95% CI: 1.07-2.14) and chronic respiratory disease (OR = 1.34; 95% CI: 1.00-1.81). |
| Parikh et al./2005/India | Green tobacco sickness; reproductive health | Case-control/ Questionnaire; Medical examination | 685 cases/33% women 655 controls/40% women | No | No | Gender stratification | Prevalence of green tobacco sickness was higher among women (55.7%) than men (42.6%). |
| Eckerman et al./2007/Brazil | Neurological health | Cross-sectional/ Questionnaire; neurobehavioral test battery (BARS) | 38 rural youth/ 53% women 28 urban youth/ 36% women | Pesticide exposure index: work tasks (i.e. pesticide handling); work hours per day/ week; years of farm work | No | No | Gender stratification | Average exposure was higher for women (55.6%) than men (25.4%) among rural (agricultural) groups. |
| Trang et al./2007/Vietnam | Skin ailments | Case-control/ Questionnaire | 636 farmers/66% women | Type of farm work; sources of irrigation; contact with wastewater; use of personal protective measures | Person time at risk Gender as covariate | Incidence of skin ailment was higher among women than men (RR = 2.02, 95% CI:1.46—2.49, adjusting for age). |
| Alterman et al./2008/US | Acute and chronic health conditions | Cross-sectional/ Questionnaire | 7137 farm operators/7% women | Job title; years of farm work; years of non-farm work | No | No | Gender stratification | Women reported more respiratory and musculoskeletal problems, fewer hearing problems. |

(Continued)
| Author/Year/Country | Studies | Study design & sampling | Occupational exposure indicators | Exposure duration or frequency | Data analysis | Health outcome |
|---------------------|---------|-------------------------|----------------------------------|-----------------------------|--------------|----------------|
| Bretveld et al./2008/Holland | Reproductive health | Cross-sectional/Questionnaire | 1,058 farmer couples/10% women farmers/1,408 control group | Job title | No | No | Gender stratification | Among primigravidous couples, when women were farmworkers, there was a twofold increased risk of prolonged TTP (time-to-pregnancy) and a three-fold increased risk of abortion than couples with men as farmworker. |
| Cha et al./2009/South Korea | Osteoarthritis; intervertebral disorders | Cross-sectional/Hospital records | 7,085 farmers/48% women 79,147 other workers/53% women | Job title | No | No | Gender stratification | Women farmers reported higher prevalence of chronic disease and greater number of doctor visits and hospitalization than other occupations. Men farmers had lower prevalence of hypertension and diabetes than other occupations. |
| Martins-Filho et al./2011/Brazil | Actinic cheilitis | Cross-sectional/Questionnaire; Clinical examination | 240 farmers/10% women | Cumulative exposure time (years); daily exposure time (hours) | No | No | Gender stratification | Exposure time to solar radiation was higher among men than women. Incidence of Actinic cheilitis higher in men (Crude PR = 2.72, 95% CI = 1.52 – 4.90). |
| Moisan et al./2011/France | Parkinson's disease | Cross-sectional/Registry | 1,659 cases/50% women | Job title; regional farming data (crops grown and farm density) | No | No | Gender stratification | Prevalence of Parkinson's disease was higher in men than women (OR = 1.52), especially among men working on farms specialized in fruits or permanent crops. |
| Humann et al./2012/US | Hearing loss | Cohort/Questionnaire/Clinical screening tests/Audiometry | 1568 participants/56% women | Lifetime exposure engaged in 11 agricultural or rural activities | Yes (with gender differentiation) | Lifetime exposure | Gender stratification | Men spent significantly more years than women in 11 agricultural tasks; hearing loss greater among men farmers than men non farmers and among women farmers than women non farmers; women spent fewer years performing farm tasks than men, faced less exposure. |

(Continued)
in agricultural work. The outcomes under study included 15 (33%) on injuries and mortality, 6 (13%) on cancers or tumors, 5 (11%) assessing acute pesticide poisoning, 4 (9%) on other chronic illnesses (kidney disease, osteoporosis), 4 (9%) on respiratory illnesses, 3 (7%) on neurological health, 3 (7%) on skin disorders, 2 (4%) on hearing loss, and additional studies on reproductive health, back pain, and green tobacco sickness, respectively.

