

The Feasibility of Adapting a Population-Based Asthma-Specific Job Exposure Matrix (JEM) to NHANES

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Background To determine the feasibility of applying a job exposure matrix (JEM) for classifying exposures to 18 asthmagens in the National Health and Nutrition Examination Survey (NHANES), 1999–2004.

Methods We cross-referenced 490 National Center for Health Statistics job codes used to develop the 40 NHANES occupation groups with 506 JEM job titles and assessed homogeneity in asthmagen exposure across job codes within each occupation group.

Results In total, 399 job codes corresponded to one JEM job title, 32 to more than one job title, and 59 were not in the JEM. Three occupation groups had the same asthmagen exposure across job codes, 11 had no asthmagen exposure, and 26 groups had heterogeneous exposures across jobs codes.

Conclusion The NHANES classification of occupations limits the use of the JEM to evaluate the association between workplace exposures and asthma and more refined occupational data are needed to enhance work-related injury/illness surveillance efforts. Am. J. Ind. Med. 2010. © 2010 Wiley-Liss, Inc.

KEY WORDS: NHANES; epidemiology; occupational asthma; O*NET; JEM

INTRODUCTION

In occupational epidemiology, using some type of monitoring data (e.g., personal exposure monitoring, air

monitoring, certain forms of biological monitoring) to assess exposure is considered an optimal assessment method; however, in practice this is not always feasible. Often occupational exposures must be inferred from other sources such as job title or longest held job. However, job titles are non-specific, and individuals with the same job titles may perform very different jobs and experience different exposures [Goldberg et al., 1993; Kromhout et al., 1993; Kennedy et al., 2000; Messing et al., 2003; Checkoway et al., 2004].

A job-exposure matrix (JEM) offers advantages over the use of job titles alone since it links information about specific industries and/or occupations with information on exposures to workplace contaminants. Cells of the matrix can be coded using qualitative (e.g., potential for exposure: yes/no), semi-quantitative (e.g., ordinal ranking of exposure), or quantitative (e.g., measured contaminant levels) data. Exposure assignments can be further modified when additional information is gathered about workers' behaviors and occupational tasks. When quantitative exposure data are limited or not available, as is the case in community-based

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studies, the JEM is often an optimal method of exposure assessment that can be inferred from subjects' work histories [Goldberg et al., 1993; Checkoway et al., 2004]. Strengths of the JEM include the ability to infer exposure status to a larger population of the same workers while allowing for exposures to be grouped into categories with biological significance [Kennedy et al., 2000; Checkoway et al., 2004].

Disease-specific JEMs have been developed to allow for a more refined classification of exposure. In 2000, an asthma-specific population-based JEM was developed to evaluate exposures to 18 asthmagenic agents for 506 job titles (based on the 1988 International Standard Classification of Occupations, ISCO88) [Kennedy et al., 2000]. The JEM was updated in August 2008 to assign job titles using the Standard Occupation Classification (SOC) 1991 structure from Statistics Canada. A job was classified as exposed (yes) to a particular asthmagen if it was determined that the probability of exposure was high for a substantial proportion of subjects in that job [Kennedy et al., 2000]. Population-based studies confirmed the utility of assessing asthma exposure using the asthma-specific JEM [Le Moual et al., 2004; Zock et al., 2004]. The purpose of our study was to determine the feasibility of applying the population-based asthma-specific JEM [Kennedy et al., 2000] for classifying workplace exposures to asthmagens based upon the occupational information included in the U.S. National Health and Nutrition Examination Survey (NHANES), 1999–2004.

METHODS

Asthma-Specific JEM

The asthma-specific JEM is a two-dimensional matrix containing 18 columns for known risk factors for asthma. For our analysis, the asthma-specific JEM and instructions for its use were downloaded from the “Estimating Occupational Risks for Asthma in Epidemiology: Asthma-specific job exposure matrix” and more information about the JEM can be found at: <http://www.cher.ubc.ca/asthmajem/index.htm> [Kennedy et al., 2000].

National Health and Nutrition and Examination Survey

Data for our analysis came from three cycles (1999–2000, 2001–2002, and 2003–2004) of the NHANES. NHANES uses a multi-stage probability sample to represent the U.S. civilian, non-institutionalized population. Trained nosologists coded occupations based upon the National Center for Health Statistics (NCHS) Industry and Occupation Classification Source Codes (hereafter referred to as NCHS job codes). Four hundred ninety NCHS job codes were collapsed into 40 NHANES occupation groups. Further information about NHANES and how the survey is

conducted can be found at: <http://www.cdc.gov/nchs/nhanes.htm> [USDHHS, 2009].

