Published in final edited form as:

Occup Environ Med. 2014 December ; 71(12): 855–864. doi:10.1136/oemed-2013-101801.

Identifying gender differences in reported occupational information from three U.S. population-based case-control studies

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Competing interests None.

Contributors SJL and MCF conceived the study, designed the statistical analysis approach to assess gender differences across the three studies, and interpreted the data analysis. JSC, PAS, and DTS provided extensive feedback on the analytical design. SJL conducted all statistical analyses. The following authors were involved in multiple aspects of the specified studies, including initiation and design, development of tools to collect occupational and other information, and supervision of all aspects of data collection and uses of the study data: DTS, JSC, PAS, DB, MRK, KRA, NR, AJ, and MS for New England Bladder Cancer Study; PAS, MPP, WHC, JSC, KS, and FD for US Kidney Cancer Study; and PH, JSC, NR, AB, JRC, ADR, MPP, WC, RS, and PAS for National Cancer Institute Surveillance, Epidemiology, and End-Results Study of Non-Hodgkin Lymphoma. SJL and MCF drafted and revised the paper based on feedback provided by all authors.

Abstract

Objectives—Growing evidence suggests that gender-blind assessment of exposure may introduce exposure misclassification, but few studies have characterized gender differences across occupations and industries. We pooled control responses to job-, industry-, and exposure-specific questionnaires (modules) that asked detailed questions about work activities from three US population-based case-control studies to examine gender differences in work tasks and their frequencies.

Methods—We calculated the ratio of female to male controls that completed each module. For four job modules (assembly worker, machinist, health professional, janitor/cleaner) and for subgroups of jobs that completed those modules, we evaluated gender differences in task prevalence and frequency using Chi-square and Mann-Whitney U-tests, respectively.

Results—The 1,360 female and 2,245 male controls reported 6,033 and 12,083 jobs, respectively. Gender differences in female:male module completion ratios were observed for 39 of 45 modules completed by ≥20 controls. Gender differences in task prevalence varied in direction and magnitude. For example, female janitors were significantly more likely to polish furniture (79% vs. 44%), while male janitors were more likely to strip floors (73% vs. 50%). Women usually reported more time spent on tasks than men. For example, the median hours per week spent degreasing for production workers in product manufacturing industries was 6.3 for women and 3.0 for men.

Conclusions—Observed gender differences may reflect actual differences in tasks performed or differences in recall, reporting, or perception, all of which contribute to exposure misclassification and impact relative risk estimates. Our findings reinforce the need to capture subject-specific information on work tasks.

Keywords

gender; population-based studies; case-control studies; occupational exposure; occupational health

INTRODUCTION

Minimizing exposure misclassification in epidemiologic studies of occupational risk factors is essential to uncovering exposure-disease relationships. One potential source of exposure misclassification that is seldom evaluated is failure of the exposure assessment process to account for the presence of work-related gender (i.e., social and behavioral) and sex (i.e., biological) differences, hereafter collectively referred to as gender differences.[1–3] Potential causes and impacts of gender differences in exposure were previously described by Kennedy and Koehoorn.[1] They found that gender differences in work and task assignments occurred even when women and men had the same job titles. Gender differences in perception, recall and reporting occurred when job and task details were self-reported. Differences in body size, proportion, and muscle mass altered the fit of personal protective equipment, changed work position relative to an exposure source, and led to gender differences in biomechanical stresses. Reproductive and family demands over the life course can differentially affect when, where, and how often women and men work outside the home. Kennedy and Koehoorn[1] concluded that the direction and degree of gender-related differences in exposure were not always predictable *a priori*. More recent studies have supported their conclusions.[4–11]

Most studies have been unable to account for gender in the exposure assessment process because of a lack of knowledge regarding the effect of gender on exposure. Studies of gender differences in exposure have focused on specific occupations and industries, and most frequently on biomechanical stresses and workplace injuries.[8, 12–16] Few studies examined gender differences in exposure across multiple occupations and industries,[6, 11] largely because few population-based datasets are available with which to evaluate broad occupational patterns.

Our objective was to evaluate gender differences in employment patterns, occupations, work tasks, and task frequencies using pooled occupational data from controls in three National Cancer Institute-sponsored US population-based case-control studies that used job and industry specific questionnaires (modules) to collect detailed information on work tasks. Our primary analyses evaluated gender differences in task prevalence and frequency at a module-level and, where sufficient numbers existed, at a job/industry group-level within a module. Our goal was to generate insights into gender differences across multiple occupations and industries that may assist with future exposure assessment efforts.

MATERIALS AND METHODS

Study population and occupational information

The study population consisted of control subjects from three population-based case-control studies: the New England Bladder Cancer Study (NEBCS),[17] the US Kidney Cancer Study (USKCS),[18] and the National Cancer Institute Surveillance, Epidemiology, and End Results Study of Non-Hodgkin Lymphoma (NCI-SEER NHL).[19] General characteristics of each study, criteria for collecting occupational information, and references for each study are provided in Table 1. We restricted our comparisons to the controls' responses to minimize potential recall bias and differential exposures that some speculate might be associated with case status.[20]

Subjects were not recontacted for this study. As part of the original studies, subjects completed a mailed work history calendar covering all jobs that met study-specific inclusion criteria (Table 1). At the subsequent home visit, a trained interviewer reviewed this information, entered it into a computer, and administered an occupational history questionnaire with open-ended questions for each job including job title, services provided or products made by the employer, job start and stop years, work frequency, tasks performed, tools and equipment used, and chemicals and materials handled. A computer program was used to link keywords from these open-ended responses to a short list of appropriate job, industry, or generic exposure modules for jobs with possible exposure to study-specific agents of interest which were displayed on the interviewer's computer screen. The interviewer assigned the module that most closely matched the subject's description of his/her job rather than strictly matching on the job title (assigned module). Limits were placed on the number of modules to reduce subject burden during the interview process, with a maximum of five assigned modules completed per subject (completed module)

(Table 1). The rationale of using these modules and their scope was previously published.[21] Each module asks detailed questions about the work environment, job characteristics, tasks performed, work location, and other determinants of exposure (e.g., chemical application method, engineering controls, and personal protective equipment use). Generic modules were assigned to jobs not captured by an existing module but that may have had exposures of interest. The modules used in each study (Table 2), and the questions asked within each module varied by study based on study-specific exposures of interest.

