DOI:10.31557/APJEC.2023.6.1.3

REVIEW

Job Exposure Matrix: Occupational Exposure Assessment to Carcinogenic Compounds

Zahra Moradpour[1], Seyed Alireza Mosavi Jarrahi[2]

[1]Student Research Committee, Department of Occupational Health Engineering and Safety, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [2]Department of Social Medicine, Medical School, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Abstract

The Job Exposure Matrix (JEM) is a cross-tabulation of workplace and job title hazards and is an essential exposure assessment tool for epidemiological studies, cancer risk monitoring, cancer risk prevention, and cancer risk quantification in health research and occupational safety. The matrices are designed based on two population-based and industry-based approaches. In the population-based matrix, all occupations of a population are recorded, and in the industry-specific matrix, the occupations in one or more industries are recorded. Exposure to carcinogens factors is measured based on the type of exposure, taking into account three factors including intensity, period and frequency of exposure. Using job exposure matrix in epidemiological studies is easier than other traditional exposure assessment methods and leads to more saving of resources, and sometimes it is the only possible way to analyze causal relationships in very large databases.

Keywords: Job exposure matrix- carcinogenic compounds- occupational exposure- tasks

Asian Pac Environ Cancer, **6 (1)**, 3-5

Submission Date: 01/20/2023 Acceptance Date: 02/17/2023

Introduction

Epidemiological investigation of occupational cancers is considered to identify new pathogens or analyze the effects of occupational hazards. It seems that today's work environment has lower levels of exposure than in the past and these exposures cause common cancers for which there are other occupational and non-occupational factors [1].

The Job Exposure Matrix (JEM) is a cross-tabulation of workplace and job title hazards and is an essential exposure assessment tool for epidemiological studies, cancer risk monitoring, cancer risk prevention, and cancer risk quantification in health research and occupational safety [2, 3]. Since the use of job titles to investigate the possible relationship between jobs and health outcomes leads to incorrect estimates, modern epidemiology tends to use job exposures instead of job titles [4]. Therefore, job exposure matrix was designed to evaluate potential health exposures in the workplace [5]. The first job exposure matrix was published in 1941 in Reed and Harcourt's handbook of occupational medicine as a cross-tabulation of a list of occupations with a list of hazards. Initially, occupations were associated with exposure to one or more substances such as asbestos, silica, or arsenic. Hoar developed the first matrix that systematically covered a set of substances, job titles, and industries that is used today in epidemiological analyses [5, 6].

Details of Job exposure matrix

Job exposure matrix is a cross table of job titles and exposures that workers are exposed to in the workplace. Each cell of the matrix contains information about exposure to an agent in a job title. All matrices have at least two axes related to occupations and the axis of risk factors, and other dimensions such as time dimension, gender and type of factory have been added to some of them to increase the validity of the matrices [5, 7]. The matrices are designed based on two population-based and industry-based approaches. In the population-based

Corresponding Author:
Dr. Seyed Alireza Mosavi Jarrahi
Department of Social Medicine, Medical School, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
Email: rmosavi@yahoo.com

matrix, all occupations of a population are recorded, and in the industry-specific matrix, the occupations in one or more industries are recorded.

Exposure to carcinogens factors is measured based on the type of exposure, taking into account three factors including intensity, period and frequency of exposure. This measurement can be qualitative (yes/no), semi-quantitative (none/ low/ moderate / severe) and quantitative, according to the unit of measurement of risk factors. The amount of exposure according to the heterogeneity of exposure among workers in the form of the average level of exposure (L) (average exposure in exposed workers) and the probability of exposure (P) (Workers exposed to harmful factors divided by the total number of workers at risk) is determined in each cell of the matrix. The index obtained from the matrix is known as the cumulative exposure index and is obtained from the sum of the product of the average level of exposure × the probability of exposure × the period of exposure.

Structure of a JEM for carcinogens

In order to optimize the performance of a JEM, its cell inputs must reflect accurate estimates of exposure. These aspects are not independent of each other. While accurate estimates of exposure may exist for specific occupations, estimates become imprecise if multiple occupations with heterogeneous exposure levels are grouped together. Therefore, the structure of the matrix (i.e. the characteristics of the axes), and the accuracy of the exposure indicators to different carcinogens are interdependent. In the French electricity industry, for the development of JEM for electromagnetic fields, selected occupational categories were modified according to the results of exposure measurements obtained in a survey [8]. Disregarding the individual characteristics of workers, which usually cannot be considered in JEM, the main factors influencing the difference in the exposure rate are distributed in four axes defined by the type of carcinogen agent (exposure), job, time and place [9].

