Sex Differences in Work-related Injury Rates among Electric Utility Workers

Michael A. Kelsh1 and Jack D. Sah2

Few epidemiologic studies have evaluated sex differences in work-related injury rates. In this study, the authors examined injury trends by type of injury, severity of injury, and how the injury occurred among a cohort of 9,582 female and 26,898 male electric utility workers employed during 1980–1992 by the Southern California Edison Company. Sex-specific unadjusted injury rates were higher throughout the period for male workers. However, after adjustment for occupation, job experience, and age, elevated rate ratios indicate that female workers have higher injury rates. Mantel-Haenszel summary rate ratios and 95% confidence intervals were 1.49 (1.43–1.54) for all types of injuries, 1.27 (1.16–1.39) for head and neck injuries, 1.48 (1.38–1.58) for upper extremity injuries, 1.11 (1.01–1.21) for back injuries, and 2.11 (1.97–2.25) for lower extremity injuries. The rate ratios were slightly higher for more severe injuries, which suggests that potential reporting bias was not a likely explanation for these findings. The authors conclude that differences between male and female workers in training, physical capacity, task assignments, and other factors could explain these injury trends.

Women now account for a larger percentage of the active work force than in earlier decades (1, 2), and women are expanding into traditionally male-dominated trade and craft occupations. As a result of these trends, there are now more women in occupations that historically have had higher injury rates (3). If injury rates are different for male and female workers, it is important to determine what factors explain those differences so that training and injury prevention programs and better work practices can be appropriately designed and implemented.

Few epidemiologic studies have evaluated whether women are at increased risk for work-related injuries, or, if they did, they have not been able to explain why sex differences in injury rates exist. A study using Bureau of Labor Statistics data reported that males and females had approximately equal injury rates (4). However, this study included broad and heterogeneous occupational classifications that could potentially mask the sex differences. Studies among postal (5), trade (6), and semiconductor industry workers (7) and among army trainees (8) have suggested that females are at higher risk for occupational injuries or musculoskeletal problems. Because the four positive studies relied on more accurate exposure data and better control of potential confounders (using more homogenous occupational categories), it seems likely that women are at higher risk for work-related injuries in these occupations.

Possible explanations for these sex differences include the following: 1) physical capacity differences exist between men and women (9); 2) workplace designs are more appropriate for males than females (10); 3) women have additional physical and stress demands due to parental and household responsibilities (11, 12); and 4) women are more likely to report injuries (5).

We examined work-related injury trends to ascertain if female electric utility workers were at higher risk for work-related injuries than their male counterparts in the same occupation, age, and job experience categories. Data from an injury surveillance system also allowed us to examine sex differences by severity, type of injury, and how the injury occurred.

MATERIALS AND METHODS

The study population consisted of active workers at the Southern California Edison Company, an electric utility company. The work-related injuries occurred between January 1, 1980 and December 31, 1992. A description of the injury was provided by the worker,
coworker, or supervisor. Lost days due to the injury were reported by the worker’s department to claims/health and safety offices and the payroll department. We included all Occupational Safety and Health Administration (OSHA) “recordable” injuries (lost time injuries, restricted duty injuries, and injuries that required medical attention) and first aid injuries. The number of work-related injuries that are not reported is unavailable. However, it is likely to be small because of the emphasis on health and safety, the stable workforce, and health care coverage offered to all employees.

Work hour information, used to determine the time at risk for an injury and the amount of time lost due to a work-related injury, was abstracted from payroll data files and summarized into occupation, age, sex, job experience, and work location categories. Job experience was determined as the length of time that the individual worked in a specific occupational category and was recalculated when a worker entered into a new occupation.

**Classification systems**

We developed classification systems for body regions affected and nature of the injury, for injury severity, for occupations (job titles), and for work locations. Four codes were used to describe the injury and its health consequences (13). Briefly, these were: 1) the part of body affected, 2) the nature of injury, 3) how the injury occurred, and 4) objects or work activities associated with the injury event. This analysis focused on part of body, nature of injury, and how injury occurred classifications.

Injury severity was classified by the amount of lost workdays following OSHA guidelines (14). The four classifications used were: 1) lost time injuries, 2) restricted duty injuries, 3) non-lost time recordable injuries, and 4) first aid injuries. Each of these categories are mutually exclusive. Lost time injuries are injuries that result in at least one full day of lost work after the date of injury. Injuries that require the worker to perform light duty or limited activities are considered restricted duty injuries. Non-lost time recordable injuries are injuries that were serious enough to require medical attention. Non-lost time injuries can involve lost work time, but this time amounts to less than one full day. First aid injuries are injuries that did not require medical attention other than standard first aid procedures. We have included first aid injuries in these analyses on the assumption that, in certain circumstances, first aid injuries could be representative of potentially more serious injuries (15). Information on the actual anatomical severity or hospitalization data rather than severity measured as lost time was not available for this study.