Treatment of occupational information

Each reported job from the occupational history questionnaires was previously assigned a 4-digit 1980 Standard Occupational Classification (SOC) code[22] and a 4-digit 1987 Standard Industrial Classification (SIC) code.[17, 18, 23, 24] The reported start and stop years and hours worked at each job were used to calculate year of first job, total number of reported jobs, duration of employment, and hours worked per week at each job.

To evaluate gender differences in tasks performed, we began by selecting four modules (assembly worker, machinist, janitor/cleaner, and health professional) that were completed by varying proportions of women versus men and by at least 20 women and 20 men. We then selected similarly worded questions regarding work tasks within each module that had responses from at least 20 members of each sex. In the assembly worker module, the three tasks with sufficient responses were clean or degrease parts with chemicals (‘degrease’), use glue or adhesives (‘glue’), and use paints (‘paint’). In the machinist module, the three tasks with sufficient responses were clean or degrease parts with chemicals (‘degrease’), weld, flame cut, or braze (‘weld/cut’), and solder (‘solder’). In the janitor/cleaner module, the three tasks with sufficient responses were strip floors (‘strip floors’), clean furniture or equipment (‘clean furniture’), and polish furniture with liquid cleaning chemicals (‘polish furniture’). In the health professional module, the five tasks with sufficient responses were work in an operating room or anywhere else where general anesthetics were being administered (‘anesthesia room work’), work in a room where instruments or other equipment were being sterilized (‘sterilization room work’), use disinfectants or antiseptics (‘disinfectant use’), work in a room while x-rays were being taken (‘x-ray room work’), and work in a lab (‘lab work’). For each task, we recoded the module responses to denote whether the subjects performed the task (yes, no, don’t know/refused, or not asked) and the frequency with which the task had been performed (continuous scale in average hours per week).

Because a specific module could be completed by a fairly diverse group of jobs from varying industries, we created two job sub-groups within each module that were similar in terms of SIC codes, SOC codes, and/or self-reported job titles (see Table 4 for the SOC and SIC codes in each job sub-group). Each defined job sub-group had at least 10 female controls and 10 male controls who completed the module. For the assembly worker module, we created job sub-groups for ‘production jobs in the product manufacturing industries and ‘fabricators/assembler jobs in the transportation equipment manufacturing industries’. For the machinist module, we created ‘production jobs in the product manufacturing industries’ and ‘self-reported machine operators in the product manufacturing industries’. For the health professional module, we created ‘health aides’ and ‘nurse’s aides/orderlies’. For the janitor module, we created ‘janitors and cleaners’ and ‘janitors and cleaners with self-reported job titles of janitor, custodian, or cleaner’. Further restrictions were not possible due to sparse data. For example, we were unable to create job subgroups for doctors, nurses, therapists, and health technicians due to small sample sizes.

Statistical analyses

All statistical analyses were performed using Stata S.E. v.11.1 (StataCorp LP, College Station, Texas, USA). We calculated descriptive statistics of basic employment trends between female and male controls enrolled in these studies, including the first year worked, number of jobs held, average hours worked per week, years worked for each job, and overall distribution of occupations and industries by 4-digit SOC and SIC codes. Arithmetic means (AMs) were reported for normally distributed data; geometric means (GMs) were reported for log-normally distributed data. Job records coded as ‘don’t know’ or ‘refused’ for the occupational history questions were rare and were excluded from job-level comparisons (average hours worked per week, years worked per job and distribution by SIC and SOC codes); subjects with these responses were excluded from subject-level comparisons (first year worked and number of jobs ever held). Job records where responses to occupational history work frequency questions were not ascertained during the interview (because the job was believed to have no exposures of interest, e.g., secretary) were assigned the median value of 40 hours per week (884 female jobs, 374 male jobs).

For each module we calculated a study-specific and overall (across the three studies) female:male completion ratio reflecting the proportion of women versus men who completed that module. Values >1 represented more modules completed by women; values <1 represented more modules completed by men. The study-specific female:male module completion ratio, R_{ij}, was calculated using equation 1, where i is the study number (1, 2, 3) and j is the specified module (71 possible modules). The numerator is the number of modules completed by females for the $j^{-\text{th}}$ module (M_{fij}) over all jobs reported by females (J_{fi}); the denominator is the number of modules completed by males for the $j^{-\text{th}}$ module (M_{mij}) over all jobs reported by males (J_{mi}).

$$R_{ij}=\frac{\frac{M_{fij}}{J_{fi}}}{\frac{M_{mij}}{J_{mi}}} \quad [1]$$

The overall female:male completion ratio across the three studies (equation 2) weighted the study-specific ratios, R_{ij}, by a study-specific module weighting factor, W_{ij} (equation 3) to account for each cancer site’s gender differences in incidence rates (and thus the varying proportions of females in each study). The completion ratio was based only on those studies that included that module.

$$R_j=\sum_{i=1}^{3}(R_{ij}\times W_{ij}) \quad [2]$$

$$W_{ij}=\frac{M_{fij}+M_{mij}}{\sum_{i=1}^{3}(M_{fij}+M_{mij})} \quad [3]$$

For each task in each module, we conducted Chi-square (χ^2) tests to assess differences in the proportion of women and men responding ‘yes’ to each task question (missing/don’t know and refused responses were excluded). For tasks that were performed by at least 5 women and 5 men, we conducted non-parametric Mann-Whitney U tests to assess gender differences in the median and overall distribution of the time spent performing that task. We report only findings with p-values less than 0.1 to suggest gender differences, using a lenient threshold given the exploratory nature of our study and the overall small sample sizes.

