Chemical and Biological Hazard Prevention

Studies and Research Projects

REPORT **R-895**

Occupational Exposure to Chemical and Physical Contaminants

Sex-Differentiated Analysis

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PEER REVIEW

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ABSTRACT

The occurrence of occupational injuries differs by sex. One of the main explanations put forward is the existence of clear differences in exposure in the workplace, stemming in particular from differences in the jobs held by men and women and the nature of the tasks involved. However, there is a lack of solid data to support this claim, and most traditional workplace analyses have been limited to reporting risks based on sex, but without identifying the reasons that might explain the observed risk differences.

The Quebec government, the World Health Organization and the Canadian Institutes of Health Research all recommend conducting sex-differentiated analyses. Although a few studies have incorporated gender into the analysis of musculoskeletal problems at work, so far only two average-quality studies have compared male and female exposure to chemicals, taking occupation and economic sector into account. The objective of our study was to explore the existence of differences in occupational exposure between men and women using existing epidemiological databases.

Two epidemiological studies done in Montreal in the late 1990s provided the exposure data; they investigated the relationship between environmental risk factors (including occupational environment) and cancer (lung cancer and breast cancer). Based on subjects' work history, experts assigned one or more exposures, from a list of 243 possible substances, to each job occupied by 1,657 men and 2,073 women. In our study, the occupational exposure associated with jobs held by men was compared with that of jobs held by women (all occupations and industries combined) to reveal any exposure differences. Exposures were subsequently compared between the jobs held by both sexes within the same occupational groups, then the same occupations and finally the same "occupational group/industry group" pairs. For the purpose of the comparisons, the agreement between the exposure of men's jobs and that of women's jobs was calculated using intraclass correlation coefficients. Then, "notable difference" proportions were calculated from the modelling of the male/female exposure differences by applying hierarchical Bayesian models.

As anticipated, given men's and women's different employment profiles, the analysis of all occupations and all economic sectors revealed differences in occupational exposure between the jobs held by men and those held by women for a large number of chemicals and some physical agents. Generally speaking, the jobs held by men were found to have higher exposure proportions, especially to motor vehicle exhaust, petroleum fractions, polycyclic aromatic hydrocarbons, building material dust and abrasive dust. In contrast, jobs held by women were found to have greater exposure to fabric and textile fibre dust and to aliphatic aldehydes.

Most of these differences in exposure proportions disappeared when the analysis was restricted to a male-female comparison within the same occupational group: out of 4,269 points of comparison for which more than 5% of jobs held by men or women were found to be exposed, only 326 (7.6%) of the points showed notable differences. However, where men's jobs and women's jobs involved exposure to a given substance, the time-weighted intensity of exposure was similar. Of the 326 notable differences in exposure proportions between men and women, 187 (57.4%) were due to a lack of precision in the occupational code, 78 (23.9%) to differences in the tasks reported by the subjects and 51 (15.6%) to differences related to the industry in

which the work was done. Finally, once occupation and industry were taken into account, only 3.1% of the differences in occupational exposure proportions were left with no obvious explanation.

To conclude, sex-differentiated analyses are needed to highlight differences in occupational exposure and injuries, as conducting analyses based on occupation and economic sector alone is not sufficient to reveal the subtle differences in job-associated tasks that are also gender related.

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LIST OF ABBREVIATIONS AND ACRONYMS

CCDO	Canadian Classification and Dictionary of Occupations (Statistics Canada)
CI	Confidence interval
CIHR	Canadian Institutes of Health Research
ICC	Intraclass correlation coefficient
INRS–IAF	Institut national de la recherche scientifique–Institut Armand-Frappier
JEM	Job-exposure matrix
n.e.c.	not elsewhere classified
SIC	Standard Industrial Classification (Statistics Canada)
TEM	Task-exposure matrix

1. INTRODUCTION

Women's participation in the labour market continues to grow. They represented 47% of the labour force according to the 2006 Census of Canada and Statistics Canada's *Survey of Employment, Payrolls and Hours*. This proportion varies by industry, ranging from 12% in construction to over 80% in health care and social assistance. Within the manufacturing sector, the proportion also varies, from a low of 11% in primary metal manufacturing to a high of 49% in leather and allied product manufacturing.[1]

1.1 Labour, Gender and Sex

While the term "sex" is generally used with regard to the biological and physiological characteristics that distinguish men from women, "gender" is often used to refer to tasks, relationships, behaviour, power and other social differences between men and women. The two concepts are interrelated and sometimes hard to separate (1).

The predisposition to develop a health problem and the occurrence of occupational injuries vary by sex (2-4). These observations are true not only in Quebec, but also in the rest of Canada, as well as in Europe (2). In Quebec, average length of compensation and the proportions of various occupational injuries (full-time equivalent) are higher for women than for men, taking into account the breakdown into manual, non-manual and mixed occupations (5). Predisposition to injury for the same exposure is known to differ by sex (6, 7). It seems, for example, that the harmful effects of cadmium are more frequently observed in women than in men, in part because women have a higher internal dose of the metal and because they are more sensitive to it than men (8). Another explanation offered for occupational injury differences between men and women is a difference in occupational exposure. But this only partly explains the differences with regard to absences due to illness, meaning that other factors related to gender, rather than sex, need to be investigated (9-14).

1.2 Comparing Occupational Exposure Between Men and Women

Many conventional workplace analyses have been limited to reporting occupational risk in terms of sex, without pushing the analysis any further. Worker sex is considered to be an illness risk factor. Instead of studying sex as such, the analysis is adjusted for sex as a factor, which makes it impossible to identify the reasons for the differences associated with sex (15). For over a decade, a number of organizations have been encouraging sex-differentiated analysis, in several fields, as a way of determining the effects of public policies (16). This type of analysis has been seen in studies on occupational exposure in particular, as researchers seek to investigate the interactions between gender, sex and work more thoroughly (17). Since December 2010, the Canadian Institutes of Health Research (CIHR) have been requiring all applicants to indicate how they intend to incorporate the concepts of gender and sex into their research plans (1). This is an emerging area of research in which very little work has been published so far.

Data on biomarkers of exposure measured for the general population point to differences between men and women, but do not make it possible to determine whether the variability is the

1. Statistics Canada, 2006 Census, customized table produced on request, 2010.

result of a difference in exposure levels or in metabolism at equal exposure, and do not specify whether the exposure was occupational. Data from the 2009 U.S. *Fourth National Report on Human Exposure to Environmental Chemicals*, as well as from the 2010 *Canadian Health Measures Survey*, show some statistically significant differences in blood lead concentrations, which are higher among men, and in urinary concentrations of certain heavy metals classified as carcinogens, such as cadmium, which are higher among women (18, 19).

The picture is even more confusing with respect to occupational exposure. Within the same industry, women are often employed in different occupations from men; it has also been postulated that even when they have the same job title, they can have different exposures (9). A number of factors might explain these differences: anthropometric variations resulting in different levels of exposure, different tasks (20-22) or problems related to measuring exposure due to the type of research design or study instruments, e.g., a greater tendency for women than men to report short-term exposure when answering questionnaires (23).

Most studies published so far have been unable to take gender into account in the exposure assessment process because very little information is available on gender's effect on exposure. They have focused on specific occupations or industries, mostly concerning biomechanical exposure or stress and industrial accidents (3, 4, 20, 24-26) and very rarely concerning exposure to chemicals. Two studies that expressly compared gender-based differences in occupational exposure were found in the literature, one by Quinn et al. in the United States (27) and the other by Eng et al. in New Zealand (28).

The U.S. analysis was based on a cross-sectional study that sought to identify the burden of occupational and social hazards to which 791 men and 456 women were exposed over the 12 months preceding the study. Focusing on 14 workplaces, the study involved a self-administered questionnaire, an interview conducted by an interviewer and a workplace fact-finding visit by an industrial hygienist. All the participants were designated by union representatives. After controlling for industry, no differences were found between men and women in the proportion reporting high exposure to chemicals or dust (27, 29).

The New Zealand researchers conducted a telephone survey of 1,431 men and 1,572 women aged 20 to 64, selected randomly from the New Zealand electoral list. In the telephone interview, respondents' employment histories were taken, including what they were exposed to at their current jobs (based on a pre-established list of exposures), certain aspects of work organization and their state of health. Men generally reported being exposed two to four times more frequently than women to several kinds of dust or chemicals, except for disinfectants, hair dyes and textile fibres, to which women said they were exposed 30% more often than men. The authors then redid the analyses for men and women having the same job title, by age group: a number of differences remained statistically significant, even though there was less of a difference between men and women (28).

Although these studies provide valuable information, they have a number of limitations. In the New Zealand study, the response rate was low (37%), with considerable differences in age, ethnic origin and socioeconomic status between respondents and non-respondents. In both studies, exposure was reported by the subjects themselves rather than established objectively (the U.S. study had assessments done by an industrial hygienist, but did not estimate differences in exposure by sex by controlling for industry (29)); self-reported exposure, while useful in some studies, is not considered to be very reliable for hard-to-perceive substances or working conditions (e.g., exposure to an odourless chemical) (30). In addition, the variations observed could also reflect differences in perceptions of the work environment rather than actual differences (29). Lastly, the analyses did not take into account the intensity of exposure or its duration in the current job, and controlling for occupation or industry was only done on the basis of major groups and not specific codes (27, 28).

1.3 Occupational Exposure Assessment and Job-Exposure Matrices

Epidemiological studies make decisive contributions to the evidence linking exposure and effects on health. But the main problem with some of the studies, especially in the case of diseases with long latency periods like cancer, is the difficulty estimating past exposure to harmful substances or situations. For estimating workplace exposure, a number of methods have been developed to increase estimate validity, such as meetings with workers using a pre-established list of substances (self-reported exposure), having exposure determined by industrial hygienists based on job titles, using job-exposure matrices (JEM) or task-exposure matrices (TEM) to assess exposure based on occupational history, or in-depth interviews with workers to ask questions concerning the specific tasks involved in their jobs and to have experts review respondents' employment histories to estimate their exposure (31-33).

Each of these methods has strengths and weaknesses, but the last method described is generally regarded as being superior to the others, especially when experienced interviewers and coding chemists are involved in collecting and coding the data (34, 35). This method is associated with fewer classification errors, because the experts can take into account local characteristics of production processes and materials used, as well as specific tasks performed by subjects (36). It is expensive in terms of time and resources (37), however, and many arguments have been raised in the last 15 years (38, 39) in favour of using JEMs that quickly associate a job title with an estimated exposure.

Aside from their usefulness in assessing past exposure as part of epidemiological studies, JEMs can also be used to estimate proportions of occupational exposure to harmful substances or working conditions (40). These figures are then used to set research priorities (41), support public health programs (42), target prevention initiatives in the workplace (43) or assess the occupational disease burden in the population (44).

In several European countries (40, 44), the United States (45) and Canada (46), decision makers, health-care professionals, researchers and employer and trade union organizations have used JEMs to estimate the extent of workplace exposure to various substances for the purposes of medical or hygiene initiatives, development of standards and identification of research needs and prevention initiatives. The vast majority of JEMs (47) are based on studies of male workers (48, 49), and worker sex is generally not taken into consideration as a factor that could influence exposure estimates. Kennedy and Koehoorn (9) have argued that the magnitude and direction of differences in exposure that could be associated with gender cannot be predicted, which has subsequently been confirmed by several authors (11, 26-28, 50-53). It is therefore important to try to shed light on the potential gender-related differences in exposure within a given occupation. In this respect, the development of task-exposure matrices is more promising, as they take into account differences in tasks for the same job title. However, very few of these matrices have been developed so far, and to our knowledge, none has been developed for more than a few types of exposure (32, 33).

1.4 Study Feasibility

At present there is a lack of reliable, precise data that could be used to confirm the presence or absence of differences in exposure between men and women holding the same jobs. Potentially notable differences between men and women need to be studied and identified with a view to prompting the developers of occupational exposure information systems, such as JEMs, to incorporate sex as an exposure-related variable, which would help refine their estimates and validate the proposed tools.

The ideal way to verify the existence of exposure differences of this kind would involve observing workers of both sexes with the same job titles and measuring their exposure objectively over a large number of workdays. But obtaining hygiene measurement data on a sufficiently large number of individuals and in a sufficiently large number of different jobs is practically impossible, given the time it would require and the associated costs. The best option would therefore appear to be to explore the question using existing data. It should be possible to compare occupational exposure between men and women based on already completed epidemiological studies for which good-quality occupational exposure data already exist. The availability of this kind of data in Quebec is what motivated this analysis.

A few large-scale epidemiological case-control studies have been conducted since the late 1980s in the greater Montreal area by researchers affiliated with the Institut Armand-Frappier (now Centre INRS–IAF), McGill University and the Université de Montréal. To assess exposure, these studies used a method that was quite innovative at the time, developed by Siemiatycki and Gérin (54). On the basis of a detailed work history (including details about tasks performed, physical surroundings, control methods, etc.) and relevant scientific and technical literature, a team of chemists and industrial hygienists specifically trained for the purpose determined, for each job, the exposure to a list of approximately 300 chemicals or physical hazards or exposure circumstances (54). This method is today considered to be one of the more reliable ways of assessing exposure in population-based case-control studies (31) and is definitely superior to other retrospective exposure assessment methods (34, 35, 37). The method has been used successfully in numerous studies, especially of lung cancer (55), prostate cancer (56), breast cancer (57) and brain cancer (58). Many of these studies used data on a large number of women and so offer exceptional, unique potential for information on women’s exposure and on differences in exposure between men and women.

Among the studies conducted in Montreal, two seem especially relevant to examining sex- or gender-based differences in occupational exposure: one on lung cancer and the other on breast cancer. They were done in the late 1990s and included both male and female subjects for the lung cancer study, and only female subjects for the breast cancer study. Besides covering similar time periods, the studies offer the advantage of having been done on the Montreal population as a whole, having compiled information concerning lifetime employment history and having used the same exposure assessment method, applied by the same experts. This situation provides an excellent opportunity to explore gender-based differences in occupational exposure based on retrospective estimates of exposure done by experts.

2. OBJECTIVES

The general objective of this study was to explore differences in occupational exposure between men and women using existing epidemiological databases.

Its specific objectives were to

- Estimate the proportion and levels of exposure to a set of chemicals and a few physical hazards among men and women regardless of occupation and
- Compare the exposure proportions and levels between men and women for a given occupational or industrial category.

3. METHODS

This study uses exposure data produced as part of two case-control studies conducted in the greater Montreal area in the late 1990s. The data preparation and statistical analysis will be presented following a brief description of the two studies and the characteristics of their respective populations, as well as the exposure assessment method.

3.1 Study Population

The two case-control studies that provided the occupational exposure data were conducted between 1996 and 2001 by two research teams that shared the same methodology: Jack Siemiatycki's team and that of Mark S. Goldberg and France Labrèche. They sought to shed light on the occupational and environmental causes of two kinds of cancer.

The first, on lung cancer, was a general population case-control study carried out between 1996 and 2001. The subjects resided in the greater Montreal area and were aged 35 to 75 at the time of recruitment for the study. The controls, selected from electoral lists, were frequency-matched to cases by age and sex. The participation rate was 86% for the cases and 70% for the controls. From this study, the occupational histories of 1,657 men and 1,004 women were included in the analysis.

