Development of the New Zealand job-exposure matrix

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Abstract

Introduction. In New Zealand there is a need for a comprehensive and accessible database with national occupational exposure information, i.e. a General Population Job-Exposure Matrix (GPJEM). However, few New Zealand-specific exposure data exist that could be used for the construction of such a GPJEM. Here we present the methods used to develop a GPJEM for New Zealand (NZJEM), by combining GPJEMs developed in other countries with New Zealand-specific exposure information, using wood dust as an example to illustrate this process.
Methods. Existing GPJEMs developed in other countries were used as a starting point for the NZJEM. The occupational classifications of these GPJEMs were recoded to the New Zealand Standard Classification of Occupations (NZSCO). The assessments of the GPJEMs were then made available to a New Zealand expert in occupational wood dust exposure, who then provided a preliminary NZJEM assessment (including the percentage exposed and the level of exposure for each occupation); wherever possible, this assessment was based on New Zealand exposure measurements. In the next step, information from a nation-wide workplace exposure survey of 3,000 members of the New Zealand workforce was used to finalize the NZJEM assessments.
Results and conclusions. The NZJEM listed 104 of the 956 NZSCO codes as exposed to wood dust. The percentage of workers exposed within an occupation ranged from 5% (e.g. boiler attendants) to 100% (e.g. cabinet makers). The level of exposure ranged from 0.05 mg/m^3 (e.g. electricians) to 3 mg/m^3 (e.g. carpenters). Of these assessments, 23% were mainly based on New Zealand exposure data, 37% on overseas GPJEMs and exposure data, and for 40% the national survey data served as the main source of information for the expert assessment. By combining the NZJEM assessments with national employment statistics, it was estimated that 5.6% of the New Zealand workforce is occupationally exposed to wood dust, corresponding to a total of 97,000 workers, of whom 86% are male and 14% female. The NZJEM will be updated when additional exposure data become available, and other exposures will be added to NZJEM using the same methodology.

Introduction

A general population job-exposure matrix (GPJEM) is a cross-classification of occupations (jobs) and exposures [1]. In epidemiology, the main purpose of a GPJEM is the retrospective assessment of occupational exposure of study subjects, based on their recorded occupations, although GPJEMs can also more broadly function as an information tool for exposure assessment data for a wide range of occupations and exposures.

Kromhout and Vermeulen[2] presented an overview of the GPJEMs that have been developed since the introduction of this methodology in the 1980s[3]. Whereas the early GPJEMs consisted of a list of jobs with a yes/no label for exposure to selected agents, more complex GPJEMs can also include an estimate of the percentage of workers exposed and a (semi)quantitative exposure level for each job. A time axis can be included giving year-specific exposure estimates if exposure has changed significantly over time. An industry axis can also be incorporated when the exposure depends not only on the job, but also on the industry in which the job is carried out. The exposure axis of a JEM can include, in addition to chemical agents, also physical, microbiological, physiological/ergonomic, and psychosocial factors. Furthermore, a GPJEM can include country-specific demographic data such as the number of people working in each occupation, including gender distributions, which can then be used to estimate the absolute numbers of workers exposed. Thus, besides functioning as a retrospective occupational exposure assessment tool in epidemiological studies, GPJEMs have been evolving into multipurpose information systems. A good example of such a JEM is FINJEM[4], a Finnish job-exposure matrix that has been used in epidemiological studies, and also serves as an information tool for policy making, risk assessment and hazard surveillance.

In New Zealand, as in other countries, there is a need for a comprehensive and accessible database with national occupational exposure information. However, few New Zealand-specific exposure data exist that could be used for the construction of such a GPJEM. This has made New Zealand reliant on GPJEMs developed overseas, although they may not be fully applicable to New Zealand working conditions. In this paper, we present the methods used to develop a GPJEM for New Zealand (NZJEM), by combining GPJEMs developed in other countries with New Zealand-specific exposure information, using wood dust as an example to illustrate this process.

Methods

The construction of the NZJEM included the following steps.