RESULTS

Study Population

Subjects from NEBCS, USKCS, and NCI-SEER NHL represented geographically diverse regions of the United States (Table 1). The range for year of first job, matching criteria, occupational history inclusion criteria, and job module assignment criteria were similar across studies. The pooled dataset contained 3,605 controls (1,360 females, 2,245 males) with full lifetime work histories who reported a total of 18,116 jobs (6,033 female jobs, 12,083 male jobs) (Table 3). There were fewer female than male controls in each study, in particular in the NEBCS (372 females vs. 1,037 males), because the incidence of the respective cancers varied by gender and controls were frequency matched to cases by sex (Table 3).[25]

Occupational Histories

The mean age at interview for female and male controls was 60 and 62, respectively (Table 3). Women’s first year worked was, on average, slightly later than men (AM 1963 vs.1959). Women reported holding fewer overall jobs (GM 3.6 vs. 4.6), working fewer hours per week (AM 37.5 vs. 44.8), and working at each job for fewer years (GM 4.7 vs. 5.2) than men.

Jobs reported by controls covered 83 2-digit SIC codes and 63 2-digit SOC codes (data not shown). The top 5 occupations for women, which accounted for 65% of all reported female jobs, were: administrative support occupations, including clerical (SOC 46 and 47, 33%); service occupations, except private household and protective (SOC 52, 16%); sales occupations, retail (SOC 43, 9%); teachers, except post-secondary (SOC 23, 4%); and registered nurses (SOC 29, 3%). The top 5 occupations for men, which accounted for 32% of reported male jobs, were: administrative support occupations, including clerical (SOC 46 and 47, 7%); transportation occupations (SOC 82, 6%); service occupations, except private household and protective (SOC 52, 6%); mechanics and repairers (SOC 61, 6%); and handlers, equipment cleaners and laborers (SOC 87, 6%)

Job and Industry Modules

Study controls completed a total of 8,273 modules (Table 3). Across all three studies the proportion of jobs with completed modules was lower for women than men (38% vs. 49%). For NCI-SEER NHL, the proportion of jobs with completed modules was much lower than

USKCS and NEBCS because modules were added to NCI-SEER NHL approximately one year after data collection began and only modules focusing on solvent exposure were administered.[19, 26] Table 2 lists the 71 modules completed by each gender across the three studies and the overall female:male module completion ratio. The modules administered varied by study; however, there was significant overlap. The female:male module completion ratios varied from 0 to 19.3. The highest ratio for modules with ≥ 20 controls were observed for the waiter/waitress (ratio=19.3), barber/hairdresser (15.3), and health professional (6.5) modules. More traditionally male-dominated trade jobs, such as carpenter, welder, mechanic and electrician had ratios ≤ 0.1. Six modules had module completion ratios near 1.0 (≥0.8 and ≤1.2): assembly worker, food processing industry, production inspector, bus driver, chemist, and janitor/cleaner. In NEBCS and NCI-SEER NHL, the study-specific generic modules had ratios of 0.3, indicating more male controls than female controls completed these modules; these modules represented ≤6% of the total number of modules completed. In USKCS, the general exposure module had a ratio of 1.0; this module represented 79% of the modules completed by female controls (number of completed general exposure modules by females in USKCS (Table 2) divided by the total number of modules completed by females in USKCS (Table 3) and 59% of the modules completed by male controls.

Task performance

The assembly worker module was completed for 108 female jobs and 206 male jobs (Table 4). The job titles of those who completed this module included assemblers, assembly line workers, laborers, packers, machine operators, and solderers and represented a variety of industries. Similar proportions of men (22%) and women (24–25%) reported degreasing overall and for production workers in product manufacturing. However, in the fabricators/assemblers in transportation equipment manufacturing sub-group, over twice as many women reported degreasing as men (female:male ratio=2.07). Among those who degreased, the median hours per week spent degreasing was twice as high for women as men both overall (6.3 vs. 2.7) and for production workers in product manufacturing (6.3 vs. 3.0), but no difference was observed for fabricators/assemblers. Men were more likely to report that they painted than women overall and for production workers in product manufacturing (female:male ratio = 0.58 and 0.42, respectively), but both genders reported similar time spent painting. No gender differences in either the prevalence or frequency of gluing were observed.

The machinist module was completed for 25 female jobs and 191 male jobs. Controls who completed this module included machinists, machine operators, millwrights, sheet metal workers, tool and die makers, and line mechanics and represented a variety of industries. No consistent pattern was observed by gender for degreasing, welding/cutting, or soldering overall or by sub-group.

The health professional module was completed for 105 female jobs and 55 male jobs. Controls who completed this module came from diverse occupations, including doctors, nurses, therapists, health technicians, health aides, and nurse’s aides/orderlies and included home, clinical, hospital and other medical settings. More male than female health professionals reported disinfectant use overall (female:male ratio=0.79) and for the nurse's aides/orderlies sub-group (female:male ratio=0.53). Similarly, more male than female health professionals reported lab work overall (ratio= 0.42) and only male nurse's aides/orderlies reported lab work. Only male nurse's aides/orderlies performed x-ray room work, while no differences were seen both overall and for the health aides sub-group. No significant differences were observed in the frequency of these tasks.

The janitor/cleaner module was completed by 64 female jobs and 126 male jobs. Controls completing this module included custodians, cleaners, janitors, housekeepers, maintenance workers, cleaners and domestic workers who worked in residential, commercial, medical, and industrial settings. More women reported cleaning furniture and polishing furniture than men overall and in both sub-groups (ratio range=1.43–1.88). More men reported stripping floors than women overall (ratio=0.51) and in the janitor/cleaner sub-group (ratio=0.68), but not in the self-reported janitor sub-group. Overall, women reported spending more time cleaning furniture (median 6.7 vs. 4.6 hours) and polishing furniture (median 3.1 vs. 1.9 hours) than men. No differences were observed for time stripping floors. These patterns remained the same in both janitor/cleaners and self-described janitors, although the differences were no longer significant.