The second, on breast cancer, was a hospital population case-control study carried out between 1996 and 1997. The subjects resided in the greater Montreal area and were aged 50 to 75 at the time of diagnosis. The controls were new cases of cancer (32 different sites). They were matched by age and selected from the same hospital and same time period as the cases. The participation rate was 81% for the cases and 75% for the controls. From that study, the occupational histories of 1,169 women were included in the analysis.

The data gathered from the cases and controls of these two studies provided a sample of 1,657 men and 2,073 women, corresponding to a total of 13,882 jobs, 6,870 of which were held by men and 7,012 by women. Table A-1, in the appendix, provides some key descriptive data on the subjects of the two studies. It can be seen that the age distributions of the men and women were similar and that the men were, on average, less educated than the women (39.4% of the men had 7 or fewer years of education, compared with 31.4% of the women, and 30.0% of the men had 11 years or more, compared with 45.9% of the women).

3.2 Data Collection

A standardized survey questionnaire was administered by trained interviewers in face-to-face or telephone interviews with the subjects. Most of the survey interviews were done face to face for the lung cancer study and by telephone for the breast cancer study. The interviews were conducted with the subjects themselves or with next of kin if the subject was deceased or too ill to answer the survey questions. The questionnaire covered sociodemographic information, medical history and lifestyle (tobacco use, alcohol use, physical activity, etc.). For the breast cancer study, gynecological and obstetrical information was also gathered.

In both studies, detailed occupational history information was obtained using the same semistructured survey questionnaire. For each job held for more than six months, the interviewer noted the start and end dates, the employer's name, the products and processes used, the type of workplace, and the primary and secondary tasks performed, and asked questions specific to the occupation in order to obtain clues as to potential exposures and the intensity of those exposures (work performed by other employees nearby, equipment maintenance, use of personal protective equipment, etc.). Each job was coded in accordance with the 1971 Canadian Classification and Dictionary of Occupations (CCDO) (59) and the 1980 Standard Industrial Classification (SIC) (60).

The CCDO is a job classification based on seven digits, which has four levels of increasingly detailed description, according to the number of digits in the code:

- Major Group: There are 23 major groups representing very broad areas of employment and identified by two-digit codes.
- Minor Group: The major groups are subdivided into 81 minor groups identified by three-digit codes.
- Unit Group: There are 499 unit groups, identified by four-digit codes. In the remainder of this report, they will be referred to as "occupational groups." The definitions of the unit groups follow the model of the major group and minor group definitions, along with a more detailed description of the occupational activity.
- Occupation: There are around 7,000 different occupations in the classification. Occupation is the most precise category specifically defined in the CCDO system. Each occupation is identified by a seven-digit code.

The SIC is a classification based on a four-digit code. The level of detail depends on the number of digits used:

- Division, indicated by the first digit
- Major Group, indicated by the first two digits. This level of classification is used in our analysis to identify the economic sector in which the work was done
- Industry Group, indicated by the first three digits
- Industry itself, indicated by four digits

Although quite old, these classification systems describe workers' exposure circumstances in greater detail than the more recent classifications now used by Statistics Canada.

3.3 Exposure Assessment Method

The retrospective assessment of exposure, based on expert judgment, was done by the same team of chemists and industrial hygienists for the two studies. This method has been amply described in earlier publications (54, 61).

All the subjects' jobs were examined and assessed in terms of estimated exposure to a list of 294 different substances or exposure circumstances frequently encountered in the workplace and for which information was available in the literature. The list includes specific substances or circumstances, such as benzene or acrylic fibres, classes such as aromatic amines or synthetic fibres; standard blends of fixed composition, like gasoline, or variable composition, like paints; complex materials, such as cement; or more general categories, such as solvents. The sources of information used by the experts included the scientific and technical literature, industrial directories, contacts with industry or occupational health experts and consultants, and industry visits. Exposure was assessed for each job without knowing whether it was for a case or a control. The final assessments were the result of a consensus among the experts. Note that the experts could find out the worker's sex when doing the assessment. Nevertheless, they worked from the detailed occupational histories gathered by the interviewers using occupation-specific questionnaires. The fact they knew the described tasks were performed by men or women should not have introduced any major bias, as sex was not a variable specifically studied at the time of the exposure assessment. In addition, the assignment of exposures was based on the description of the tasks in the occupation and the industry of the job in question.

For each combination of agent and job, exposure was described in terms of three dimensions:

- Coder's degree of certainty of the presence of the agent in the job (possible, probable, certain)
- Proportion of usual weekly exposure (percentage of a typical 40-hour week)
- Relative level of exposure (low, moderate, high) weighted according to a semiquantitative scale (low = 1, moderate = 5, high = 25)

By combining the weekly exposure proportion and the relative level of exposure, a result corresponding to the mean intensity of exposure weighted over a workweek could be obtained. An absence of exposure was defined as any exposure less than or equal to the levels found in the general (non-occupational) environment.

3.4 Analysis

In the analysis, we investigated 243 chemical and physical agents coded in the two studies and for which exposures had been assessed (see full list in Table A-2, in the appendix).

As the study objective was to compare job exposure data for men and women, the unit of analysis was the job (corresponding to an occupation held in an industry by a subject during his or her life) and not the individuals themselves (case or control). Following a general description of the jobs by their occupational and industrial classifications, the proportion of exposure to the various substances and the frequency-weighted mean intensity of exposure were calculated by sex for all the jobs analysed, and the analyses were then stratified by occupation.

3.4.1 Exposure Proportion by Sex for All Jobs

To meet the first specific objective of estimating the proportion and levels of exposure to a set of chemicals and physical agents among men and women (regardless of occupation), an overall comparison of the exposure proportions of jobs held by men and those held by women, all occupations and all industries combined, was conducted by class of chemicals (total of

45 classes, see the list in Section 4.1) for each of the 243 chemical and physical agents assessed. Note that the exposure proportions calculated here are those associated with jobs deemed exposed, and not with the subjects, men or women. Thus, an exposure proportion of 10% means that for 100 jobs assessed in the study, 10 were deemed to be exposed to the agent in question.

3.4.2 Comparison of Exposure by Sex, Stratified by Occupational Category

To meet the second specific objective (compare the exposure proportion and exposure levels of men and women for the same occupational category or industry), the exposure proportion and the frequency-weighted intensity of exposure of the jobs held by men and those held by women were compared by stratifying by occupation. Three analysis groups were created based on the level of detail of the stratification:

- Occupational groups (four-digit CCDO code)
- Individual occupations (seven-digit CCDO code)
- A combination of occupational groups (four-digit CCDO code) and major industry groups (two-digit SIC code), referred to here as “occupational group/industry group pairs”

3.4.2.1 Exposure Proportion

Whatever the degree of detail of the stratification, the analysis was restricted to groups having at least 10 jobs held by both men and women. An exposed job was defined, regardless of the chemical agent, as being one for which the weekly exposure proportion was at least 5% of the workweek (corresponding to two hours per week), at an exposure level of at least low. For comparison analyses stratified by occupation, an occupational group (or an occupation or an occupational group/industry group pair) was considered to be exposed when the experts assessed exposure for 5% or more of the jobs in the group in most tables; however, results are also presented for an exposure threshold of 1% of the jobs in the group (62).

3.4.2.2 Frequency-Weighted Intensity of Exposure

For the frequency-weighted intensity of exposure, regardless of the level of stratification, the analysis was restricted to combinations of agents and occupational or industrial codes having at least five jobs exposed for both men and women.

3.4.2.3 Comparisons Between Jobs Held by Men and by Women

This comparison between men and women was defined, for the exposure proportion and the frequency-weighted intensity of exposure, by the combination of an occupational code and a given chemical agent.

First, the general agreement between the proportions and the frequency-weighted intensities of exposure of the men and the women, across all the points of comparison meeting the inclusion criteria, was estimated by the intraclass correlation coefficient (ICC).

Then, for each chemical agent studied, the difference in exposure proportion or frequency-weighted intensity of exposure between men and women was estimated by modelling for each point of comparison, based on a hierarchical binomial Bayesian model. In order to identify major differences from a practical standpoint, "notable difference" criteria for exposure proportions and frequency-weighted intensities of exposure between men and women, for the same occupation, were established using predefined thresholds (Table 1).

The absolute value of these predefined thresholds was not the same for the exposure proportion and the frequency-weighted intensity of exposure and also varied in relation to the smallest range of estimates for men and women. For example, for the same occupation, if the minimum exposure proportion for men or women was 20%, then the difference of proportion between the sexes had to be greater than 7.5%, with a probability of 95%, in order to be considered a "notable difference." For the frequency-weighted intensity of exposure, when the minimum intensity for men or women was 15, for instance, the difference between the two sexes had to be greater than 5 in order to be considered notable.

Table 1 – Predefined thresholds for determining notable differences in exposure proportion and frequency-weighted intensity of exposure

Exposure proportion		Frequency-weighted intensity of exposure[1]	
Minimum estimate range[2] (%)	**Difference threshold between sexes[3] (%)**	**Minimum estimate range[2]**	**Difference threshold between sexes[3]**
≤ 1	0.25	≤ 1	0.25
> 1-5	1.25	> 1-5	1.25
> 5-15	3.75	> 5-10	2.50
> 15-30	7.50	> 10-15	3.75
> 30-50	12.50	> 15-20	5.00
> 50-80	20.00	> 20	6.25
> 80	25.00		

[1] The frequency-weighted intensity of exposure was calculated by multiplying the weekly exposure proportion (percentage of a 40-hour week with exposure) by the relative exposure level (low = 1, moderate = 5, high = 25).

[2] Minimum estimate of exposure proportion or frequency-weighted intensity of exposure between men and women, obtained (with a probability of 95%) by modelling based on a hierarchical binomial Bayesian model.

[3] Arbitrary threshold defining a notable difference and corresponding to a quarter of the upper limit of the range of values considered.

3.4.3 Statistical Methods

3.4.3.1 Agreement Testing

The agreement between the exposures assessed for jobs held by men and by women was evaluated by means of the intraclass correlation coefficient (ICC, for the exposure proportions and the frequency-weighted intensities of exposure of the jobs) and a confidence interval (CI) of 95%, calculated using R software (63).

3.4.3.2 Bayesian Modelling

The differences in exposure proportions or frequency-weighted intensities of exposure between men and women for each occupational stratum combination were estimated by means of a hierarchical binomial Bayesian model specific to each agent, with the occupation defining the hierarchy. The exposure proportion was modelled as a binomial distribution, of parameters p_i and n_i (for the i^{th} occupation) where the logit of p_i followed a normal distribution with hyperparameters mu and tau.. The prior distributions for the hyperparameters were derived from a previous case-control study of men in Montreal concerning several different cancer sites (64). The frequency-weighted intensity of exposure was modelled, for each agent, as a linear combination of an intercept and a sex effect. Both parameters differed for each occupation and came from normal distributions with hyperparameters set with uninformative priors. For each model, the distributions of proportions and frequency-weighted intensities were derived from the 100,000 iterations leading, for each occupation-agent combination, to a posterior distribution of the two indices. The median of the posterior distributions was used for the final estimate.

4. RESULTS

4.1 Descriptive Analysis for All Jobs

The data analysed consisted of 13,882 jobs, 6,870 of which were held by men and 7,012 by women, between the years 1935 and 2000. For these jobs, 439 different occupational unit groups (four-digit CCDO code) were identified, 411 among men and 291 among women. If the definition of job title is further refined, our sample covered 1,745 different occupations (seven-digit CCDO code), 1,367 among men and 863 among women. Lastly, these 13,882 jobs correspond to 2,595 occupational group/industry group pairs (four-digit CCDO codes and two-digit SIC codes), that is, 1,855 among men and 1,277 among women. Whatever degree of coding precision is used to define job titles, the diversity of occupational groups, occupations and occupational group/industry group pairs is greater among men.

Table 2 lists, in declining order, the 15 most common occupational groups among the jobs held by men (top part of the table) and the 15 most common occupational groups among those held by women (bottom part of table). In the appendix, Table A-3 gives the corresponding results for occupations (seven-digit CCDO code) and Table A-4 the results for occupational group/industry group pairs. As expected, men and women do not have the same employment profiles. Around 5% of the jobs held by men fell into the occupational group of *Truck Drivers*, while only one woman held such a job. On the other hand, 11% of the jobs held by women were in the *Secretary and Stenographer* occupational group, compared with only 0.1% of the jobs held by men. With respect to occupations (seven-digit CCDO code), in addition to the differences noted regarding truckers and secretaries and stenographers, the *Construction Labourers* occupational group was only found among men, while the *Sewing Machine Operators* group was essentially female (Table A-3 in the appendix). An examination of the distribution of the occupational group/industry group pairs revealed some categories in which no jobs were held by women (in particular those of *Truck and Taxi Drivers* and *Drivers in the Transportation Industry*, *Construction Labourers*, *Armed Forces*, *Motor Vehicle Mechanics and Repairers* and *Loggers* in the forestry industry). The opposite was more uncommon: even the occupational group/industry group pairs in which virtually all jobs were held by women had some categories where men were employed (including those of *Sewing Machine Operators* in the clothing industry, *Elementary and Kindergarten Teachers* and *Nurses and Nursing Attendants*) (Table A-4 in the appendix).

When exposure to classes of chemicals is considered (Table 3), it can be seen that 34.4% of jobs held by men were deemed to be exposed to motor vehicle exhaust, compared with only 3% of jobs held by women. Likewise, a major difference can be seen with respect to exposure to petroleum fractions, polycyclic aromatic hydrocarbons, building material dust and abrasive dust, to which primarily men are exposed, whereas the jobs held by women were found to be more exposed to fabric and textile fibre dust and to aliphatic aldehydes.

Table 2 – Most common occupational groups among jobs held by men and women

CCDO code[1]	Name of occupational group[2]	Jobs held by men (*N* = 6,870)			Jobs held by women (*N* = 7,012)		
		Rank	*n*	%	Rank	*n*	%
Most common occupational groups among jobs held by men							
9175	Truck Drivers	*1*	337	4.9	*230*	1	0.0
9318	Occupations in Labouring, Material Handling, n.e.c.	*2*	176	2.6	*13*	152	2.2
6191	Janitors, Charworkers and Cleaners	*3*	169	2.5	*16*	106	1.5
8798	Occupations in Labouring, Other Construction Trades, n.e.c.	*4*	149	2.2	*292*	0	0.0
8581	Motor-Vehicle Mechanics and Repairmen	*5*	140	2.0	*201*	2	0.0
1179	Occupations Related to Management and Administration, n.e.c.	*6*	122	1.8	*24*	56	0.8
5130	Supervisors: Sales Occupations, Commodities	*7*	114	1.7	*21*	68	1.0
8781	Carpenters and Related Occupations	*8*	108	1.6	*292*	0	0.0
6115	Guards and Watchmen	*9*	102	1.5	*40*	30	0.4
8799	Other Construction Trades Occupations, n.e.c.	*10*	100	1.5	*202*	2	0.0
5135	Salesmen and Salespersons, Commodities, n.e.c.	*11*	98	1.4	*8*	174	2.5
5137	Sales Clerks, Commodities	*12*	96	1.4	*11*	164	2.3
8335	Welding and Flame Cutting Occupations	*13*	95	1.4	*48*	26	0.4
7181	Farm Workers, General	*14*	93	1.4	*49*	26	0.4
5133	Commercial Travellers	*15*	93	1.4	*60*	20	0.3
Most common occupational groups among jobs held by women							
4111	Secretaries and Stenographers	*239*	4	0.1	*1*	775	11.1
8563	Sewing Machine Operators, Textile and Similar Materials	*47*	35	0.5	*2*	550	7.8
6125	Waiters, Hostesses and Stewards, Food and Beverage	*19*	86	1.3	*3*	358	5.1
4131	Bookkeepers and Accounting Clerks	*20*	85	1.2	*4*	357	5.1
4197	General Office Clerks	*25*	67	1.0	*5*	275	3.9
2731	Elementary and Kindergarten Teachers	*102*	16	0.2	*6*	199	2.8
4171	Receptionists and Information Clerks	*203*	6	0.1	*7*	175	2.5
5135	Salesmen and Salespersons, Commodities, n.e.c.	*11*	98	1.4	*8*	174	2.5
4133	Tellers and Cashiers	*97*	17	0.2	*9*	170	2.4
3135	Nursing Aides and Orderlies	*94*	18	0.3	*10*	168	2.4
5137	Sales Clerks, Commodities	*12*	96	1.4	*11*	164	2.3
6142	Housekeepers, Servants and Related Occupations	*355*	1	0.0	*12*	159	2.3
9318	Occupations in Labouring, Material Handling, n.e.c.	*2*	176	2.6	*13*	152	2.2
3131	Nurses, Graduate, Except Supervisors	*307*	2	0.0	*14*	148	2.1
6121	Chefs and Cooks	*21*	85	1.2	*15*	131	1.9

[1] Canadian Classification and Dictionary of Occupations, 1971.
[2] Original occupational group names, used in 1971. Some group names are no longer used today.