At the time of the “Household Sample Person Questionnaire,” NHANES interviewers asked the question “What kind of work were you doing?” and then coded the response into one of the 40 NHANES occupation groups [USDHHS, 2009]. More refined job titles or duties were not collected as part of the interview. For example, participants who indicated they were a registered nurse (NCHS job code 95), optometrist (NCHS job code 87), or veterinarian (NCHS job code 86), to name a few, were all coded as the single “Health diagnosing, assessing, and treating occupations” in the NHANES database.

Cross-Referencing NCHS Job Codes Within Each NHANES Occupation Group to the Asthma-Specific JEM

First, we identified the NCHS job codes that had been collapsed to create the 40 NHANES occupation groups. Next, we identified how each of the 490 NCHS job codes corresponded with the 506 job titles in the asthma-specific JEM. Our goal was to identify matches between the NCHS job codes and the JEM job titles to determine the exposure for each of the 18 asthmagens in the asthma-specific JEM. Finally, we identified if asthmagen exposure for all the NCHS job codes that comprised each of the 40 NHANES occupation groups were homogenous (i.e., each of the NCHS job codes within a NHANES occupation group had the same exposure assignment for all 18 asthmagens or each of the NCHS job codes within a NHANES occupation group had no exposure to any asthmagen) or heterogeneous (i.e., there was differential classification of asthmagen exposure across NCHS job codes within each NHANES occupation group; Fig. 1).

RESULTS

The 490 NCHS job codes were collapsed into 40 NHANES occupation groups, with the number of NCHS job codes within each of the 40 NHANES occupation groups ranging from 1 to 45 (Table I). Fifty-nine (12%) of the NCHS job codes (e.g., medical scientists, physician assistants, tool programmers) did not correspond to any of the JEM job titles or were too broadly defined to complete a match. Thirty-two (7%) NCHS job codes corresponded to more than one JEM job title. For example, the NCHS job code for “patternmakers, lay-out workers, and cutters” (NCHS job code 676) corresponded to multiple JEM job titles (e.g., JEM job title J15: machine operators and related textile processing workers; JEM job title J162: fabric, fur, and leather cutters; and JEM job title F145: patternmakers-textile, leather, and fur products). The remaining 399 NCHS job codes (81%) corresponded with an equivalent JEM job title (Fig. 1).

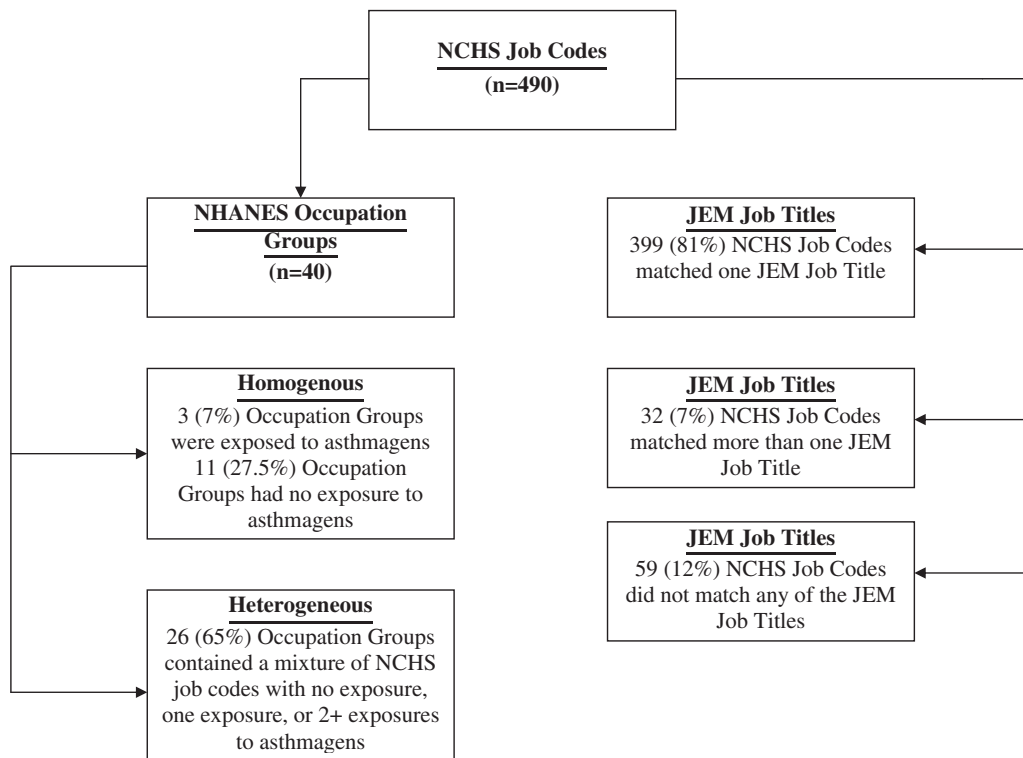


FIGURE 1. Flowchart depicting how the National Center for Health Statistics (NCHS) job codes were collapsed into the National Health and Nutritional Examination Survey (NHANES) occupation groups, as well as how many NCHS job codes could be matched to job titles in the asthma-specific job exposure matrix (JEM). Those NHANES occupation groups with similar exposures to all 18 asthmagens across jobs within the same occupation group were identified as homogenous. Those NHANES occupation groups that had differing exposure to asthmagens across jobs within an occupation group were identified as heterogeneous.