DISCUSSION

This study used pooled occupational questionnaire response data from three population-based case-control studies to identify gender differences in when, where, and how often women and men work. These results support past work[27] by quantifying differential employment and occupation patterns across six decades. For several, but not all, job groups, we observed differences in both the proportion of each gender reporting specific tasks performed and in the time spent performing those tasks. These differences varied in magnitude and direction. Our findings provide additional evidence that gender differences in occupational exposure may exist both across and within occupations and that care must be taken to consider these differences to avoid exposure misclassification in occupational epidemiologic studies.[1–3, 28–30]

The gender-based differences in occupation and employment patterns we observed are consistent with previous studies from the United States and elsewhere.[5, 6, 11, 31] Women on average worked fewer hours per job, held each job for shorter periods of time, and held fewer jobs over the course of their work history than men, all of which would be expected to lower women's cumulative exposure to workplace exposures over their working lives relative to men.

Gender differences were observed in the module completion rates, overall and by module. Overall, female controls completed fewer modules (Table 3); however, this varied by study based on the modules used in each study (see Table 2). For instance, the gender difference in overall module completion rates was negligible in NEBCS (females: 47%; males: 51%), which included more modules because the original study had more exposures of interest. Some of the modules used represented traditionally female jobs (e.g., waiter/waitresses, barber/hairdressers, health professionals, and office professionals). In contrast, the difference was more pronounced in USKCS (females: 52%; males: 67%), which incorporated only 36 modules because of fewer exposures of interest and did not include many of the modules where we observed the highest female:male completion ratios. As expected, female:male completion ratios were higher for traditionally female dominated jobs (e.g., waitress, hairdresser, and health professional) and lower for traditionally male dominated jobs (e.g., welder mechanic, and electrician). Some differences in module completion may have also resulted from gender differences in how subjects described their jobs, which could have influenced the list of modules suggested by the computer program and the interviewer's selection of the most appropriate module. Gender differences in module completion may have been also influenced by study-specific constraints to minimize participant burden. Subjects were assigned a module if the reported job was held for a study-specific minimum total number of hours, and male jobs were more likely to meet this minimum hour criteria than female jobs. Men were also more likely than women to reach the maximum of five modules regardless of the number of relevant jobs. Sensitivity analyses based on the 'assigned' (but not necessarily completed) module show the same trends overall by study and module, suggesting our findings were robust (not shown).

Gender differences were observed in work task performance for some tasks and in some job subgroups. As we restricted comparisons to more similar job sub-groups, the direction of the gender differences tended to remain the same, although the magnitude of the differences varied. The most consistent differences occurred in the janitor/cleaner module. Across all job sub-groups, more women completing this module reported that they cleaned furniture and polished furniture, while more men said they stripped floors. This pattern was consistent with other studies that found task segregation based on real or perceived physical strength requirements.[8, 12, 15, 16] We also found that restricting analyses to more similar job sub-groups sometimes minimized and sometimes accentuated gender differences. For instance, for the assembly worker module we found significant differences in time spent degreasing both overall and among production workers in product manufacturing; however, this difference was considerably smaller and non-significant for fabricators/assemblers in transportation equipment manufacturing. We also found the reverse pattern for the health professional module, where there were no differences in X-ray room work both overall and in health aides, but only male nurse's aides/orderlies reported X-ray room work. Here, task segregation and time spent on tasks could result in women and men being exposed to different, and differing amounts of, chemicals used while performing those tasks. These differences may in part reflect remaining heterogeneity within the job sub-groups, because our efforts to restrict comparisons to increasingly similar jobs and industries were hampered by small numbers. Other studies looking at gender differences within jobs from a broader working population have faced similar issues.[6, 11]

Women tended to report spending more time on tasks than men, although the within-task and within-gender inter-quartile ranges were wide for both sexes and the differences were generally not significant. This could reflect real gender differences in task performance or differences in recall and reporting or could occur by chance because of the large number of comparisons and small sample sizes. Two studies have reported that women were more likely to report higher levels of exposures or frequencies of work activities than men compared to direct measurements or expert evaluation.[32, 33] If these differences reflect a systematic over-reporting of the time spent on activities by women (or underreporting by men), a gender-specific systematic bias in exposure misclassification may result. The substantial variability and lack of significance in task frequency for both genders may reflect the natural variability within similar jobs or remaining heterogeneity in our job sub-group classifications, may be related to time period effects, may be associated with other sociodemographic factors not evaluated in this study,[11] or may reflect difficulties in recalling task-related details for work performed years or decades in the past.

This study had a relatively large sample size and had comparable data from detailed occupational health questionnaires for a variety of occupations and industries from geographically diverse regions of the United States. The use of job and industry modules allowed for the detection of gender-specific task-related differences that occupational histories alone could not.

The largest limitation was our inability to fully account for the heterogeneity of jobs and industries within each module due to small sample sizes, despite pooling three studies. This heterogeneity may account for some, or all, of the task differences reported here. When possible, we restricted comparisons to more similar job sub-groups based on SOC codes, SIC codes and self-reported job titles, but we were limited in how restrictive the job sub-groups could be by small sample sizes. Most population-based occupational studies would similarly have to combine similar jobs and industries together for their analyses because of low prevalence of most jobs. We were also unable to examine time period effects because of sparse data and because jobs held by the same subject across time periods were correlated. Time period may be an important factor for jobs where patterns of employment changed over time, particularly for jobs that were historically predominantly female (e.g., health aides) or predominantly male (e.g., machinists). Other factors not evaluated here that could explain some of observed gender differences include age at employment, job tenure and job seniority. Larger studies with direct observations of women and men completing the same jobs are necessary to provide more clarity regarding information about gender differences in time spent on specific tasks. Such observations are difficult to obtain in population-based case-control studies where occupational health questionnaires remain the major source of historical occupational data.

An additional limitation was that this study relied entirely on self-reported job and task characteristics, thus leaving us unable to distinguish between gender differences in recall, reporting, or risk perception and actual gender differences in task performance. Past studies have reported similar limitations.[6, 8, 11, 12, 34] Recall, reporting and perception differences could introduce bias into the exposure estimates when using self-reported task alone, whereas actual gender differences in task performance could introduce bias into estimates based solely on job and/or industry. Studies need information on task performance from sources other than self-reports to distinquish between recall, reporting and perception differences and actual gender differences to determine the direction and magnitude of the bias; however, this is difficult to obtain in retrospective epidemiologic studies looking at past exposures.