Carcinogen agents

The number of exposures (carcinogens) is determined by the objectives of the study. If the study is designed to examine a specific risk, the JEM has a limited number of exposures and may include only a few confounders. While for general cancer surveillance, JEM is designed to include a large number of exposures. The profile of an exposure can vary significantly. For example, one can put all solvents in one general solvent category, or specify solvents in different specific categories. By determining the type of exposures, the design of other JEM axes can be determined. For example, if the objective is to assess exposure to benzene, the grouping should be such that occupations with benzene exposure are separated from occupations without benzene exposure. Also, if the purpose of the study is to evaluate the overall solvents, all jobs with exposure to solvents are placed in a single category [9].

Jobs

The amount of exposure to carcinogenic compounds depends on the job and workplace. Therefore, occupations are usually classified into categories that are homogeneous in terms of exposure. Therefore, all individuals exposed to a given carcinogen under the same conditions should correspond to one entry in the matrix, and this is an ideal case. To achieve this goal, the specific "tasks" associated with each job are identified, as the tasks performed by workers lead to specific exposures. It is possible to list all tasks that lead to exposure to carcinogens and classify jobs based on these tasks. "Job-Task-Exposure" has been carried out in several studies [10-12]. However, sometimes some misclassification is unavoidable. A task may be performed by workers with different job titles, and workers with the same job title, may not all perform the same tasks or perform those tasks at different frequencies and under different conditions.

Also, to determine the AXIS of the job, ILO-ISCO code 19 can be used and the codes of a specific industry can be added. In this way, new sub-codes are created and workers with the same ILO-ISCO code are classified according to the specific tasks they perform. The advantage of using this method is to create groups of job that are consistent with the International Classification of Occupations and were used in the rubber industry, "in the metal plating industry" and in the shoe industry [11]. Some studies classify jobs based on the observed distribution of exposures. In this method, jobs are grouped into homogenous "exposure zones" [13, 14]. And sometimes they use statistical criteria to increase diversity among groups. One of the disadvantages of this method is its limited feasibility. These methods require a very large database of exposure data that should be representative of all JEM toxicants. This information may be rarely available for the past and expensive for current exposures [9].

Time

For retrospective studies, including historical cohort studies and case-control studies within a cohort, the JEM should usually be designed to account for changes in exposure that have occurred over a period of several decades. A given job can undergo major changes over time and even changes in related tasks. Also, working methods and materials and equipment used change with time. On the other hand, personal protection and engineering have changed significantly in recent decades and its progress has often led to a large reduction in exposure levels. One of the features of JEM is the reflection of changes in the distribution of jobs and related exposures. Therefore, changing the exposure levels in the desired time period requires the definition of a time axis. The studies by Kauppinen and Partanen [15] for the wood industry in Finland and by Goldberg et al. [14] for the nickel industry in New Caledonia are cases with a time axis in JEM.

Site

The type of exposure is usually different in similar industries that use different working methods or different materials. These differences are mentioned for nickel [16], wood [15] and rubber [9] industries . The reasons for the difference in exposure in industries may be in the same work done in different workshops for different reasons, especially ventilation and environment. Due to these issues, it may be necessary to place a site axis in the JEM.

Job exposure matrix by linking the data of the disease registration and reporting system, death certificates, health insurance and epidemiological studies that include the occupational history of people, can transform their occupational information into occupational exposures to carcinogens. In addition to the purposes of epidemiological studies, job exposure matrix is used to assess exposure and estimate the burden of cancers and to predict future occupational exposures to carcinogens in the workplace. Using job exposure matrix in epidemiological studies is easier than other traditional exposure assessment methods and leads to more saving of resources, and sometimes it is the only possible way to analyze causal relationships in very large databases. The main advantage of using the matrix is the reduction of non-differential misclassification, the lack of differentiation between sick people and non-sick people, and the absence of errors caused by workers' reminders [17]. The inability to calculate the variety of exposure in job classes and the laborious process of job coding are the limitations of the matrix [18].

Despite the aforementioned limitations, the use of job exposure matrix is considered a valuable supplement in occupational epidemiological studies, and although it does not completely eliminate misclassification, it reduces it to a large extent.

