



Editorial

Scand J Work Environ Health [2020;46\(3\):231-234](#)

doi:10.5271/sjweh.3894

Although a valuable method in occupational epidemiology, job-exposure matrices are no magic fix

by [Peters S](#)

Affiliation: Institute for Risk Assessment Sciences, Utrecht University, Utrecht, The Netherlands. s.peters@uu.nl

Refers to the following texts of the Journal: [2019;45\(3\):239-247](#)
[2020;46\(3\):259-267](#) [2020;46\(3\):268-277](#) [2020;46\(4\):437-445](#)

The following article refers to this text: [2020;46\(5\):552-553](#)

Key terms: [editorial](#); [epidemiology](#); [JEM](#); [job-exposure matrix](#); [method](#); [methodology](#); [occupational epidemiology](#)

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/32356897



This work is licensed under a [Creative Commons Attribution 4.0 International License](#).

Although a valuable method in occupational epidemiology, job-exposure matrices are no magic fix

Job-exposure matrices (JEM) are a common method for exposure assessment in occupational epidemiology. The first JEM were described in the early 1980s (1, 2) and have been used in a wide range of settings ever since. A recent review on methods for retrospective exposure assessment in the general population revealed that more than a quarter of the studies on cancer applied a JEM (3). Where JEM originally assigned exposures at a qualitative or semi-quantitative level based on expert ratings, quantitative exposure estimates can also be derived when measurements are used to calibrate these ratings (4–6).

A JEM typically consists of job and exposure axes. The major advantage of JEM is that job histories can be translated into specific exposures in a systematic and unbiased way. It is basically a computerized linkage of exposure estimates to job codes, and, as such, JEM represent a highly efficient and reproducible methodology. This way, a standardized exposure assessment within and between studies can be guaranteed, and any misclassification is expected to be non-differential with respect to the health outcome. Once developed, a JEM is relatively easy to apply and less costly than case-by-case expert assessment.

These benefits make JEM a particularly useful instrument for exposure assessment in large-scale, general population studies. Such studies (eg, based on register data) permit collection of full occupational histories and enable the study of rare diseases or subtypes. Subjects have typically worked in a wide variety of occupations and industries. Detailed exposure information, which can more easily be collected in industry-based cohorts, is often not available. For register-based cohorts, collected occupational histories are also typically limited to the basic information of job titles and industries. Using JEM, exposures can be assessed for many agents and stressors, based solely on job titles.

The DOC*X project is a good example of the use of register data in occupational epidemiology (7). The large number of subjects – the full working population of Denmark for several decades – offers unique opportunities for studying new associations between a variety of exposures and various health outcomes. Individual data from several databases, including health and labour registries, were linked by a personal identifier. For each cohort member, job title and industry have been annually registered and coded (7). Subsequently, the project has been linking a series of JEM to this nationwide cohort to assess several kinds of occupational exposures. A couple of these efforts have been published in this issue of the *Scandinavian Journal of Work, Environment and Health* to assess the association between physical activities at work and acute myocardial infarction (8) and the risk of work-related hand eczema in relation to wet work (9). It is impossible to go back to all individuals in this cohort to collect detailed information on their occupations: firstly because part of the cohort has died over the years but also due to practical reasons given the large numbers. So, by applying JEM, the Danes make the best use of the information available in their registry data.

The ease of using a JEM, by simply assigning exposures based on job titles, also has a flipside. By design, a JEM allocates the same exposure estimates to all workers with the same job title. This aspect represents the main drawback since it is well-recognized that there can be substantial inter-individual variability (10). In other words, a JEM completely dismisses exposure heterogeneity between workers in similar jobs, as has also been acknowledged by the authors of the DOC*X studies (8, 9).

Heterogeneity between workers may be larger for some types of exposures than others, particularly when exposures are largely determined by specific tasks. To illustrate, when assessing welding fumes, job title alone does not provide information on different tasks and circumstances that influence the level and frequency of

exposure to welding fumes (11). For exposures related to tasks like welding, decreasing or pesticide application – but also exposures such as shift work or certain psychosocial working conditions – exposure assessment based on job title alone may not be sufficient. Thus, researchers need to critically evaluate for each given exposure, if that exposure can be reasonably assessed on the job group level or if further assessment on the workplace, work unit or individual-worker level is needed.

A large part of heterogeneity is determined by the workers' behavior (12). Although this is virtually impossible to take into account in a JEM, some of the exposure heterogeneity may be accounted for by adding more detail, ie, by expanding the number of axes of the JEM. For example, an industry-axis, a time dimension, or region-, sex- and age-specific estimates may help explain part of the exposure heterogeneity. Importantly, this type of information is also typically available in the large studies where the JEM are being applied to. The JEM for wet work used by Lund et al (9) provided sex-specific estimates. A similar effort has been described for mechanical and psychosocial work exposures in Norway (13).