In summary, we found some evidence for gender differences in reported task performance among controls holding similar jobs by pooling responses to occupational questions from three population-based case-control studies. These results provide insight into the potential magnitude of gender differences in tasks that should be considered when developing exposure assessment strategies for epidemiologic studies. Significant gender differences were in some but not all tasks. However, the direction was not always predictable, variability within similar jobs remained high, and differences may have been masked by small numbers. Future studies are needed to evaluate the potential for gender differences in reporting and recall and to quantify the magnitude of the effect on risk estimates.

Acknowledgments

Funding: This study was supported by the Intramural Research Program of the National Institutes of Health, National Cancer Institute, Division of Cancer Epidemiology and Genetics. USKCS was supported by the Intramural Research Program of the National Institutes of Health and the National Cancer Institute with contract N02-CP-11004 (Wayne State University), and N02-CP-11161 (University of Illinois at Chicago). NCI-SEER NHL was supported in part by the Intramural Research Program of the National Institutes of Health (National Cancer Institute) and by National Cancer Institute SEER Contracts N01-PC-65064 (Detroit), N01-PC-67009 (Seattle), N01-CN-67008 (Iowa) and N01-CN-67010 (Los Angeles).

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What this paper adds

- Growing evidence suggests gender differences in exposures at work can lead to exposure misclassification, but few studies have evaluated differences across multiple occupations and industries.
- We pooled occupational questionnaire data from three population-based case-control studies to evaluate potential gender differences in responses to occupational questionnaires.
- Gender differences in reported task performance were observed and occurred in both directions with no predictable pattern.
- Women tended to report more time spent on each task than men; however, we could not distinguish whether these were true differences, differences in recall, reporting, or perception or occurred by chance due to small numbers in some comparisons.
- These findings provide insight into the potential magnitude of gender differences in tasks and highlight the need to capture subject-specific information on work activities to account for gender and workplace differences in work activities that can impact exposure estimates.

Table 1

Characteristics of the three US population-based case-control studies.

Study name	Study location	Case selection	Control selection	Case/control matching criteria	Start year of first job range	Job inclusion criteria	Module assignment and completion criteria[a]	Reference
New England Bladder Cancer Study (NEBCS)	ME, NH, VT	Diagnosed 2001–2004; 30–79 years old at diagnosis	Department of Motor Vehicle records and Medicare files	State; age within 5 years; gender	1938–1999	Job held at least 6 months from age 16	Job worked at least 1000 hours assigned module; up to 5 total and 3 of the same modules completed per subject	[17]
US Kidney Cancer Study (USKCS)	Chicago, IL, Detroit, MI	Diagnosed 2002–2007; 20–79 years old at diagnosis	Department of Motor Vehicle records and Medicare files	Study center; age within 5 years; gender; race	1939–2002	Job held at least 12 months from age 16	Job worked at least 3500 hours assigned module; up to 5 total and 3 of the same modules completed per subject	[18]
National Cancer Institute-Surveillance, Epidemiology, and End-Results Study of Non-Hodgkin Lymphoma (NCI-SEER NHL)	Los Angeles County, CA; Seattle, WA; Detroit, MI, IA	Diagnosed 1998–2000; 20–74 years old at diagnosis	Random digit dialing and Medicare files	Study center; age within 5 years; gender; race	1946–1999	Job held after 1945 for at least 12 months from age 16	Up to 5 modules completed per subject	[19]

[a]Subjects were assigned modules based on study-specific jobs, industries and exposures of interest. Limits were placed on the total number of modules to be completed by each subject to reduce subject burden during the interview process.

Table 2

Job, industry, and generic exposure modules completed by controls by gender and sorted by female:male completion ratios in each job and industry, from most females to fewest females.

Module	**Female controls**	**Male controls**	**Female:male completion ratio (weighted[a])**	**Study where module was used by controls[b]**
Job or industry (type)				
Waiter/waitress (job)	51	9	19.3	B
Barber/hairdresser (job)	18	4	15.3	B
Semiconductor industry (industry)	8	4	6.8	B
Health professional (job)	105	55	6.5	B
Office professional (job)	267	244	3.7	B
Dry cleaning/laundry industry (industry)	31	15	3.5	B, K, NHL
Textile industry (industry)	33	31	3.1	B, K, NHL
Packing machine operator (job)	2	1	2.9	K
Teacher (job)	243	208	2.7	B, K, NHL
Kitchen worker (job)	53	68	2.7	B
Shoe industry (industry)	26	56	1.6	B
Assembly worker (job)	108	206	1.2	B, K, NHL
Rubber industry (industry)	3	6	1.2	B, K, NHL
Food processing industry (industry)	9	28	1.1	B
Production inspector (job)	24	41	1.1	B, K, NHL
Bus driver (job)	6	20	1.0	B
Chemist (job)	22	62	0.9	B, K, NHL
Janitor/cleaner (job)	64	126	0.9	B, K, NHL
Glass industry (industry)	1	4	0.9	B
Fisherman (job)	3	18	0.6	B
Printing industry (industry)	27	85	0.6	B, K, NHL
Leather industry (industry)	3	14	0.5	B, K, NHL
Mail carrier (job)	3	23	0.4	B
Manager/executive/supervisor (job)	59	468	0.4	B
Tool and die maker (job)	1	8	0.4	B
Butcher (job)	2	22	0.3	B
Electroplating industry (industry)	1	8	0.3	B, K, NHL
Taxicab/limo driver (job)	1	12	0.3	B
Fork lift operator (job)	1	15	0.2	B
Gardener (job)	2	31	0.2	B
Machinist (job)	25	191	0.2	B, K, NHL
Painter (job)	6	61	0.2	B, K, NHL
Laborer (job)	19	233	0.2	B, K, NHL
Gas station attendant (job)	4	68	0.2	B, K, NHL
Plumber (job)	2	42	0.2	B, K, NHL
Farmer/rancher/farm worker (job)	6	148	0.1	B

