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Women in Agriculture: Risks for Occupational Injury within the Contexts of Role, and Haddon's Injury Model.

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Abstract

This paper examines exposure to occupational injury producing events among women within the context of role and Haddon's Injury Model. According to the 1998 Statistical Abstract of the United States, 23% of farm operators and managers and 19% of farm workers were female. Until recently few studies have focused on occupational injury in farm women. Sociologists suggest that contributing factors may be the gendered division of labor on farms and the invisibility of farm women's work. This gendered division of labor is culturally mediated and influences the types of farm tasks performed and subsequent exposure to agents of injury. Role, commodity and economics all influence the number and types of farm tasks. Women on farms are exposed to a multitude of biologic, chemical, physical, and mechanical agents while performing farm tasks. Whether these exposures result in an injury outcome is dependent upon factors intrinsic to the individual (host), a catalyst that produces the outcome (agent), and external factors (environment). Research to date has focused on the injury event. There is a lack of studies examining both the pre-event phase, and the interaction between host, agent, and environment among women in agriculture.

Introduction

This paper will examine exposure to occupational injury-producing events among women in agriculture within the context of gendered role and Haddon's Injury Model. Gender affects the type and extent of women's involvement in farming (Saito & Spurling, 1992). Studies have shown that what is considered an appropriate division of labor, and thus exposure to farm tasks, varies from region to region, from group to group, and even from family to family (Adams, 1994). Each farm family has its own set of values that are influenced by the family's ethnicity, socioeconomic status, level of education, and cultural traditions (Weinert & Burman, 1994). These values influence the division of labor on farms, and women's potential exposure to multiple roles, factors contributing to occupational illness, stress, fatigue, and agricultural injuries.

According to Haddon, injuries do not occur by accident (Haddon, 1968). Injuries occur because of an uncontrolled interaction between a host (farm woman), an agent of injury and the environment. Injury agents are forms of energy (mechanical, chemical, thermal, electrical) transferred to the host by a vector (animate object, e.g., animal, insect) or vehicle (inanimate object, e.g., machinery, tool, chemical, slippery surface). Haddon noted that factors contributing

to injury could be present pre-event, during the injury event, and post-event. The pre-event phase addresses all the factors that increase the likelihood that a person will be exposed to a particular environmental hazard. The event phase involves the interaction of the person with the etiologic agent (slip on wet floor). The post event phase focuses on whether the severity of injury consequences can be reduced, i.e., maximizing salvage once damage has been done to reduce the likelihood of death or a disability event. Host, agent and environmental factors are addressed in all three phases. (Baker & Haddon, 1974; Haddon, 1968,1980). An example of how Haddon's Matrix can be applied to farm women is illustrated in Table 1.

Table 1. Haddon's Matrix				
	Phase	Host	Agent (Vector)	Environment
Pre-event	Leg too short to easily reach tractor pedal	Pedal is difficult to depress secondary to angle of foot and decreased strength	Raining, helping husband in unfamiliar farm task because hired man is ill	
Event	Shoes with smooth soles	Foot slips off brake	Tractor has no rollover protection	Tractor hits uneven ground and rolls over
Post-event	Pre-existing diabetes interferes with healing	Farm wife is pinned under tractor	Far from emergency aid	

Profile of Farm Women

According to the 1998 Statistical Abstract of the United States, 23.1% of farm operators and managers and 19.0% of farm workers are female. According to the latest census conducted by the U.S. Department of Agriculture in 1997 (USDA, 1999), women operated 165,102 farms (8.6% of all farms). Of this total, 45.5% of female farm operators listed farming as their principal occupation compared to 50.1% of male farm operators, that is, more than half of all female farm operators listed an occupation other than farming as their principal occupation. Farms operated by women are smaller than the national average of 487 acres (Effland, Hoppe, & Cook, 1998; USDA, 1999). In 1997 almost 43% of female-operated farms were less than 50 acres, while only 28% of male-operated farms were less than 50 acres. Most female-operated farms (68.5%) had sales of less than \$10,000 compared to 48.7% of male-operated farms.