Table 3 – Proportion of exposure by sex to 45 classes of chemicals studied

Chemical agent	Jobs held by men (%)	Jobs held by women (%)
Abrasive dusts	13.9	3.0
Aliphatic aldehydes	9.6	13.5
Alkalis, caustic solution	2.1	1.9
Alkanes (C1-C4)	6.5	1.2
Animal dusts	1.2	1.9
Aromatic alcohols	1.0	1.3
Building materials dusts	16.3	1.7
Carbon dust	2.8	1.0
Complex organic liquids	17.9	6.8
Cutting fluids	2.9	0.2
Exhaust fumes	34.4	3.0
Fabric and textile fibre dusts	5.6	12.4
Fillers	9.8	6.5
Flour, grain and derivatives dusts	4.6	2.4
Fluorocarbons	0.7	0.4
Halogenated aromatic hydrocarbons	0.7	0.1
Herbicides	0.4	0.0
Inorganic acids	7.6	1.5
Inorganic acids, solution	7.1	1.5
Inorganic insulation dusts	9.9	0.5
Inorganic pigments	8.6	1.3
Insecticides	3.7	1.8
Metal and metal oxide fumes	8.9	0.6
Metal dust	12.2	1.6
Nitrogen oxides	11.9	0.4
Organic solvents	26.7	17.5
Other combustion fumes	40.9	31.3
Other inorganic dusts	4.0	3.9
Other inorganic gases	30.0	21.7
Other inorganic liquids	0.4	0.7
Other organic dusts	9.0	6.9
Other organic gases	1.8	3.9
Paints, varnishes and inks	8.5	3.9
Petroleum fractions	29.6	6.6
Plastic dusts	4.9	1.7
Polycyclic aromatic hydrocarbons	26.4	6.2
Pyrolysis fumes	7.3	1.7
Rubber dust	1.4	0.4
Soot from all sources	2.3	0.1
Synthetic oils and greases	0.4	0.0
Unsaturated aliphatic hydrocarbons	2.5	0.1
Volatile organic liquids	30.3	17.4
Welding fumes	9.9	1.1
Wood dust	11.3	0.7
Wood preservative products	0.6	0.0

Table A-2, in the appendix, breaks down the exposure proportions by sex for all the chemical and physical agents to which all the jobs held by men or women were deemed to be exposed. The four leading agents for the proportion of jobs deemed exposed among both men and women are magnetic fields, pulsed electromagnetic fields, second-hand tobacco smoke and volatile organic liquids. Organic solvents and carbon monoxide are two other exposures frequently found among both men and women. Finally, some jobs held by men are more associated with diesel engine exhaust exposure, while others, held by women, are associated in greater proportion with exposure to cleaning agents and formaldehyde.

4.2 Analysis Stratified by Occupational Group

This section presents the results of comparing the occupational exposures of men's and women's jobs to the 243 chemical and physical agents studied, stratified by occupation, defined by occupational unit group (four-digit CCDO code).

By considering only jobs having at least 10 occurrences both among men and among women, we were able to compare occupational exposure to the 243 chemical and physical agents studied for 59 occupational groups. The list of these occupational unit groups is given in Table A-5 in the appendix.

4.2.1 Exposure Proportion

In total, 14,337 "occupational group-agent" combinations were compared (59 four-digit CCDO codes × 243 chemical and physical agents). Among these combinations, the exposure proportion was null (in other words, less than 1% of the jobs of a point of comparison were associated with an exposure) among both men and women for 10,068 points of comparison. For the remaining 4,269 combinations, 38.9% of jobs were deemed to be exposed for men and women, i.e., an exact correspondence of 1,662/4,269. The experts assigned more exposures to the jobs held by men (1,584/4,269) than to those held by women (1,023/4,269) (Table 4).

Table 4 – Number of "occupational group-agent" combinations by exposure and sex (1% or more of jobs having one exposure per group)

		Jobs held by men		Total
		Exposed[1]	**Non-exposed**	
Jobs held by women	**Exposed[1]**	1,662	1,023	2,685
	Non-exposed	1,584	10,068	11,652
Total		3,246	11,091	14,337

[1] An exposed "occupational group-agent" combination has a non-null exposure proportion (i.e., at least 1% of the jobs are associated with an exposure frequency of at least 5% of the workweek, as determined by the experts; see Section 3.4.2.1).

When a stricter exposure criterion was used for these combinations (i.e., 5% or more of the jobs of a point of comparison are linked to an exposure), the null exposure proportion among both men and women rose to 12,687 points of comparison. For the remaining 1,650 combinations, the exact agreement was 48.1%, i.e., 794/1,650, and there were more points of comparison with exposure only among men (552) than only among women (304) (Table 5).

Table 5 – Number of "occupational group-agent" combinations by exposure and sex (5% or more of jobs having one exposure per group)

		Jobs held by men		Total
		Exposed[1]	**Non-exposed**	
Jobs held by women	**Exposed[1]**	794	304	1,098
	Non-exposed	552	12,687	13,239
Total		1,346	11,091	14,337

[1] An exposed "occupational group-agent" combination has a non-null exposure proportion (i.e., at least 5% of the jobs are associated with an exposure frequency of at least 5% of the workweek, as determined by the experts; see Section 3.4.2.1).

Table 6 presents in greater detail the cross-breakdown of the exposure proportions for the 14,337 points of comparison by sex. The exact agreement (rectangle running diagonally across the table) between the estimated proportions of exposure among men and those estimated among women was 91.0% (13,041/14,337 "occupational group-agent" combinations). Nevertheless, when we consider the cells representing disagreement (cells outside the diagonal), nearly twice as many points of comparison lie in the upper triangle than in the lower triangle, suggesting that for equivalent occupational groups and chemical agents, the jobs held by men are deemed proportionally more exposed than the jobs held by women. In fact, for 803 points of comparison, the exposure proportions are higher among men than among women, whereas the reverse is true for 493 points of comparison. Based on this table, the intraclass correlation coefficient is 0.74 (CI 95%: 0.71–0.77) for the comparison of occupational groups with 5% or more of jobs associated with an exposure. If an exposure threshold of 1% or more of jobs exposed is used, the intraclass correlation coefficient is higher (ICC of 0.80, CI 95%: 0.78–0.82).

Table 6 – Breakdown of "occupational group-agent" points of comparison by exposure proportion, by sex

Jobs held by women Exposure proportion (%)	Jobs held by men – Exposure proportion (%) > 0–5	> 5–15	> 15–30	> 30–50	> 50–80	> 80	Total
> 0–5	12,687	416	97	22	11	6	13,239
> 5–15	237	125	79	22	10	1	474
> 15–30	57	60	65	33	17	5	237
> 30–50	7	17	41	43	41	10	159
> 50–80	3	4	11	30	68	33	149
> 80	0	1	2	2	21	53	79
Total	12,991	623	295	152	168	108	14,337

Table 7 presents the breakdown of the 4,269 points of comparison with non-null exposure (> 0% exposure) by the criterion of notable difference and by smallest estimated exposure proportion stratum between men and women. A notable difference can be seen for 326 points of comparison (7.6%), with the jobs held by men being deemed exposed in greater proportion than those held by women (219 notable differences compared with 107). Nevertheless, when a notable difference exists, the magnitude of that difference is similar for men and women, regardless of the direction of the difference (see Table A-6 in the appendix).

Table 7 – Breakdown of the median of the exposure proportion differences between men and women for each "occupational group-agent" point of comparison having a non-null exposure proportion

Smallest estimated proportion (%)	Non-notable differences		Notable differences[1] Women > Men[2]		Men > Women[3]		Total		Total
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
> 0–5	3,261	*93.8*	66	*1.9*	148	*4.3*	214	*6.2*	3,475
> 5–15	266	*83.4*	21	*6.6*	32	*10.0*	53	*16.6*	319
> 15–30	137	*78.7*	15	*8.6*	22	*12.6*	37	*21.3*	174
> 30–50	105	*83.3*	5	*4.0*	16	*12.7*	21	*16.7*	126
> 50–80	121	*99.2*	0	*0.0*	1	*0.8*	1	*0.8*	122
> 80	53	*100.0*	0	*0.0*	0	*0.0*	0	*0*	53
Total	3,943	*92.4*	107	*2.5*	219	*5.1*	326	*7.6*	4,269

[1] A difference is notable when it is greater than a predefined value, which varies by exposure proportion stratum. See the predefined values in Table 1.

[2] Exposure proportion greater in jobs held by women than in those held by men.

3. Exposure proportion greater in jobs held by men than in those held by women.

4.2.2 Frequency-Weighted Intensity of Exposure

Work similar to that done for exposure proportions was carried out for frequency-weighted intensity of exposure. In the analysis stratified by occupational group (four-digit CCDO code), we examined 118 chemical and physical agents. The number of occupational groups studied varied from one agent to the next (from 1 to 67 occupational groups, with a mean of 5 per agent and a median of 2). The occupational groups studied also varied from one chemical or physical agent to the next, and it is impossible to list them as was done for exposure proportions.

Table 8 presents the cross breakdown of estimated frequency-weighted intensity of exposure among men and among women for the 654 “occupational group-agent” combinations studied. Most of the points are located on the agreement diagonal, and the exact agreement between the estimated frequency-weighted intensities among men and those estimated among women was 66.8% (437/654 “occupational group-agent” combinations with non-null exposure). The calculated intraclass correlation coefficient was 0.82 (CI 95%: 0.79–0.84) when only levels greater than 1 (corresponding, for instance, to low exposure throughout the workweek) were considered. When all exposure was considered (i.e., levels greater than 0), the ICC did not change noticeably (ICC of 0.82, CI 95%: 0.79–0.85).

Table 8 – Breakdown of “occupational group-agent” points of comparison by frequency-weighted intensity of exposure, by sex

Jobs held by women – Frequency-weighted intensity of exposure	Jobs held by men – Frequency-weighted intensity of exposure						
	> 0–1	**> 1–5**	**> 5–10**	**> 10–15**	**> 15–20**	**> 20**	**Total**
> 0–1	52	123	1	0	0	0	176
> 1–5	19	355	33	2	0	0	409
> 5–10	0	21	19	8	0	1	49
> 10–15	0	0	7	6	1	0	14
> 15–20	0	0	0	0	3	0	3
> 20	0	0	0	1	0	2	3
Total	71	499	60	17	4	3	654

An examination of the breakdown of notable differences, as shown in Table 9, reveals that there are only 15 points of comparison for which such a difference can be seen (2.3%). At the same time, there are almost as many notable differences for women (1.1%) as for men (1.2%), if their respective frequency-weighted intensities of exposure are taken into account. As the number of notable differences is very limited, it is impossible to detect a pattern by sex with respect to these differences (see Table A-7 in the appendix).

Table 9 – Breakdown of differences in frequency-weighted intensity of exposure between men and women for each "occupational group-agent" point of comparison

Smallest estimated frequency-weighted intensity of exposure	Non-notable differences		Notable differences[1]						Total
			Women > Men[2]		Men > Women[3]		Total		
	n	%	n	%	n	%	n	%	
> 0–1	195	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	195
> 1–5	402	*97.8*	4	*1.0*	5	*1.2*	9	*2.2*	411
> 5–10	30	*85.7*	2	*5.7*	3	*8.6*	5	*14.3*	35
> 10–15	7	*87.5*	1	*12.5*	0	*0.0*	1	*12.5*	8
> 15–20	3	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	3
> 20	2	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	2
Total	639	*97.7*	7	*1.1*	8	*1.2*	15	*2.3*	654

[1] A difference is notable when it is larger than a predefined value, which varies by frequency-weighted intensity of exposure stratum. See the predefined values in Table 1.

[2] Frequency-weighted intensity of exposure greater in jobs held by women than in those held by men.

[3] Frequency-weighted intensity of exposure greater in jobs held by men than in those held by women.

4.3 Analysis Stratified by Occupation (seven-digit CCDO code)

Some of the differences noted above may be explained by the degree of precision of the code used in the analyses. This section compares the occupational exposure of men's jobs and women's jobs to the 243 chemical and physical agents studied, stratified by occupation, defined by a more precise occupational code, i.e., the seven-digit CCDO code. To compare occupational exposures, the occupations common to both sexes had to be defined. Retaining only occupations having at least 10 occurrences among both men and women, we compared occupational exposure to these 243 chemical and physical agents for 30 occupations, which are presented in Table A-8 in the appendix.

With this degree of detail, we were able to identify 86 chemical and physical agents. The number of occupations studied also varied from one agent to the next (from 1 to 41 occupations, with a mean of 4 and a median of 2 occupations per chemical agent, respectively).

4.3.1 Exposure Proportion

A total of 7,290 "occupation-agent" combinations were compared (30 seven-digit CCDO codes × 243 chemical and physical agents). Among these combinations, the exposure proportion was null (i.e., less than 1% of the jobs of a point of comparison were associated with an exposure) among both men and women for 5,397 points of comparison. For the remaining 1,893 combinations, there were more with exposure only in jobs held by men (*n* = 641 combinations) than only in jobs held by women (*n* = 464 combinations) (Table 10).

Table 10 – Number of "occupation-agent" combinations by exposure and by sex (1% or more of jobs having an exposure per occupation)

		Jobs held by men		Total
		Exposed[1]	Non-exposed	
Jobs held by women	Exposed[1]	788	464	1,252
	Non-exposed	641	5,397	6,705
Total		1,429	5,861	7,290

[1] An exposed "occupation-agent" combination has a non-null exposure proportion (i.e., at least 1% of the jobs are associated with an exposure frequency of at least 5% of the workweek, as determined by the experts; see Section 3.4.2.1).

If a stricter exposure criterion is used for these combinations (5% or more of jobs of a point of comparison associated with an exposure), the number of points of comparison with null exposure among both men and women increases to 6,563 points of comparison. For the remaining 727 combinations, the exact agreement is 54.5%, i.e., 396/727, and there are then more points of comparison with exposure only among women than the reverse (Table 11).