### Cancer

Studies focusing on cancer (n = 6) as their primary health outcome [Lee et al., 2005, 2008; Mills et al., 2005; Dodge et al., 2007; Ruder et al., 2009; Behrens et al., 2012] generally found men and women reporting differential cancer outcomes, especially as some cancers are sex/gender specific (i.e. prostate for men, uterine and cervical for women). Across the studies, men were more diagnosed with elevated rates of lung, esophageal, stomach, brain, bone and glioma cancers, while women had increased risk of cancers of the esophagus and stomach. Farmworker men were found to have higher rates of prostate cancer compared to a general population, while women reported more uterine, cervical, and breast cancer than the general population. Dodge et al. reported that the age of cancer diagnosis was higher for men than for women [Dodge et al., 2007].

All studies showed sex/gender differences between exposure and cancer diagnosis. In their research of rural South Korea, Lee and colleagues found that as regional farm exposure (i.e. number of farm households, farm size, crop type) increased, men showed higher cancer mortality of the esophagus, stomach, brain and leukemia, while women had increased risk of cancers of the esophagus and stomach. Farmworker men were found to have higher rates of prostate cancer compared to a general population, while women reported more uterine, cervical, and breast cancer than the general population. Dodge et al. reported that the age of cancer diagnosis was higher for men than for women [Dodge et al., 2007].

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### Injuries and Mortality

Differences in injury rates for men and women varied in the reviewed papers (n = 15), with the majority of studies reporting higher incidence of injuries among men farmers. This difference was attributed to the tasks assigned to men and women, but also the higher number of men and their greater number of hours worked in agriculture in the study populations. In these studies, men are more likely to use...
machinery and tractors [Locker et al., 2002; McCurdy et al., 2003; Stallones and Beseler, 2003; Virtanen et al., 2003; Dimich-Ward et al., 2004; Simpson et al., 2004; Carlson et al., 2005; Hendricks and Hendricks, 2010; Lee et al., 2012], while women more often worked with farm animals [Alexe et al., 2003; Virtanen et al., 2003; Pickett et al., 2008; Hendricks and Hendricks, 2010] and engaged in hoeing [McCurdy et al., 2003] or worked with chemicals [Marcum et al., 2011]. Each task was related to its own unique injury profile.

One study found that injury risk increased with levels of stress for women much more than men because women release epinephrine with stress, which could increase risk of injury [Simpson et al., 2004]. The two other injury studies assessing exposure duration and frequency [McCurdy et al., 2003; Stallones and Beseler, 2003] found higher frequencies of men injury reports but equivalent injury rates when accounting for exposure time. Age was also closely related to injury: older men reported higher injury rates than older women [Locker et al., 2002; Dimich-Ward et al., 2004; Pickett et al., 2008], likely because men continue to work in hazardous tasks even after retirement age [Pickett et al., 2008] and the onset of age-related physiological changes [Dimich-Ward et al., 2004]. Men were also more likely to engage in more hazardous tasks [Rautiainen et al., 2009; Van den Broucke and Colemont, 2011] such as working with tractors [Carlson et al., 2005], while women practiced greater safety than men while handling animals and in fall prevention [Van den Broucke and Colemont, 2011].

Pesticide Poisoning

Studies on pesticide poisoning (n = 5) also attributed sex/gender variation in their results. Two studies found that the incidence of a pesticide exposure event were lower for women than men [Bell et al., 2006; Kachaiyaphum et al., 2010]. Bell and colleagues report that among men, increased application days per year, not removing work boots while entering home, and not wearing personal protective equipment increased the risk of an exposure event and its related health symptoms [Bell et al., 2006]. Two other studies found the opposite relation, where women farmworkers had higher incidence of pesticide exposure than men [Zhang et al., 2011; Kasner et al., 2012]. Zhang and colleagues [2011] showed that a higher proportion of women reported acute pesticide poisoning; while Kasner et al. [2012] report that women had higher incidence with exposure to fungicides and inorganic compounds, though men were more frequently exposed to cholinesterase inhibitors [Kasner et al., 2012]. The difference in exposure patterns were attributed to men and women working on different crops, as well as each having biologically different responses to pesticides [Zhang et al., 2011; Kasner et al., 2012]. Another revelatory finding by Calvert et al. [2008] was that though women were predominant as processing/packing plant workers, men had higher incident rates of acute pesticide poisoning in these settings; paradoxically, incidence rates were higher among women farmers in agricultural settings where they work much less frequently and are significantly less likely to be pesticide handlers than men [Calvert et al., 2008].