Female farm operators on average were older and more likely to own the land they farm. The average female farm operator was 58 years old in 1997, compared to an average age of 54 years

among male farm operators. Among the female operators, 79.9% were full owners (USDA, 1999).

Census of Agriculture data most likely under-represents the role of farm women, because only one primary operator per farm is counted in the Census. The Census does not classify women who farm alongside their husbands as operators, unless they are the primary operators, nor does the Census tally more than one operator in partnerships. The population census records data only on individuals' principal occupations and does not count people who farm as a second job. Thus, the farmer count in the population census is below that of the agriculture census. However, the population census does record more than one operator per farm where spouses or grown children are partners in the work. Unfortunately, information on farm characteristics is not available from the population census (Effland, et al., 1998).

Women's Contributions to Agriculture

Invisible Farmers — To date, few studies have examined work-related unintentional injuries in farm women. Two major factors may contribute to this lack of research. The first factor is the invisibility of farm women's work (Sachs, 1996; Walter & Wilson, 1996; Whitener, Sachs, Ross, Kalbacher, & Salant, 1985; Reed, Westneat, Browning, & Skarke 1999). The second factor is the gendered division of labor on farms (Bokemeir & Garkovich, 1987; Feldman & Welsh, 1995; Hardesty & Harmon, 1994; Rosenfeld, 1986). Until the late 1970's, women in agriculture were virtually ignored by both the government and rural scholars (Walter & Wilson, 1996). More recently, however, increased emphasis has been placed on women's work roles within agriculture (Rickson, 1997).

Role — A growing number of farm women participate in the farming operation as managers by marketing farm products, maintaining computer records, making purchases and helping with long term planning (Taylor, 1997). In recent years a trend toward larger farms and smaller families has resulted in more daughters entering the farming business, either as partners with other family members or as independent operators (Henderson, 2000). However, findings from a 1997 poll of a random sample of 964 farm women from the Farm Journal publication database suggested that traditional roles were still the norm (Taylor, 1997). Forty-one percent continued to describe themselves as their husbands' assistants on the farm and 34% described themselves as silent partners. Farm women spent an average of 21 hours per week working off the farm, 22 hours per week working on the farm, and 35 hours per week engaged in household and family duties. Lee's (1995) research highlights that 86% of women with children working on Wisconsin dairy farms participate in off-farm work, with more than half of them working more than 20 hours/week. These findings raise the issue of occupational exposure risk for farm women. For example, farm women who spend most of their time in farm management duties have different pre-event exposures to injury producing agents than farm women who participate in traditional farm work.

Recently, Reed et al. (1999) examined the role of farm women in Kentucky and Texas. The authors reported that although 46% of women in both states characterized themselves as farm homemakers, they regularly engaged in farm work. Reported farm tasks included work with

animals, tobacco-related chores, field irrigation, farm equipment operation, and farm management. The authors concluded that "role definition may influence a woman's perception of risk on the farm, preclude participation in farm safety programs, and prevent an accurate occupational medical history" (p. 317). For example, farm women who describe themselves as farm wives and who also work off the farm in other physically strenuous jobs may not be asked about farm related exposures when they present to their doctor with back pain. Women who describe themselves as homemakers may not perceive themselves at risk for farm-related injuries because they may not see themselves as exposed to farm tasks on a regular basis. For example, helping with tobacco by riding on the back of a tobacco setter may not seem to be risky behavior, however, risk of poisoning occurs when women inhale carbon monoxide from defective tractor exhaust systems as they ride behind the tractor (Struttman, Brandt, & Scheerer, 1997).