In addition to within-job (ie, between-worker) variability, exposures may have large temporal (ie, within-worker) variability. Levels can vary from day-to-day or over the course of the work day, the variability of which is not captured in a JEM. When studying acute health effects, for example, short-term high exposures may be more relevant than the annual average or cumulative levels and a JEM may not provide the appropriate assessment.

Many different JEM, in all forms and shapes, have been developed over the last 40 years. Due to the lack of a gold standard, JEM cannot be truly validated. Several studies, however, have described the performance of JEM (14–16). For asbestos, for instance, poor agreement between different JEM has been reported, indicating variable performance (14). Exposure assessment methods can also be evaluated using known associations with health outcomes. Using lung cancer case-control data, comparisons with other methods showed that a JEM for asbestos could outperform self-reported exposure (16) and perform as well as case-by-case expert assessment in a multicenter study (15). Yet, as indicated above, the performance of a JEM will depend on the exposure and effect of interest.

Improvement in the use of JEM could be achieved by harmonizing existing JEM. A harmonized JEM, which provides a standardized exposure assessment across regions and time periods, would be highly valuable for pooled analyses. Such large-scale analyses will offer unique opportunities to study exposure-disease associations that have been understudied until now due to lack of statistical power. JEM will be invaluable instruments to such (exploratory) exercises.

Derivation of exposure-response relations requires quantification of exposure. Development of more quantitative JEM, as first described for the multinational SYNERGY project on lung cancer (4) and the Shanghai Women's Health Study (6), may further increase the impact of occupational studies. However, a quantitative JEM will still have the same limitation of assuming homogeneity within jobs and large amounts of (measurement) data are needed to develop a quantitative JEM. Data mining techniques could be explored to make better use of existing data sources for high-quality exposure assessment.

The coding of job titles is another major challenge related to the use of JEM. Manual coding of each individual's job history in large epidemiological studies is a very time-consuming task. As a result, many of these studies are not used to their full potential for occupational health outcomes. Further improvement could therefore be achieved by systems that automatically translate free text into occupational codes, increasing the efficiency and feasibility of investigating occupational risk factors (using JEM) in large-scale epidemiological studies. Efforts in developing automatic coding in the US have shown agreements with manual coding of around 50% (17, 18).

Automated coding systems would not be applicable to most registry data, however, since job information is only available as a code. For pooling these registry data with other data, or for application of another JEM, crosswalks between systems can be the solution. In addition to differences between human coders, crosswalks may also introduce disagreement between codes and actual jobs, possibly leading to further misclassification of exposure. Interestingly, within DOC*X it was shown that errors in job coding had limited effect on the exposure assessment of wood dust, lifting, standing/walking, arm elevation, and noise (19). Previous studies also reported that the effects of disagreements in job coding generally diminish in the exposure assessment stage (12, 20).

Specificity is crucial when the prevalence of occupational exposure is low, which is often the case in the general population because possible associations may otherwise be severely underestimated. When exposures are more prevalent, sensitivity becomes more important (12). Since the performance of a JEM is also determined by the between-worker (ie, within job) and between-job variance, the level of detail of the job classification plays an important role. Occupational classification systems have primarily been developed from a social-economic perspective. These systems, either international or national coding schemes, are therefore not necessarily reflecting exposure categories in the best way. Developing new or adjusted coding systems for exposure assessment may help moving the occupational health field forward.

Several research initiatives are currently working on such improvements in the use of JEM, including the Network on the Coordination and Harmonisation of European Occupational Cohorts (OMEGA-NET, omeganet-cohorts.eu) and the Exposome Project for Health and Occupational Research (EPHOR, www.ephor-project.eu).

In conclusion, a JEM can be a very handy tool for exposure assessment in occupational epidemiology, particularly in large-scale studies with limited occupational information. When selecting the most suitable exposure assessment method, however, researchers should always remain critical. Know when a JEM has added value and recognize its limitations.

