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# Comparison of exposure estimates in the Finnish job-exposure matrix FINJEM with a JEM derived from expert assessments performed in Montreal

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There are no competing interests

## ABSTRACT 249 words

### Context

Retrospective exposure assessment in population-based case-control studies poses a major challenge due to the wide range of occupations and industries involved. The FINJEM is a generic job-exposure matrix developed in Finland which represents a potentially cost effective exposure assessment tool. While FINJEM has been used in several studies outside Finland, little is known of its applicability in other countries.

### Methods

We compared prevalence and intensity of exposure in FINJEM with a job-exposure matrix developed from expert assessments of occupational histories obtained in a population-based case-control study in Montreal. Agreement for prevalence of exposure was measured by weighted kappa coefficients between prevalence categories. Agreement for exposure intensity was measured by Spearman correlation coefficients between cells with non-null exposure.

### Results

The comparison involved 27 chemicals, the time period 1945-1995, and included 4,743 jobs initially assessed by the Montreal experts. 4,293 combinations of agent, occupational title, and period were available for comparison of prevalence. Agent-specific prevalence was consistently higher in the Montreal JEM (median difference 1.7%). Agent-specific kappas between prevalence categories varied from 0.89 (welding fumes) to 0.07 (flour dust). The comparison of exposure levels involved 14 agents and 198 cells with non-null exposure in both sources. Agent-specific Spearman correlation varied from 0.89 (flour dust) to -0.35 (Benzo[a]pyrene).

### Conclusion

Our observations suggest that information concerning several agents (e.g. metals, welding fumes) can be successfully transported from Finland to Canada and probably other countries. However, for other agents there was considerable disagreement and hence transportability of FINJEM cannot be assumed by default.

## WHAT THIS PAPER ADDS

- FINJEM is a generic job-exposure matrix created in Finland which can provide exposure information for community-based case-control studies, but has not been extensively evaluated for use outside Finland
- Compared with occupational exposure data based on Montreal workers' description of their jobs and exposure assessments by local Montreal experts, FINJEM performed reasonably well in general.
- FINJEM exposure estimates can be used in urban Northern-American areas for assessing occupational exposure to some agents (e.g. welding fumes, iron), but its transportability for other agents or settings cannot be assumed by default.

## INTRODUCTION

The assessment of retrospective occupational exposure poses major challenges in population-based case-control studies. Exposure has to be evaluated for a wide spectrum of occupations and industries for the lifetime occupational histories of study subjects, representing hundreds or even thousands of different exposure scenarios. The main existing approaches include self-reported exposure, job-exposure matrices (JEMs) and expert review of individual work histories [1-4]. Self-assessment of exposure is typically based on questionnaire checklists and subjects' knowledge and perception about their own exposure [5]. Job-exposure matrices are tools that automatically assign exposure to subjects on the basis of their occupational title [6]. The expert assessment approach is based on detailed exposure-related information, obtained from the subjects for each job ever held. The resulting descriptions are translated into an assessment of exposure by a panel of hygienists/chemists [7-8].

Notwithstanding the inherent inability of JEMs to account for exposure variations within occupations, using such a tool is an attractive option for exposure assessment because it can be implemented at low cost compared to the individual expert assessment approach, and it does not depend on error-prone self-reports of exposure. Therefore, the availability of a valid and generalizable JEM would be of great benefit in many circumstances.

Among currently available JEMs, the one that is perhaps most widely used is the FINJEM developed at the Finnish Institute of Occupational Health (FIOH) in the late 90s [9], and regularly updated since then [10]. By contrast with most other JEMs, FINJEM is based on an extensive national occupational exposure database and the rationale for each estimate is reported in detail. The FINJEM has been used frequently to elucidate relationships between occupational exposures and adverse outcomes in Finland and in other countries [9-11]. To our knowledge, the only research efforts attempting to evaluate the applicability of FINJEM to countries other than Finland are studies by Benke et al. (Australia) and Kauppinen et al. (other Scandinavian countries) [10,12]. Benke et al. concluded that FINJEM gave satisfactory results in Australia for some of the chemicals studied, underlining the need to further evaluate the transportability of this JEM to other settings. Kauppinen et al. identified few major differences between the 5 Nordic countries studied but underlined the homogeneity of their economic structures.

The main purpose of this study was to assess the transportability of FINJEM estimates outside Finland within the framework of the INTEROCC project, a multicenter case-control study examining the relationship between occupational exposures and brain cancer. We compared estimates of intensity and prevalence of exposure in FINJEM with a JEM derived from expert-reviews of individual occupational histories obtained in a population based case-control study on lung cancer in Montreal.

## METHODS

### The FINJEM matrix

A detailed description of the original FINJEM is available elsewhere [9-10]. The 2008 version of FINJEM, purchased for the INTEROCC project, was used in this report. Briefly, the FINJEM has three dimensions: agent, occupation and time period. There were 83 agents in the version of FINJEM used in this study, of which 52 are chemical agents. The occupation axis of FINJEM includes 311 occupational titles from a Finnish classification system. The time axis includes six periods spanning 1945-2003. For each combination of these three dimensions, FINJEM provides two metrics: a prevalence of exposure denoted as P expressed as a percentage, and a quantitative estimate of exposure intensity denoted as L, expressed in units of concentration, representing the yearly average exposure level among the exposed workers. A given occupational category is considered unexposed to a given agent if P is less than 5% or if the L does not exceed non-occupational background levels. The estimates in FINJEM were derived by a team of over 20 experts from the FIOH. Their sources of information included, among others, over 80 000 exposure measurements contained in the Finnish occupational exposure databank [11].

**The Montreal expert evaluations**

From 1996 to 2004, a case-control study was undertaken in Montreal to explore the relationship between lung cancer and several risk factors, including occupational agents [13-14]. The study included 2,716 subjects who had held in total 13,817 jobs. The exposure assessment for occupational risk factors has been described in detail elsewhere [15-18]. Briefly, during a face-to-face interview, each subject provided a detailed description of all jobs ever held, including information on tasks, working environment and protective measures. An expert team of chemists and industrial hygienists, blinded to case-control status, then reviewed the information collected and translated each job into potential exposures from a list of 294 possible substances. Exposure assignment was performed by at least 2 experts and checked for consistency. For each substance considered present in each job, the experts noted three dimensions of information: the likelihood that the exposure had actually occurred (possible, probable, definite), the frequency of exposure (percentage of the number of hours per week exposed), and the relative exposure level of the agent (low, medium, high). Non-exposure was interpreted as exposure up to the level that can be found in the general environment.