Table 11 – Number of "occupation-agent" combinations by exposure and by sex (5% or more of jobs having an exposure per occupation)

		Jobs held by men		Total
		Exposed[1]	Non-exposed	
Jobs held by women	Exposed[1]	396	189	585
	Non-exposed	142	6,563	6,705
Total		538	6,752	7,290

[1] An exposed "occupation-agent" combination has a non-null exposure proportion (i.e., at least 5% of the jobs are associated with an exposure frequency of at least 5% of the workweek, as determined by the experts; see Section 3.4.2.1).

Table 12 gives the cross-breakdown of the proportions of exposure to 243 chemical and physical agents for the 30 occupations, by sex. The exact agreement between the estimated exposure proportions among men and those estimated among women is 92.7% (6,761/7,290 combinations). When stratified by occupation, the agreement between the estimated exposure proportions among men and those estimated among women is slightly better than the agreement obtained by stratifying by occupational group. As for the disagreement (cells outside the diagonal), unlike the analysis based on occupational group, this time there are more points of comparison that lie in the lower triangle than in the upper one, which suggests that for equivalent occupations and chemical agents, jobs held by women are more exposed in terms of proportion than jobs held by men. In fact, for 293 points of comparison, the exposure proportion is higher among women than among men, whereas the reverse is true for 236 points of comparison. Based on this table, the intraclass correlation coefficient is 0.80 (CI 95%: 0.76–0.84) for the comparison of occupations with 5% or more of jobs associated with an exposure; if an exposure threshold of 1% or more of jobs exposed is used, the intraclass correlation coefficient is higher (ICC of 0.85, CI 95%: 0.83–0.87).

Table 12 – Breakdown of "occupation-agent" points of comparison by exposure proportion, by sex

Jobs held by women Exposure proportion (%)	Jobs held by men – Exposure proportion (%)						
	0–5	**> 5–15**	**> 15–30**	**> 30–50**	**> 50–80**	**> 80**	**Total**
0–5	6,563	127	12	2	1	0	6,705
> 5–15	140	77	30	8	2	0	257
> 15–30	46	37	30	8	7	1	129
> 30–50	3	11	23	22	17	4	80
> 50–80	0	2	5	15	34	17	73
> 80	0	0	0	2	9	35	46
Total	6,752	254	100	57	70	57	7,290

Table 13 gives the breakdown of the 1,893 points of comparison with non-null exposure (> 0% exposure) based on the criterion of notable difference and by smallest estimated exposure proportion stratum between men and women. A notable difference can be seen for 103 points of comparison (5.4%) and in this case, the jobs held by women were deemed to be exposed in greater proportion than the jobs held by men (67 notable differences compared with 36). Nevertheless, the magnitude of the difference is similar, regardless of the direction of the difference (see Table A-9 in the appendix).

Table 13 – Breakdown of the median of the differences in exposure proportion between men and women for each "occupation-agent" point of comparison having a non-null exposure proportion

Smallest estimated exposure proportion (%)	Non-notable differences		Notable differences[1]						Total
			Women > Men[2]		Men > Women[3]		Total		
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
> 0–5	1,444	*96.5*	40	*2.7*	13	*0.9*	53	*3.5*	1,497
> 5–15	144	*86.2*	14	*8.4*	9	*5.4*	23	*13.8*	167
> 15–30	60	*81.1*	7	*9.5*	7	*9.5*	14	*18.9*	74
> 30–50	48	*80.0*	6	*10.0*	6	*10.0*	12	*20.0*	60
> 50–80	59	*98.3*	0	*0.0*	1	*1.7*	1	*1.7*	60
> 80	35	*100.0*	0	*0.0*	0	*0.0*	0	*0*	35
Total	1,790	*94.6*	67	*3.5*	36	*1.9*	103	*5.4*	1,893

[1] A difference is notable when it is greater than a predefined value, which varies by exposure proportion stratum. See the predefined values in Table 1.

[2] Exposure proportion greater in jobs held by women than in those held by men.

[3] Exposure proportion greater in jobs held by men than in those held by women.

4.3.2 Frequency-Weighted Intensity of Exposure

The frequency-weighted intensities of exposure in occupations having at least five jobs with an exposure for both men and women were compared for 86 chemical and physical agents. Depending on the agent in question, the number of occupations compared varied from 1 to 41.

Table 14 presents the cross breakdown of estimated frequency-weighted intensities of exposure among men and among women for the 390 "occupation-agent" combinations studied. As with the preceding tables, most of the points are located on the agreement diagonal, and the exact agreement between the estimated frequency-weighted intensities among men and those estimated among women was 77.4% (302/390 "occupation-agent" combinations with non-null exposure). The calculated intraclass correlation coefficient was 0.94 (CI 95%: 0.93–0.95) with an exposure level threshold of 1 or more and was practically unchanged with a lower level threshold (ICC 0.95, CI 95%: 0.93–0.95).

Only three points of comparison out of the 390 non-null "occupation-agent" combinations show a notable difference, which is equivalent to 0.8% of all the points analysed and therefore is not sufficient to identify a pattern by sex with respect to the magnitude of the differences (Table 15).

Table 14 – Breakdown of "occupation-agent" points of comparison by frequency-weighted intensity of exposure, by sex

Jobs held by women – Frequency-weighted intensity of exposure	Jobs held by men – Frequency-weighted intensity of exposure						
	> 0–1	**> 1–5**	**> 5–10**	**> 10–15**	**> 15–20**	**> 20**	**Total**
> 0–1	64	49	0	0	0	0	113
> 1–5	19	219	6	0	0	0	244
> 5–10	0	6	11	1	1	0	19
> 10–15	0	1	2	1	0	0	4
> 15–20	0	0	0	2	4	0	6
> 20	0	0	0	0	1	3	4
Total	83	275	19	4	6	3	390

Table 15 – Breakdown of the median of frequency-weighted intensity of exposure differences between men and women for each "occupation-agent" point of comparison

Smallest estimated frequency-weighted intensity of exposure	Non-notable differences		Notable differences[1]						Total
			Women > Men[2]		Men > Women[3]		Total		
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
> 0–1	132	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	132
> 1–5	230	*99.1*	1	*0.4*	1	*0.4*	2	*0.9*	232
> 5–10	14	*93.3*	0	*0.0*	1	*6.7*	1	*6.7*	15
> 10–15	3	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	3
> 15–20	5	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	5
> 20	3	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	3
Total	387	*99.2*	1	*0.3*	2	*0.5*	3	*0.8*	390

[1] A difference is notable when it is greater than a predefined value, which varies by frequency-weighted intensity of exposure stratum. See the predefined values in Table 1.

[2] Frequency-weighted intensity of exposure greater in jobs held by women than in jobs held by men.

[3] Frequency-weighted intensity of exposure greater in jobs held by men then in jobs held by women.

4.4 Analysis Stratified by "Occupational Group/Industry Group" Pairs

In this analysis taking into account both occupational groups and industries, 89 chemical and physical agents were studied. The number of "occupational group/industry group" pairs varied from one agent to the next (from 1 to 51 pairs, with a mean of 5 and a median of 2 pairs per chemical agent, respectively). To compare occupational exposure, the pairs common to both men and women were selected. Retaining only pairs having at least 10 occurrences both among men and among women, we compared occupational exposure to the 243 chemical and physical agents studied for 37 "occupational group/industry group" pairs, which are presented in Table A-10 in the appendix.

4.4.1 Exposure Proportion

A total of 8,991 "occupational group/industry group-agent" combinations were compared (37 "occupational group/industry group" pairs × 243 chemical and physical agents). The exposure proportion was null (less than 1% of jobs associated with an exposure) among both men and women for 7,290 points of comparison. For the 1,701 other combinations, more exposure was found in the jobs held solely by women than the reverse (Table 16).

Table 16 – Number of "occupational group/industry group-agent" combinations by exposure and by sex (1% or more of jobs having an exposure per pair)

		Jobs held by men		Total
		Exposed[1]	**Non-exposed**	
Jobs held by women	**Exposed[1]**	758	556	1,314
	Non-exposed	387	7,290	7,677
Total		1,145	7,846	8,991

[1] An exposed "occupational group/industry group-agent" combination has a non-null exposure proportion (i.e., at least 1% of the jobs are associated with an exposure frequency of at least 5% of the workweek, as determined by the experts; see Section 3.4.2.1).

If a stricter exposure criterion is used (5% or more of jobs associated with an exposure of a point of comparison), the number of points of comparison with null exposure among both men and women increases to 8,127 points of comparison. For the remaining 864 combinations, the exact agreement is 56.9% (i.e., 492/864), and there are more points of comparison with exposure only among women than the reverse (Table 17).

Table 17 – Number of "occupational group/industry group-agent" combinations by exposure and by sex (5% or more of jobs having an exposure per pair)

		Jobs held by men		Total
		Exposed[1]	Non-exposed	
Jobs held by women	Exposed[1]	492	223	715
	Non-exposed	149	8,127	8,276
Total		641	8,350	8,991

[1] An exposed "occupational group/industry group-agent" combination has a non-null exposure proportion (i.e., at least 5% of the jobs are associated with an exposure frequency of at least 5% of the workweek, as determined by the experts; see Section 3.4.2.1).

Table 18 gives the cross-breakdown of the proportions of exposure to the 243 chemical and physical agents studied for the 37 "occupational group/industry group" pairs, by sex. The exact agreement between the estimated exposure proportions among men and those estimated among women is 92.6% (8,327/8,990 combinations). When stratified by "occupational group/industry group" pairs, the exact agreement between the estimated exposure proportions among men and those estimated among women was weaker than that obtained by stratifying by occupational group or by occupation. As for disagreement (cells outside the diagonal), 664 points of comparison out of the total of 8,991 lie outside the agreement diagonal, with as many points of comparison in the lower triangle as in the upper triangle, which suggests that for equivalent occupation/industry pairs and chemical agents, there is no exposure preponderance for jobs held by women or jobs held by men. Based on this table, the intraclass correlation coefficient is 0.76 (CI 95%: 0.71–0.79) for the comparison of "occupational group/industry group" pairs with 5% or more of jobs exposed; if an exposure threshold of 1% or more of jobs exposed is used, the intraclass correlation coefficient was higher in this case, too (ICC of 0.83, CI 95%: 0.80–0.85).

Table 18 – Breakdown of "occupational group/industry group-agent" points of comparison by exposure proportion, by sex

Jobs held by women Exposure proportion (%)	Jobs held by men – Exposure proportion (%)						
	> 0–5	> 5–15	> 15–30	> 30–50	> 50–80	> 80	Total
> 0–5	8,127	107	35	6	1	0	8,276
> 5–15	155	43	33	9	5	1	246
> 15–30	56	35	34	27	7	2	161
> 30–50	11	9	30	23	28	17	118
> 50–80	1	2	10	21	38	38	110
> 80	0	1	0	1	16	62	80
Total	8,350	197	142	87	95	120	8,991

Table 19 shows the breakdown of the 1,701 points of comparison with non-null exposure (> 0% exposure) based on the criterion of notable difference and by smallest estimated exposure proportion stratum between men and women. A notable difference can be seen for 115 points of comparison (8.9%), without any obvious disequilibrium between men and women. The number of notable differences for which jobs held by women were deemed more exposed than jobs held by men is approximately equal to the number of notable differences for which the reverse was observed (5.2% compared with 3.7%). As mentioned earlier, when a notable difference exists, its magnitude is similar, regardless of the direction of the difference (see Table A-11 in the appendix).

Table 19 – Breakdown of the median of exposure proportion differences between men and women for each "occupational group/industry group-agent" point of comparison having a non-null exposure proportion

Smallest estimated exposure proportion (%)	Non-notable differences		Notable differences[1]						Total
			Women > Men[2]		Men > Women[3]		Total		
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
> 0–5	1,119	*92.6*	63	*5.2*	27	*2.2*	90	*7.4*	1,209
> 5–15	116	*84.1*	12	*8.7*	10	*7.2*	22	*15.9*	138
> 15–30	92	*83.6*	10	*9.1*	8	*7.3*	18	*16.4*	110
> 30–50	70	*77.8*	3	*3.3*	17	*18.9*	20	*22.2*	90
> 50–80	91	*98.9*	0	*0.0*	1	*1.1*	1	*1.1*	92
> 80	62	*100.0*	0	*0.0*	0	*0.0*	0	*0*	62
Total	1,550	*91.1*	88	*5.2*	63	*3.7*	151	*8.9*	1,701

[1] A difference is notable when it is greater than a predefined value, which varies by exposure proportion stratum. See the predefined values in Table 1.

[2] Exposure proportion greater in jobs held by women than in those held by men.

[3] Exposure proportion greater in jobs held by men than in those held by women.

4.4.2 Frequency-Weighted Intensity of Exposure

Frequency-weighted intensities of exposure in "occupational group/industry group" pairs having at least five jobs with an exposure among both men and women were compared for 89 chemical and physical agents. Depending on the agent in question, the number of pairs compared ranged from 1 to 51.

Table 20 gives the breakdown of the estimated frequency-weighted intensities among men and among women for the 425 points of comparison of the "occupational group/industry group-agent" pairs studied. Despite a considerable number of zeros outside the agreement diagonal, the exact agreement between the estimated frequency-weighted intensities among men and those estimated among women was 66.6% (283/425 combinations). The calculated intraclass correlation coefficient was 0.83 (CI 95%: 0.79–0.86).

Table 20 – Breakdown of "occupational group/industry group-agent" points of comparison by frequency-weighted intensity of exposure, by sex

Jobs held by women – Frequency-weighted intensity of exposure	Jobs held by men – Frequency-weighted intensity of exposure						
	> 0–1	**> 1–5**	**> 5–10**	**> 10–15**	**> 15–20**	**> 20**	**Total**
> 0–1	46	74	0	0	0	0	120
> 1–5	25	225	15	2	0	0	267
> 5–10	0	13	9	2	1	0	25
> 10–15	0	0	6	0	0	0	6
> 15–20	0	0	2	0	1	1	4
> 20	0	0	0	0	1	2	3
Total	71	312	32	4	3	3	425

A total of 11 notable differences (2.6%) were identified between men and women, in Table 21, although it was not possible to detect a systematic pattern regarding the direction of the difference.

Table 21 – Breakdown of the median of frequency-weighted intensity of exposure differences between men and women for each "occupational group/industry group-agent" point of comparison

Smallest estimated frequency-weighted intensity of exposure	Non-notable differences		Notable differences[1]						Total
			Women > Men[2]		Men > Women[3]		Total		
	n	***%***	***n***	***%***	***n***	***%***	***n***	***%***	
> 0–1	145	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	145
> 1–5	248	*97.3*	0	*0.0*	7	*2.7*	7	*2.7*	255
> 5–10	17	*85.0*	1	*5.0*	2	*10.0*	3	*15.0*	20
> 10–15	0	*0.0*	0	*0.0*	0	*0.0*	0	*0.0*	0
> 15–20	2	*66.7*	1	*33.3*	0	*0.0*	1	*33.3*	3
> 20	2	*100.0*	0	*0.0*	0	*0.0*	0	*0.0*	2
Total	414	*97.4*	2	*0.5*	9	*2.1*	11	*2.6*	425

[1] A difference is notable when it is greater than a predefined value, which varies by frequency-weighted intensity of exposure stratum. See the predefined values in Table 1.
[2] Frequency-weighted intensity of exposure greater in jobs held by women than in jobs held by men.
[3] Frequency-weighted intensity of exposure greater in jobs held by men than in jobs held by women.