Step 1. Search of existing GPJEMs

The starting point was the already available 'overseas' GPJEMs. For the development of the wood dust NZJEM, these included FINJEM, MRCJEM and CEEJEM.

(i) FINJEM [4]. FINJEM is a multipurpose exposure information system developed by the Finnish Institute of Occupational Health (FIOH). Occupations cover 311 classes of the Finnish Census classification [4]. The prevalence of exposure (0% -100%) and the quantitative mean level of exposure are available.

(ii) MRCJEM [5]. MRCJEM is a job-exposure matrix developed in the Medical Research Council's Environmental Epidemiology Unit in Southampton, UK. This British job-exposure Matrix was based on cross-tabulated combinations of industrial and occupational classes. Occupations cover 211 classes of the Office of Population Censuses and Surveys 1966 classification[6], and industries cover the 248 classes of the UK SIC 68 classification (Standard Industry Classification).

(iii) CEEJEM [7]. This JEM is entirely based on case-by-case expert assessments conducted for a lung cancer case-control study in Central and Eastern Europe (CEE) and coordinated by the International Agency for Research on Cancer (IARC) [7]. Local expert teams evaluated the exposures of the jobs of approximately 3000 cases and 3000 controls. The case-by-case evaluations were used to make a JEM using the ISCO 68 [8] codes in the job-axis. For each ISCO 68 code, the percentage exposed was calculated, as well as the average level of exposure for the exposed within that job. In order to have sufficient number of assessments within each occupation, all jobs of all cases and controls were included (the 6000 cases and controls had 3-4 jobs on average).

Step 2. Recoding occupational classifications used in GPJEM into NZSCO

For the job-axis of NZJEM, the 1999 New Zealand Standard Classification of Occupations (NZSCO) was used[9], thus enabling direct linkage to New Zealand labour statistics. NZSCO 1999 is a hierarchical classification scheme, based on ISCO 88 [10], including a total of 956 occupational codes (562 five-digit, 261 four-digit, 99 three-digit, 25 two-digit and 9 one-digit codes). The occupation classifications used in FINJEM, MRCJEM and CEEJEM were recoded to NZSCO codes through one-way coding, i.e. each NZSCO code was linked to the most applicable GPJEM code. A comparability rating was included for each NZSCO code, classifying a 'good fit' if the NZSCO job was very similar to the GPJEM job, but classifying an 'average fit' or 'bad fit' if this was not the case.

Step 3. Construction of ACCESS database for use by the expert

An ACCESS database was developed which linked FINJEM, MRCJEM and CEEJEM by NZSCO-code. ACCESS form-views were developed that enabled the simultaneous consultation of the 3 GPJEMs, for use during the NZJEM expert evaluation. Also directly available on screen were the definition of exposure, a link to an electronic version of the full NZSCO classification book [11], the number of people employed in each NZSCO job and the male/female distribution from the 1996 Census of Population and Dwellings. In the same form-view, the NZJEM assessment could be entered, consisting of the following fields for each NZSCO code:

- *Exposure present:* recorded as either "yes", "no", or "depends on industry". Exposure was recorded as "yes" or "depends on industry" if at least 5% of the workers within the NZSCO code were considered exposed. If the exposure within the specific occupation heavily depended on the industry in which the job was performed, the industries in which the exposure occurred could be specified. For this industry axis of the NZJEM, the ANZSIC classification was used (the Australian and New Zealand Standard Industrial Classification

1993)[12].

- *Percentage exposed:* if the exposure was deemed present, the percentage of workers exposed within the job was estimated (5%-100%).
- *Exposure level:* if the exposure was deemed present, the 8-hour average exposure level for the exposed percentage within the job was estimated. For wood dust this was expressed as mg/m^3 inhalable dust (8-hour time weighted average).
- *Source of exposure:* if the exposure was deemed present, the source of exposure (e.g. during what tasks, during use of which products), could be specified in a text field.
- *Exposure information:* if the exposure was deemed present, the main sources of information that were used by the expert to reach this assessment could be specified in a text field (e.g. the assessment was mainly based on other GPJEMs, overseas exposure data, New Zealand exposure data, or New Zealand survey data). Where possible, references to these sources of information were included.
- *Time periods:* if exposure had changed dramatically over time, due to changes in i.e. regulation or production processes, this could be specified by giving separate assessments for different time periods.
- *Type of wood dust:* if the exposure was deemed present, the type of wood dust (hard wood/soft wood/both) mainly handled in the job could also be specified.