**Creation of the Montreal JEM**

The Montreal JEM was created by aggregating the exposure information from all individual jobs held only by controls in the study.

Definition of the Montreal JEM axes

The lists of agents in the two databases (FINJEM and Montreal) were not identical, and sometimes the definition and demarcation of a given agent differed between the databases. Twenty seven agents were common to the two databases and defined similarly enough that we could include them in this comparison. Some had to be combined to achieve comparability; welding fumes in FINJEM corresponded to the combination of arc welding fumes and gas welding fumes in Montreal data and chlorinated solvents in FINJEM corresponded to chlorinated alkanes and chlorinated alkenes in Montreal data. For these combined agents, exposure level was equated to the maximal exposure level of the two component agents. The Montreal jobs were already coded to multiple occupation classification systems, including the International Labour Organization (ILO)'s International standard classification of occupations (ISCO, version 1968), used within the INTEROCC project. ISCO'68 therefore was selected as the occupational axis for the Montreal JEM. An expert-based crosswalk between the ISCO'68 and the Finnish classification was created for jobs reported within the INTEROCC study [19]. Because 96% of the Montreal jobs that could be linked to FINJEM through the occupational crosswalk were within the three FINJEM periods 1945-1959, 1960-1984 and 1985-1995, we selected these time periods for comparison.

Derivation of the prevalence estimates for each cell of the Montreal JEM

Prevalence was estimated as the number of jobs associated with exposure divided by the total number of jobs in the cell (i.e. a combination of agent, ISCO'68 code, and period) of interest. In order to be included in the denominator a job had to have at least one year in the time period corresponding to the cell. Cells with less than ten jobs fulfilling this criterion were excluded from the comparison. A job was regarded as exposed if it was assigned exposure at least equivalent to low intensity for 1 hour a week with a likelihood rating of probable or definite. In order to mimic the FINJEM interpretation of no exposure, cells with prevalence values <5% were considered unexposed.

Derivation of the exposure level estimates for each cell of the Montreal JEM

The Montreal ordinal classification of exposure (low, medium, high) was converted into a quantitative index using exposure weights of 1 for low, 5 for medium, and 25 for high exposure. This choice represents what we believe to approximately mimic the way the Montreal experts used the three semiquantitative levels. Moreover, we combined the obtained indices of exposure with the frequency of exposure (expressed as percentage of number of hours per week exposed) to obtain a 40 hour time-weighted exposure index for each job, hereafter referred to as Montreal exposure level. For example, assuming a typical 40 hour work week, a job evaluated as 20 hours of medium exposure per week would yield a level of: 5*20/40=2.5. The exposure level for a cell of the Montreal JEM was defined as the arithmetic average of the 40 hour time-weighted indices of all exposed jobs corresponding to that cell. Cells for which there were less than 5 exposed jobs in the Montreal dataset were excluded from the analysis. This threshold was preferred to 10 used for the estimation of prevalence because of the generally low prevalence of exposure in our data.

**Comparison of the FINJEM and the Montreal JEM**

Agreement between the prevalence estimates in both sources was measured by weighted kappa (quadratic weights) [20] between prevalence levels in all cells categorized as follows: 0%, 5-15%, 15-40%, ≥40%. The 15% and 40% values represent tertiles of the non-null prevalence estimates for all cells included in the comparison across the Montreal and FINJEM data. Overall prevalence values for each agent across occupations and time periods were calculated by taking the mean of the Montreal and FINJEM-based cell-specific estimates weighted by the number of jobs amongst Montreal controls in each occupational category (within an occupation the same weight was given to all periods). The resulting estimates are therefore directly relevant to the Montreal general population. Agreement between exposure levels in the Montreal JEM and FINJEM was assessed for each agent for all cells with exposure in both FINJEM and the Montreal JEM using the Spearman correlation coefficient [21]. In order to estimate agreement across agents, exposure levels in the Montreal JEM and FINJEM were standardized (divided) by their respective agent-specific 90$^{th}$ percentiles of exposure levels in the comparison dataset.

Sensitivity analyses were conducted to evaluate the influence of several assumptions made for the comparison. Analyses common to prevalence and intensity included: (1) using an alternative definition to declare a given job "exposed" in the Montreal dataset: at least a 40 hour time weighted index equivalent to 1 hour per week where the experts coded the concentration level as medium or higher (i.e. excluding the low category); (2) using no minimum exposure likelihood criterion; and (3) using the FINJEM classification of occupations as a basis for comparison instead of ISCO'68 codes. Additional analyses specific to exposure intensity included : (4) Using other scales for the transformation of Montreal exposure categories into quantitative levels (1-2-3, 1-3-9, and 1-10-100 instead of 1-5-25); (5) using a Montreal exposure level not weighted by exposure frequency, i.e. the original exposure estimate; (6) performing the comparison between the product of prevalence and level of exposure (in both datasets) instead of the level of exposure only; and (7) using the median (instead of mean) of job-specific levels to estimate the intensity of exposure within a cell.

## RESULTS

### Coverage of the comparison

The crosswalk between the ISCO'68 and FINJEM classification included 769 ISCO'68 codes, 108 being 3-digit instead of 5-digit codes. A total of 114 FINJEM codes were associated with at least 2 different ISCO'68 codes. Restriction of the Montreal evaluations to those pertaining to controls, occupations included in the crosswalk, and the time window studied (1945-1995), yielded a database of 4,743 jobs (1945-1959 n=1,382; 1960-1984 n=2,499; 1985-1995 n=853), of which 2,669 were associated with probable exposure to at least one of the 27 selected agents. Restrictions for the comparison of prevalence (≥10 jobs per cell) led to the inclusion of 84 ISCO'68 codes (linked to 56 FINJEM codes), covering 64% of the Montreal study population.

**Comparison of exposure prevalence**

There were 159 combinations of occupation and time period which had at least 10 jobs in the Montreal data. With 27 agents this corresponded to 4,293 comparison units. Table 1 presents the distribution of prevalence estimates based on the Montreal data and FINJEM. Cells in bold font in Table 1 highlight instances of strong disagreement between the 2 sources (at least 3 categories in the table). The 116 combinations of ISCO'68 and agent corresponding to strong disagreement (Montreal > FINJEM for 106, FINJEM>Montreal for 10) are listed in appendix 1 (see online supplementary file).