4.5 Descriptive Analysis of Differences Between Men and Women

The 326 notable differences observed in exposure proportions were examined comprehensively by an expert coder to identify potential causes of the differences between men and women. The results of the analysis are presented in Figure 1. For 187 cases (57.4%), the difference can be explained by different occupations (seven-digit CCDO codes) between men and women within the same four-digit group.

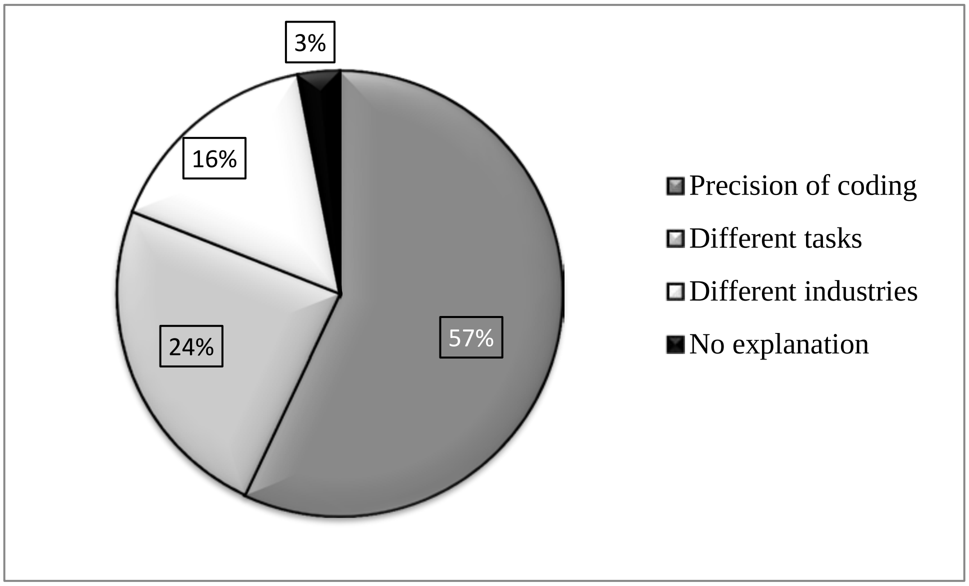

Figure 1 – Explanation of notable differences in exposure proportions between jobs

For instance, for the *Welding and Flame Cutting Occupations* group (CCDO 8335; 95 jobs among men and 26 among women), a notable difference in exposure proportions was seen for several chemical or physical agents, including abrasives, various metals, asbestos fibres, inorganic gases (carbon and nitrogen oxides, etc.), formaldehyde, organic liquids and electromagnetic fields. For the majority of these agents, the exposure proportion is higher among men than among women, with differences ranging from 10% for metal coatings to 92% for nitrogen oxide. For agents where the exposure proportion is higher among women than among men, the differences range from 32% for silver to 83% for soldering fumes (data not presented). In Table 22, a more precise definition (seven-digit CCDO code) of welding jobs shows that men's and women's jobs do not correspond to the same occupations, with men working chiefly as *Gas and Arc Welders* and *Flame-Cutting-Machine Operators*, whereas women were primarily involved in soldering metals together (metal joining without melting the workpieces).

Table 22 – Breakdown of occupational codes included in occupational group "8335 – Welding and Flame Cutting Occupations," by sex

CCDO code[1]	Name of occupation[2]	Jobs held by men (*N* = 95)		Jobs held by women (*N* = 26)	
		n	**%**	***n***	**%**
8335115	Apprentice Welder	1	1.1	0	0
8335126	Gas and Arc Welder	37	38.9	0	0
8335138	Electric Arc Welder	22	23.2	0	0
8335142	Gas Welder	4	4.2	0	0
8335146	Tack Welder, Assembler	5	5.3	0	0
8335162	Spot Resistance Welder	1	1.1	0	0
8335170	Resistance Welder Tender	2	2.1	0	0
8335214	Solderer	3	3.2	19	73.1
8335222	Jewellery Solderer	0	0	1	3.8
8335238	Solderer, Assembler	0	0	6	23.1
8335298	Flame-Cutting-Machine Operator	1	1.1	0	0
8335310	Hand Flame Cutter	13	13.7	0	0
8335314	Scrap Flame Cutter	1	1.1	0	0
8335342	Welder Helper	4	4.2	0	0
8335399	Other Welding and Flame-Cutting Occupations	1	1.1	0	0

[1] Canadian Classification and Dictionary of Occupations, 1971.
[2] Original occupational names, used in 1971. Some names are no longer used today.

For 51 additional cases (15.6%) where notable differences in exposure proportions were found, the men and women did not work in the same industry within the same occupational group. Thus, the differences in exposure in the occupational group *Salesmen and Salespersons, Commodities, n.e.c.* (5135) varied essentially according to the product sold, with men being more exposed to wood and metal dust, and women more to ammonia, formaldehyde and other aliphatic aldehydes and various textile fibres. In fact, an examination of the industry concerned shows that half of the jobs held by men are in shoe sales and hardware, while 65% of the jobs held by women are in clothing sales (Table 23).

Table 23 – Breakdown of industrial codes in the occupational group "5135 – Salesmen and Salespersons, Commodities, n.e.c.," by sex

SIC code[1]	Name of industry[2]	Jobs held by men (*N* = 34)		Jobs held by women (*N* = 97)	
		n	**%**	***n***	**%**
6111	Shoe Stores	7	20.6	1	1.0
6121	Men's Clothing Stores	4	11.8	5	5.2
6131	Women's Clothing Stores	1	2.9	53	54.6
6141	Children's Clothing Stores	0	0.0	6	6.2
6149	Other Clothing Stores, n.e.c.	0	0.0	6	6.2
6151	Fabric and Yarn Stores	0	0.0	6	6.2
6511	Book and Stationery Stores	4	11.8	4	4.1
6531	Hardware Stores	12	35.3	5	5.2
6541	Sporting Goods Stores	3	8.8	0	0.0
6542	Bicycle Shops	2	5.9	0	0.0
6561	Jewellery Stores	0	0.0	8	8.2
6571	Camera and Photographic Supply Stores	0	0.0	1	1.0
6591	Second-hand Merchandise Stores, n.e.c	1	2.9	0	0.0
6594	Luggage and Leather Goods Stores	0	0.0	2	2.1

[1] Standard Industrial Classification, 1980.
[2] Original industrial names, used in 1980. Some names are no longer used.

For 78 other cases (23.9%) with notable differences in exposure proportions, an examination of the original questionnaires revealed that the male and female respondents did not report the same tasks within the same occupational group. For instance, for code 5137 (*Sales Clerks, Commodities*), the jobs held by women were more often exposed to volatile organic compounds, organic solvents, isopropanol and aliphatic alcohols than those held by men, because women reported using cleaning products to wipe the checkout conveyor belt, a task not reported by men.

Finally, no explanation was found for 10 of the 326 notable differences in exposure proportions: these differences all concerned microorganism exposure assessed for male teachers but not female teachers.

5. DISCUSSION

The table below summarizes the main results. It can be seen that when the job description is refined using a more specific occupational code or by adding the industry to the occupational group, the correlation coefficients for the exposure proportions and frequency-weighted intensities among men and among women increase, while the notable difference proportions decline. As for the notable differences in exposure proportions, it should be noted that when the description of the occupation is more specific, there is a larger proportion of women than men exposed within the same occupation (seven-digit CCDO) or the same occupational group/industry group pair (four-digit CCDO, two-digit SIC). There is no preponderance of exposure among men or women with respect to frequency-weighted intensity of exposure, which indicates that when men and women are exposed within the same occupation, their intensity of exposure is the same.

Table 24 – Summary of main results

	Occupational group (4-digit CCDO)	Occupation (7-digit CCDO)	Occupational group and industry group (4-digit CCDO and 2-digit SIC)
Exposure proportion			
Number of points of comparison	14,337	7,290	8,991
Exact agreement[1]			
Exposure: 1% or more	38.9%	41.6%	44.6%
Exposure: 5% or more	48.1%	54.5%	56.9%
Intraclass correlation coefficient (CI 95%)			
Exposure: 1% or more	0.80 (0.78–0.82)	0.85 (0.83–0.87)	0.83 (0.80–0.85)
Exposure: 5% or more	0.74 (0.71–0.77)	0.80 (0.76–0.84)	0.76 (0.71–0.79)
Number of points with notable differences (%)	326 (7.6%)	103 (5.4%)	151 (8.9%)
W > M	107 (2.5%)	67 (3.5%)	88 (5.2%)
M > W	219 (5.1%)	36 (1.9%)	63 (3.7%)
Frequency-weighted intensity of exposure			
Number of points of comparison	654	390	425
Intraclass correlation coefficient (CI 95%)			
Exposure: 0.1 or more	0.82 (0.79–0.85)	0.95 (0.93–0.95)	0.83 (0.80–0.86)
Exposure: 1 or more	0.82 (0.79–0.84)	0.94 (0.93–0.95)	0.83 (0.79–0.86)
Number of points with notable differences (%)	15 (2.3%)	3 (0.8%)	11 (2.6%)
W > M	7 (1.1%)	1 (0.3%)	2 (0.5%)
M > W	8 (1.2%)	2 (0.5%)	9 (2.1%)

CCDO: Canadian Classification and Dictionary of Occupations; SIC: Standard Industrial Classification; W > M: Exposure proportion or intensity greater in jobs held by women than in those held by men; M > W: Exposure proportion or intensity greater in jobs held by men than in those held by women; CI 95%: Confidence interval of 95%.

[1] Exact agreement: Proportion of points of comparison with exposure among men and women, according to the definition of exposure, i.e., 1% or 5% or more of jobs exposed in the occupational group, occupation or occupational group/industry group pair.

5.1 General Characteristics of Jobs

As anticipated, men and women do not work in the same occupations and are not exposed to the same substances in the workplace. In our sample, for which the relevant work period runs from the 1950s to 1995, men's jobs are in a larger number of occupational groups (four-digit CCDO codes), occupations (seven-digit CCDO codes) and "occupational group/industry group" pairs than women's. *Occupations in Labouring and Other Elemental Work: Material Handling, n.e.c.* (CCDO code 9318) and *Salesmen, Salespersons and Sales Clerks, Commodities* (codes 5135 and 5137) are the only two occupational groups to figure among the 15 occupations most commonly found among both men and women. This picture is consistent with the 2006 data published by Quebec's Conseil du statut de la femme (CSF, council on the status of women) (16) suggesting that women work "in a narrower range of occupations than … men" (p. 18). The CSF figures also indicate that a third of the jobs held by women are concentrated in 10 occupations associated with services, personal care and teaching, whereas approximately 20% of jobs held by men are in the 10 main occupations associated with sales, services, various trades and transportation.

Jobs held by men were deemed exposed in greater proportion to motor vehicle exhaust, petroleum fractions, polycyclic aromatic hydrocarbons, construction materials dusts and abrasive dusts, while those held by women were exposed in greater proportion to fabric and textile fibre dusts and aliphatic aldehydes. These exposure profiles are in line with the results of a New Zealand study published in 2011 (28).

5.2 Proportion of Jobs Having an Exposure, by Occupational Group

At first glance, the notable differences in exposure between the jobs held by men and those held by women had primarily to do with the proportions of exposure to various substances, but when the job analysis was refined by using more precise (seven-digit) occupational codes or when the specific industry of each job was taken into account, these differences were less noticeable. Similar results were obtained in New Zealand for exposure to dust and chemicals using more precise occupational codes (28). However, the jobs held by men were not systematically deemed more, or less, exposed than those held women, with the direction of the exposure differences varying by occupational group.

Within the same industry, women are often employed in different occupations from men; it has also been postulated that even when they have the same job title, they can have different exposures (9). A number of factors might explain these differences: anthropometric variations resulting in different levels of exposure (65), different tasks (20-22) or problems related to measuring exposure due to the type of research design or study instruments, e.g., a greater tendency of women than men to report short-term exposure when answering questionnaires (23).

In this study, approximately a quarter of the notable differences in exposure proportions between jobs held by men and those held by women cannot be explained entirely by the degree of precision of the occupational code and by the industry. A review of the descriptions of the jobs in question revealed that men and women do not report the same duties for a given occupational group. It was hard to determine whether men and women were actually doing different tasks or whether they remembered or reported them differently. Very little work has been done on this topic (22). Messing et al. report gender-based segregation of tasks within the same occupation, in a variety of industries (20, 24, 66). Other studies have shown that job titles alone do not sufficiently reflect the variability of exposures within the same occupation (67). Men and women may remember and report exposures differently for the same occupation because they do not perceive risk in the same way (9, 27, 68, 69). Teschke et al. examined the validity of self-reported exposures to five classes of chemicals among men, compared with measurements, and reported sensitivity values ranging from 0.44 to 0.85 and specificity values from 0.66 to 0.92 (70). In a similar study on women, Bauer et al. found sensitivity values ranging from 0.14 to 0.44 and specificity values from 0.81 to 0.98 (71). It does not appear possible to determine *a priori* the direction of gender-based, self-reported differences (9). More recent studies have produced similar results (11, 26-28, 50-53). Joffe et al. found greater sensitivity among men and greater specificity among women for exposures related to printing and working with plastic (72), while Sembajwe et al. noted higher reporting of exposure to chemicals among women than among men (29). One of these studies found that a greater proportion of exposures reported by women were deemed non-existent by industrial hygienists (based on judgment by experts) and women had a greater tendency to report shorter-term exposures than men did (23).

5.3 Frequency-Weighted Intensity of Exposure by Occupational Group

When the same exposures were assigned to the jobs held by men and by women, the frequency-weighted intensity of the exposures was very similar for both sexes. This may mean that when tasks are the same, men and women are exposed similarly, although their internal dose may vary because of exposure conditions and sex-related physiological differences: size and muscle mass, for instance, may influence the tight fitting of personal protective equipment and the work position in relation to the source of exposure or the absorption and metabolism of substances to which workers are exposed (6, 8, 73).

5.4 Methodological Issues

5.4.1 Data Sources

The fact that the jobs examined here are comparable to data from general population surveys suggests that the selected data seem appropriate for comparing jobs on the basis of gender.

5.4.1.1 Inclusion of Cases and Controls

Some of the subjects whose jobs are studied here had cancer. This should not have introduced any significant bias into the comparison of exposures: first, many of the substances evaluated are not carcinogens and, second, with respect to carcinogens, the differences between the cancer cases and the controls would appear to be due more to a differential distribution of occupations and industries, over the course of the subjects’ employment history, than to differences in exposure within the same occupational or industrial classes. This situation was verified in the case of the lung cancer study of 243 distinct chemical and physical agents, including 47 classified as known carcinogens. As for the substances examined, the exposure proportions and intensities were almost identical for the cases and controls within the same occupation (74).

5.4.1.2 Pooling of Data from Two Studies

The two studies used concerned different types of cancer having different non-occupational risk factors (e.g., smoking for lung cancer and reproductive factors for breast cancer) and could be associated with a variety of choices in terms of employment and, consequently, exposure. However, within occupational groups (four digits) there was a good correlation (Spearman's $r = 0.88$) in exposure proportions between the jobs held by the women in the lung cancer study and those in the breast cancer study (see Section 3.1). It is therefore unlikely that the notable differences found in our analysis are due to differences between the two studies rather than to differences between men and women.