The expert could make use of different form-views of the data, including a view that showed all NZSCO codes and their evaluations in one screen, which could be sorted by any of the above variables, allowing easy comparisons of assessments between jobs in order to improve internal consistency of the NZJEM assessments.

Step 4. Evaluation by expert, resulting in preliminary NZJEM assessments

Assessments were made for all 4 and 5 digit codes of NZSCO. For the 3, 2 and 1 digit codes the percentages exposed and exposure levels were then calculated using the prevalence of exposure and number of workers in each 4- and 5-digit NZSCO code.

Step 5. Adjusting of NZJEM assessments by using NZ survey data

After the NZJEM assessments for all NZSCO codes were completed, national survey data on self-reported exposure to wood dust were made available to the expert. During 2004-2006, we conducted a telephone survey in a random sample of the New Zealand workforce, aged 20-64, collecting information on work practices and self-reported exposures. The detailed study methodology is described elsewhere {Eng et al}. Briefly, for the current or most recent job, self-reported exposure to wood dust (among other exposures) was collected using a structured questionnaire. For each occupation of NZSCO 1999, the prevalence of self-reported exposure to wood dust was calculated. This could not be done for all NZSCO codes: of the 562 5-digit NZSCO codes, there were no survey respondents for 36% and 11% contained more than 10 respondents (4-digit codes: 19%, 28%; 3-digit codes: 9%, 56%). The survey data were presented to the expert as a percentage (% within the NZSCO occupation reported to be exposed to wood dust), as well as the number of respondents on which this percentage estimate was based.

Step 6. Final evaluation by expert

The expert then revised the NZJEM assessments by comparing them with the survey data, resulting in a final NZJEM assessment.

Step 7. Finalisation of multipurpose NZJEM database

A final ACCESS database was then constructed to provide easy access to the NZJEM, including easy search and tabulation options, background information such as the numbers of workers in each NZSCO occupation, estimates of the absolute numbers of workers exposed based on NZJEM assessments, the definition of exposure, and standards for national and international

occupational exposure limits.

Comparisons between GPJEMs, national survey data, and NZJEM.
Cohen's kappa statistics were calculated to evaluate the agreement between NZJEM and the three GPJEMs as well as the survey data. The kappa statistics were calculated for the presence of exposure (yes/no) over all NZSCO codes (n=956), with an NZSCO code defined as exposed if at least 5% of the workers within the NZSCO code were considered exposed. Both the preliminary and final NZJEM assessments were compared with the three available 'overseas' GPJEMs and the survey data.

Results

The final NZJEM listed 104 of the 956 NZSCO codes as exposed to wood dust (4 1-digit codes; 8 2-digit codes; 17 3-digit codes; 27 4-digit codes; 48 5 digit codes). Table 1 lists all 3-digit occupational groups that were evaluated as exposed in the final NZJEM. The percentage of workers exposed ranged between 5% (e.g. boiler attendant) and 100% (e.g. cabinet makers). The level of exposure ranged from 0.05 mg/m^3 (e.g. electricians) to 3 mg/m^3 (e.g. carpenters).