Other Health Outcomes

Other reviewed studies included research on skin ailments [Park et al., 2001; Trang et al., 2007], green tobacco sickness [Parikh et al., 2005], reproductive health [Parikh et al., 2005; Bretveld et al., 2008], respiratory illnesses [Kimbell-Dunn et al., 2001; Melbostad and Eduard, 2001; Lembke et al., 2004; Faria et al., 2005], kidney disease [Peraza et al., 2012], osteoarthritis [Holmberg et al., 2004; Cha et al., 2009], actinic cheilitis [Martins-Filho et al., 2011], hearing loss [Hwang et al., 2001; Humann et al., 2012], Parkinson’s disease [Tuchsen and Jensen, 2000; Moisan et al., 2011], back pain [Liu et al., 2012] and neurobehavorial performance [Eckerman et al., 2007]. All studies indicated noticeable sex/gender differences for the studied health outcomes and attributed such differences to several factors including, agriculture tasks on the farm, years of working in agriculture work, workloads, history (or hereditary) of illness, and lifestyles (such as smoking and weight), sociocultural and behavioral explanations, and biological differences.

DISCUSSION

This review found that farm work remains hazardous for both men and women in unique ways, and that the relationship between exposure and outcome is shaped by sex/gender. The following discussion analyzes the findings of this study, identifying shortfalls in gender-sensitive analyses and possible areas of improvement within this field.

Sex/Gender Differences in Outcomes

The reviewed studies found substantial differences between men and women in health outcomes relating to farm work, although researchers must be cautious in generalizing across contexts. Inconsistencies were common: some studies identified higher injury rates among men farmworkers, while the reverse was found elsewhere. Studies of pesticide-related symptoms also reported opposing data on rates for men and women. These reported inconsistencies highlight the complex context-specific conditions that give rise to health outcomes among farmworkers, as well as the
strengthen strengths and weaknesses of different methodologies utilized to collect and categorize outcomes data (issues that will be addressed below).

One consistency across numerous studies was a relationship between age and sex/gender. Men were found to engage in farm tasks much more frequently in their youth as well as into old age. This led to higher frequencies of injuries and mortalities in both age groups. Older men, in particular, had the highest fatality rates, explained as a potential by-product of their continued work in hazardous physical environment despite age-related physiological changes. Yet it is likely that these outcomes would appear much different in farming contexts where women were much more likely to engage in work later into life, such as in poorer communities. More broadly, studies hypothesized physiological, biological, and social explanations to explain differences in health outcomes; yet most did not analyze occupational risk factors and social determinants that would help establish evidence to support these claims.

Sample, Design, and exposure Assessment

The vast majority of reviewed studies marginalized sex/gender at an early point in their research, primarily by not recruiting enough women participants to analyze gender. In most studies, men represented the majority of those sampled, reflecting the proportion of men in the formal agricultural workforce or among those in the relevant exposure category. However, in epidemiological studies that establish risk associations, representativeness is less important than securing adequate sample sizes to garner statistically significant results.

Further, for research to assess exposure/outcome rates using equivalent exposure duration and frequency measures, oversampling women may not be enough; rather studies might also consider collecting equivalent exposure frequencies and durations for each sex/gender group. If women participants largely work or engage in specific exposure-related tasks for fewer hours than men participants, researchers may have to include more women than men to collect equivalent exposure data.

Large longitudinal studies are one approach to increase catchment of women participants, yet there was a notable dearth of these studies in the review, likely because farm workforces are seasonal and migrant. While long-term prospective studies prove difficult to implement in such contexts, shorter-term studies with larger catchment areas may be possible and would be valuable in understanding acute health concerns like pesticide poisonings, injuries, and musculoskeletal complaints. Alternately, many farming communities in developing countries have more stationary labor forces and could be a valuable location to engage in occupational health research, addressing both issues of equity and scientific rigor in research.

Another trend was for large studies on injury, mortality, and chronic illness to gather data from hospital records and death certificates, an approach with known limitations. For example, mortality studies run a potential risk of excluding farmer “spouses” from their samples, as many who do engage in farm work may not be identified as farmers on their death certificates, substantially deflating the number of women cases identified through surveillance programs. Concerns over selection bias when relying on hospital records are also well warranted. Bell et al. [2006] found that only 15% of farmers reporting pesticide poisoning symptoms sought medical attention; while another California study reported only 22% of workers had health insurance [McCurdy et al., 2003]. In contexts where health care is not guaranteed to low-income and/or undocumented workers, this is a fundamental methodological concern that was not problematized by studies using this methodology.

Echoed in our findings, one of the important methodological concerns in this literature is that a majority of studies on farmworker populations continue to pool men and women together for analysis, effectively silencing findings of any gender differences in outcomes or exposures. A second methodological concern which requires reflection is the analysis of sex/gender as a covariate. As Messing and colleagues [2009] suggest, this approach has its limitations. Their study of population wide data on musculoskeletal disorders in Canada analyzed the same dataset with and without sex/gender stratification, finding a greater range and stronger associations between occupational exposures, individual characteristics and musculoskeletal health in the stratified analysis.