**Table 1: Bivariate distribution of ISCO'68 and agent-specific estimates of prevalence of exposure (%) in FINJEM and the Montreal data**

| | Montreal | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0% | 5-20% | 20-40% | 40-60% | 60-80% | > 80% | Total |
| FINJEM | | | | | | | |
| 0% | 3346 | 494 | 143 | **49** | **17** | **27** | 4076 |
| 5-20% | 24 | 17 | 8 | 16 | **4** | **8** | 77 |
| 20-40% | 10 | 17 | 11 | 8 | 5 | **1** | 52 |
| 40-60% | **2** | 4 | 8 | 11 | 10 | 10 | 45 |
| 60-80% | **0** | **1** | 2 | 0 | 0 | 1 | 4 |
| > 80% | **0** | **2** | **5** | 5 | 10 | 17 | 39 |
| Total | 3382 | 535 | 177 | 89 | 46 | 64 | **4293** |

Note: The prevalence of exposure signifies the percentage of jobs in a given cell (combination of period and occupation) that were considered exposed to a given agent. 159 occupation-time period cells and 27 agents yield 4293 comparison points.

Overall weighted kappa for prevalence categories based on prevalence tertiles was 0.42. There was an increase in agreement from 1945-1959 (weighted kappa 0.33) to 1960-1684 (0.43) and 1985-1995 (0.48). Agreement was higher for generic (e.g. welding fumes) vs. specific agents (0.47 vs. 0.33, agents in the 'specific' category are identified in Table 2). When stratifying by ISCO'68 divisions (large occupational groups), weighted kappa was 0.59 for '7-8-9 Production and related workers, transport equipment operators and labourers' and lower than 0.1 for the 6 other divisions. Table 2 presents prevalence values for FINJEM and the Montreal data as well as weighted kappa coefficients by agent. Table 2 also presents the number of cells with non-null exposure in both datasets and the proportion of these cells for which FINJEM and Montreal agreed. Agent-specific weighted kappa coefficients varied from 0.07 (flour dust) to 0.89 (welding fumes). Restricting the Montreal definition of exposure to a minimum of 1 hour per week at medium or higher consistently reduced agent-specific prevalence values (median 1.8%) and increased the overall weighted kappa to 0.51. None of the other sensitivity analyses performed showed any discernible effect on agreement.

**Table 2: Comparison between FINJEM and Montreal data in prevalence of exposure**

| Agent | Prevalence FINJEM (%) | Prevalence Montreal (%) | Weighted kappa | Non-null cells (C) | Agreed non-null cells (%) (D) |
|---|---|---|---|---|---|
| Asbestos (A) | 1.9 | 2.7 | 0.77 | 9 | 78 |
| Manmade mineral fibres (A) | 0.0 | 0.8 | (B)- | 0 | - |
| Cadmium compounds | 0.1 | 0.2 | - | 0 | - |
| Iron compounds | 2.8 | 4.8 | 0.83 | 13 | 92 |
| Lead compounds | 1.5 | 5.0 | 0.49 | 15 | 20 |
| Nickel compounds | 1.4 | 0.8 | 0.66 | 7 | 57 |
| Chromium compounds | 1.3 | 1.8 | 0.76 | 11 | 45 |
| Welding fumes | 2.4 | 3.8 | 0.89 | 12 | 33 |
| Chlorinated hydrocarbon solvents | 0.1 | 0.8 | 0.07 | 2 | 100 |
| Aromatic hydrocarbon solvents | 0.6 | 5.5 | 0.21 | 3 | 33 |
| Toluene (A) | 0.8 | 4.5 | 0.39 | 3 | 0 |
| Benzene (A) | 0.4 | 2.6 | 0.39 | 4 | 25 |
| Formaldehyde (A) | 0.6 | 9.6 | 0.11 | 7 | 14 |
| Carbon monoxide (A) | 7.6 | 25.3 | 0.17 | 20 | 75 |
| Sulphur dioxide (A) | 0.0 | 1.7 | - | 0 | - |
| Polycyclic aromatic hydrocarbons | 3.8 | 12.4 | 0.30 | 10 | 80 |
| Benzo(a)pyrene (A) | 1.5 | 2.7 | 0.52 | 10 | 20 |
| Bitumen fumes | 0.0 | 0.5 | - | 0 | - |
| Diesel engine exhaust | 1.5 | 4.9 | 0.51 | 15 | 40 |
| Gasoline engine exhaust | 2.6 | 15.9 | 0.32 | 14 | 50 |
| Gasoline (A) | 0.2 | 2.4 | 0.29 | 3 | 33 |
| Oil mist | 0.3 | 0.7 | 0.40 | 1 | 100 |
| Insecticides | 0.0 | 0.5 | - | 0 | - |
| Leather dust | 0.0 | 0.3 | - | 0 | - |
| Flour dust | 0.3 | 1.0 | 0.07 | 1 | 0 |
| Quartz dust | 0.2 | 2.3 | 0.25 | 1 | 100 |
| Wood dust | 0.2 | 3.8 | 0.15 | 1 | 100 |

(A) Agent considered as specific rather than generic (e.g. toluene v. welding fumes)
(B) Undefined since there was no exposure to this agent in FINJEM for the occupations and periods included in the analysis
(C) Number of combinations of occupation and time periods with non-null exposure in both FINJEM and Montréal
(D) Percentage of cells in column 'non-null cells' in the same prevalence category for FINJEM and Montreal

**Comparison of exposure levels**

The comparison of assigned exposure levels was conducted on the 198 combinations of ISCO'68 code, time period and agent (JEM cells) that had at least 5 jobs with exposure in the Montreal data and could be linked to a FINJEM non-null estimate. The overall Spearman correlation coefficient between Montreal and FINJEM standardized exposure levels was 0.37. There was an increase in agreement over time (from 0.29 in 1945-1959 to 0.32 in 1960-1984 and 0.47 in 1985-1995). Agreement was higher for generic vs. specific agents (0.44 vs. 0.04). It was not possible to stratify the comparison by ISCO'68 division due to the small number of cells with non-null exposure outside of the '7-8-9' division. Table 3 provides summary statistics of the FINJEM and Montreal exposure estimates separately for each agent, along with correlation coefficients and p-values. Table 3 is limited to the 14 agents which had at least 5 cells with non-null estimates in both datasets. Agreement varied from -0.35 (Benzo[a]pyrene) to 0.89 (Flour dust). Table 4 presents results of the sensitivity analyses conducted to assess the effect of various assumptions made to perform the comparison. Although some of the sensitivity analyses had a significant effect on agreement for some agents (e.g. correlation coefficient from 0.47 to 0.05 for lead when restricting the Montreal data to medium or high exposure intensity), no common pattern was apparent across all agents.