Table 2 shows that the GPJEMs differed considerably in terms of the number of occupations (NZSCO codes) they considered exposed, with FINJEM being much less likely to consider a job as exposed compared with MRCJEM and CEEJEM. The survey data provided the highest number of NZSCO codes that were considered as exposed. Before the expert had access the national survey data, the preliminary NZJEM assessments showed reasonable agreement with the three GPJEM, with kappa's ranging between 0.45 and 0.56. These kappa's did not change appreciably when only including NZSCO codes for which the fit with the occupational classification of the GPJEM was good (results not shown). The agreement of the preliminary NZJEM assessments with the national survey data was poor (kappa=0.23). After the expert had received access to the survey data, the expert considered an additional 50 NZSCO codes as exposed. Typically, these represented more general occupations for which, from the title and description, it was not directly obvious they were exposed to wood dust, but for which the survey data clearly indicated that wood dust exposure was common. Examples included "structural engineer", "production manager", "plumber", "painter", and "electrician". As a result, the agreement with the national survey data increased to kappa=0.56 while the agreement between the final NZJEM assessments and the GPJEM dropped to kappa=0.32-0.43.

This is also reflected in the sources of information the expert reported to have used for the final NZJEM assessments. In total 40% of all 5-digit NZSCO codes evaluated as exposed in the final NZJEM assessments were primarily based on the survey data. For a relatively small percentage of exposed NZSCO codes (23%) the NZJEM estimates could be based on actual exposure measurements performed in New Zealand, including sawmill workers, carpenters, boiler attendants and wood products machine operators. The rest (37%) of the exposed NZJEM assessments were mainly based on 'overseas' exposure data and the GPJEMs.

Combining the final NZJEM assessments (percentage exposed in each job) with national employment statistics, indicated that an estimated 5.6% of the New Zealand workforce is exposed to wood dust in their work place, corresponding to a total of 97,000 workers. The wood dust exposed jobs tended to be male-dominant jobs, and therefore the actual percentage of wood dust exposed workers was considerably higher among males (9%) than females (2%). Of the 97.000 exposed workers, 86% were male and 14% female.

Future plans for NZJEM

The NZJEM is a work in progress, and will contain features enabling it to be updated when new information becomes available. The features that can be updated include:

(i) Exposure data: if new exposure data become available, references to the data can be added, the NZJEM assessment can be changed, and the anonymised exposure data will be stored at the Centre for Public Health Research.

(ii) Occupational classifications (i.e. if a new occupational classification is introduced, cross-classifications between the old and new versions of NZSCO will be included)

(iii) Labour statistics: as new labour statistics become available, these will be added to NZJEM, thus reflecting changes in the occupational profile of New Zealand, which may in turn affect the total number of workers exposed.

(iv) Logfile: A log file with the changes made and on which date will be included

(v) Additional exposures: the same methodology will be used to add additional exposures to

NZJEM, including chemical, biological and physical exposures.

Discussion

During the development of the NZJEM, we relied heavily on overseas exposure data and overseas GPJEMs, due to the lack of occupational exposure data available in New Zealand. There were two main reasons for this: firstly, New Zealand does not have a strong history of collecting occupational exposure data and; secondly, there has been no effort to centrally store and conserve occupational exposure data. In contrast, some other countries have been able to collect a large amount of occupational exposure data, e.g. in Germany the MEGA-database [13] is a chemical workplace exposure database of the Institute for Occupational Safety of the German Berufsgenossenschaften and includes 1,000,000 measurements of more than 400 substances dating back to 1972. The French COLCHIC database [14] includes 400,000 measurements of 600 substances collected over a period of 10 years. The situation in New Zealand is far removed from this. For the wood dust NZJEM, the estimates of 23% of all exposed occupations were based on actual exposure measurements conducted in New Zealand work places, an estimated total of 200-300 individual measurements. For most other occupational exposures, it is likely that considerably less exposure measurement data will be retrievable.

The survey data of self-reported occupational exposure in a random sample of the New Zealand workforce (n=3,000) proved a valuable resource for the purpose of making NZJEM more New Zealand specific, mainly by improving the sensitivity of NZJEM by including an additional 50 occupations as exposed, while largely leaving the 'exposed jobs' of the preliminary NZJEM assessments unchanged. The additional 50 occupations were generally not considered exposed by the other GPJEMs, and were by and large occupations for which wood dust exposure may be specific to the New Zealand situation. These occupations included, for example, structural engineer, plumber, painter and electrician, in which wood dust exposure is common because the majority of New Zealand houses are made of wood. However, although very useful, the survey data were not sufficient to form the only information source to the expert because: (i) occupations that are relatively rare in the population are not covered; (ii) self reported information can either over or underestimate exposure prevalence; (iii) it does not give any information about levels of exposure. In addition, because the survey collected information on self-reported exposures, the survey data are not likely to be equally valuable for exposures that are generally not known to be present in the work environment, or are not recognised by survey respondents.