References

1. Goldberg M, Imbernon E. The use of job exposure matrices for cancer epidemiology research and surveillance. Arch Public Health. 2002;60:173-85.
2. García AM, González-Galarzo MC, Kauppinen T, Delclos GL, Benavides FG. A job-exposure matrix for research and surveillance of occupational health and safety in Spanish workers: MatEmESp. American Journal of Industrial Medicine. 2013 Oct;56(10):1226-1238. https://doi.org/10.1002/ajim.22213
3. Garcia, de FREMAP P, y Salud A. A job-exposure matrix for Spanish workers. Seguridad y Medio Ambiente. 2011;31:123.
4. Cole P, Merletti F. Chemical agents and occupational cancer. Journal of Environmental Pathology and Toxicology. 1980 03;3(4 Spec No):399-417.
5. Hoar S. Job exposure matrix methodology. Journal of Toxicology. Clinical Toxicology. 1983;21(1-2):9-26. https://doi.org/10.3109/15563658308990408
6. Gamble J, Spirtas R. Job Classification and Utilization of Complete Work Histories in Occupational Epidemiology. Journal of Occupational Medicine. 1976;18(6):399-404.
7. Nasseri K. A comprehensive dictionary of epidemiology. Tehran: GAP Publishers. 2010.
8. Guénel P, Nicolau J, Imbernon E, Warret G, Goldberg M. Design of a job exposure matrix on electric and magnetic fields: selection of an efficient job classification for workers in thermoelectric power production plants. International Journal of Epidemiology. 1993;22 Suppl 2:S16-21. https://doi.org/10.1093/ije/22.supplement_2.s16
9. Goldberg M, Kromhout H, Guénel P, Fletcher AC, Gérin M, Glass DC, Heederik D, Kauppinen T, Ponti A. Job exposure matrices in industry. International Journal of Epidemiology. 1993;22 Suppl 2:S10-15. https://doi.org/10.1093/ije/22.supplement_2.s10
10. Lagorio S, Forastiere F, Iavarone I, Vanacore N, Fuselli S, Carere A. Exposure assessment in a historical cohort of filling station attendants. International Journal of Epidemiology. 1993;22 Suppl 2:S51-56. https://doi.org/10.1093/ije/22.supplement_2.s51
11. Scarpelli A, Miligi L, Seniori Costantini A, Alberghini Maltoni S. Exposure to solvents in the shoe and leather goods industries. International Journal of Epidemiology. 1993;22 Suppl 2:S46-50. https://doi.org/10.1093/ije/22.supplement_2.s46
12. Gérin M, Fletcher AC, Gray C, Winkelmann R, Boffetta P, Simonato L. Development and use of a welding process exposure matrix in a historical prospective study of lung cancer risk in European welders. International Journal of Epidemiology. 1993;22 Suppl 2:S22-28. https://doi.org/10.1093/ije/22.supplement_2.s22
13. Corn M, Esmen NA. Workplace exposure zones for classification of employee exposures to physical and chemical agents. American Industrial Hygiene Association Journal. 1979 01;40(1):47-57. https://doi.org/10.1080/15298667991429318
14. Goldberg M, Leclerc A, Chastang J, Goldberg P, Brodeur J. Evaluation rétrospective d'expositions professionnelles dans les études épidémiologiques. Utilisation de la méthode Delphi. Revue d'épidémiologie et de santé publique. 1986;34(4-5):245-51.. 1986;34(4-5):245-51.
15. Kauppinen T, Partanen T. Use of plant- and period-specific job-exposure matrices in studies on occupational cancer. Scandinavian Journal of Work, Environment & Health. 1988 06;14(3):161-167. https://doi.org/10.5271/sjweh.1936
16. Doll R. Report of the International Committee on Nickel Carcinogenesis in Man. Scandinavian journal of work, environment & health. 1990 02;16(1 Spec No). https://doi.org/10.5271/sjweh.1813
17. Coughlin SS, Chiazze L. Job-exposure matrices in epidemiologic research and medical surveillance. Occupational Medicine (Philadelphia, Pa.). 1990;5(3):633-646.
18. Kauppinen T, Toikkanen J, Pukkala E. From cross-tabulations to multipurpose exposure information systems: a new job-exposure matrix. American Journal of Industrial Medicine. 1998 04;33(4):409-417. https://doi.org/10.1002/(sici)1097-0274(199804)33:4<409::aid-ajim12>3.0.co;2-2