According to Bokemeir and Garkovich (1987), gender division of labor and authority in farm households is conditioned by individual self-identified role. Women who see themselves as agricultural partners and producers are more integrally involved in farm tasks. Perceived self-efficacy (belief in ability to do the work) also plays a key role in determining women's attitudes toward farm work and their participation in farm tasks (Pearson, 1979; Keating & Little, 1994; Alston, 1995).

Participation in Farm Tasks. Participation in farm tasks exposes women in the pre-event phase to potential injury events. Several studies have documented the wide variety of tasks in which farm women participate. Activities most frequently cited include taking care of the vegetable garden and animals (including milking), bookkeeping, running farm errands and helping with harvesting. Tasks less commonly performed are plowing and other fieldwork with machines, making major purchases, supervising hired hands, and marketing products. Women were least likely to help apply herbicides, fertilizers, or insecticides (Bokemeier & Garkovich, 1987; Hardesty & Harmon, 1994; Reimer, 1986; Rosenfeld, 1986).

Size of farm, farm commodity, marital status, control of land, children on the farm, husband's off-farm work, education, and experience in farming all affected the extent to which women were involved in tasks and decisions. Women who lived on smaller farms, controlled land (i.e., name on deed or lease), or were not married performed more farm tasks than women who either lived on larger farms, did not control land or were married. Having children, husband's off-farm work, higher level of education and farming experiences were all associated with women participating in more farm tasks (Alston, 1995; Bokemeir & Garkovich, 1987; Buttel & Gillespie, 1984; Feldman & Welsh, 1995; Reimer, 1986; Rosenfeld, 1986; Reed et al., 1999).

Differences in exposure to farm tasks are related to farm commodity. Women on dairy farms spend a considerable amount of time involved in farm tasks (Wilkening & Ahrens, 1979; Sander, 1986; Sachs, 1996). Bokemeir and Garkovich (1987) surveyed 880 Kentucky farm women and reported that women who lived on farms with livestock operations routinely had higher levels of involvement in farm production than those who lived on farms with crop operations. Women who resided on diversified farms had the highest level of involvement. Thus, farm commodity may be related to exposure to potential injury events, because commodity affects both the amount of manual labor required and the tasks that need to be done on the farm.

Restructuring of the farm economy also has an effect on women's exposure to agricultural tasks. In the past, during times of economic crisis, farm women increased participation in alternative agricultural enterprises, such as chicken and egg production to provide additional income. However, off-farm employment now offers the most common diversification strategy for U.S. farmers (Ollenburger, Grana, & Moore, 1989; Rosenfeld, 1985) and an escalating number of farm women have off-farm employment. Yet, many women continue regular farm and household tasks in addition to outside employment (Alston, 1995; Sachs, 1996; Garkovich, Bokemeier, & Foote, 1995). Gallagher and Delworth (1993) refer to "the third-shift" phenomenon in which farm women attempt to balance home, employment away from the farm, and farm work. Women in rural communities are often sandwiched between caring for elderly and children. This was emphasized in a study in which farm caregivers of elderly family were found to spend more time in household-related activities compared to rural nonfarm and urban counterparts (Horwitz & Rosenthal, 1994). These added responsibilities can lead to role overload and increased stress. "Whatever additional roles they assume, most farm wives are still expected to do 'the little of everything all at once' that keeps the farm business and family life running smoothly" (Delworth, Veach, & Grohe, 1988, p. 424). Added economic stresses, along with role overload, are consistent with the Farm Family Stress and Injury Model and recent psychological reports (Kidd, Scharf & Veazie, 1996; Mulder, et al., 2000). These multiple roles may add to the risk of injury in the pre-event phase because of stress and fatigue. Although male farmers also take off-farm jobs, women have the added burden of household responsibilities and may feel stress because they are not able maintain the household in the way that they would like (Garkovich, Bokemeier, & Foote, 1995).