Furthermore, even if the pooling of data from the two studies might give rise to concerns about possible bias, an analysis based solely on the lung cancer study was not a feasible option because the number of women involved was too small to allow a comparison on the basis of a satisfactory number of occupations. As the two studies were done at the same time and in the same hospitals, with respect to the cases, and in the same source population for a random sampling of controls, the chance of introducing bias related to the selection of subjects is fairly low. The men and women compared were close in age, but the women were better educated than the men. Although education probably had an influence on the occupation and industry in which the subjects worked, the difference in education should not have invalidated the comparisons stratified by type of occupation and industry. Exposure was assessed similarly in both studies: occupational histories were taken using the same questionnaires and by the same interviewers, and the same experts assigned exposures to the various substances. These characteristics reduced the possibility of observational bias related to the source of the data.

5.4.2 Retrospective Assessments of Exposure

The exposure data were obtained from retrospective assessments of exposure done by expert chemists and industrial hygienists based on the subjects' occupational histories. Although this method is regarded as one of the best for estimating exposure retrospectively (34), the frequency-weighted intensity was estimated only on a semi-quantitative scale, which may not be refined enough to detect small, yet relevant differences in concentration.

In addition, this assessment is based on occupational histories and self-reported task descriptions, as well as on the experts' knowledge of workplaces and exposure to hundreds of substances that occurred decades ago. While the validity of the exposure assessments may have varied from substance to substance and from job to job, the assessment procedure showed good intercoder agreement (75, 76). The expert coders could furthermore easily find out the sex of the subject. This situation could have introduced a bias in their assignment of exposures for some substances or some occupations, even though the assessment procedure, which focused on the description of the tasks performed in each job, was systematic. For example, it is possible that the coders may have had a tendency not to mention certain low exposures for some occupations in multiple-pollutant environments (e.g., foundries) and where workers are mostly men, whereas they could have insisted on including very low exposures, in order not to neglect exposures in "clean" environments (e.g. clothing stores), where most workers are women. However, since most of our comparisons between men and women were within the same occupational group, this bias should have applied similarly to the men and women working there. Nevertheless, it is impossible to assess this bias with our data. Finally, the employment histories and tasks may have been reported differently by the men and women; the few studies that have been done on the validity of employment histories suggest that it is comparable between men and women, at least for the jobs held (34). The tasks reported do not seem to have been validated.

We were not able to stratify the analyses by decade of work because of the small number of jobs in occupational groups where both men and women were represented. It is possible that some of the differences in exposure were associated with the occupation in the same occupational groups, but at different periods of time; a subanalysis restricted to jobs held during the same decades did not give different results (data not presented). In addition, the men and women whose jobs were studied were the same age on average (93.8% of the women and 94.6% of the men were aged 50 or older at the time of diagnosis or recruitment; Table A-1), which suggests they were in the labour market at the same time.

5.4.3 Data Analysis Method

We chose to analyse the data using Bayesian estimation methods, which allowed us to obtain probability distributions for the parameters we were interested in (instead of a single estimate and a confidence interval) and which are appropriate when there are not a lot of data and some non-negligible uncertainties (77). The Bayesian approach involves mathematical aggregation of a prior probability on the parameters and direct information from the data, which gives the final, or “posterior” distribution. As using a prior probability in Bayesian methods has sometimes been criticized, we began the analysis with non-informative priors (which amounts to null prior information and gives similar results to a frequentist analysis) (77). However, owing to convergence problems, we had to make the prior distribution of the exposure proportions informative. We drew the information from a previous case-control study conducted on men in Montreal concerning several different cancer sites. The advantage of that study was that it used essentially the same methods to estimate exposure based on occupational histories as the lung cancer and breast cancer studies (64). In order to explore the effect of such prior information on our results, we conducted several analyses with various pieces of prior information, but no noticeable changes were seen in the results (data not presented).

Differences in exposure between jobs held by men and those held by women were defined according to whether or not they were “notable,” rather than by a statistical test determining that the differences were “statistically” non-null: this choice makes it possible to identify differences deemed noteworthy by the researchers and to reduce the area of investigation with respect to statistically significant differences that could be of no practical importance. A comparison of the results obtained through the use of “notable” difference criteria in relation to a frequentist approach shows that it would reveal over 25% of significant differences between men and women for the exposure proportion (in comparison with 7.6% in our main analysis on four-digit CCDO occupational groups) and over 15% of differences for the frequency-weighted intensity of exposure (2.3% in the main analysis; see Tables A-12 and A-13 in the appendix).

The exposure thresholds[2] selected for the comparison analyses stratified by occupation are arbitrary, and the choice of a more liberal threshold increases the intraclass correlation coefficients for the exposure proportion (Table 24), but has no effect for the frequency-weighted intensity of exposure.

5.4.4 Other Remarks

To the best of our knowledge, this study is the first to compare occupational exposure to a broad range of chemical and physical agents deduced, by experts, from men's and women's occupational histories. Like some earlier studies, this one was not able to identify precisely all the determinants of these differences; a good part could be attributable to differences in the interviewed workers' remembering or reporting the tasks they performed or, of course, to actual gender-related differences in the tasks performed at work (9, 20, 26, 28, 29).

Two studies have produced comparisons of exposure between men and women, taking into account occupational group or industry. Eng et al. conducted a survey in the general population to explore gender-related differences with respect to occupation, tasks and exposure, but only the results regarding current employment have been published (28). Their study, conducted by telephone interview, had a quite low response rate of around 37% (28), compared with much higher rates for the lung cancer study (86% for the cases and 70% for the controls) (78) and breast cancer study (81% for the cases and 75% for the controls) (57). Finally, while exposures were self-reported in the New Zealand study (28), in our study they were assigned by experts based on the subjects' occupational histories, which makes the assessments reproducible. U.S. researchers have shown that adjustments to their models for occupation or industry reduced differences in exposure to chemicals between men and women; their study was cross-sectional and considered only the last job held (27).

[2] For the exposure proportion: occupational group, occupation or occupational group/industry group combination considered to be exposed when the experts assigned exposure to 5% or more of jobs in the group; for the frequency-weighted intensity of exposure, any level greater than 1.

6. CONCLUSION

This study is one of the first analyses of differences in occupational exposure to chemical substances and physical agents that uses high-quality Canadian data. The highlighting of notable differences between men and women in the same occupations underscores the importance of precisely describing not only the occupation and industry, but also the tasks performed, when seeking to characterize occupational exposure. When men and women report the same tasks associated with a given occupation, their exposures are similar.

None of the current information tools on previous occupational exposure, such as individual measurement data or job-exposure matrices, contains information on the sex of workers, yet these tools are used to justify preventive initiatives, set standards and research priorities and support public health programs in the workplace. Our study emphasizes the need to develop ways to incorporate more detailed information regarding tasks performed, or at least sex as a substitute for men's and women's different tasks, in order to provide more accurate descriptions of occupational exposure. It also underscores the current need to refocus measurement campaigns on jobs held by women so that data critical for the future can be collected.

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APPENDIXES

Table A-1 – Description of subjects from two studies, by sex and case/control status

		Breast cancer study				Lung cancer study							
		Women				Women				Men			
		Cases		Controls		Cases		Controls		Cases		Controls	
		n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Total number of subjects		**556**	**(100)**	**613**	**(100)**	**465**	**(100)**	**614**	**(100)**	**738**	**(100)**	**899**	**(100)**
Age* (years)	30–34	–		–		2	(0.4)	0	(0.0)	3	(0.4)	0	(0.0)
	35–39	–		–		5	(1.1)	7	(1.1)	4	(0.5)	2	(0.2)
	40–44	–		–		17	(3.7)	27	(4.4)	7	(0.9)	16	(1.8)
	45–49	–		–		37	(8.0)	45	(7.3)	30	(4.1)	26	(2.9)
	50–54	79	(14.2)	70	(11.4)	48	(10.3)	74	(12.1)	56	(7.6)	61	(6.8)
	55–59	110	(19.8)	101	(16.5)	87	(18.7)	95	(15.5)	97	(13.1)	98	(10.9)
	60–64	113	(20.3)	119	(19.4)	76	(16.3)	96	(15.6)	145	(19.6)	159	(17.7)
	65–69	122	(21.9)	143	(23.3)	92	(19.8)	134	(21.8)	208	(28.2)	297	(33.0)
	70–75	132	(23.7)	180	(29.4)	101	(21.7)	136	(22.1)	188	(25.5)	240	(26.7)
Education (years)	≤ 7	148	(26.6)	229	(37.4)	168	(36.1)	161	(26.2)	329	(44.6)	316	(35.2)
	8–10	120	(21.6)	147	(24.0)	133	(28.6)	110	(17.9)	172	(23.3)	182	(20.2)
	≥11	286	(51.4)	237	(38.7)	164	(35.3)	343	(55.9)	237	(32.1)	401	(44.6)
Number of jobs		1,787		1,730		2,124		3,017		3,884		4,834	

*Age at diagnosis for cases, age at recruitment for controls.

Table A-2 – Proportion of exposure to the 243 chemical and physical agents studied for all jobs held by men or women

Chemical agents	Proportion (%)		Chemical agents	Proportion (%)	
	Jobs held by men	Jobs held by women		Jobs held by men	Jobs held by women
Abrasive dusts	8.4	2.8	Art paints	0	0.2
Acetate fibres	0.4	0.5	Ashes	2.3	2.5
Acetic acid	0.9	1.3	Asphalt	1.6	0
Acetone	0.8	0.9	Benzene	6.4	1.1
Acetylene	2.1	0	Benzo(a)pyrene	8.4	0.5
Acrylic fibres	0.6	1.1	Biocides	6.5	10.3
Aliphatic alcohols	6.1	10.2	Brass dust	0.6	0.1
Aliphatic aldehydes	9.6	13.5	Brick dust	1.6	0
Aliphatic esters	0.8	0.1	Cadmium compounds	1.9	0.2
Aliphatic ketones	1.9	1.1	Calcium carbonate	6.4	3.5
Alkalis, caustic solution	2.1	1.9	Calcium oxide	2.5	0.8
Alkanes (C18+)	17.7	3.1	Calcium sulphate	4.8	0.3
Alkanes (C1–C4)	6.5	1.2	Carbon black	1.6	1
Alkanes (C5–C17)	22	4	Carbon monoxide	23.2	10.9
Alkyds	1.7	0.1	Carbon tetrachloride	0.6	0.2
Alumina	6.1	0.2	Cellulose	5.7	4.8
Aluminum compounds	7.7	0.4	Cellulose acetate	0.2	0.1
Ammonia	7.5	6.8	Cellulose nitrate	0.3	0.2
Amphibole asbestos	2.6	0.2	Chlorinated alkanes	2.2	0.8
Anesthetic gases	0.1	1.1	Chlorinated alkenes	1.7	0.9
Animal and vegetable glues	0.4	0.6	Chloroform	0.1	0
Arc welding fumes	6.4	0.3	Chromium (VI) compounds	2.6	0.2
Aromatic alcohols	1	1.3	Chromium compounds	5.6	0.4
Aromatic amines	2.2	1	Chrysotile asbestos	7.9	0.2
Arsenic compounds	0.6	0	Clay dust	1.1	0.1

Table A-2 (cont'd) – Proportion of exposure to the 243 chemical and physical agents studied for all jobs held by men or women

Chemical agents	Proportion (%)		Chemical agents	Proportion (%)	
	Jobs held by men	Jobs held by women		Jobs held by men	Jobs held by women
Cleaning agents	10.9	15.3	Ethylene glycol	1.9	0.2
Coal combustion products	1.7	0.2	Ethylene oxide	0	0.3
Coal dust	1	0	Excavation dust	11.1	0.6
Coal gas	0.1	0	Exhaust gases (aviation fuel)	0.5	0.1
Coatings for gypsum and plaster	2.3	0.2	Exhaust gases (diesel)	17.4	0.8
Cobalt compounds	0.3	0.1	Exhaust gases (leaded gasoline)	23.6	2
Concrete dust	5.2	0.1	Exhaust gases (propane)	3.4	0.2
Cooking fumes	3.1	6.9	Exhaust gases (unleaded gasoline)	8.6	1.5
Copper compounds	3.5	0.4	Felt dust	0.1	0.2
Cosmetic talc	0.5	2.8	Fertilizers	1.1	0.2
Cotton dust	4	9.7	Fibreglass	1.6	0.1
Cresylic acid	0	0.6	Fillers	3.2	0.2
Crystalline silica	8.1	2.5	Flour dust	1.8	1.3
Cutting fluids (emulsified mineral oils)	0.6	0	Fluorocarbons	0.7	0.4
Cutting fluids post-1955 (mineral oils)	2.2	0.1	Formaldehyde	7.2	11.7
Cutting fluids pre-1955 (mineral oils)	1	0.1	Formic acid	0	0
Cyanides	0.5	0.1	Fuel oil	1.1	0
DDT	0.4	0.1	Fur dust	0.2	0.4
Decolourants	0.7	1.8	Gas welding fumes	6	0.3
Dichloromethane	0.7	0.4	Glass dust	0.4	0.1
Diesel fuel	2.4	0.1	Glycol ethers	0.3	0.5
Diethyl ether	0.1	0.5	Grain dust	2.3	0.4
Electric fields	1.9	0.1	Graphite dust	0.1	0
Epoxy	0.5	0	Hair dust	0.2	0.5
Ethanol	0.6	0.9	Herbicides	0.4	0

Table A-2 (cont'd) – Proportion of exposure to the 243 chemical and physical agents studied for all jobs held by men or women

Chemical agents	Proportion (%)		Chemical agents	Proportion (%)	
	Jobs held by men	Jobs held by women		Jobs held by men	Jobs held by women
Hydraulic fluids	2.7	0	Linseed oil	1.9	0.2
Hydrogen	0.2	0.1	Liquid fuel combustion products	2.1	0.1
Hydrogen chloride	3.7	1.2	Lubricating mineral oils and greases	9	1.9
Hydrogen cyanide	0.3	0.1	Magnesium compounds	0.1	0
Hydrogen peroxide	0.2	0.7	Magnetic fields	37.1	46.9
Hydrogen sulphide	2.9	0.3	Manganese compounds	6.7	0.2
Hypochlorites	1.7	4.1	Mercury compounds	0.3	1.2
Industrial talc	1.5	0.1	Metal coatings	3	0.3
Ink oils	1.1	0.4	Metal dust	12	1.6
Inks	2.2	3	Metal oxide fumes	8.8	0.6
Inorganic acids in solution	5.8	1.3	Methane	2.8	0.6
Inorganic insulation dusts	4.8	0.1	Methanol	2.7	2.3
Inorganic pigments	5.6	1.2	Mica	0.5	0
Insecticides	3.7	1.8	Microorganisms	9.6	7.9
Ionizing radiation	0.9	0.9	Mild steel dust	8.9	0.8
Iron compounds	12.8	0.9	Mineral oil and grease pyrolysis fumes	5.3	0.3
Iron oxides	4	0.1	Mineral spirits post-1970	5.1	1.1
Isopropanol	3.9	7.2	Mineral spirits pre-1970	6.4	1.1
Kerosene	1.1	0.1	Mineral wool fibres	2.9	0
Lead chromate	0.7	0	Mononuclear aromatic hydrocarbons	14.5	2.3
Lead compounds	10.7	0.9	Natural gas	0.4	0.2
Lead oxides	0.3	0	Natural gas combustion products	2	1.4
Leaded gasoline	8.6	0.4	Natural rubber	0.4	0.1
Leather dust	0.9	1.1	*n*-Hexane	1.4	0.6
Linen fibres	0.5	1.2	Nickel compounds	3.6	0.2