Module	Female controls	Male controls	Female:male completion ratio (weighted[a])	Study where module was used by controls[b]
Carpenter (job)	2	61	0.1	K, NHL
Foundry industry (industry)	1	23	0.1	B, K
Heavy construction industry (industry)	1	54	0.1	B
Lumber industry (industry)	1	54	0.1	B
Police officer/detective (job)	4	67	0.1	B, K
Pulp and paper industry (industry)	2	47	0.1	B, K, NHL
Welder (job)	3	82	0.1	B, K, NHL
Handyman (job)	1	30	<0.1	K, NHL
Cabinet maker (job)	1	184	<0.1	B, NHL
Engineer (job)	4	273	<0.1	B, K, NHL
Mechanic (job)	2	220	<0.1	B, K, NHL
Aircraft mechanic (job)	0	7	-	NHL
Boiler operator (job)	0	9	-	B
Brick/block/stone mason (job)	0	12	-	B
Chemical industry (industry)	0	35	-	B, K, NHL
Electrician (job)	0	104	-	B, K, NHL
Fire fighter (job)	0	17	-	B
Furniture industry (industry)	0	4	-	K, NHL
Industrial machine repairer (job)	0	65	-	B, K, NHL
Insulator (job)	0	1	-	B
Maritime shipping industry (industry)	0	13	-	B
Military (job)	0	62	-	B
Miner (job)	0	8	-	B
Oil refining industry (industry)	0	2	-	NHL
Packager/filler (job)	0	2	-	B
Pesticide applicator (job)	0	2	-	B
Railroad industry (industry)	0	9	-	B
Roofer (job)	0	5	-	B
Sheet metal worker (job)	0	7	-	B
Steel industry (industry)	0	7	-	B
Truck driver (job)	0	207	-	B
Tile setter (job)	0	5	-	B, NHL
Generic				
Engine exhaust exposure	18	206	0.3	B
General exposure	1022	1436	1.0	K
Solvent exposure	3	14	0.3	NHL

NA, not available, B=New England Bladder Cancer Study, K=US Kidney Cancer Study, NHL=National Cancer Institute Surveillance Epidemiology and End Results Study of Non-Hodgkin Lymphoma

[a]Weights were applied to adjust for the unequal number of male and female controls in each study as per equations 1–3 provided in the text.

[b]Modules used in a study but not completed by controls included carpenter, oil refining industry, rigger, and traffic clerk in New England Bladder Cancer Study; ammunition industry, battery manufacturer, cabinet maker, oil refining industry, semiconductor industry, and tile setter in US

Kidney Cancer Study; packaging machine operator, and semiconductor industry in National Cancer Institute Surveillance Epidemiology and End Results Study of Non-Hodgkin Lymphoma Study.

Table 3

Gender differences in age at interview, employment patterns and module assignment and completion among controls overall and by study.

Study	N controls	N reported Jobs	Mean age at interview AM (range)	First year worked per subject[a] AM (IQR)	Number of jobs per subject[a,b] GM (GSD)	Hours worked per week per job[c] AM (ASD)	Years worked per job[b,d] GM (GSD)	N completed modules	% Jobs with completed modules
NEBCS									
female	372	1,821	64 (31–81)	1960 (1948–1969)	4.2 (1.8)	36.4 (12.7)	4.7 (2.3)	858	47
male	1,037	6,194	66 (32–81)	1956 (1947–1963)	5.2 (1.7)	45.2 (14.9)	5.2 (2.4)	3,176	51
USKCS									
female	530	2,496	58 (20–80)	1966 (1956–1975)	3.9 (1.9)	38.6 (8.7)	4.6 (2.2)	1,291	52
male	684	3,639	59 (21–80)	1963 (1953–1972)	4.6 (1.8)	44.8 (13.8)	5.3 (2.2)	2,428	67
NCI-SEER NHL									
female	458	1,716	59 (23–76)	1962 (1950–1971)	3.0 (2.0)	37.2 (11.3)	4.7 (2.6)	154	9
male	524	2,250	59 (20–76)	1960 (1949–1968)	3.6 (1.8)	43.7 (13.8)	5.2 (2.8)	366	16
Total									
female	1,360	6,033	60 (20–81)	1963 (1951–1972)	3.6 (1.9)	37.5 (10.8)	4.7 (2.3)	2,303	38
male	2,245	12,083	62 (20–81)	1959 (1949–1967)	4.6 (1.8)	44.8 (14.4)	5.2 (2.4)	5,970	49

AM, arithmetic mean; ASD, arithmetic standard deviation; GM, geometric mean; GSD, geometric standard deviation; IQR, inter-quartile range; NEBCS, New England Bladder Cancer Study; NCI-SEER NHL, National Cancer Institute Surveillance Epidemiology and End Results Study of Non-Hodgkin's Lymphoma; N, number; USKCS, US Kidney Cancer Study

[a] Excludes subjects with start or stop years ='don't know' or 'refused'; Subjects included in analysis: NEBCS, females=371, males=1,036; USKCS, females=525, males=671; NCI-SEER NHL, females=458, males=523.

[b] Geometric mean and standard deviation were calculated when data followed a lognormal distribution.

[c] Excludes jobs with hours worked per week = 'don't know' or 'refused'; Jobs included in analysis: NEBCS, female jobs=1,813, male jobs=6,166; USKCS, female jobs=2,470, male jobs=3,598; NCI-SEER NHL, female jobs=1708, male jobs=2215.

[d] Excludes jobs with start or stop years = 'don't know' or 'refused'; Jobs included in analysis: NEBCS, female jobs=1,820, male jobs=6,193; USKCS, female jobs=2,488, male jobs=3,625; NCI-SEER NHL, female jobs=1708, male jobs=2,249.

Table 4

Gender differences in reported tasks and time spent performing those tasks for those controls completing the assembly worker, machinist, health professional and janitor/housekeeper job modules. Analyses conducted for all who completed the module and for two defined job groups within a module.