**Table 3: Comparison between FINJEM and Montreal data in exposure level**

| Agent (A) | N cells (B) | N exposed jobs (C) | Median frequency (D) | Median level (E) | Rho(F) | p-value (G) |
|---|---|---|---|---|---|---|
| Asbestos | 8 | 99 | 14 | 1.7 | 0.60 | 0.12 |
| Iron compounds | 23 | 220 | 19 | 2.2 | 0.52 | 0.01 |
| Lead compounds | 12 | 109 | 14 | 1.4 | 0.47 | 0.13 |
| Chromium compounds | 9 | 66 | 18 | 2.1 | 0.87 | <0.01 |
| Welding fume | 17 | 149 | 12 | 4.5 | 0.65 | <0.01 |
| Aromatic hydrocarbon solvents | 5 | 32 | 21 | 5.5 | 0.45 | 0.45 |
| Toluene | 6 | 47 | 16 | 4.0 | -0.24 | 0.65 |
| Formaldehyde | 9 | 120 | 39 | 1.0 | 0.60 | 0.09 |
| Carbon monoxide | 23 | 226 | 20 | 1.5 | -0.01 | 0.97 |
| Polycyclic aromatic hydrocarbons | 20 | 217 | 29 | 3.0 | 0.03 | 0.90 |
| Benzo(a)pyrene | 5 | 31 | 20 | 1.0 | -0.35 | 0.56 |
| Diesel engine exhaust | 15 | 107 | 19 | 3.0 | 0.65 | 0.01 |
| Gasoline engine exhaust | 21 | 236 | 30 | 1.9 | 0.31 | 0.17 |
| Flour dust | 5 | 40 | 5 | 1.4 | 0.89 | 0.04 |

(A) Manmade mineral fibers, cadmium, chlorinated solvents, leather dust, wood dust, oil mist, gasoline, sulfur dioxide, bitumen fumes, nickel, benzene, quartz dust and insecticides could not be compared because less than 10 cells met the criterion of having a non-null exposure estimate in both FINJEM and the Montreal JEM
(B) Number of ISCO-period combinations with non-null exposure in FINJEM and Montreal, and at least 5 exposed jobs in the Montreal dataset
(C) Number of jobs on which the Montreal estimates are based (only jobs with exposure were used)
(D) Median frequency of exposure (hours per week) in the Montreal data included in the comparison
(E) Median level of exposure (1=low,5=medium,25=high) in the Montreal data included in the comparison
(F) Spearman correlation coefficient between the Montreal and FINJEM estimates. Unit of comparison is a combination of ISCO'68 code and period
(G) p-value corresponding to the Spearman coefficient of column (F)

**Table 4: Influence of different assumptions on the observed Spearman correlation coefficient between FINJEM and Montreal exposure estimates**

| Agent | Main(A) | Montreal level 1-2-3(B) | Montreal level 1-3-9(C) | Montreal level 1-10-100(D) | FINJEM occupation(E) | Montreal medium or High(F) | Montreal unweighted Level (G) | Prevalence* level(H) | Montreal median (I) |
|---|---|---|---|---|---|---|---|---|---|
| Asbestos | 8 | 0.60 | 0.30(J) | 0.53 | 0.60 | 0.80 | - | 0.77 | 0.16 |
| Iron compounds | 23 | 0.52 | 0.63 | 0.57 | 0.43 | 0.65 | - | 0.47 | 0.82 |
| Lead compounds | 12 | 0.47 | 0.44 | 0.50 | 0.39 | 0.05 | - | 0.31 | 0.62 |
| Chromium compounds | 9 | 0.87 | 0.82 | 0.87 | 0.68 | 0.57 | - | 0.40 | 0.74 |
| Welding fume | 17 | 0.65 | 0.62 | 0.61 | 0.64 | 0.90 | 0.87 | 0.53 | 0.74 |
| Aromatic hydrocarbon solvents | 5 | 0.45 | 0.22 | 0.45 | 0.45 | 0.21 | - | 0.67 | 0.22 |
| Toluene | 6 | -0.24 | -0.38 | -0.24 | -0.35 | -0.21 | - | -0.31 | -0.15 |
| Formaldehyde | 9 | 0.60 | 0.60 | 0.60 | 0.60 | 0.76 | - | 0.88 | - |
| Carbon monoxide | 23 | -0.01 | -0.04 | 0.01 | -0.08 | -0.23 | - | 0.00 | 0.01 |
| Polycyclic aromatic hydrocarbons | 20 | 0.03 | 0.16 | 0.09 | -0.04 | -0.44 | 0.68 | 0.02 | 0.21 |
| Benzo(a)pyrene | 5 | -0.35 | -0.35 | -0.35 | -0.35 | -0.18 | - | -0.54 | -0.35 |
| Diesel engine exhaust | 15 | 0.65 | 0.40 | 0.60 | 0.70 | 0.24 | 0.64 | 0.07 | 0.10 |
| Gasoline engine exhaust | 21 | 0.31 | 0.24 | 0.34 | 0.27 | 0.72 | 0.53 | 0.26 | 0.31 |
| Flour dust | 5 | 0.89 | 0.89 | 0.89 | 0.89 | - | - | 0.92 | 0.89 |

(A) Spearman correlation coefficient between Montreal and FINJEM estimates using a combination of ISCO'68 code and period as the unit of comparison, the 1-5-25 scaling scheme to average the low-medium-high exposure levels in Montreal data, only Montreal data corresponding to likelihood rating 'probable' or 'definite', only Montreal data corresponding to exposed for at least low exposure during 5 hours a week, and calculating a weekly average index from concentration and frequency of exposure for the Montreal estimate.