References

1. Hoar SK, Morrison AS, Cole P, Silverman DT. An occupation and exposure linkage system for the study of occupational carcinogenesis. *J Occup Med*. 1980;22(11):722-6.
2. Pannett B, Coggon D, Acheson ED. A job-exposure matrix for use in population based studies in England and Wales. *Br J Ind Med*. 1985;42(11):777-83. <https://doi.org/10.1136/oem.42.11.777>
3. Ge CB, Friesen MC, Kromhout H, Peters S, Rothman N, Lan Q, et al. Use and Reliability of Exposure Assessment Methods in Occupational Case-Control Studies in the General Population: Past, Present, and Future. *Ann Work Expo Health*. 2018;62(9):1047-63. <https://doi.org/10.1093/annweh/wxy080>
4. Peters S, Vermeulen R, Portengen L, Olsson A, Kendzia B, Vincent R, et al. Modelling of occupational respirable crystalline silica exposure for quantitative exposure assessment in community-based case-control studies. *J Environ Monit*. 2011;13(11):3262-8. <https://doi.org/10.1039/c1em10628g>
5. Peters S, Vermeulen R, Portengen L, Olsson A, Kendzia B, Vincent R, et al. SYN-JEM: A Quantitative Job-Exposure Matrix for Five Lung Carcinogens. *Ann Occup Hyg*. 2016;60(7):795-811. <https://doi.org/10.1093/annhyg/mew034>
6. Friesen MC, Coble JB, Lu W, Shu XO, Ji BT, Xue S, et al. Combining a job-exposure matrix with exposure measurements to assess occupational exposure to benzene in a population cohort in shanghai, china. *Ann Occup Hyg*. 2012;56(1):80-91. <https://doi.org/10.1136/oemed-2011-100382.81>
7. Flachs EM, Petersen SEB, Kolstad HA, Schlunssen V, Svendsen SW, Hansen J, et al. Cohort Profile: DOC*X: a nationwide Danish occupational cohort with eXposure data - an open research resource. *Int J Epidemiol*. 2019;48(5):1413-k. <https://doi.org/10.1093/ije/dyz110>
8. Bonde JPE, Flachs EM, Madsen IE, Petersen SB, Andersen JH, Hansen J, et al. Acute myocardial infarction in relation to physical activities at work: a nationwide follow-up study based on job-exposure matrices. *Scand J Work Environ Health*. 2020;46(3):268–277. <https://doi.org/10.5271/sjweh.3863>
9. Lund T, Petersen SB, Flachs EM, Ebbeløj NE, Bonde JP, Agner T. Risk of work-related hand eczema in relation to wet work exposure. *Scand J Work Environ Health*. 2020. <https://doi.org/10.5271/sjweh.3876>
10. Kromhout H, Symanski E, Rappaport SM. A comprehensive evaluation of within- and between-worker components of occupational exposure to chemical agents. *Ann Occup Hyg*. 1993;37(3):253-70.
11. IARC Working Group. Volume 118: Welding, Indium Tin Oxide, Molybdenum Trioxide.: IARC Monogr Eval Carcinog Risks Hum; 2018.
12. Kromhout H, Vermeulen R. Application of job-exposure matrices in studies of the general population. Some clues to their performance. *European Respiratory Review*. 2001;11:80-90.
13. Hanvold TN, Sterud T, Kristensen P, Mehlum IS. Mechanical and psychosocial work exposures: the construction and evaluation of a gender-specific job exposure matrix (JEM). *Scand J Work Environ Health*. 2019;45(3):239-47. <https://doi.org/10.5271/sjweh.3774>

14. Offermans NS, Vermeulen R, Burdorf A, Peters S, Goldbohm RA, Koeman T, et al. Comparison of expert and job-exposure matrix-based retrospective exposure assessment of occupational carcinogens in The Netherlands Cohort Study. *Occup Environ Med.* 2012;69(10):745-51. <https://doi.org/10.1136/oemed-2011-100556>
15. Peters S, Vermeulen R, Cassidy A, Mannetje A, van Tongeren M, Boffetta P, et al. Comparison of exposure assessment methods for occupational carcinogens in a multi-centre lung cancer case-control study. *Occup Environ Med.* 2011;68(2):148-53. <https://doi.org/10.1136/oem.2010.055608>
16. Hardt JS, Vermeulen R, Peters S, Kromhout H, McLaughlin JR, Demers PA. A comparison of exposure assessment approaches: lung cancer and occupational asbestos exposure in a population-based case-control study. *Occup Environ Med.* 2014;71(4):282-8. <https://doi.org/10.1136/oemed-2013-101735>
17. Russ DE, Ho KY, Colt JS, Armenti KR, Baris D, Chow WH, et al. Computer-based coding of free-text job descriptions to efficiently identify occupations in epidemiological studies. *Occup Environ Med.* 2016;73(6):417-24. <https://doi.org/10.1136/oemed-2015-103152>
18. Burstyn I, Slutsky A, Lee DG, Singer AB, An Y, Michael YL. Beyond crosswalks: reliability of exposure assessment following automated coding of free-text job descriptions for occupational epidemiology. *Ann Occup Hyg.* 2014;58(4):482-92.
19. Petersen SB, Flachs EM, Svendsen SW, Marott JL, Budtz-Jorgensen E, Hansen J, et al. Influence of errors in job codes on job exposure matrix-based exposure assessment in the register-based occupational cohort DOC*X. *Scand J Work Environ Health.* 2020;46(3):259–267. <https://doi.org/10.5271/sjweh.3857>
20. Koeman T, Offermans NS, Christopher-de Vries Y, Slottje P, Van Den Brandt PA, Goldbohm RA, et al. JEMs and incompatible occupational coding systems: effect of manual and automatic recoding of job codes on exposure assignment. *Ann Occup Hyg.* 2013;57(1):107-14.

Dr Susan Peters
 Institute for Risk Assessment Sciences,
 Utrecht University,
 Utrecht, The Netherlands
 [e-mail: s.peters@uu.nl]