The other GPJEMs were considered a very useful starting point for NZJEM by the expert, although agreement with the final NZJEM assessments was low. The main advantage of having other GPJEMs available during the first NZJEM evaluation was that they give a complete overview of all occupations while the expert generally does not have experience or knowledge of exposure levels for all possible occupations. Access to these GPJEMs provided a structural means to think about exposures in all possible jobs. Having evaluations of different GPJEMs simultaneously available on screen showed that other GPJEM often disagreed among themselves, which in some cases may indicate real differences in working circumstances in different countries.

In conclusion, although very few occupational exposure data are publicly available in New Zealand, the combination of overseas GPJEMs, national exposure survey data and expert assessment had enabled the development of a job-exposure matrix tailor-made for the New Zealand situation. The methodology for creating a New Zealand specific GPJEM described here was feasible and practical, and has resulted in a multipurpose information system that can be used in New Zealand based epidemiological studies, as well as functioning as an information source for policy makers and other occupational health professionals.

Acknowledgements

This project was funded from a Joint Research Portfolio of the Health Research Council, the Accident Compensation Corporation, and the Department of Labour for a study of the burden of occupational ill-health in New Zealand (HRC 04/072), and from grants from the Health Research Council (HRC 02/159), Lotteries Health Research, the Cancer Society of New Zealand and the Accident Compensation Corporation for a study of occupational cancer in adult New Zealanders. The Centre for Public Health Research is supported by a Programme Grant from the Health Research Council of New Zealand (HRC 02/159). We also thank Tracey Whaanga, Zoe Harding, Cecil Priest, Penelope Whitson, Michaela Skelly, Phoebe Taptiklis, Emma Drummond, Anna McCarty, Natasha Holland, Kelly Gray, Adam Hoskins, Alister Thomson, Jess Fargher, Cilla Blackwell, Emma Turner, Selena Richards, Kim Crothall, Alice Harding, Joelene Wilkie, Joanne Dow, and Tania McKenzie who conducted the interviews, and Rebecca Jones, Alice Harding, Zoe Harding, Alister Thomson, Chani Tromop van Dalen, Jessica Fargher, Cecil Priest, and Miria Hudson who completed the data entry.

Table 1. All 3-digit NZSCO codes considered >5% exposed to wood dust

	level	%
824-Wood Products Machine Operators	0.71	96
742-Cabinet Makers and Related Workers	2.00	91
711-Building Frame and Related Trades Workers	2.00	83
814-Wood-Processing and Papermaking Plant Operators	0.50	82
613-Forestry and Related Workers	1.00	50
712-Building Finishers and Related Trades Workers	0.05	45
713-Electricians	0.05	33
315-Safety and Health Inspectors	0.05	25
915-Labourers	0.40	25
113-Senior Business Administrators	0.05	14
611-Market Farmers and Crop Growers	0.05	13
214-Architects, Engineers and Related Professionals	0.05	10
121-General Managers	0.05	9
612-Market Oriented Animal Producers	0.05	8
122-Specialised Managers	0.05	6
829-Assemblers	0.10	6
833-Agricultural, Earthmoving & Other Materials-Handling Equipment Operators	0.75	5

Table 2. Agreement between NZJEM and other available GPJEMs

N(total)=956		Comparison with NZJEM before access to survey (n jobs exposed=54)		Comparison with NZJEM after access to survey (n jobs exposed=104)	
		Jobs exposed according to			
Exposed 5-digit NZSCO codes (48 out of 562)	New Zealand exposure measurements	overseas exposure data and GPJEM		NZ workforce survey	
n	n	%	n	%	n	%
48	11	23	18	37	19	40

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