Injury Risk in Context of Host, Agent and Environment

With few exceptions (Stueland, Lee, Nordstrom, Layde, Wittman, & Gunderson, 1997; Reed et al., 1999), previous occupational studies targeting farm women have focused on cancer (Alavanja et al., 1994; McDuffie, 1994; Pottner, & Zahm, 1994) and reproductive issues (Fenster & Coyle, 1990; Goulet & Theriault, 1991; McDonald et al., 1988; Willis, De-Peyster, Molgaard, Walker, & MacKendrick, 1993). However, as illustrated by the farm roles and tasks identified above, farm women are exposed to a multitude of biologic, chemical, physical, and mechanical agents in the pre-event phase. Whether these exposures result in uncontrolled transfer of energy and an injury outcome depends on factors intrinsic to the individual (host), a catalyst that produces the outcome (agent), and external factors (environment).

Host Risks for Injury — Several host factors contribute to farm women's exposure to injury-producing events. Social cultural and psychological factors already identified, such as role identity (Bokemeier, & Garkovich, 1987; Pearson, 1979), self-efficacy (Bandura, 1991), and perceived vulnerability to injury (Beyth-Marom, Austin, Fischhoff, Palmgren, & Jacobs-Quadrel, 1993; Slovic, 1987; Zuckerman, 1994), affect the types of tasks performed and thus pre-exposure to potential agents of injury. Physical factors such as age, physical stature, and physical health status (osteoporosis, chronic illness, vision problems), use of medications (balance, hypotension), fatigue and stress in the pre-event phase have all been reported to contribute to occupational injury (Cordes & Rea, 1988; Pheasant, 1991; Brison & Pickett, 1992; Pickett, Chipman, Brison, and Holness, 1996; Wright, 1993). Knowledge about safety and use of

personal protective equipment, and beliefs about preventing injuries, may affect safety behavior in the pre-event phase (Long, 1993; Dewar, 1996; Lexau, Kingsbury, Lenz, Nelson, Voehl, 1993). Additionally, immunization status, farm women's definition of injury, health seeking behavior, age, and physical health may affect recovery in the post-event phase.

Few studies reported ages of injured women farmers. When age was reported in studies that included both male and female farmers, age was not stratified by gender. Average ages of farm women in studies have ranged from the mid thirties to the late forties (Cogbill, Steenlage, Landercasper, & Strutt, 1991; Lewis et al., 1998). Myers and Hard (1995), reporting on a review of 6,727 fatal agricultural injuries between 1980 and 1989, found that only 1.5% of the deaths were women, and many of these were older women. Although many older adults are healthy, as women age they are more susceptible to age-related changes and chronic illnesses that can affect their ability to avoid as well as recover from injury (Archbold, 1999). Myers et al., (1999) reported that the death rate of female farm workers age 55 and older was twice that for females under age 55. Older farm women also may have reduced immunity to tetanus following injury (Gergen et al., 1995; Schatz, 1998). According to Keating and Little (1994), women's roles change through the life cycle, and thus exposure to injury-producing events may change with age.

Women have anatomical and physiological differences that may place them at risk for farm injuries (Engberg, 1993). Females are, on average, shorter than men and have more adipose tissue. Females also have narrower shoulders, wider hips and proportionally have shorter legs and arms than their male counterparts (Mackay, & Bishop, 1984). On average upper body strength is 40% - 75% less in females than in males, while lower body strength is 5% - 30% less in females (Falkel, Sawka, Levine, Pimental, & Pandolf., 1986). The higher prevalence of shoulder-neck disorders among women in industry has been associated with weaker muscle strength in the upper body (Kilbom & Broberg, 1988). However, other literature reports that both strength and endurance were similar for men and women when body composition and size were controlled (Falkel, Sawka, Levine, & Pandolk, 1985; Hosler & Morrow, 1982). Whole body vibration affects women more than men because of anatomic and physiologic characteristics. Circulatory changes in the pelvic organs were found in a study of female tractor drivers; vascular tone decreased and venous stasis occurred at times, depending on the intensity and duration of the vibration (Engberg, 1993). Excessive physical strain has been associated with injury events in women (Pickett, Brison, Niezgod, & Chipman, 1995). Ahonen, Venalainen, Kononen and Klen (1990) reported the physical strain of dairy farming to be high in women because of heavy work tasks and relatively low maximal oxygen uptake (VO₂max).