Over 4,000 job titles were grouped into 20 occupational categories based on similar work locations, job tasks, and physical demands. Over 200 work sites (offices, substations, and generating stations, etc.) were combined into work location categories that are similar with respect to the work activities performed and the type of exposures. In this classification system, each type of generating facility (e.g., gas, coal, hydroelectric, and nuclear) was grouped into a separate work location category.

**Analytical methods**

We first examined the sex-specific injury rates by calendar time, age, and job experience. We then calculated rate ratios and 95 percent confidence intervals for injuries by 1) occupational groups, 2) work location, 3) part of body, 4) nature of injury, 5) severity classification, and 6) how the injury occurred. Injury reports with missing information were excluded in the analysis that involved that classification. However, they were included in other analyses if relevant information was available.

Person-time injury rates were calculated as the number of injuries per hours worked. Injury rates were standardized per 200,000 hours worked, which is equivalent to 100 full-time workers working for one year. By using work hours as the “at risk” parameter (i.e., a person-time rather than a cumulative incidence rate), we can account for changes in time-dependent variables such as age and job experience. This method of rate calculations also allows for the occurrence of more than one injury per individual worker during the follow-up period. Even though multiple injuries for the same worker were included, each injury was considered an independent event in the statistical analysis.

Injury rate ratios were calculated as the ratio for females compared with males. Mantel-Haenszel stratified analysis methods (16) were used to estimate the summary or common rate ratios while controlling for occupation, age, and job experience. Greenland-Robins methods for estimating variances for sparse data were used in all stratified analyses (17). We classified age into four groups (<24, 25–29, 30–39, and ≥40 years) and job experience into five categories (1–3 months, 4–12 months, 1–4 years, 5–19 years, and ≥20 years) for stratified analyses. Age and job experience strata were defined in this manner to maintain relatively homogenous injury rates within each stratum. Strata with no female workers were excluded.

We addressed occupation in two ways: 1) by examining sex differences within occupations (occupation-specific analysis) and 2) by treating occupation as a confounding variable. For occupation-specific analyses, we have presented data only for the larger occu-
pational groups that had a reasonable number of female workers. Welders, machinists, and electricians were excluded because they had very few female workers. When occupation was treated as a confounding variable, all 20 occupational categories were included. These categories were further grouped into five broad categories (office-administrative/technical, office-clerical, plant workers, field workers, and other trade workers) for the stratified analyses.

RESULTS

Over the 13-year period, there were 9,582 female workers and 26,898 male workers in this dynamic cohort. The average annual workforce size was 4,102 females and 12,898 males. Female workers accrued over 95 million hours of follow-up time and male workers accumulated over 331 million hours of follow-up. A total of 26,902 injury reports were available for analysis among male workers and 4,536 among female workers. All of these injury reports had information on severity of injury (lost days). Among the 26,902 injuries to males, the analysis included 24,518 injuries (91 percent) with part of body classification, 23,665 (88 percent) with nature of injury classification, and 25,032 (93 percent) with “how the injury occurred” classification. Among the 4,536 injuries to females, the analysis included 4,180 injuries (92 percent) with part of body classification, 4,049 (89 percent) with nature of injury classification, and 4,228 (93 percent) with “how the injury occurred” classification. Injuries not included in the analyses either had missing information or were classified into “other” categories.

Sex-specific crude injury rates have been decreasing over the period for both males and females. However, males experienced substantially higher injury rates than females throughout the follow-up period (figure 1). Without controlling for occupational group, the unadjusted rates for males were also higher than females for all age groups, with the largest differences in rates among younger age groups (figure 2). Males also had higher unadjusted rates for all job experience groups (data not shown). Although the unadjusted rates for males were always higher, the pattern of injury occurrence by age and job experience was similar for both sexes i.e., younger, less experienced workers had higher injury rates.

Occupation and work location

The age/job experience-adjusted injury rate ratios for selected occupational groups are shown in table 1. The trend of higher rates among male workers, evident from the crude rates, were reversed once we examined the rate ratios within specific occupational groups. Among trade and craft workers (line crews, plant and system operators, mechanics, and laborers), the rate ratios ranged from 1.6 to 2.1, with all of the lower 95 percent confidence limits exceeding 1.0. The overall female/male rate ratio, adjusting for occupation, age, and job experience, was 1.49 (95 percent confidence interval 1.43–1.54).