(B) The Montreal quantitative index was constructed using a linear (1-2-3) scaling scheme for the Low, Medium, High categories

(C) The Montreal quantitative index was constructed using an exponential (1-3-9) scaling scheme for the Low, Medium, High categories

(D) The Montreal quantitative index was constructed using an exponential (1-10-100) scaling scheme for the Low, Medium, High categories

(E) The comparison cell was based on the FINJEM job codes instead of on the ISCO'68 codes

(F) Only Montreal jobs corresponding to exposed for at least 5 hr per week at Medium or higher were included in the comparison

(G) Montreal exposure level not weighted by frequency of exposure

(H) Comparison of FINJEM P*L to the product of prevalence and exposure level for Montreal instead of FINJEM L to Montreal exposure level

(I) Each cell specific estimate is calculated using the median of individual jobs level instead of the arithmetic mean.

(J) Shaded cells indicate important differences with the agreement seen in the main comparison effort

**DISCUSSION**

The present work represents to our knowledge the most comprehensive comparison effort between two multi-occupation sources of exposure information. FINJEM provides a more detailed and more documented population-based assessment than other generic JEMs that have been presented in the literature. The Montreal exposure database includes almost 14 000 jobs for which exposure to hundreds of chemicals was assessed using state-of-the-art expert-based exposure assessment. This quantity of data allowed us to perform the comparison by first agglomerating the Montreal evaluations into a JEM format, covering the majority of occupations prevalent in the general population. Whereas most previous studies have used an 'exposed/not exposed' dichotomy, we were able to compare prevalence and exposure levels. This design allowed us to address the question: do these two sources of information provide the same overall message on occupational exposure for the past 50 years? Not unexpectedly, our results suggest a mixed answer to this question.

The majority of marked disagreements in prevalence categories for each JEM cell corresponded to Montreal estimates being higher than FINJEM estimates. Prevalence estimates across occupations and agents confirmed this trend of more frequent assignment of exposure by the Montreal JEM. On an agent by agent basis, agreement in prevalence estimates varied from poor (flour dust, weighted kappa 0.07) to good (welding fumes, 0.89). Despite some variability, agreement was in general highest for metals (including welding fumes) and lowest for solvents, gases and dust. Our results are compatible with recent observations by Mester et al., who compared an industry-specific JEM to expert assessment within a cohort in the car manufacturing industry [22]. They reported that experts tended to overrule the JEM-based assessment more often for solvents than for metals. When comparing individual expert assessments from a group of experts within an international multicentre case-control study of lung cancer, 'tMannetje at al. also observed low agreement for 'organic solvents' and 'chlorinated solvents'[23]. However, agreement for metals ranged from poor to good. We observed a better agreement for agents with a generic (e.g. welding fumes) rather than specific (e.g. toluene) title. These observations are similar to results reported by 'tMannetje et al [23]. Agreement between FINJEM and Montreal prevalence estimates were higher for the most recent time period in the comparison. While this might reflect the better availability of industrial hygiene data available to both groups of experts, the fact that prevalence was significantly lower in the Montreal data for this period (results not shown) is a likely explanation. After stratification by broad occupational group, most of the agreement between FINJEM and the Montreal JEM appeared concentrated in traditional 'blue collar' occupations (ISCO'68 divisions 7-8-9). This might be explained by the usually very low prevalence of exposure in FINJEM for other categories, but also by the fact that occupations in this group have traditionally been the focus of industrial hygiene studies.

Due to the low prevalence of exposure to most agents studied, the comparison of exposure intensities between FINJEM and the Montreal JEM was limited to fewer agents and occupations than the prevalence comparison, and was therefore subject to more variability. Spearman correlation coefficients varied substantially between substances, ranging from poor (benzo[a]pyrene,-0.35) to very good (flour dust, 0.89), with rankings generally similar to the prevalence results. Notable exceptions included flour dust and formaldehyde (kappa~0.1 vs. rho~0.6-0.9) and benzo[a]pyrene (kappa=0.52 vs. rho=-0.35). In accordance to the prevalence comparison, agreement for exposure intensity was higher for recent vs. older periods and for generic vs. specific agent.

There are several potential sources of disagreement between FINJEM and the Montreal JEM.

Firstly, differences in true exposure conditions are likely to exist between Finland and Canada, or more specifically, Finland and the region of greater Montreal. These differences are not easy to predict without an extensive comparative study of the economic, industrial and legal settings in each location.

Secondly, because the FINJEM occupation classification is less precise than ISCO'68, it is plausible that observed disagreements could be partly due to comparison being based on ISCO'68 job codes. Changing the occupational classification from ISCO'68 to the Finnish job codes did not increase agreement for prevalence or intensity estimates, suggesting little influence of the job classification system on the comparison itself. However, a little over one third of the FINJEM occupational codes involved in the comparison were linked to more than two ISCO'68 codes. Moreover, for 65 combinations of agent and FINJEM codes (16 unique FINJEM codes), ISCO-specific exposure estimates from the Montreal JEM differed significantly within one FINJEM code (results not shown). Our observations suggest that using non 'one-to-one' crosswalks between occupational classification systems constitutes an added potential for misclassification in the broader scope of assigning exposure estimates for an epidemiological analysis. However, it remains unclear to what extent this adds to any misclassification from the use of classification systems not designed for exposure assessment purposes.

Thirdly, the exposure metrics used in both systems were very different: FINJEM provides an estimate of yearly average concentration based on measurements complemented with expert assessment, and the Montreal JEM estimate was derived by averaging an ordinal exposure classification across jobs weighted by exposure frequency to arrive at an index representing an average weekly level. The results of the sensitivity analyses we performed suggest that our results actually reflect how similarly both systems rank occupations with regard to exposure.