Women may also be more susceptible to some types of injury. For example, entrapment of the median nerve in the proximal forearm (pronator syndrome) is more common in women and has been identified in Swedish female milkers using milking machines (Stal, Hagert & Moritz, 1998). Layne and Landen (1997) examined emergency department hospital records of workers aged 55 and older. Women workers accounted for 63% of falls resulting in fracture dislocation and hospitalization. Most falls occurred on stairs or steps while the women carried objects. Research also has demonstrated that falls are a common mechanism of injury among farm women. Nordstrom et al., (1996) reported that although the crude rate for falls was higher for men, the rate based on hours worked was higher for women. Among a case series of 154 injured

farm women, 26% of injuries resulted from falls (McCoy, 2000). A study among farm women in Texas and Louisiana found falls to be the second leading cause of external injury (Carruth et al., 2001).

Women farmers may also be at higher risk for musculoskeletal disability. Leigh and Fries (1992) examined subsamples of men and women from the National Health and Nutrition Examination Survey (NHANES I) Epidemiological Follow-up (NHEFS) conducted from 1982 to 1984 (N = 6,096). Farming was the longest held occupation with the highest disability for women.

Cooper, Buffler, and Wagener (1993) examined data obtained from the National Center for Health Statistics' 1980 National Health Interview Survey, the first survey to collect data on longest-held occupation and industry employment. Women age 65 and over were more likely than younger women to report farm labor or farm foreman work as their longest-held occupation. In those less than 65 years old, a greater percentage of female (26.0%) than male (15.2%) farm laborers and farm foremen reported some limitation of activity. Also, nearly 32% of the women farmers and farm managers reported limitations of activity compared to 17.2% of the male farmers and farm managers. Women in farming, including farm management and farm labor, reported over a month of restricted activity days per person per year. However the reasons for restriction were not reported. For example, it is not clear to what extent disability contributes to restriction of work or the risk of injury.

The literature suggests that farm women do not have the same access to transfer of knowledge in the farming culture as do male farmers. Leckie (1996) interviewed 32 female farmers from southern Ontario and reported that the division of labor by gender constrains the information passed on to farm women. According to Leckie, "parents as definers or interpreters of farming skills, combined with hands on work experience, are key elements in the intra-family transfer of agricultural information . . . parents construct and maintain various social limitations on the amount and type of agricultural information that their daughters are potentially able to gain" (p. 317). A major constraining factor for transfer of knowledge was the attitude parents held about what is acceptable farm work for girls. Additionally, current farm-related agricultural extension services are geared toward male farmers (Saito & Spurling, 1992).

Zeuli and Levins (1995) reported that among women farmers in Minnesota, lack of knowledge was a major issue. They reported that sons were given more opportunities to learn about farming than daughters were, because sons were considered the future farmers. One farm woman related that it was only after she took over the family farm that her father taught her how to farm. Others have reported that daughters were less likely to be taught about tractors (Kidd, Townley, Cole, McKnight, & Piercy, 1997) and were less familiar with rollover protection (Schulman, Evensen, Runyan, Cohen, & Dunn, 1997). Jones-Webb and Nickols (1984) identified care and operation of large equipment among the educational needs of farm women.