Another area of emphasis that must be addressed in future studies is how best to assess exposure in ways that capture gender differences. The use of job title or crop type to classify employees may also minimize the diversity of risks facing workers within the same job or working the same crops. This danger becomes more pronounced when equating women ‘farmers’ or ‘spouses’ with men ‘farmers’ or ‘spouses’ working similar crops. The type of tasks and frequency and intensity of exposure within these occupational categories are diverse when comparing some women to other women and men to other men, and different still when comparing men and women.

Task differentiation has proven a valuable indicator to identify health risk factors. McCurdy and peers’ injury study highlighted manual harvesting and machine operation as major sources of injury in California’s agriculture industry [McCurdy et al., 2003], while several other articles found machinery as a leading cause of injury or death, especially among men [Locker et al., 2002; Pickett et al., 2008; Lee et al., 2012]. Papers have often speculated that these observations are a result of task differentiation and exposure-
time at work and home, yet few studies evaluated task and exposure-time by sex/gender. In particular, the lack of exposure-time or frequency measures in this literature severely limits the ability of researchers to identify outcome rates in relation to occupational exposure for men and women.

There is also a need to account for physiological differences between men and women (i.e. anthropometric measures such as height and weight, body fat percentages and hormonal, chemical and organ differences). For instance, Mergler [2012] found neurotoxic exposure research has largely ignored the influence of sex/gender on exposure to pesticides despite the variables’ evident impacts. The sociological literature also foregrounds this interaction between physiology, tasks, tools and health. Tools of the farm trade have often been conceived as masculine objects and may therefore be designed with men’s physiology in mind [Brandth, 2002, 2006]. Women using hand or machine tools not designed for their anatomical dimensions may face additional negative health consequences, especially injury or musculoskeletal problems. Future injury studies may attempt to incorporate indicators on tool ‘awkwardness’, ‘discomfort’, or other factors reflecting the ease of use of tools ranging from pesticide application devices and hand tools to large farm equipment between men and women.

There is a pressing need to research the use of hand tools such as hoes, shovels and sheers, as studies of agricultural workers using rudimentary equipment are underrepresented in the epidemiological literature. This reality has clear ethical dimensions, as most of the world’s farmers and especially women farmers in disadvantaged communities work using these tools [ILO, 2004, 2007; USDOL, 2005]. These settings where the vast majority of farmer work-related injuries and deaths take place, the lack of research among these populations silences the global inequities they bear the brunt of.

**Women and “Other” Occupational issues on the Farm**

Research on farmworker health has struggled to assess the occupational risks affecting women farmworkers. In fact, numerous studies in the review found it difficult to categorize the exposures associated with women’s health outcomes. Both Stallones and Beseler [2003] injury study and Simpson et al. [2004] found that women were injured at much higher per-hour rates than men while completing tasks categorized as “other.” This “other” grouped various work activities that did not fall into frequently performed tasks on the farm. Bell et al. [2006] found that while most high pesticide exposure events for men occurred during pesticide application, applicator spouses reported “other” activities, such as walking by a freshly treated field, at fault as commonly as the application of pesticides. Calvert and colleagues [2008] found a similar gray area in reporting to health surveillance systems: women were less likely to be identified by traditional surveillance organizations—government agencies, workers’ compensation and poison control centers. These observations convey a certain invisibility of women farmworkers to the primary methods of epidemiological study [London et al., 2002].

The role of women as homemakers is another issue that remains inadequately conceptualized, although housework activities expose women to risk factors that often aggravate workplace exposures [Messing et al., 2003; Habib et al., 2010]. While several studies touched on this issue, the vast majority did not include indicators that accounted for women’s other occupation and its effect on farming-related health outcomes. Many studies asked participants about ‘off-farm employment’ without considering women’s household responsibilities as a source of risk. Off-farm employment was often protective against many health outcomes for women, which could very well reflect poorer health outcomes for women engaged in farming activities compounded by increased homemaking responsibilities. Moreover, many of these women live on or near farms, which may compound exposures to farm chemicals and other risk factors.

The designation of ‘farmer spouse’ also presents a particularly tricky methodological challenge for researchers, as one US study identified 40% of farm ‘homemakers’ that frequently engaged in farm work tasks [Reed et al., 1999]. Studies including farmer spouses in their samples without assessing their engagement in farm work may confound occupational risk factors experienced by spouses who engage in farm work with spouses who do not.