Job Module / **Job Group (N)** / **Common Task(s)**	**Proportion Who Performed Task**				**Time Spent Performing Task**										
					Female					**Male**					
	Female (%)	**Male (%)**	**Female: male ratio**[a]	**Chi-square p-value**	**N freq > 0**[b]	**AM (hr/wk)**	**Median (hr/wk)**	**IQR (hr/wk)**	**Range (hr/wk)**	**N freq > 0**	**AM (hr/wk)**	**Median (hr/wk)**	**IQR (hr/wk)**	**Range (hr/wk)**	**U test p-value**
<u>*Assembly Worker*</u>															
All who completed module[c] *(♀=108, ♂=206)*															
Degrease	24	22	1.08	0.73	26	10.5	6.3	1.4–16.0	0.2–40.0	43	6.4	2.7	0.9–5.0	<0.1–60.0	0.02
Glue	21	24	0.85	0.47	20	14.7	10.0	3.1–22.4	0.1–40.0	47	15.8	5.0	1.0–36.2	<0.1–56.0	0.68
Paint	9	16	0.58	0.09	9	7.9	0.4	0.2–10.0	<0.1–40.0	32	7.8	0.6	0.3–6.2	<0.1–56.0	0.65
Production workers in product manufacturing[d] *(♀=76, ♂=164)*															
Degrease	25	22	1.14	0.60	19	9.8	6.3	1.7–16.0	0.3–39.8	33	6.7	3.0	1.0–6.0	<0.1–60.0	0.04
Glue	16	22	0.73	0.29	11	12.6	4.0	2.0–24.8	0.1–40.0	33	18.4	10.0	1.0–40.0	<0.1–56.0	0.53
Paint	7	16	0.42	0.05	4	0.2	0.1	0.1–0.3	<0.1–0.4	25	8.5	0.8	0.5–8.3	<0.1–56.0	-
Fabricators/assemblers in transportation equipment manufacturing[e] *(♀=23, ♂=95)*															
Degrease	35	17	2.07	0.06	8	11.8	6.3	1.0–20.0	0.3–39.8	15	10.8	5.0	0.2–11.2	<0.1–60.0	0.58
Glue	18	22	0.85	0.73	3	20.4	24.8	0.1–36.2	0.1–36.2	17	15.2	5.0	1.0–27.7	<0.1–56.0	-
Paint	13	19	0.69	0.51	2	0.1		-	<0.1, 0.1	16	8.4	0.7	0.5–9.2	0.1–56.0	-
<u>*Machinist*</u>															
All who completed module[c] (♀=25, ♂=191)															
Degrease (♀=21, ♂=174)[f]	36	41	0.87	0.61	9	11.8	2.0	0.3–4.0	0.1–48	78	5.5	2.0	0.8–5.0	<0.1–60.0	0.86
Weld or Cut	24	21	1.12	0.79	5	11.3	4.0	2.0–10.0	0.5–40.0	36	4.7	1.7	0.4–3.0	<0.1–60.0	0.12
Solder	14	11	1.32	0.64	2	1.5	1.5	-	1.0, 2.0	19	3.5	0.6	0.2–4.0	<0.1–40.0	-
Production workers in product manufacturing[g] *(♀=17, ♂=149)*															
Degrease (♀=14, ♂=136)[f]	47	39	1.21	0.52	8	13.3	2.8	0.4–26.0	0.1–48.0	58	5.3	1.0	0.6–5.0	<0.1–60.0	0.59
Weld or Cut	36	19	1.87	0.14	5	11.3	4.0	2.0–10.0	0.5–40.0	26	4.3	1.7	0.5–3.0	<0.1–60.0	0.13
Solder	14	9	1.63	0.50	2	1.5	-	-	1.0, 2.0	12	4.9	0.7	0.1–5.0	<0.1–40.0	-

Job Module / Job Group (N) / Common Task(s)	Proportion Who Performed Task				Time Spent Performing Task										
					Female					Male					
	Female (%)	Male (%)	Female: male ratio[a]	Chi-square p-value	N freq > 0[b]	AM (hr/wk)	Median (hr/wk)	IQR (hr/wk)	Range (hr/wk)	N freq > 0	AM (hr/wk)	Median (hr/wk)	IQR (hr/wk)	Range (hr/wk)	U test p-value
Self-reported machine operators in product manufacturing[h] (♀=15, ♂=49)															
Degrease (♀=13, ♂=43)[f]	40	31	1.31	0.50	6	17.4	3.8	0.5–48.0	0.1–48.0	15	4.8	2.0	0.8–6.0	0.1–18.5	0.53
Weld or Cut	36	19	1.87	0.16	4	13.6	7.0	2.3–25.0	0.5–40.0	6	1.7	1.3	1.0–2.0	0.4–4.0	-
Solder	8	9	0.83	0.86	1	1.0	-	-	-	4	11.9	3.5	0.7–23.0	0.4–40.0	-
Health Professional															
All who completed module[c] (♀=105, ♂=55)															
Anesthesia room work	22	35	0.64	0.09	23	8.6	2.5	0.7–8.0	<0.1–72.0	19	10.0	2.8	0.6–16.0	0.2–48.0	0.90
Sterilize room work	32	33	0.99	0.96	34	8.9	4.5	0.8–12.0	<0.1–64.8	17	11.5	5.0	1.8–12.0	0.2–42.0	0.54
Disinfectant use	63	80	0.79	0.03	68	14.3	5.5	1.0–27.5	<0.1–72.0	44	10.8	4.0	1.0–11.0	0.1–58.8	0.41
X-ray room work	25	29	0.86	0.60	29	10.6	2.0	0.4–18.0	<0.1–40.0	16	3.6	2.0	0.5–4.9	0.1–12.0	0.49
Lab work	10	24	0.42	0.02	9	10.8	12.0	4.0–15.0	0.3–24.0	13	16.0	14.0	1.2–25.0	0.5–48.0	0.71
Health aides[i] (♀=27, ♂=22)															
Anesthesia room work	11	23	0.49	0.27	3	2.2	1.5	0.1–5.0	0.1–5.0	5	13.9	6.4	4.5–16.0	2.8–40.0	-
Sterilize room work	48	59	0.81	0.44	13	9.9	5.0	1.0–20.0	<0.1–28.0	13	13.8	6.4	1.8–16.0	0.2–42.0	0.59
Disinfectant use	56	77	0.72	0.11	15	11.8	2.0	0.8–24.0	0.1–35.0	17	9.9	5.0	1.5–10.0	0.7–42.0	0.98
X-ray room work	15	18	0.85	0.80	5	14.8	20.0	0.2–24.0	<0.1–30.0	4	1.7	1.9	0.5–2.9	0.1–3.0	-
Lab work	15	23	0.65	0.48	4	15.5	17.5	9.0–22.0	3.0–24.0	5	12.1	14.0	1.0–20.0	0.5–25.0	-
Nurse's aides/orderlies[j] (♀=20, ♂=13)															
Anesthesia room work	5	23	0.22	0.12	1	0.1	-	-	-	3	4.6	4.5	2.8–6.4	2.8–6.4	-
Sterilize room work	30	54	0.56	0.17	6	2.7	0.9	0.1–4.0	<0.1–10.0	7	9.9	5.0	1.0–10.0	0.2–42.0	0.11
Disinfectant use	45	85	0.53	0.02	9	3.6	1.6	0.7–2.0	0.1–15.0	11	10.2	5.0	1.3–10.0	0.8–42.0	0.17
X-ray room work	0	31	0	<0.01	0	-	-	-	-	4	1.7	1.9	0.5–2.9	0.1–3.0	-
Lab work	0	23	0	0.02	0	-	-	-	-	3	11.5	14.0	0.5–20.0	0.5–20.0	-
Janitor/maid															
All who completed module[c] (♀=64, ♂=126)															