A widely held belief is that farm women are more concerned with safety on the farm than men. This difference is difficult to assess from the literature due to the differences in the measurement of variables. In an attempt to compare priorities among men and women, Dewar (1996) determined that women were most concerned with farm health (breathing, trauma, skin disease, hearing loss, chemical exposure, and occupational cancer) and the need for screening (dosimetry,

spirometry, pesticide exposure) while men were most concerned with counseling services provided to address accidents. However, in a random sample of farm operators in Kentucky, researchers found no significant sex differences in tractor safety perceptions and behavior (Cole, Westneat, Browning, Piercy & Struttmann, 2000). This raises an interesting question: Are men just as likely as women to be concerned with safety, or are women just as likely as men to give in to economic/environmental pressures?

Vehicle/Vectors of Injury — Few studies have examined the vehicles and vectors (agents) associated with injury in farm women and most have been case reports. Four cases of scalping among women farmers baling hay in New York (MMWR, 1992; Roerig, 1993) illustrate this point. The incidents occurred when the farmers dismounted tractors and approached hay balers, with the power take-off unit (a rapidly rotating shaft) still engaged. While adjusting the baler, they placed their heads in close proximity to the exposed unit to reach adjusting levers, and their hair became entangled in a secondary drive line on the balers used to power a bale thrower. These women suffered severe injuries and months of despondence, disfigurement, loss of body image, and inability to return to work on the farm. In these particular cases the interaction between the hosts, and the vehicles of injury resulted in severe injuries. The injury event occurred when mechanical energy of the drive shaft was redirected to the women. Several prevent host factors present in these women, not necessarily present in a male counterpart, might have placed women at higher risk for injury than men during the event phase. These factors include; long hair, shorter stature and less body mass and strength than men (Mital & Kumar, 1998).

Equipment size and length of time driving equipment also may be a factor in injuries. Most farm equipment is sized and designed for men. The placement of levers and the strength required to move them may be more suited to the average male. Driving tractors an average of one day a week has been found to increase the risk of nonfatal farm injury (Carruth et al., 2001).

Large animals have also been identified as vectors of injury for farm women. Studies support that the presence of large animals on the farm contributes to risk of injury and death (Browning, Truszczynska, Reed, & McKnight, 1998; Carruth et al., 2001; Gerberich et al., 1994; McCoy 2000; Myers, et al., 1999; Stueland et al., 1997). The force of impact on the body between the large mass of animals and a hard surface (e.g., fence, wall of barn, ground) contributes to crushing injuries. Bites and kicks contribute to injury with various degrees of severity ranging from contusions to complex fractures.

Environmental Risks — The environment includes both the physical and the social-cultural environment. By nature of their work, and home farm women are exposed to multiple environmental risk factors. The physical environment includes farm commodity, maintenance, and weather related issues. Examples of hazards in the physical environment that may increase the risk of falls include loose boards, uneven or cluttered floors, and wet slippery floors, from water, cleaning agents, urine, manure or hay. Temperature extremes result in icy conditions or risk of heat related injury. For example, a woman who feeds small calves in the winter, may have to carry milk across icy ground to another building. The same women may be exposed to caustic cleaning solutions used to clean milking equipment, or high environmental temperatures in the summer.

Women who work in dairy farming may be at special risk for occupational injury. Nordstrom et al., (1995) reported that dairy farmers were 2.5 times more likely to be injured than residents of other types of farms. Boyle et al. (1997), in a case control study of dairy farmers, found that milking and feeding caused most injuries. In that study 52% of the injuries occurred among women. Many injuries were reported to have occurred in barns, or while carrying out tasks such as feeding or milking (Nordstrom et al., 1995; Pickett et al., 1995; Reed et al., 1999; Boyle et al., 1997; Stueland et al., 1997). Unfortunately little information is known about the pre-event factors.

Social cultural factors that contribute to injury include cultural norms regarding the division of labor on farms and economic pressures. Traditionally women have cared for animals (Sachs, 1996) and animals have been identified as vectors of injury. However, little is known about the effect of division of labor and other risks for injury. For example, are women more likely to be injured "while helping out" or while working independently? A review of narrative data from a case series of injured farm women suggests that women may be at risk for injury while working on the ground around others who are operating tractors, however it is not known whether this risk is greater for women than for men (McCoy, 2000).