Identifying farming activities that women engage in is important to a literature often tangentially exploring the experiences of the wives of farmers. This issue has been touched upon by Stallones and Beseler [2003] who attribute different injury reports between women and men to women’s perceived role on the farm; women may downplay their work risks, as they view their role on the farm as minor, emphasizing instead their position as homemakers. Another study identified housework and the use of detergents and exposure to other irritants as likely risk factors for increased rates of dermatitis for women compared to men [Park et al., 2001]. These studies’ hypotheses—that women’s role as homemakers is instrumental in determining the prevalence, risk and understanding of injury and illness—highlight the need for research to deeply examine the relationship between farm work, housework and other non-occupational exposures.

**CONCLUSIONS AND POLICY RECOMMENDATIONS**

The literature suggests important health differences between men and women farmworkers; yet this body of
research does not adequately incorporate sex/gender analysis into its design and analytical approaches. A positive sign is that an increasing number of studies now assess occupational health outcomes using sex/gender-stratified analysis, although the vast majority do not. Even when research stratifies by sex/gender, it is rarely considered or used as a justification for study design, suggesting that understanding sex/gender differences is not a primary concern of disciplinary research.

The emerging framework of intersectionality research may offer a vehicle to improve understandings of sex/gender in occupational health research. Intersectionality research applied within the agricultural context would attempt to elucidate the intersection of class, gender, race, ethnicity, physiology, task, exposure to hazards, and other variables that impact health outcomes. Intersectional research lends itself more to qualitative methodologies and can be difficult to apply in quantitative research [Shields, 2008]. Notwithstanding, the quantitative papers we reviewed did not mention intersectionality as a possible research framework. Future studies might consider this approach as a means of eliciting data that produces more holistic understandings of the interactions of farm work and health outcomes.

Encouraging sex/gender-sensitive approaches in occupational health research of farmworkers requires funding agencies and academic publishing institutions to be proactive beyond current efforts. Funding agencies can place calls for proposals focusing on these issues, especially for research in traditional agriculture industries in developing countries. Specifically, international agencies and large foundations funding health research must lead in promoting sex/gender-based research in less-mechanized agriculture industries, as this is likely an area where great sex/gender disparities in health outcomes exist.

Scientific journals can contribute by calling for special issues and manuscripts focusing on this approach in studies of agricultural workers. Along these lines, the Gender and Work Technical Committee of the International Ergonomics Association, chaired by the lead author of this paper, has called upon journal editorial boards to consider incentivizing authors to adopt sex/gender-sensitive approaches in their research.

Research on farmer health has strides to take before understanding the role sex/gender plays in shaping health outcomes for this population. Utilizing sex/gender-sensitive methodologies, study designs and analyses will advance knowledge and help tailor future interventions and policies that meet the health needs of this diverse workforce. This issue is more than an academic argument over methodological merit: the subjects of this research are 50% of the worlds' workforce [ILO, 2009]—mostly low-income people living in developing economies, 40% women and 60% men farmworkers [FAO, 2011a], who stand to benefit from progresses made.

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REFERENCES

Alexe DM, Petridou E, Dessypris N, Skenderis N, Trichopoulos D. 2003. Characteristics of farm injuries in Greece. J Agric Saf Health 9:233–240.

Alterman T, Steege AL, Li J, Petersen MR, Muntaner C. 2008. Ethnic, racial, and gender variations in health among farm operators in the United States. Ann Epidemiol 18:179–186.

Arcury TA, Quandt SA. 2007. Delivery of health services to migrant and seasonal farmworkers. Annu Rev Public Health 28:345–363.

Behrens T, Lype E, Cree I, Lutz JM, Eriksson M, Guenel P, Merletti F, Morales-Suarez-Varela M, Afonso N, Stengrevics A, et al. 2012. Pesticide exposure in farming and forestry and the risk of uveal melanoma. Cancer Causes Control 23:141–151.

Bell EM, Sandler DP, Alavanja MC. 2006. High pesticide exposure events among farmers and spouses enrolled in the Agricultural Health Study. J Agric Saf Health 12:101–116.

Brandth B. 2002. Gender identity in European family farming: A literature review. Sociologia Ruralis 42:181–200.

Brandth B. 2006. Agricultural body-building: Incorporations of gender, body and work. Journal of Rural Studies 22:17–27.

Bretveld RW, Hooveld M, Zielhuis GA, Pellegrino A, van Rooij IA, Roeleveld N. 2008. Reproductive disorders among male and female greenhouse workers. Reprod Toxicol 25:107–114.

Calvert GM, Karnik J, Mehler L, Beckman J, Morrissey B, Sievert J, Barrett R, Lackovic M, Mabee L, Schwartz A, et al. 2008. Acute pesticide poisoning among agricultural workers in the United States, 1998–2005. Am J Ind Med 51:883–898.