Among office worker classifications, both supervisors and technical support staff had elevated odds ratios. However, for clerical and data entry staff, the odds ratios were at or below 1.0, which indicates that male workers had similar or higher injury rates in these occupational categories. Security officers had the highest rate ratio (3.1), while meter readers, the occupation group with the highest injury risk, had a rate ratio of 1.4 (table 1).

To evaluate whether some of the differences between male and female workers could be explained by work location, we examined the injury rate ratios for
specific work locations, adjusted and unadjusted by occupational category (table 2). For some locations (substations, nuclear generating stations, and hydroelectric generating stations), the unadjusted effect was larger among females. However, for most locations, males had higher rates than females when we did not control for occupational category. For all work locations, the rate ratios increased once we adjusted for occupational classification.

Part of body and nature of injury

For the part of body affected, the highest injury rate ratios were among the lower extremities, particularly hip and ankle injuries, and the lowest ratio was for back injuries (table 3). These effects were observed after controlling for occupation, age, and job experience.

Of the eight nature of injury classifications we selected, strains and sprains were the most common type of injury and resulted in the most lost work days (table 4). Surface wounds were the next most common injury type. For all types of injuries except “objects in orifice” (primarily particles in the eye), the rate ratios were greater than 1.0 (table 4).

We observed higher rate ratios (table 5) for more severe injuries (lost time and restricted duty injuries) compared with less severe injuries (non-lost time and first aid). Women appear at higher risk for most types of injury-producing events (how injury occurred) except for overexertion injuries and working with equipment injuries (table 6). Dog attacks, struck by/against events, falls, and job stress showed the higher injury rate ratios (table 6).

DISCUSSION

Our initial comparison of crude injury rates by sex suggested that males were at higher risk for occupational injuries than females. However, once we controlled for occupation, we found elevated rate ratios for female workers, which indicated that they had the higher injury rates. Thus, the higher unadjusted rates in males are explained by the fact that occupation was a very strong confounder in the relation between work-related injuries and sex. The increased risk persisted across a variety of injury outcomes defined in terms of the part of body affected, nature of injury, severity of injury, how the injury occurred, and where the injury occurred (work location). Women were at higher risk for both acute and chronic or cumulative injuries. These trends persisted for all electric utility occupations except occupations traditionally dominated by women (clerical office workers and data entry positions), where the rate ratios indicated higher injury rates for males.

These findings are consistent with earlier studies among postal workers (5), semiconductor industry workers (7), and army trainees (8). Among postal worker occupations, female letter carriers and letter sorting machine clerks had higher injury rates than male workers, whereas male and female mail handlers had similar rates. For the majority of occupational groups in the semiconductor industry, the injury rates for female workers were higher than male workers. Only “skilled labor” and clerical workers had higher rates among males. In all semiconductor industry occupational groups, except clerical workers, the average number of lost days per injury was higher for females. The overall relative risk of female to male army trainees was 1.8, similar to the relative risks observed in this cohort. Female army trainees also had higher relative risks for lower extremity injuries (relative risk (RR) = 2.1) and for stress fractures (RR = 5.1), with the risk for fractures being higher than the relative risk for fractures that we observed (8).

### Table 2. Injury rate ratios and 95% confidence intervals (CI) for selected work locations, adjusted and not adjusted by occupational category, among Southern California Edison electric utility workers, 1980–1992