Economic pressures and the third-shift phenomenon result in long hours of work without rest and increased hours of exposure to potential injury producing agents (Delworth et al., 1988; Gallagher & Delworth, 1993; Garkovich et al., 1995). The added pressures of multiple roles, including concurrent on and off-farm employment was recently cited as contributing to depression in rural and farm women (Gallagher & Delworth, 1993; Mulder, et al., 2000). To date studies have not examined the relationship between injury and combined social cultural factors.

Limitations of Current Research

Injury control includes identifying a problem, designing and implementing programs and interventions to address that problem, and evaluating the results (Kidd et al., 1996). Researchers are beginning to establish that some agents (vectors) such as animals, are associated with injury in farm women to a greater extent than other agents (Pickett et al., 1995; Stueland et al., 1997). Studies also support that certain types of injuries, particularly sprain/strains, fractures, bruises, and wounds are more common than other types of injuries (e.g. poisoning, burns) in farm women (Hopkins, 1989; Stueland, Zoch, Stamas, Krieg, & Boulet, 1990; Stueland et al., 1997).

National studies of fatal and nonfatal agricultural-related injuries among women have rarely been reported. Most research has been descriptive in nature, reporting only the incidence of a particular injury and the percentage of injuries associated with a particular agent. Some studies reported very low incidence of injury in women compared to men; other studies found similar incidence, and still others studies found a higher incidence of injury in women. In a study in New York, the injury rate to women was one-third that of men (Pratt, Marvel, Darrow, Stallones, May, & Jenkins, 1992). Brison & Pickett (1992) reported a much higher proportion of injuries among women (45.3%) from a study in eastern Ontario, Canada). One study demonstrated different patterns of injury within a single age group of men and women (Pickett et al., 1995) suggesting possible differences in exposure. However, the type of injury studied (i.e.,

mechanical, tractor operations) and status of the farmer (farm operator) might have resulted in selection bias, particularly if women were not considered farm operators or were engaged in different tasks than their male counterparts. Unfortunately it is difficult to compare studies because they used different populations, different methods to collect data, and different definitions of injury.

Although researchers are beginning to address issues related to women in agriculture, many limitations are evident. For example, Stueland et al. (1997) addressed only injuries that required medical care, and the study was limited to one geographic region within one state where dairies were the primary farming operation. Reed et al. (1999) suggested that role may be a factor in injury risk, but did not compare farm tasks performed by homemakers to farm tasks performed by other farm women. Additionally, rather than conducting separate analysis of data by gender, gender was treated as a confounder in some studies (Boyle et al., 1997).

Another limitation of current studies is the type of data collected. Most studies have focused on the injury event using quantitative data. The USDA collected narrative data along with quantitative data during its 1993-1995 Traumatic Injury Surveillance of Farmers (TISF) survey project, but did not link the data (McCoy, 2000). Yet within the narrative data were descriptions of how women were injured while working with animals or helping their husbands that provided information about the pre-event phase (McCoy, 2000).

Recommendations for the Future

Although studies to date suggest that farm women may be at risk for injury, no studies have analyzed the relationships between host, agent, and environment. Research is needed to analyze host, agent, and environmental factors contributing to injury risk in order to develop intervention models to reduce the risk of injury. Little is known about the pre-event phase of injury for farm women, yet preventive measures used in the pre-event phase have the greatest potential to reduce injury (Baker & Haddon, 1974). Also, it is unclear how the changing social and cultural environment affects women's roles and exposures associated with farm work. Studies should examine how changes in women's roles within agriculture affect women's risk for occupational injury. Future studies also should examine age-specific rates of injury among farm women. For example, are age-specific injury rates different for female farm operators, partners, helpers, homemakers or employees?