Carlson KE, Gerberich SG, Church TR, Ryan AD, Alexander BH, Mengin SJ, Renier CM, Zhang X, French LR, Masten A. 2005. Tractor-related injuries: a population-based study of a five-state region in the Midwest. Am J Ind Med 47:254–264.

Cha ES, Kong KA, Moon EK, Lee WJ. 2009. Prevalence and changes in chronic diseases among South Korean farmers: 1998 to 2005. BMC Public Health 9:268. doi: 10.1186/1471-2458-9-268.

CIHR. 2010. Gender, Sex and Health Research Guide: A Tool for CIHR Applicants: Canadian Institutes of Health Research (CIHR).

Coeen S, Banister E, editors. 2012. What a Difference Sex and Gender Make: A Gender, Sex and Health Research Casebook. Canada: Canadian Institute of Health Research.

Deere CD, Leon M. 2001. Who Owns the Land? Gender and Land-Titling Programmes in Latin America. Journal of Agrarian Change 1:440–467.

Dimich-Ward H, Guernsey JR, Pickett W, Rennie D, Hartling L, Brison RJ. 2004. Gender differences in the occurrence of farm related injuries. Occup Environ Med 61:52–56.
Dodge JL, Mills PK, Riordan DG. 2007. Cancer survival in California Hispanic farmworkers, 1988–2001. J Rural Health 23:33–41.

Doss C, Kovarik C, Peterman A, Quisumbing A, van den Bold M. 2013. Gender inequalities in ownership control of land in Africa: myths versus reality. International Food Policy Research Institute (IFPRI) discussion paper. 01308. http://www.ifpri.org/publication/gender-inequalities-ownership-and-control-land-africa

Eckerman DA, Gimenes LS, de Souza RC, Galvao PR, Sarcinelli PN, Chrisman JR. 2007. Age related effects of pesticide exposure on neurobehavioral performance of adolescent farm workers in Brazil. Neurotoxicology Teratol 29:164–175.

FAO. 2011. The Role of Women in Agriculture In: 11-02 EWPN editor: Food and Agriculture Organization (FAO).

FAO. 2011. Women in Agriculture: Closing the gender gap for development. Food and Agriculture Organization (FAO). Rome, Italy.

Faria NM, Facchini LA, Fassa AG, Tomasi E. 2005. Pesticides and respiratory symptoms among farmers. Revista de saude publica 39:973–981.

Habib RR, Fathallah FA, Messing K. 2010. Full-time homemakers: workers who cannot “go home and relax”. Int J Occup Saf Ergon 16:113–128.

Hendricks KJ, Hendricks SA. 2010. Changing farm injury trends by sex for youth living on US farms, 1998–2006. J Rural Health 26:182–188.

Holmberg S, Thelin A, Thelin N. 2004. Is there an increased risk of knee osteoarthritis among farmers? A population-based case-control study. Int Arch Occup Environ Health 77:345–350.

Humann MJ, Sanderson WT, Gerr F, Kelly KM, Merchant JA. 2012. Effects of common agricultural tasks on measures of hearing loss. Am J Ind Med 55:904–916.

Hwang SA, Gomez MI, Sobotova L, Stark AD, May JJ, Hallman EM. 2001. Predictors of hearing loss in New York farmers. Am J Ind Med 40:23–31.

ILO. 2003. Facts on Agriculture: International Labour Organization (ILO).

ILO. 2004. Towards a fair deal for migrant workers in the global economy. International Labour Conference, 92nd Session. Geneva, Switzerland: International Labour Office (ILO).

ILO. 2007. Global employment trends for women. Geneva, Switzerland: International Labour Office (ILO).

ILO. 2009. Agriculture: a hazardous work: International Labour Organization (ILO).

Kachaiyaphum P, Howteerakul N, Suirarat D, Siri S, Suwannapong N. 2010. Serum cholinesterase levels of Thai chili-farm workers exposed to chemical pesticides: prevalence estimates and associated factors. Journal of occupational health 52:89–98.

Kasner EJ, Keralis JM, Mehler L, Beckman J, Bonnar-Prado J, Lee SJ, Diebolt-Brown B, Mulay P, Lackovic M, Waltz J, et al. 2012. Gender differences in acute pesticide-related illnesses and injuries among farmworkers in the United States, 1998–2007. Am J Ind Med 55:571–583.

Kimbell-Dunn MR, Fishwick RD, Bradshaw L, Erkinjuntti-Pekkanen R, Pearce N. 2001. Work-related respiratory symptoms in New Zealand farmers. Am J Ind Med 39:292–300.