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Injury rate ratio adjusted for age and job experience only (females/males)</th>
<th>95% CI</th>
<th>Injury rate ratio adjusted for occupation, age, and job experience (females/males)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>General office</td>
<td>0.6</td>
<td>0.56–0.63</td>
<td>1.2</td>
<td>1.10–1.27</td>
</tr>
<tr>
<td>District offices</td>
<td>0.8</td>
<td>0.74–0.82</td>
<td>1.6</td>
<td>1.73–1.93</td>
</tr>
<tr>
<td>Field services</td>
<td>0.4</td>
<td>0.33–0.47</td>
<td>1.3</td>
<td>1.08–1.61</td>
</tr>
<tr>
<td>Shop test</td>
<td>0.5</td>
<td>0.37–0.75</td>
<td>1.3</td>
<td>0.80–1.99</td>
</tr>
<tr>
<td>Substations</td>
<td>1.3</td>
<td>0.98–1.82</td>
<td>1.6</td>
<td>1.17–2.20</td>
</tr>
<tr>
<td>Generating station: oil/gas</td>
<td>0.6</td>
<td>0.68–0.91</td>
<td>1.3</td>
<td>1.14–1.54</td>
</tr>
<tr>
<td>Generating station: coal</td>
<td>0.9</td>
<td>0.79–1.10</td>
<td>1.8</td>
<td>1.52–2.18</td>
</tr>
<tr>
<td>Generating station: nuclear</td>
<td>1.4</td>
<td>1.26–1.50</td>
<td>1.7</td>
<td>1.52–1.89</td>
</tr>
<tr>
<td>Generating station: hydro-electric</td>
<td>1.6</td>
<td>1.21–2.21</td>
<td>1.9</td>
<td>1.40–2.53</td>
</tr>
</tbody>
</table>
The occurrence and impact of work-related injuries can be described as the consequences of four phases: 1) occurrence, 2) recognition, 3) reporting, and 4) response to the injury. Males and females may differ, to some degree, on all four phases of the injury phenomena.

Injury reporting involves not only reporting the event itself, but also reporting on how it occurred, the nature of injury, and what body parts were affected. If a strong reporting bias were present, we would expect to see increasing rate ratios for less severe injuries. This assumes that female workers were more likely to report injuries than males except for severe injuries, which would be equally reported by males and females. This trend was not observed. In fact, with less severe injuries, the ratios were lower than the ratios for the more severe, lost time injuries. A comparison of the objective and subjective nature of the injury can be a useful approach for assessing potential reporting bias. Injuries that have obvious tissue damage (i.e., fractures, burns, and surface wounds) are, in theory, less influenced by reporting bias. The risk for these types of injuries was higher among female workers. Injuries that are not as obvious with respect to visible tissue damage (i.e., strains, sprains, cumulative trauma) were even higher than for injuries with obvious visible tissue damage. The trends for injury severity and by nature of injury suggest that differential injury reporting occurred to some degree. This, however, is unlikely to
fully account for the observed differences in injury rates.

Response to the injury refers to the body’s ability to counteract, resist, or minimize the physical/environmental demand (i.e., the resulting health impairment), and the lost work time due to the injury. By part of body and nature of injury classifications, females generally had more average lost work time for the same type of injuries than did males.

Potential reporting bias in the occurrence of an injury and the possibility of differential response (lost time) to injuries by female workers that is not due to the actual clinical severity of the injury are two important limitations to interpreting the injury data. Our statistical methods may have produced overly narrow confidence intervals for injury rates because we assume independence of injury events when, in fact, individual workers reported more than one injury that may or may not have been an independent event. Among female workers who reported injuries, 77 percent reported one or two injuries, 13 percent reported three to four injuries, and 9 percent reported five or more injuries. Among male workers, the proportions were 63 percent, 20 percent, and 17 percent, respectively. Our analysis is based on the injury event (recorded as an injury claim) as the unit of analysis. We expect the bias in confidence interval estimation to be relatively small because most workers only reported one or two injuries, and separate injury claims generally represented distinct injuries. It is difficult to accurately quantify these biases. However, we conclude that these biases would not alter our general findings.

Assuming that differential reporting can only partially account for sex differences in injury risk, other factors must be involved. Different physical capacities between men and women in combination with workplace design are frequently cited as key factors in women’s occupational health (5, 9, 11, 18). Studies that have measured physical strength among men and women report that women have 30 to 70 percent less upper body strength than men and 5 to 20 percent less lower body strength (19). This implies that women in physically demanding occupations will be working closer to their physical capacity for longer periods of time, putting them at higher risk for both acute and cumulative injuries (19). “Average” males typically have more strength and aerobic capacity than “average” females. However, strength differences vary depending on the body region examined. Data on strength differences were collected nearly 15 years ago and may not be applicable today (18). Others have argued that physical capacity and strength differences result from differences in activities. After control for work and leisure activities, sex differences in physical capacity and strength will likely diminish (20).

We observed generally higher effects by sex among physically demanding occupations (table 1), which supported the theories that suggest physical capacities/strength differences are important injury risk factors. However, if differences in physical capacities were the main factor, the highest effects should have occurred among upper extremity injuries and low back injuries, since these are the body regions with the largest strength differences. In fact, in this cohort, the largest effect was for lower extremity injuries and there was very little difference for back injuries.