More research is needed to explore the relationships between injury to farm women and the social, cultural, and economic aspects of the work environment. For example, do men and women differ in risk perception and risk taking behavior? How do women's roles affect safety knowledge transfer to females in the farm household?

Little is known about specifics of exposure to injury agents in farm women. Studies are needed that examine dose response relationships between exposure and injury outcome. Are women being injured while performing farm tasks they do every day or during farm tasks in which they only occasionally participate or complete? In a study that was not stratified by gender, Nordstrom et al., (1995) reported when injury rates were adjusted for hours worked, the injury

rate was highest among persons working the fewest hours and lowest among those working the most hours. What aspects of work with animals contribute to the most injuries? Except in one study (MMWR, 1999), back injury (the most common source of disability in the non-agricultural workplace) has not been addressed for farm women. Carruth, Skarke, Moffett, & Prestholdt, (2001) examined chronic conditions as risk factors and reported that farm women who reported recurrent back pain in the preceding 12 months were two times more likely to sustain a nonfatal farm injury. Women who reported weakness had a four-fold risk for nonfatal farm injury.

Engineering research should be conducted to design machinery and equipment that is ergonomically appropriate for smaller body frames. In Sweden, where women comprise a large proportion of farm workers, innovations in technology and engineering modifications have been made (Stål et al., 1994), but these advances have not been universally adopted. Within the physical environment research is needed to identify what aspects of the physical environment in the pre-event phase contribute to the most injuries in women. For example are stanchion barns particularly dangerous? Little is known about musculoskeletal disorders in farm women, yet both NIOSH and OSHA recommend ergonomic improvements in industry to combat the high incidence and prevalence of musculoskeletal disorders. Research needs to evaluate how working both on and off the farm affects the incidence of musculoskeletal disorders in farm women. It is reasonable to assume that a synergistic effect may exist, placing farm women who hold multiple jobs at even greater risk for musculoskeletal disorders and subsequent disability.

Researchers should include both quantitative and qualitative design components and link these data. Qualitative research provides a fuller and richer description of the injury circumstances across the pre-injury event, time of injury, and post injury phases (Reed, 1996). Qualitative methods are most useful when little is known about the phenomena under study (Strauss & Corbin, 1990). For example quantitative data may only report one mechanism of injury (kicked by a cow), yet both a direct and indirect mechanism might be involved and actually increase the severity of injury, (e.g., knocked down by an unrestrained cow while engaged in breeding procedure). Triangulation of research methods can provide a more complete understanding of farm injury. Qualitative data also allows the injury event to be analyzed within the context of the work situation. These types of complementary methods of inquiry may yield a more complete understanding of women's farm injury.

Summary

The 1997 Census of Agriculture demonstrated a continued increase in the number of female farm operators. There has been an increased interest in women farmers by the USDA (Effland et al., 1998), and women are becoming more organized as evidenced by greater visibility of the Women in Agriculture organization. A recent study conducted for Top Producer (Taylor, 1997), reported that one out of every four women view themselves as a manager in the farm family business, actively partnering on their own or with their husbands in the farm operation.

A trend to both larger farms and smaller families are allowing women to pursue farming aspirations once reserved for sons. The National Foundation for Women Business Owners (NFWBO) reported that women-owned agricultural firms increased nearly 60% over the past

seven years, compared with less than a 40% increase in traditional industries like services and retail. Many women are taking over management aspects of the farm rather than participating in traditional farm tasks, while others are tackling traditional male roles (Henderson, 2000).

It is evident that women will be an increasing force in agriculture. It is also evident that women in agriculture take on many roles and that these differing roles place women at risk for different types of injuries. Examining role within a framework such as Haddon's Injury Model, with emphasis on the pre-event phase, and event phase will assist researchers in designing studies that address the interaction between host agent and environmental factors. The inclusion of qualitative methods will enrich the research base and aid in the identification of both direct and indirect mechanisms of injury. Results from these studies can be used to identify intervention foci in the pre-event phase.

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