Lawanson OI. 2008. Female labour force participation in Nigeria: Determinants and Trends’. Oxford Business and Economic Conference Program, Oxford United Kingdom.

Lee E, Burnett CA, Lalich N, Cameron LL, Sestito JP. 2002. Proportionate mortality of crop and livestock farmers in the United States, 1984–1993. Am J Ind Med 42:410–420.

Lee SJ, Kim I, Ryoo H, Lee KS, Kwon YJ. 2012. Work-related injuries and fatalities among farmers in South Korea. Am J Ind Med 55:76–83.

Lee WJ, Colt JS, Heineman EF, McCombs R, Weisenburger DD, Lijinsky W, Ward MH. 2005. Agricultural pesticide use and risk of glioma in Nebraska, United States. Occup Environ Med 62:786–792.

Lee WJ, Son M, Chun BC, Park ES, Lee HK, Coble J, Dosemeci M. 2008. Cancer mortality and farming in South Korea: an ecologic study. Cancer Causes Control 19:505–513.

Lembke B, Janson C, Norback D, Rask-Andersen A. 2004. High risk of adult-onset asthma and work-related wheeze in farmers despite low prevalence of asthma in young farmers. Int J Tuberc Lung Dis 8:1285–1291.

Liu X, Wang L, Stallones L, Wheeler KK, Zhao W, Smith GA, Xiang H. 2012. Back pain among farmers in a northern area of China. Spine 37:508–514.

Locker AR, Pickett W, Hartling L, Dorland JL. 2002. Agricultural machinery injuries in Ontario, 1985–1996: a comparison of males and females. J Agric Saf Health 8:215–223.

London L, de GS, Wesseling C, Kisting S, Rother HA, Mergler D. 2002. Pesticide usage and health consequences for women in developing countries: out of sight, out of mind? Int J Occup Environ Health 8:46–59.

Marcum JL, Browning SR, Reed DB, Chamrigo RJ. 2011. Farmwork-related injury among farmers 50 years of age and older in Kentucky and South Carolina: a cohort study, 2002–2005. J Agric Saf Health 17:259–273.

Martins-Filho PR, Da Silva LC, Piva MR. 2011. The prevalence of actinic cheilitis in farmers in a semi-arid northeastern region of Brazil. International journal of dermatology 50:1109–1114.

McCurdy SA, Samuels SJ, Carroll DJ, Beaumont JJ, Morrin L. 2003. Agricultural injury in California migrant Hispanic farm workers. Am J Ind Med 44:225–235.

Melbostad E, Eduard W. 2001. Organic dust-related respiratory and eye irritation in Norwegian farmers. Am J Ind Med 39:209–217.

Mergler D. 2012. Neurotoxic exposures and effects: gender and sex matter! Hanninen Lecture 2011. Neurotoxicology 33:644–651.

Messer K, Mager Stellman J. 2006. Sex, gender and women’s occupational health: the importance of considering mechanism. Environ Res 101:149–162.

Messer K, Punnett L, Bond M, Alexanderson K, Pyle J, Zahm S, Wegman D, Stoto MA, de Grosois S. 2003. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. Am J Ind Med 43:618–629.

Messer K, Stock SR, Tissot F. 2009. Should studies of risk factors for musculoskeletal disorders be stratified by gender? Lessons from the 1998 Quebec Health and Social Survey. Scan J Work Environ Health 35:96–112.

Mills PK, Yang R, Riordan D. 2005. Lymphohematopoietic cancers in the United Farm Workers of America (UFW), 1988–2001. Cancer Causes Control 16:823–830.

Moisan F, Spinosi J, Dupupet JL, Delahre L, Mazurie JL, Goldberg M, Imberson E, Tzourio C, Elbaz A. 2011. The relation between type of farming and prevalence of Parkinson’s disease among agricultural workers in five French districts. Mov Disord 26:271–279.

Niedhammer I, Saurel-Cubizolles MJ, Picotti M, Bonenfant S. 2000. How is sex considered in recent epidemiological publications on occupational risks? Occup Environ Med 57:521–527.

Parikh JR, Gokani VN, Doctor PB, Kulkarni PK, Shah AR, Saiyed HN. 2005. Acute and chronic health effects due to green tobacco exposure in agricultural workers. Am J Ind Med 47:494–499.
Park H, Sprince NL, Whitten PS, Burmeister LF, Zwerling C. 2001. Farm-related dermatoses in Iowa male farmers and wives of farmers: a cross-sectional analysis of the Iowa Farm Family Health and Hazard Surveillance Project. J Occup Environ Med 43:364–369.