Fourthly, while the experts from both teams operationally define their criterion for the 'exposed' status as concentrations above environmental background (FINJEM provides an explicit quantitative threshold for most agents), it is plausible that their appraisal of this threshold would be different, explaining the higher prevalence observed in the Montreal data. Indeed, using a stricter threshold for Montreal (by excluding the lowest exposure category) increased agreement on prevalence estimation. 'tMannetje et al. observed a similar pattern of lower prevalence in FINJEM than in a JEM built from individual expert evaluations in a European multicentre case-control study of lung cancer [24]. Interestingly, Benke et al.[12] reported higher prevalence in FINJEM than in individual assessments by a team of three experts for 3 out of 5 agents tested. In particular, they obtained 11% prevalence for formaldehyde, whereas we observed 0.6%, both based on FINJEM. While we estimated overall prevalence by weighting occupation-specific estimates to reflect our study population, Benke at al.[12] defined an individual job as exposed according to FINJEM if it belonged to a combination of period and occupation with P>5% in FINJEM, and then calculated prevalence by counting individual jobs exposed according to this criterion. Using such a low threshold most probably increased the resulting prevalence estimates by a significant amount. Indeed we found 7.3% using their approach. Benke et al.'s results would have therefore probably shown similar patterns as ours (expert prevalence > FINJEM prevalence) had they estimated prevalence by weighting occupation-specific estimates. Because we have no gold standard, it is difficult to say that FINJEM missed exposure or that the Montreal (and other) experts overestimated exposure. Based on the main rationale in each approach (process knowledge and task descriptions for Montreal and exposure measurement database for FINJEM), it is possible that the Montreal experts picked up exposures that would not seem 'interesting' for hygienists to monitor. This hypothesis has been mentioned by Fritschi et al., but remains speculative [25]. The results in Appendix 1 illustrate the differences in exposure threshold used by both approaches.

Lastly, differential validity of the assessments provided by the two sources of information is another potential reason for observing discrepancies. FINJEM is more advanced and more transparent than many of the JEMs mentioned in the available reviews, both in terms of the exposure indices provided and of the knowledge database used for its development. Insight about the validity of FINJEM has mostly come from studies identifying well known risk factors using FINJEM estimates [10 11]. Regarding the Montreal expert assessment database, evaluations based on a previous study in Montreal with the same approach and the same experts in our study also identified well established carcinogens and showed weighted kappas around 0.70 in inter and intra-rater agreement evaluation [15,26].

It bears emphasis that this was not a comparison of the Montreal expert-based assessment of individuals with a FINJEM-based assessment of individual subjects; rather, it was a comparison after transforming the Montreal data into a FINJEM-like format and more pertinently addresses the question of transportability of FINJEM, rather than of the performance of individual assessment vs JEM-based assessment.

Finally, restricting the creation of the Montreal JEM to information from the controls resulted in the use of only ~60% of the Montreal exposure database. This was motivated by the concern that cases are not necessarily representative of the study base, especially in regard to exposure to carcinogens. Among recent uses of experts evaluations from past case-control studies to create JEMs, Peters et al.[27] excluded cases but 'tMannetje et al.[24] included them. None of the authors provided empirical evidence supporting one approach or the other. We believe the question of including data from cases and control, while not the focus of the present work, raises an important bias/precision trade-off issue which should be addressed empirically in future studies through detailed comparisons of case and controls exposure estimates.

In conclusion, although there was a substantial potential for observing no agreement, we found at least moderate agreement between FINJEM and the Montreal JEM for more than half of the agents studied, well in the range of published intra- and inter-rater studies available in the literature. Welding fumes and iron were associated with good agreement consistently across comparisons based on prevalence, exposure intensity, and in sensitivity analyses. These observations, while formally only representative of the Montreal area, offer optimistic insight on the transportability of FINJEM to similar settings for these agents, i.e. urban Northern-American areas. For other agents or settings, depending on the availability of local expertise, international users could use FINJEM as a starting point for developing region specific JEMs, such as was done for Scandinavian countries and New Zealand[10,24]. Other extensive comparison efforts involving FINJEM should be performed to increase knowledge about its applicability in various settings. FINJEM seems to have a higher threshold for assigning exposure compared to the Montreal JEM as well as other JEMs based on individual evaluations. While the impact of this characteristic on dose-response relationships estimation might be minor when it is only important to have a well-defined 'high exposed' group, other applications such as the estimation of number workers exposed will be affected, especially for agents occurring infrequently within occupations.

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**Appendix 1. List of ISCO68 codes, by Agent and Period, with strong disagreement in prevalence estimates (%) between Montreal and FINJEM.**

**Part 1. FINJEM higher than Montreal**

| Agent | ISCO-68 Code and Label | | FINJEM Code and Label | | Period | Prevalence (%) Montreal | Prevalence (%) FinJEM |
|---|---|---|---|---|---|---|---|
| ASBESTOS | | | | | | | |
| | 9-51.20 | Bricklayer (construction) | 690 | Bricklayers, plasterers and tile setters | 1945-1959 | 0.0 | 40.0 |
| | 8-49.70 | Plant maintenance mechanic | 652 | Machine and engine mechanics | 1960-1984 | 0.0 | 41.0 |
| CARBON MONOXIDE | | | | | | | |
| | 8-49.70 | Plant maintenance mechanic | 652 | Machine and engine mechanics | 1960-1984 | 37.0 | 100.0 |
| | 9-71.45 | Warehouse porter | 781 | Warehousemen | 1945-1959 | 21.7 | 100.0 |
| | 9-71.45 | Warehouse porter | 781 | Warehousemen | 1960-1984 | 13.8 | 100.0 |
| | 9-79.20 | Lifting-truck operator | 771 | Forklift operators etc. | 1985-1994 | 16.7 | 90.0 |
| TOLUENE | | | | | | | |
| | 9-31.20 | Building painter | 680 | Painters, lacquerers and floor layers | 1960-1984 | 35.3 | 80.0 |
| | 9-31.20 | Building painter | 680 | Painters, lacquerers and floor layers | 1985-1994 | 18.2 | 70.0 |
| WELDING FUME | | | | | | | |
| | 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1960-1984 | 36.4 | 80.0 |
| | 8-73.10 | Sheet-metal worker, general | 653 | Sheet metal workers | 1960-1984 | 36.4 | 90.0 |