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Job Module / Job Group (N) / Common Task(s)	Proportion Who Performed Task				Time Spent Performing Task										
					Female					Male					
	Female (%)	Male (%)	Female: male ratio[a]	Chi-square p-value	N freq > 0[b]	AM (hr/wk)	Median (hr/wk)	IQR (hr/wk)	Range (hr/wk)	N freq > 0	AM (hr/wk)	Median (hr/wk)	IQR (hr/wk)	Range (hr/wk)	U test p-value
Clean furniture (♀=54, ♂=88)[k]	67	47	1.43	0.01	40	10.0	6.7	3.4–11.6	<0.1–56.0	55	7.5	4.6	1.0–9.6	<0.1–40.0	0.05
Strip floors	36	70	0.51	<0.01	13	4.6	2.9	0.1–6.4	<0.1–15.0	54	5.8	2.3	0.5–9.2	<0.1–24.8	0.65
Polish furniture	62	40	1.55	0.01	32	7.0	3.1	1.6–6.2	<0.1–40.0	34	3.8	1.9	0.5–5.0	<0.1–24.8	0.06
Janitor/cleaner[l] (♀=16, ♂=88)															
Clean furniture (♀=14, ♂=63)[k]	75	49	1.53	0.05	11	14.6	7.7	4.2–24.8	1.0–56.0	41	8.3	4.8	1.0–10.0	<0.1–40.0	0.11
Strip floors	50	73	0.68	0.09	6	4.5	4.3	2.3–6.4	<0.1–10.0	41	6.5	2.9	0.6–10.0	0.1–24.8	0.84
Polish furniture	79	44	1.80	0.02	11	9.3	2.3	2.0–12.0	1.0–40.0	28	4.4	2.1	0.9–7.0	<0.1–24.8	0.13
Self-reported janitor[m] (♀=14, ♂=65)															
Clean furniture (♀=12, ♂=47)[k]	71	45	1.58	0.07	9	16.8	8.0	5.0–24.8	1.0–56.0	27	8.1	5.0	1.0–12.0	0.1–30.0	0.11
Strip floors	58	72	0.81	0.35	6	4.5	4.3	2.3–6.4	<0.1–10.0	29	6.9	1.7	1.0–9.2	<0.1–24.8	0.81
Polish furniture	75	40	1.88	0.03	9	8.9	2.3	2.0–4.0	1.0–40.0	19	4.5	1.3	0.4–7.0	<0.1–24.8	0.25

N, number; AM, arithmetic mean; IQR, inter-quartile range; %, percent; U-test, Mann-Whitney Test; hr/wk = hours per week; ♀, female, ♂, male

[a] Ratio female:male=%female/%male.

[b] N freq>0, number of controls who reported they performed the task and who reported a time spent performing the task greater than zero.

[c] All controls who completed the module.

[d] Restricted to production jobs (3-digit SOCs: 682,686,688,710,731,751,752,753,754,763,765,766,767,771,772,774,775,782) in product manufacturing industries (3-digit SICs: 302,306,308,313,314,323,327,331,335,341,343,344–346,348–360,362–367,369–373,376,381,382,384,394,395,396,399).

[e] Restricted to fabricator/assembler jobs (3-digit SOCs: 771,772,774,775) in the transportation equipment manufacturing industry (3-digit SICs: 370,371,372,376).

[f] NCI-SEER NHL subjects were not asked welding and soldering questions.

[g] Restricted to production jobs (3-digit SOCs: 681,682,686,710–732,734,746,750–754,764,766,767,772,774,775,782,783) in the product manufacturing industries (3-digit SICs: 305,308,322,329–331,340,342–346,348–357,359,361–363,366,367,370–373,376,379,382,394,399).

[h] Restricted to self-reported machine operators in production jobs (3-digit SOCs: 681,731,734,746,751–754,764,766,767,783,872) in product manufacturing industries (3-digit SICs: 305,308,329–331,342,343,345,346,349–351,354–356,359,361,363,371,372,394,399).

[i] Restricted to health aide occupations (3-digit SOC 523).

[j] Restricted to nurse’s aides and orderlies (4-digit SOC 5236).

[k]NEBC subjects were not asked strip floor or polish furniture questions.

[l]Restricted to janitors and cleaners (4-digit SOC 5244).

[m]Restricted to self-reported janitors, custodians or cleaners in janitors and cleaners (4-digit SOC 5244).