Table A-2 (cont'd) – Proportion of exposure to the 243 chemical and physical agents studied for all jobs held by men or women

Chemical agents	Proportion (%)		Chemical agents	Proportion (%)	
	Jobs held by men	Jobs held by women		Jobs held by men	Jobs held by women
Nitrates	0.1	0	Plating solution	0.2	0.1
Nitric acid	0.2	0.2	Polyacrylates	0.9	0.1
Nitrogen oxides	11.9	0.4	Polyamides	0	0
Nitroglycerin	0	0	Polychloroprene	0.1	0
Nylon fibres	1.4	3.3	Polyester fibres	1.9	4.5
Oil soot	1.9	0.1	Polyethylene	0.1	0.1
Organic dyes and pigments	2.9	1.5	Polystyrene	0.1	0.1
Organic solvents	20.9	13	Polyurethanes	0.8	0.5
Other mineral oils	0	0	Polyvinyl acetate	1.2	0.1
Ozone	5.9	8.1	Polyvinyl chloride	0.6	0.3
PAHs derived from coal	2.7	0.3	Portland cement	3.5	0
PAHs derived from oil	20.3	3.3	Propane	1.4	0.5
PAHs derived from other sources	4.6	1	Propane combustion products	2.3	1
PAHs derived from wood	2	0.4	Propellant gases	1	2.6
PAHs from all sources	26.4	6.2	Pulsed electromagnetic fields	33.9	41.9
Paint pyrolysis fumes	2.1	0.1	Radiofrequency (microwave)	2.7	0.5
Pentachlorophenol	0.2	0.1	Rayon fibres	0.8	1.6
Perchloroethylene	0.5	0.6	RDX	0	0
Pesticides	3.8	1.8	Rubber dust	1.2	0.4
Phenol	0.3	0.2	Rubber pyrolysis fumes	1	0.2
Phosgene	0.3	0.1	Rubber, styrene-butadiene	0.5	0
Phosphoric acid	0.5	0.2	Second-hand tobacco smoke	36.6	27.5
Photography products	0.3	0.4	Silicon carbide	4.1	0.1
Plastic dusts	2.4	1	Silk fibres	0.8	2.1
Plastic pyrolysis fumes	1.4	1.2	Silver compounds	1.1	0.6

Table A-2 (cont'd) – Proportion of exposure to the 243 chemical and physical agents studied for all jobs held by men or women

Chemical agents	Proportion (%)		Chemical agents	Proportion (%)	
	Jobs held by men	Jobs held by women		Jobs held by men	Jobs held by women
Sodium carbonate	0.7	1.5	Trichloroethylene	0.4	0
Sodium hydrosulphite	0.2	0.2	Trinitrotoluene	0	0.1
Soldering fumes	2.7	0.7	Turpentine	0.9	0.1
Solvent-based coatings	5.1	0.6	Ultraviolet rays	14.4	0.7
Soot from all sources	2.3	0.1	Unleaded gasoline	3.3	0.5
Starch dust	2	1.3	Unsaturated aliphatic hydrocarbons	2.5	0.1
Steel dust	2.7	0.1	Untreated textile fibres	0.7	0.4
Styrene	0.6	0	Video display terminal (VDT)	3.8	6.7
Sugar dust	1.2	1.2	Vinyl chloride	0.5	0.3
Sulphur dioxide	5.7	0.3	Volatile organic liquids	30.1	16.9
Sulphuric acid	3.7	0.6	Water-borne coatings	1.8	0.3
Synthetic adhesives	5.6	3	Waxes, polishes	1.8	1.5
Synthetic fibres	3	7	Wood combustion products	1.9	0.4
Tar and coal-tar pitch	0.8	0	Wood dust	11.2	0.7
Textile oils	0.5	0.4	Wood paints	1.4	0.1
Tin compounds	3.3	0.6	Wood stains	0.8	0.1
Titanium compounds	2.7	0.1	Wood varnishes	1.3	0.2
Titanium dioxide	1.4	0.1	Wool fibres	2.2	3.6
Tobacco dust	0.2	0.3	Xylene	4.8	1
Toluene	8.1	3.2	Zinc compounds	4	0.6
Treated textile fibres	4.5	11.5	Zinc oxide	0.3	0
Trichloroethane (1,1,1-)	0.6	0			

Table A-3 – Most common occupations among jobs held by men and women

CCDO code	Name of occupation	Jobs held by men (*n* = 6,870)			Jobs held by women (*n* = 7,012)		
		Rank	*n*	%	*Rank*	*n*	%
Most common occupations among jobs held by men							
8798114	Construction Labourers (construction)	*1*	148	2.2	*420*	0	0.0
9175110	Truck Drivers, General	*2*	130	1.9	*363*	0	0.0
7181110	Farm Workers, General	*3*	93	1.4	*37*	25	0.4
7513122	Loggers, All-Round (forestry and logging)	*4*	90	1.3	–	0	0.0
6191110	Janitors (any industry)	*5*	87	1.3	*137*	9	0.1
6115138	Security Guards (any industry)	*6*	85	1.2	*81*	11	0.2
1179299	Other Occupations Related to Management and Administration, n.e.c.	*7*	83	1.2	*34*	38	0.5
6117190	Infantry Soldiers (armed forces)	*8*	75	1.1	–	0	0.0
5137114	Sales Clerks (retail trade)	*9*	74	1.1	*7*	142	2.0
4177122	Delivery Boys (retail trade)	*10*	73	1.1	–	0	0.0
8581110	Motor-Vehicle Mechanics (motor vehicles)	*11*	72	1.0	*629*	1	0.0
6125126	Waiters (catering and lodging)	*12*	71	1.0	*3*	275	3.9
5193118	Drivers/Salesmen (any industry)	*13*	70	1.0	–	0	0.0
9173110	Taxi Drivers (motor transportation)	*14*	69	1.0	*365*	1	0.0
5130114	Managing Supervisors, Retail Store (retail trade)	*15*	68	1.0	*19*	60	0.9
Most common occupations among jobs held by women							
4111110	Secretaries (clerical)	*324*	4	0.1	*1*	577	8.2
8563114	Sewing-Machine Operators (any industry)	*40*	28	0.4	*2*	533	7.6
6125126	Waiters (catering and lodging)	*12*	71	1.0	*3*	275	3.9
4197114	Clerks, General Office (clerical)	*18*	64	0.9	*4*	264	3.8
4131134	Accounting Clerks (clerical)	*21*	54	0.8	*5*	226	3.2
2731110	Elementary School Teachers (education)	*86*	14	0.2	*6*	171	2.4
5137114	Sales Clerks (retail trade)	*9*	74	1.1	*7*	142	2.0
4171118	Receptionists (clerical)	*396*	3	0.0	*8*	141	2.0
9318122	Hand Packagers (any industry)	*32*	35	0.5	*9*	134	1.9
3131130	Nurses (medical)	*788*	1	0.0	*10*	126	1.8
5135178	Salesperson, Wearing Apparel (retail trade, wholesale trade)	*137*	9	0.1	*11*	113	1.6
3135114	Orderlies (medical)	*99*	13	0.2	*12*	111	1.6
6142110	Housekeepers (personal services, n.e.c.)	*789*	1	0.0	*13*	105	1.5
4111111	Executive Secretaries (clerical)	–	0	0.0	*14*	88	1.3
6191114	Charwomen (any industry)	*29*	36	0.5	*15*	69	1.0

CCDO: Canadian Classification and Dictionary of Occupations.

Table A-4 – Most common "occupational group/industry group" pairs among jobs held by men and women

CCDO code	Name of occupational group	SIC code	Name of industry group	Jobs held by men		Jobs held by women	
				n	**%**	***n***	**%**
Most common "occupational group/industry group" pairs among jobs held by men							
9175	Truck Drivers	45	Transportation	117	1.7	0	0.0
8798	Labourers (other construction trades)	40	Building, Developing and General Contracting	101	1.5	0	0.0
7181	Farm Workers, General	01	Agricultural	93	1.4	26	0.4
6117	Other Ranks, Armed Forces	81	Federal Administration	91	1.3	0	0.0
8581	Motor Vehicle Mechanics and Repairers	63	Automotive Vehicles, Parts and Accessories, Sales and Service	90	1.3	2	0.0
7513	Timber Cutting and Related Occupations	04	Logging	90	1.3	0	0.0
9173	Taxi Drivers and Chauffeurs	45	Transportation	72	1.0	1	0.0
5137	Sales Clerks, Commodities	60	Food, Beverage and Drug Industries, Retail	71	1.0	49	0.7
8781	Carpenters and Related Occupations	40	Building, Developing and General Contracting	69	1.0	0	0.0
6125	Waiters, Hostesses and Stewards, Food and Beverage	92	Food and Beverage Service Industries	67	1.0	259	3.7
4177	Messengers	60	Food, Beverage and Drug Industries, Retail	57	0.8	0	0.0
6121	Chefs and Cooks	92	Food and Beverage Service Industries	53	0.8	42	0.6
2733	Secondary School Teachers	85	Educational Services	40	0.6	99	1.4
8798	Labourers (other construction trades)	41	Industrial and Heavy Construction Industries	39	0.6	0	0.0
8215	Slaughtering and Meat Cutting, Canning, Curing and Packing Occupations	60	Food, Beverage and Drug Industries, Retail	39	0.6	3	0.0

Table A-4 (cont'd) – Most common "occupational group/industry group" pairs among jobs held by men and women

CCDO code	Name of occupational group	SIC code	Name of industry group	Jobs held by men		Jobs held by women	
				n	%	*n*	%
Most common "occupational group/industrial group" pairs among jobs held by women							
8563	Sewing Machine Operators, Textile and Similar Materials	24	Clothing Industries	22	0.3	437	6.2
6125	Waiters, Hostesses and Stewards, Food and Beverage	92	Food and Beverage Service Industries	67	1.0	259	3.7
2731	Elementary and Kindergarten Teachers	85	Educational Services	16	0.2	191	2.7
3135	Nursing Aides and Orderlies	86	Health and Social Service Industries	16	0.2	161	2.3
6142	Housekeepers, Servants and Related Occupations	97	Personal and Household Service Industries	1	0.0	149	2.1
3131	Nurses, Graduate, Except Supervisors	86	Health and Social Service Industries	2	0.0	143	2.0
4111	Secretaries and Stenographers	77	Business Services	0	0.0	123	1.8
2733	Secondary School Teachers	85	Educational Services	40	0.6	99	1.4
5135	Salesmen and Salespersons, Commodities, n.e.c.	61	Shoe, Apparel, Fabric and Yarn Industries, Retail	12	0.2	77	1.1
8569	Fabricating, Assembling and Repairing Occupations: Textile, Fur and Leather Products, n.e.c.	24	Clothing Industries	3	0.0	74	1.1
5137	Sales Clerks, Commodities	64	General Retail Merchandising	7	0.1	72	1.0
9318	Occupations in Labouring and Other Elemental Work, Material Handling, n.e.c.	10	Food Industries	16	0.2	65	0.9
6147	Babysitters	97	Personal and Household Service Industries	0	0.0	64	0.9
4133	Tellers and Cashiers	70	Deposit Accepting Intermediary Industries	9	0.1	59	0.8
5135	Salesmen and Salespersons, Commodities, n.e.c.	64	General Retail Merchandising	7	0.1	57	0.8

CCDO: Canadian Classification and Dictionary of Occupations; SIC: Standard Industrial Classification; n.e.c.: not elsewhere classified.

Table A-5 – Occupational groups studied to compare occupational exposures, stratified by occupational unit group

CCDO code	Name of occupation	Jobs held by men		Jobs held by women	
		n	%	*n*	%
1119	Officials and Administrators Unique to Government, n.e.c.	16	0.2	13	0.2
1130	General Managers and Other Senior Officials	27	0.4	13	0.2
1133	Administrators in Teaching and Related Fields	10	0.1	10	0.1
1137	Sales and Advertising Management Occupations	34	0.5	14	0.2
1142	Services Management Occupations	13	0.2	13	0.2
1149	Other Managers and Administrators, n.e.c.	29	0.4	29	0.4
1171	Accountants, Auditors and Other Financial Officers	65	0.9	53	0.8
1179	Occupations Related To Management and Administration, n.e.c.	122	1.8	56	0.8
2711	University Teachers	20	0.3	21	0.3
2731	Elementary and Kindergarten Teachers	16	0.2	199	2.8
2733	Secondary School Teachers	42	0.6	104	1.5
2791	Community College and Vocational School Teachers	21	0.3	11	0.2
2792	Fine Arts Teachers	10	0.1	11	0.2
2793	Post-secondary School Teachers, n.e.c.	11	0.2	16	0.2
3135	Nursing Aides and Orderlies	18	0.3	168	2.4
3351	Writers and Editors, Publication	16	0.2	25	0.4
4130	Supervisors: Bookkeeping, Account Recording and Related Occupations	16	0.2	34	0.5
4131	Bookkeepers and Accounting Clerks	85	1.2	357	5.1
4133	Tellers and Cashiers	17	0.2	170	2.4
4135	Insurance, Bank and Other Finance Clerks	21	0.3	47	0.7
4143	Electronic Data-processing Equipment Operators	11	0.2	48	0.7
4153	Shipping and Receiving Clerks	83	1.2	29	0.4
4155	Stock Clerks and Related Occupations	62	0.9	16	0.2
4173	Mail and Postal Clerks	21	0.3	24	0.3
4197	General Office Clerks	67	1.0	275	3.9
4199	Other Clerical and Related Occupations, n.e.c.	16	0.2	33	0.5
5130	Supervisors: Sales Occupations, Commodities	114	1.7	68	1.0
5133	Commercial Travellers	93	1.4	20	0.3

Table A-5 (cont'd) – Occupational groups studied to compare occupational exposures, stratified by occupational unit group

CCDO code	Name of occupation	Jobs held by men		Jobs held by women	
		n	**%**	***n***	**%**
5135	Salesmen and Salespersons, Commodities, n.e.c.	98	1.4	174	2.5
5137	Sales Clerks, Commodities	96	1.4	164	2.3
5172	Real Estate Salesmen	30	0.4	20	0.3
6115	Guards and Watchmen	102	1.5	30	0.4
6120	Supervisors: Food and Beverage Preparation and Related Service Occupations	26	0.4	23	0.3
6121	Chefs and Cooks	85	1.2	131	1.9
6123	Bartenders	23	0.3	29	0.4
6125	Waiters, Hostesses and Stewards, Food and Beverage	86	1.3	358	5.1
6130	Supervisors: Occupations in Lodging and Other Accommodation	30	0.4	10	0.1
6143	Barbers, Hairdressers and Related Occupations	18	0.3	47	0.7
6165	Pressing Occupations	28	0.4	47	0.7
6191	Janitors, Charworkers and Cleaners	169	2.5	106	1.5
6198	Occupations in Labouring and Other Elemental Work: Services	59	0.9	66	0.9
7181	Farm Workers, General	93	1.4	26	0.4
8213	Baking, Confectionery Making and Related Occupations	39	0.6	22	0.3
8228	Occupations in Labouring and Other Elemental Work: Food, Beverage and Related Processing	16	0.2	28	0.4
8265	Textile Winding and Reeling Occupations	10	0.1	31	0.4
8335	Welding and Flame Cutting Occupations	95	1.4	26	0.4
8393	Filing, Grinding, Buffing, Cleaning and Polishing Occupations, n.e.c.	31	0.5	10	0.1
8538	Occupations in Labouring and Other Elemental Work: Fabricating, Assembling, Installing and Repairing Electrical, Electronic and Related Equipment	11	0.2	20	0.3
8551	Patternmaking, Marking and Cutting Occupations: Textile, Fur and Leather Products	39	0.6	11	0.2
8553	Tailors and Dressmakers	38	0.6	11	0.2
8555	Furriers	12	0.2	14	0.2
8561	Shoemaking and Repairing Occupations	33	0.5	24	0.3
8563	Sewing Machine Operators, Textile and Similar Materials	35	0.5	550	7.8

Table A-5 (cont'd) – Occupational groups studied to compare occupational exposures, stratified by occupational unit group

CCDO code	Name of occupation	Jobs held by men		Jobs held by women	
		n	**%**	***n***	**%**
8568	Occupations in Labouring and Other Elemental Work: Fabricating, Assembling and Repairing Textile, Fur and Leather Products	24	0.3	53	0.8
8593	Paper Product Fabricating and Assembling Occupations	14	0.2	21	0.3
8599	Other Product Fabricating, Assembling and Repairing Occupations, n.e.c.	10	0.1	46	0.7
9171	Bus Drivers	34	0.5	15	0.2
9317	Packaging Occupations, n.e.c.	21	0.3	38	0.5
9318	Occupations in Labouring and Other Elemental Work, Material Handling, n.e.c.	176	2.6	152	2.2

CCDO: Canadian Classification and Dictionary of Occupations; n.e.c.: not elsewhere classified.