**Part 2. Montreal higher than FINJEM**

| Agent | ISCO-68 Code and Label | | FINJEM Code and Label | | Period | Prevalence (%) Montreal | Prevalence (%) FinJEM |
|---|---|---|---|---|---|---|---|
| ASBESTOS | | | | | | | |
| | 8-43.20 | Automobile mechanic | 652 | Machine and engine mechanics | 1985-1994 | 90.9 | 5.0 |
| MAN MADE MINERAL FIBERS | | | | | | | |
| | 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1945-1959 | 46.7 | 0.0 |
| LEAD | | | | | | | |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 54.1 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| | 8-43.20 | Automobile mechanic | 652 | Machine and engine mechanics | 1985-1994 | 72.7 | 15.0 |
| | 9-85.30 | Taxi driver | 540 | Motor vehicle and tram drivers | 1945-1959 | 42.1 | 0.0 |
| | 9-85.30 | Taxi driver | 540 | Motor vehicle and tram drivers | 1960-1984 | 44.4 | 0.0 |
| CHROMIUM | | | | | | | |
| | 9-31.20 | Building painter | 680 | Painters, lacquerers and floor layers | 1945-1959 | 80.0 | 15.0 |
| | 9-31.20 | Building painter | 680 | Painters, lacquerers and floor layers | 1960-1984 | 82.4 | 20.0 |
| | 9-31.20 | Building painter | 680 | Painters, lacquerers and floor layers | 1985-1994 | 81.8 | 5.0 |
| CHLORINATED HYDROCARBON SOLVENTS | | | | | | | |
| | 5-60.60 | Laundry pressing-machine operator | 851 | Pressing workers and other laundry and pressing w | 1960-1984 | 46.7 | 0.0 |
| AROMATIC HYDROCARBON SOLVENTS | | | | | | | |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 54.1 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| | 8-43.00 | Motor-Vehicle Mechanics | 652 | Machine and engine mechanics | 1960-1984 | 65.0 | 0.0 |
| | 8-43.00 | Motor-Vehicle Mechanics | 652 | Machine and engine mechanics | 1985-1994 | 58.3 | 0.0 |
| | 8-43.20 | Automobile mechanic | 652 | Machine and engine mechanics | 1945-1959 | 82.1 | 0.0 |
| | 8-43.20 | Automobile mechanic | 652 | Machine and engine mechanics | 1960-1984 | 85.7 | 0.0 |
| | 8-43.20 | Automobile mechanic | 652 | Machine and engine mechanics | 1985-1994 | 72.7 | 0.0 |
| | 8-72.10 | Gas and electric welder (general) | 655 | Welders and flame cutters | 1960-1984 | 42.9 | 0.0 |
| TOLUENE | | | | | | | |
| | 5-32.50 | Bartender | 820 | Headwaiters, restaurant waiters | 1960-1984 | 93.3 | 0.0 |
| BENZENE | | | | | | | |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 54.1 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| FORMALDEHYDE | | | | | | | |
| | 5-10.30 | Working proprietor (restaurant) | 816 | Hotel and restaurant matrons | 1960-1984 | 63.6 | 0.0 |
| | 5-10.30 | Working proprietor (restaurant) | 816 | Hotel and restaurant matrons | 1985-1994 | 60.0 | 0.0 |
| | 5-31.20 | Head cook | 811 | Cooks etc. | 1960-1984 | 90.9 | 0.0 |
| | 5-31.30 | Cook, except private service | 811 | Cooks etc. | 1945-1959 | 64.3 | 0.0 |
| | 5-31.30 | Cook, except private service | 811 | Cooks etc. | 1960-1984 | 67.6 | 0.0 |
| | 5-31.30 | Cook, except private service | 811 | Cooks etc. | 1985-1994 | 60.9 | 0.0 |
| | 5-32.10 | Waiter, general | 820 | Headwaiters, restaurant waiters | 1985-1994 | 41.4 | 0.0 |
| | 5-60.60 | Laundry pressing-machine operator | 851 | Pressing workers and other laundry and pressing | 1945-1959 | 81.3 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 5-60.60 | Laundry pressing-machine operator | 851 | Pressing workers and other laundry and pressing | 1960-1984 | 93.3 | 0.0 |
| | 5-70.20 | Women's hairdresser | 840 | Hairdressers and barbers | 1960-1984 | 54.5 | 0.0 |
| | 7-91.20 | Tailor (made-to-measure garments) | 610 | Tailors, salon seamstresses | 1945-1959 | 56.3 | 0.0 |
| | 7-91.20 | Tailor (made-to-measure garments) | 610 | Tailors, salon seamstresses | 1960-1984 | 76.9 | 0.0 |
| | 7-91.90 | Other tailors and dressmakers | 610 | Tailors, salon seamstresses | 1960-1984 | 60.0 | 0.0 |
| | 7-94.50 | Garment cutter, except leather | 614 | Patternmakers and cutters (also leather garments a | 1945-1959 | 80.0 | 5.0 |
| | 7-94.50 | Garment cutter, except leather | 614 | Patternmakers and cutters (also leather garments a | 1960-1984 | 100.0 | 6.5 |
| | 7-95.10 | Hand and machine sewer (general) | 615 | Industrial sewers etc. (also leather garments and | 1960-1984 | 85.7 | 5.8 |
| | 7-95.20 | Garment hand sewer (except leather and fur) | 615 | Industrial sewers etc. (also leather garments and | 1960-1984 | 70.0 | 5.8 |
| CARBON MONOXIDE | | | | | | | |
| | 0-32.10 | Draughtsman, general | 18 | Draftsmen and survey assistants | 1960-1984 | 41.2 | 0.0 |
| | 0-71.10 | Professional nurse (general) | 32 | Nurses | 1960-1984 | 50.0 | 0.0 |
| | 0-71.20 | Specialised nurse | 32 | Nurses | 1985-1994 | 41.7 | 0.0 |
| | 2-11.10 | General manager | 110 | Business management | 1945-1959 | 52.4 | 0.0 |
| | 3-10.10 | Government executive official | 100 | Senior officials and employees in public administr | 1960-1984 | 43.8 | 0.0 |
| | 3-21.40 | Typist | 131 | Typists or stenographer | 1960-1984 | 41.7 | 0.0 |
| | 3-31.40 | Bank teller | 120 | Bookkeepers | 1960-1984 | 63.6 | 0.0 |
| | 3-39.30 | Wages clerk | 120 | Bookkeepers | 1960-1984 | 40.0 | 0.0 |
| | 5-10.30 | Working proprietor (restaurant) | 816 | Hotel and restaurant matrons | 1960-1984 | 72.7 | 0.0 |