Ergonomic design factors include items such as overreaching to operate controls or perform work activities, working with knobs or tools with grips that are too large, or other factors (21). Most workplaces, especially trade and craft shops, are designed for men by men. Thus, the workplace design, presumably more suitable for male than female workers, will place additional physical demands on female workers and may contribute to increased injury rates. These factors may explain some of the sex differences for upper extremity injuries; however, they are probably not relevant for differences in lower extremity or fall injuries.

For the majority of occupational groups, it is likely that factors other than ergonomic and physical capacity also influence the differences in injury rates. Injury occurrence may be influenced by such work culture factors as 1) formal and informal training (11), 2) differences in work skills, 3) job task differences, and 4) less team cooperation or poorer communication in male/female work teams than in male-only teams (22).
Age and job experience may be considered proxy variables for formal and informal training. However, the formal training may not be appropriate for female workers, and females may not have the same access to informal training as males. Childhood and youth experiences, which probably exposed boys to more repair, maintenance, and construction activities than girls, may be important for future work activities and injury occurrence. Female workers may gain their first experience through on-the-job training experience. If potential training differences are important, we would have expected higher rate ratios for workers with less job experience. However, we observed that injury rate ratios across job experience categories did not consistently decrease (data not shown). These data trends do not rule out the possibility of a training effect. For example, as workers gain more experience, they may become involved in more complex tasks where training is relevant in preventing injuries. Different job task assignments within occupations are common. Often the younger workers will be assigned to more physically demanding tasks, and in some cases only the more experienced workers perform certain specialized tasks. Female workers could end up performing more difficult tasks because of work assignments or because they volunteer for the more difficult tasks to gain experience. All of these work factors limit our ability to use job experience as a surrogate for training.

In addition to sex differences in work practices and communication, there is an unresolved debate in regard to the potential health effects to women due to their multiple roles of parenting, domestic responsibilities, and occupational demands (9, 10, 18, 20, 23, 24). Despite some trends toward increasing parenting and household roles for fathers, the main change has been an expansion of women into the workforce, not a shifting of domestic responsibilities between men and women. Some researchers argue that the expanded roles of women as housekeeper, mother, and worker benefit women's health by improving self-esteem, social networking, and social economic status, and by providing multiple outlets for the release of stress and depression (24). Others suggest that women's health will be negatively affected because of workplace exposures, stress, and fatigue (25). As a consequence of their minority status, women may feel that they are under more scrutiny, which may create greater work stress (26). This debate is relevant to our results if we assume that stress, whether originating at home or in the workplace, is associated with, causes, or increases the reporting of work-related injuries (27). Among our cohort of utility workers, the rate of stress claims among female workers was higher than among males (rate ratio = 2.9). This suggests that female workers experience more work-related stress and that this could cause other types of injuries. At the time of these analyses, data on marital status or the number and ages of dependent children were not available to evaluate whether these factors influenced the occurrence, severity, or reporting of work-related injuries, as has been reported among aerospace workers (11).

Higher injury rates among male clerical workers, consistent with the injury trends among semiconductor manufacturing workers, has interesting implications (8). Potential explanations for this are 1) psychosocial factors, 2) task differences between male and female workers, and 3) ergonomic designs that may be more beneficial to female workers. The descriptive nature of the available data do not allow for further evaluation of these factors among clerical office workers.

Our finding that women have higher injury rates confirms the findings of previous research (5–7). In addition, we were able to show that females had higher injury rates across different body regions, injury types, injury severity (defined by OSHA criteria), and in most electric utility occupational groups. These specific factors were not evaluated in most of the previous research. The large cohort, relatively long follow-up period, and the numerous injury events led to precise estimates of risk. Our results and previous research essentially establish that an injury risk difference exists. However, they do not explain why there are differences. Research that focuses on women's occupational health issues, particularly injury, is limited. Further research may identify why women are at higher risk for injury and justify the need to develop specialized training, modify workplace design, or develop other injury prevention programs. Research that focuses on sex differences in injury risk should also provide information useful for the prevention of injuries among all workers.

ACKNOWLEDGMENTS

This work was funded by Southern California Edison Company, Health Research and Evaluation Division.

The authors thank Delia Games, Claire McCain, Beth Alexander, and Isabel Perez for coding and data abstraction; Frederick Sands, Linda Southwick, Karen Haines, and David Guggenheim for programming assistance; Dr. Sander Greenland for statistical assistance; Deborah Aseltine, Laura Riege, and Dr. Brock Bernstein for their comments on the manuscript; and Dena Sherick for technical assistance with the manuscript.

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