Table A-6 – Quartiles of exposure proportion differences between men and women for each “occupational group/agent” point of comparison having a non-null exposure proportion and corresponding to a notable difference

Smallest estimated proportion (%)	Notable difference quartiles[1] (%)							
	W > M[2]				M > W[3]			
	n	25%	50%	75%	*n*	25%	50%	75%
> 0–5	66	14.0	19.0	23.0	148	14.0	19.0	29.2
> 5–15	21	19.0	34.0	38.0	32	21.0	29.5	42.2
> 15–30	15	25.0	40.0	55.0	22	28.5	40.5	53.0
> 30–50	5	33.0	39.0	39.0	16	37.5	42.5	46.0
> 50–80	0	–	–	–	1	33.0	33.0	33.0
> 80	0	–	–	–	0	–	–	–

1. A difference is notable when it is larger than a predefined value, which varies by exposure proportion stratum.
2. Exposure proportion greater in jobs held by women than in those held by men.
3. Exposure proportion greater in jobs held by men than in those held by women.

Table A-7 – Quartiles of frequency-weighted intensity of exposure differences between men and women for each “occupational group/agent” point of comparison having a non-null exposure proportion and corresponding to a notable difference

Smallest estimated frequency-weighted intensity of exposure	Notable difference quartiles[1] (%)							
	W > M[2]				M > W[3]			
	n	25%	50%	75%	*n*	25%	50%	75%
> 0–1	0	–	–	–	0	–	–	–
> 1–5	4	4.7	5.2	5.5	5	6.9	7.1	11.0
> 5–10	2	6.2	6.3	6.5	3	6.5	8.7	12.3
> 10–15	1	9.9	9.9	9.9	0	–	–	–
> 15–20	0	–	–	–	0	–	–	–
> 20	0	–	–	–	0	–	–	–

[1] A difference is notable when it is larger than a predefined value, which varies by frequency-weighted intensity of exposure stratum.
[2] Frequency-weighted intensity of exposure greater in jobs held by women than in jobs held by men.
[3] Frequency-weighted intensity of exposure greater in jobs held by men than in jobs held by women.

Table A-8 – Occupations (seven-digit CCDO codes) studied for stratified comparison of occupational exposures

CCDO code	Occupations	Jobs held by men (*N* = 6,870)		Jobs held by women (*N* = 7,012)	
		n	%	*n*	%
1149126	Managers, Administration (prof. and tech. serv., n.e.c.)	21	0.3	24	0.3
1171114	Accountants (prof. and tech. serv., n.e.c.)	44	0.6	31	0.4
1179299	Other Occupations Related to Management and Administration, n.e.c.	83	1.2	38	0.5
2731110	Elementary School Teachers, General (education)	14	0.2	171	2.4
3135114	Orderlies (medical)	13	0.2	111	1.6
4131134	Accounting Clerks (clerical)	54	0.8	226	3.2
4135182	Utility Bank Clerks (banking and finance)	14	0.2	28	0.4
4153118	Shipping and Receiving Clerks (clerical)	39	0.6	15	0.2
4197114	Clerks, General Office (clerical)	64	0.9	264	3.8
5130114	Managing Supervisors, Retail Store (retail trade)	68	1.0	60	0.9
5137111	Supermarket Clerks (retail trade)	22	0.3	12	0.2
5137114	Sales Clerks (retail trade)	74	1.1	142	2.0
5172118	Salesmen, Real Estate (insurance & real estate)	26	0.4	12	0.2
6115138	Security Guards (any industry)	85	1.2	11	0.2
6120110	Managing Supervisors, Dining Establishment (catering and lodging)	15	0.2	12	0.2
6121130	Short-order Cooks (catering and lodging)	13	0.2	16	0.2
6121134	Cook's Helpers (catering and lodging)	16	0.2	47	0.7
6123110	Bartenders (catering and lodging)	23	0.3	29	0.4
6125126	Waiters (catering and lodging)	71	1.0	275	3.9
6165126	Machine Pressers (garment and fabrics; laundering, dry cleaning and pressing)	28	0.4	45	0.6
6191114	Charwomen (any industry)	36	0.5	69	1.0
6198134	Kitchen Helpers (catering and lodging)	10	0.1	22	0.3
7181110	Farm Workers, General	93	1.4	25	0.4
8538199	Miscellaneous Occupations in Labouring and Other Elemental Work: Electrical and Electronic Equipment Fabricating, Assembling, Installing and Repairing	11	0.2	20	0.3
8563114	Sewing-Machine Operators (any industry)	28	0.4	533	7.6
8568299	Miscellaneous Occupations in Labouring and Other Elemental Work: Textile, Fur and Leather Products	14	0.2	27	0.4
9171110	Bus Drivers (motor transportation)	34	0.5	15	0.2
9317218	Machine Packagers (any industry)	14	0.2	32	0.5
9318118	Light Material Handlers (any industry)	34	0.5	14	0.2
9318122	Hand Packagers (any industry)	35	0.5	134	1.9

CCDO: Canadian Classification and Dictionary of Occupations; prof. and tech. serv.: professional and technical services; n.e.c.: not elsewhere classified.

Table A-9 – Quartiles of exposure proportion differences between men and women for each "occupation/agent" point of comparison having a non-null exposure proportion and corresponding to a notable difference

Smallest estimated proportion (%)	Notable difference quartiles[1] (%)							
	Women > Men[2]				Men > Women[3]			
	n	25%	50%	75%	*n*	25%	50%	75%
> 0–5	40	16.7	21.0	25.0	13	16.0	19.0	28.0
> 5–15	14	18.2	29.5	39.2	9	25.0	31.0	36.0
> 15–30	7	29.5	41.0	44.5	7	41.5	46.0	50.5
> 30–50	6	39.2	40.5	42.5	6	36.2	46.0	52.0
> 50–80	0	–	–	–	1	36.0	36.0	36.0
> 80	0	–	–	–	0	–	–	–

1. A difference is notable when it is larger than a predefined value, which varies by exposure proportion stratum.
2. Exposure proportion greater in jobs held by women than in those held by men.
3. Exposure proportion greater in jobs held by men than in those held by women.

Table A-10 – “Occupational group/industry group” combinations studied for stratified comparison of occupational exposures

Occupational group (four-digit CCDO code) and industry group (two-digit SIC code) combinations				Women (*N* = 7,012)		Men (*N* = 6,870)	
				n	**%**	***n***	**%**
2711	University Teachers	85	Educational Services	20	0.3	21	0.3
2731	Elementary and Kindergarten Teachers	85	Educational Services	16	0.2	191	2.7
2733	Secondary School Teachers	85	Educational Services	40	0.6	99	1.4
2793	Post-secondary School Teachers, n.e.c.	85	Educational Services	10	0.1	13	0.2
3135	Nursing Aides and Orderlies	86	Health and Social Service Industries	16	0.2	161	2.3
4131	Bookkeepers and Accounting Clerks	45	Transportation	15	0.2	11	0.2
4135	Insurance, Bank and Other Finance Clerks	70	Deposit Accepting Intermediary Industries	16	0.2	33	0.5
4173	Mail and Postal Clerks	48	Communications	15	0.2	14	0.2
5130	Supervisors: Sales Occupations, Commodities	60	Food, Beverage and Drug Industries, Retail	38	0.6	17	0.2
		61	Shoe, Apparel, Fabric and Yarn Industries, Retail	10	0.1	25	0.4
		65	Other Retail Stores	16	0.2	13	0.2
5135	Salesmen and Salespersons, Commodities, n.e.c.	61	Shoe, Apparel, Fabric and Yarn Industries, Retail	12	0.2	77	1.1
		65	Other Retail Stores	22	0.3	20	0.3
5137	Sales Clerks, Commodities	60	Food, Beverage and Drug Industries, Retail	71	1.0	49	0.7
		65	Other Retail Stores	12	0.2	22	0.3
5172	Real Estate Salesmen	76	Insurance and Real Estate Agencies	24	0.3	11	0.2
6120	Supervisors: Food and Beverage Preparation and Related Service Occupations	92	Food and Beverage Service Industries	23	0.3	17	0.2
6121	Chefs and Cooks	92	Food and Beverage Service Industries	53	0.8	42	0.6
6123	Bartenders	92	Food and Beverage Service Industries	17	0.2	27	0.4
6125	Waiters, Hostesses and Stewards, Food and Beverage	91	Accommodation Services	10	0.1	19	0.3
		92	Food and Beverage Service Industries	67	1.0	259	3.7
6143	Barbers, Hairdressers and Related Occupations	97	Personal and Household Service Industries	18	0.3	44	0.6
6165	Pressing Occupations	24	Clothing Industries	20	0.3	22	0.3
6191	Janitors, Charworkers and Cleaners	86	Health and Social Service Industries	17	0.2	33	0.5
		99	Other Service Industries	36	0.5	29	0.4
7181	Farm Workers, General	1	Agricultural	93	1.4	26	0.4
8213	Baking, Confectionery Making and Related Occupations	10	Food Industries	31	0.5	16	0.2
8228	Occupations in Labouring and Other Elemental Work: Food, Beverage and Related Processing	10	Food Industries	14	0.2	25	0.4

Table A-10 (cont'd) – "Occupational group/industry group" combinations studied for stratified comparison of occupational exposures

Occupational group (four-digit CCDO code) and industry group (two-digit SIC code) combinations				Women (*N* = 7,012)		Men (*N* = 6,870)	
				n	**%**	***n***	**%**
8538	Occupations in Labouring and Other Elemental Work: Fabricating, Assembling, Installing and Repairing Electrical, Electronic and Related Equipment	33	Electrical and Electronic Products Industries	11	0.2	19	0.3
8551	Patternmaking, Marking and Cutting Occupations: Textile, Fur and Leather Products	24	Clothing Industries	22	0.3	10	0.1
8555	Furriers	24	Clothing Industries	11	0.2	14	0.2
8561	Shoemaking and Repairing Occupations	17	Leather and Allied Products Industries	25	0.4	21	0.3
8563	Sewing Machine Operators, Textile and Similar Materials	24	Clothing Industries	22	0.3	437	6.2
8593	Paper Product Fabricating and Assembling Occupations	27	Paper and Allied Products Industries	10	0.1	18	0.3
9171	Bus Drivers	45	Transportation	29	0.4	12	0.2
9318	Occupations in Labouring and Other Elemental Work, Material Handling, n.e.c.	10	Food Industries	16	0.2	65	0.9
		24	Clothing Industries	11	0.2	11	0.2

CCDO: Canadian Classification and Dictionary of Occupations; SIC: Standard Industrial Classification; n.e.c.: not elsewhere classified; spec. occup.: specialized occupations.

Table A-11 – Quartiles of exposure proportion differences between men and women for each "occupational group/industry group-agent" point of comparison having a non-null exposure proportion and corresponding to a notable difference

Smallest estimated proportion (%)	Notable difference quartiles[1] (%)							
	Women > Men[2]				Men > Women[3]			
	n	**25%**	**50%**	**75%**	***n***	**25%**	**50%**	**75%**
> 0–5	63	16.5	22.0	26.5	27	18.5	24.0	29.0
> 5–15	12	15.0	22.5	34.0	10	29.7	48.0	54.7
> 15–30	10	31.8	45.5	54.8	8	36.8	45.0	54.2
> 30–50	3	33.0	41.0	42.5	18	42.0	45.0	51.0
> 50–80	0	–	–	–	1	39.0	39.0	39.0
> 80	0	–	–	–	0	–	–	–

1. A difference is notable when it is larger than a predefined value, which varies by exposure proportion stratum. See the predefined values in Table 1.

2. Exposure proportion greater in jobs held by women than in those held by men.

3. Exposure proportion greater in jobs held by men than in those held by women.

Table A-12 – Breakdown of the median of exposure proportion differences between men and women for each "occupational group/agent" point of comparison having a non-null exposure proportion – Statistical definition of notable difference (P(|Diff|) > 0) ≥ 95%)

Exposure Proportion Minimum estimate between men and women	Non-notable differences		Notable differences: Women > Men		Notable differences: Men > Women		Total
	n	%	*n*	%	*n*	%	
> 0–5	2605	75.0	253	7.3	617	17.8	3475
> 5–15	219	68.7	47	14.7	53	16.6	319
> 15–30	119	68.4	25	14.4	30	17.2	174
> 30–50	81	64.3	18	14.3	27	21.4	126
> 50–80	90	73.8	12	9.8	20	16.4	122
> 80	51	96.2	0	0.0	2	3.8	53
Total	3165	74.1	355	8.3	749	17.5	4269

Table A-13 – Breakdown of the median of frequency-weighted intensity of exposure differences between men and women for each "occupational group/agent" point of comparison – Statistical definition of notable difference (P(|Diff|) > 0) ≥ 95%)

Frequency-weighted intensity of exposure Minimum estimate between men and women	Non-notable differences		Notable differences: Women > Men		Notable differences: Men > Women		Total
	n	%	*n*	%	*n*	%	
> 0–1	184	94.4	3	1.5	8	4.1	195
> 1–5	344	83.7	20	4.9	47	11.4	411
> 5–10	24	68.6	6	17.1	5	14.3	35
> 10–15	6	75.0	1	12.5	1	12.5	8
> 15–20	1	33.3	0	0.0	2	66.7	3
> 20	2	100.0	0	0.0	0	0.0	2
Total	561	85.8	30	4.6	63	9.6	654