| | 5-10.30 | Working proprietor (restaurant) | 816 | Hotel and restaurant matrons | 1985-1994 | 80.0 | 0.0 |
| | 5-32.10 | Waiter, general | 820 | Headwaiters, restaurant waiters | 1945-1959 | 90.9 | 0.0 |
| | 5-32.10 | Waiter, general | 820 | Headwaiters, restaurant waiters | 1960-1984 | 95.8 | 0.0 |
| | 5-32.10 | Waiter, general | 820 | Headwaiters, restaurant waiters | 1985-1994 | 89.7 | 0.0 |
| | 5-32.50 | Bartender | 820 | Headwaiters, restaurant waiters | 1960-1984 | 100.0 | 0.0 |
| | 5-70.20 | Women's hairdresser | 840 | Hairdressers and barbers | 1960-1984 | 54.5 | 0.0 |
| | 5-82.20 | Policemen | 801 | Policemen | 1960-1984 | 41.7 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 59.5 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| | 8-34.10 | Machine-tool operator (general) | 650 | Turners, toolmakers and machine-tool setters | 1960-1984 | 40.0 | 0.0 |
| | 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1945-1959 | 40.0 | 0.0 |
| | 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1960-1984 | 63.6 | 0.0 |
| | 9-51.20 | Bricklayer (construction) | 690 | Bricklayers, plasterers and tile setters | 1945-1959 | 54.5 | 0.0 |
| SULPHUR DIOXIDE | | | | | | | |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 54.1 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| | 9-51.20 | Bricklayer (construction) | 690 | Bricklayers, plasterers and tile setters | 1945-1959 | 45.5 | 0.0 |
| POLYCYCLIC AROMATIC HYDROCARBONS | | | | | | | |
| | 5-31.30 | Cook, except private service | 811 | Cooks etc. | 1945-1959 | 42.9 | 0.0 |
| | 5-32.10 | Waiter, general | 820 | Headwaiters, restaurant waiters | 1945-1959 | 42.4 | 0.0 |
| | 5-32.50 | Bartender | 820 | Headwaiters, restaurant waiters | 1960-1984 | 93.3 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 64.9 | 0.0 |
| | 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| | 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1945-1959 | 53.3 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1960-1984 | 63.6 | 0.0 |
| 8-72.10 | Gas and electric welder (general) | 655 | Welders and flame cutters | 1960-1984 | 85.7 | 9.6 |
| 8-72.50 | Flame-cutter (hand) | 655 | Welders and flame cutters | 1960-1984 | 66.7 | 9.6 |
| 9-51.20 | Bricklayer (construction) | 690 | Bricklayers, plasterers and tile setters | 1945-1959 | 45.5 | 0.0 |
| 9-79.20 | Lifting-truck operator | 771 | Forklift operators etc. | 1960-1984 | 57.9 | 0.0 |
| 9-79.20 | Lifting-truck operator | 771 | Forklift operators etc. | 1985-1994 | 41.7 | 0.0 |
| 9-85.30 | Taxi driver | 540 | Motor vehicle and tram drivers | 1945-1959 | 42.1 | 0.0 |
| 9-85.30 | Taxi driver | 540 | Motor vehicle and tram drivers | 1960-1984 | 44.4 | 0.0 |
| 9-85.40 | Motor bus driver | 540 | Motor vehicle and tram drivers | 1960-1984 | 72.7 | 0.0 |
| BENZO(A)PYRENE | | | | | | |
| 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 54.1 | 0.0 |
| 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| 9-51.20 | Bricklayer (construction) | 690 | Bricklayers, plasterers and tile setters | 1945-1959 | 45.5 | 0.0 |
| GASOLINE ENGINE EXHAUST | | | | | | |
| 2-11.10 | General manager | 110 | Business management | 1945-1959 | 47.6 | 0.0 |
| 3-10.10 | Government executive official | 100 | Senior officials and employees in public administr | 1960-1984 | 43.8 | 0.0 |
| 4-00.30 | Manager, retail trade | 200 | Wholesalers | 1960-1984 | 40.0 | 0.0 |
| 4-32.20 | Commercial traveller | 220 | Commercial travellers and salesmen | 1945-1959 | 93.3 | 0.0 |
| 4-32.20 | Commercial traveller | 220 | Commercial travellers and salesmen | 1960-1984 | 83.6 | 0.0 |
| 4-32.20 | Commercial traveller | 220 | Commercial travellers and salesmen | 1985-1994 | 67.7 | 0.0 |
| 4-41.20 | Insurance salesman | 210 | Insurance salesmen | 1960-1984 | 80.0 | 0.0 |
| 4-41.30 | Real estate salesman | 210 | Insurance salesmen | 1960-1984 | 76.5 | 0.0 |
| 4-41.30 | Real estate salesman | 210 | Insurance salesmen | 1985-1994 | 82.4 | 0.0 |
| 5-82.20 | Policemen | 801 | Policemen | 1960-1984 | 83.3 | 2.9 |
| 5-99.90 | Other Service Workers NEC | 890 | Hotel hall porters | 1960-1984 | 40.0 | 0.0 |
| 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 56.8 | 0.0 |
| 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 100.0 | 9.9 |
| 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1945-1959 | 46.7 | 0.0 |
| 8-71.10 | Pipe fitter (general) | 654 | Plumbers | 1960-1984 | 54.5 | 0.0 |
| 9-89.50 | Pedal-vehicle driver | 599 | Occupations in transport and communications, nec | 1945-1959 | 90.0 | 0.0 |
| GASOLINE | | | | | | |
| 8-43.20 | Automobile mechanic | 652 | Machine and engine mechanics | 1945-1959 | 60.7 | 10.0 |
| 9-85.30 | Taxi driver | 540 | Motor vehicle and tram drivers | 1985-1994 | 44.4 | 0.0 |
| FLOUR DUST | | | | | | |
| 5-31.20 | Head cook | 811 | Cooks etc. | 1960-1984 | 45.5 | 3.6 |
| 5-31.30 | Cook, except private service | 811 | Cooks etc. | 1985-1994 | 52.2 | 3.6 |
| WOOD DUST | | | | | | |
| 2-11.10 | General manager | 110 | Business management | 1945-1959 | 42.9 | 0.0 |
| 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1945-1959 | 97.3 | 0.0 |
| 6-31.20 | Tree feller and bucker | 340 | Forestry workers and lumberjacks | 1960-1984 | 90.0 | 0.0 |
| 8-55.20 | Building electrician | 660 | Electricians | 1960-1984 | 54.5 | 0.0 |