Peraza S, Wesseling C, Aragon A, Leiva R, Garcia-Trabanino RA, Torres C, Jakobsson K, Elinder CG, Hogstedt C. 2012. Decreased kidney function among agricultural workers in El Salvador. Am J Kidney Dis 59:531–540.

Peter G. 2000. Coming Back Across the Fence: Masculinity and the Transition to Small-scale Agriculture. Rural Sociology 65:215–233.

Pickett W, Dostaler S, Berg RL, Brison RJ, Linneman JG, Marlenga B. 2008. Hospitalized head injuries in agricultural settings: who are the vulnerable groups? Accid Anal Prev 40:1943–1948.

Quandt SA, Kucera KL, Haynes C, Klein BG, Langley R, Agnew M, Levin JL, Howard T, Nussbaum MA. 2013. Occupational health outcomes for workers in the agriculture, forestry and fishing sector: implications for immigrant workers in the southeastern US. Am J Ind Med 56:940–959.

Rautiainen RH, Ledolter J, Donham KJ, Ohsfeldt RL, Zwerling C. 2009. Risk factors for serious injury in Finnish agriculture. Am J Ind Med 52:419–428.

Reed DB, Westneat SC, Browning SR, Skarke L. 1999. The hidden work of the farm homemaker. J Agricultural Safety and Health 5:317–327.

Ruder AM, Carreon T, Butler MA, Calvert GM, Davis-King KE, Waters MA, Schulte PA, Mandel JS, Morton RF, Reding DJ, Rosenman KD. 2009. Exposure to farm crops, livestock, and farm tasks and risk of glioma: the Upper Midwest Health Study. Am J Epidemiol 169:1479–1491.

Saugeres L. 2002. The cultural representation of the farming landscape: Masculinity, power and nature. Journal of Rural Studies 18:373–384.

Shields SA. 2008. Gender: An intersectionality perspective. Sex Roles 59:301–311.

Shipp EM, Cooper SP, del Junco DJ, Cooper CJ, Whitworth RE. 2013. Acute occupational injury among adolescent farmworkers from South Texas. Inj Prev. Prevention 19:264–270.

Simpson K, Sebastian R, Arbucke TE, Bancej C, Pickett W. 2004. Stress on the farm and its association with injury. J Agric Saf Health 10:141–153.

Stallones L, Beseler C. 2003. Farm work practices and farm injuries in Colorado. Inj Prev. 9:241–244.

Stallones L, Beseler C. 2004. Safety practices and depression among farm residents. Ann Epidemiol 14:571–578.

Trang DT, Molbak K, Cam PD, Dalsgaard A. 2007. Incidence of and risk factors for skin ailments among farmers working with wastewater-fed agriculture in Hanoi, Vietnam. T Roy Soc Trop Med H 101:502–510.

Tuchsen F, Jensen AA. 2000. Agricultural work and the risk of Parkinson’s disease in Denmark, 1981–1993. Scand J Work Environ Health 26:359–362.

USDOL. 2005. Findings from the National Agricultural Workers Survey (NAWS) 2001–2002: A Demographic and Employment Profile of United States Farm Workers. Washington, D.C.: United States Department of Labor (USDOL).

Van den Broucke S, Colemont A. 2011. Behavioral and nonbehavioral risk factors for occupational injuries and health problems among Belgian farmers. Journal of agromedicine 16:299–310.

Villarejo D, McCurdy SA. 2008. The California Agricultural Workers Health Survey. J Agric Saf Health 14:135–146.

Virtanen SV, Nokkala R, Luukkonen R, Eskola E, Kurppa K. 2003. Work injuries among Finnish farmers: a national register linkage study 1996–1997. Am J Ind Med 43:314–325.

Wang S, Myers JR, Layne LA. 2011. Injuries to hired crop workers in the United States: a descriptive analysis of a national probability survey. Am J Ind Med 54:734–747.

Xiao H, McCurdy SA, Stoecklin-Marois MT, Li CS, Schenker MB. 2013. Agricultural work and chronic musculoskeletal pain among Latino farm workers: the MICASA study. Am J Ind Med 56:216–225.

Zhang X, Zhao W, Jing R, Wheeler K, Smith GA, Stallones L, Xiang H. 2011. Work-related pesticide poisoning among farmers in two villages of Southern China: a cross-sectional survey. BMC Public Health 11:429. doi: 10.1186/1471-2458-11-429

Zheng L, Zhao N, Chen D, Hu M, Fu X, Stallones L, Xiang H, Wang Z. 2013. Nonfatal work-related injuries among agricultural machinery operators in northern China: A cross-sectional study. Injury, Int J Care Injured 45:599–604.

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