When evaluating the potential for exposure to asthmagens for each of the NCHS job codes within the 40 NHANES occupation groups, only three NHANES occupation groups (7%) had homogenous exposures to asthmagens, 11 (28%) NHANES occupation groups were characterized as having “no” exposure to all 18 asthmagens, and 26 (65%) NHANES occupation groups were heterogeneous for exposure to one or more asthmagens (Fig. 1 and Table I). NHANES occupation group “Waiters and waitresses” had the same asthmagen exposure across all 18 asthmagens and, thus, provides an example of a homogenous group. An example of a heterogeneous NHANES occupation group was the “Health diagnosing, assessing, and treating” group. This NHANES occupation group consisted of 14 NCHS job codes (NCHS job codes 84–89, NCHS job codes 95–99, and NCHS job codes 103–106) and of these 14 NCHS job codes, 8 of the NCHS job codes had no asthmagen exposure (i.e., physicians, dentists, podiatrists, registered nurses, occupational therapists, speech therapists, physical therapists, and other health practitioners), three of the NCHS job codes were exposed to “low antigens” (i.e., optometrists, pharmacists, and dieticians), respiratory therapists were exposed to HMW

latex antigens, veterinarians were exposed to HMW animal antigens and HWM latex antigens, and physician assistants were not found in the JEM job titles.

DISCUSSION

The broad occupational categories used in NHANES hindered our ability to successfully apply the asthma-specific JEM for purposes of classifying exposures to asthmagens within these categories. Given this limitation, we recommend that the NCHS modify the NHANES “Household Interview Sample Person Questionnaire” to procure more refined information on the occupations of U.S. workers. One option for improvement might be for the NHANES interviewer to collect data on occupational title and work responsibilities and then consult a source such as O*NET <http://online.onetcenter.org/find/> [O*NET, 2009] for purposes of providing additional occupational coding. O*NET is a program based on the Standard Occupational Classification (SOC) and the current taxonomy includes 965 occupations. O*NET collects data from a broad range of workers and occupation experts for each occupation based on distinguishing characteristics (i.e.,

TABLE I. Cross-Referencing the Occupation Groups in the National Health and Nutrition Examination Survey (NHANES) to the Asthma-Specific Job Exposure Matrix (JEM)*

Total number of NCHS ^a job codes that correspond to the 40 NHANES Occupation Groups ^{b,c}		490
NCHS ^a job codes that correspond to one asthma-specific JEM (SOC91) ^d		399
NCHS ^a job codes that are not found in the asthma-specific JEM (SOC91) ^d job titles or too broadly classified to complete a match		59
NCHS ^a job codes that correspond to more than one asthma-specific JEM (SOC91) ^d job title		32
Total number of NHANES Occupation Groups ^{b,c}		40
Homogenous NHANES Occupation Groups ^{b,c} : The same exposure assignment for all 18 asthmagens across NCHS ^a job codes:		3
Waiters and waitresses (NCHS ^a 435)		Cooks (NCHS ^a 436)
Construction laborers (NCHS ^a 869)		
Homogenous NHANES Occupation Groups ^{b,c} : NO exposure to any asthmagens across NCHS ^a job codes ^e :		
Executive, administrators, and managers (NCHS ^a 3—9, 13—19, 21, 22)		
Teachers (NCHS ^a 113—119, 123—129, 133—139, 143—149)		Management-related occupations (NCHS ^a 23—29, 33—37) Records processing (NCHS ^a 325—329, 335—339, 343, 344) Sales representatives (NCHS ^a 253—259) Secretaries, stenographers, and typists (NCHS ^a 313—315) Information clerks (NCHS ^a 316—319, 323)
Supervisors and proprietors in sales occupations (NCHS ^a 243)		
Sales workers (NCHS ^a 263—269, 274—278, 283—285)		
Miscellaneous administrative support (NCHS ^a 303—309, 345—348, 353—357, 375—379, 389)		
Material recording, scheduling, and distribution (NCHS ^a 359, 363—366, 368, 373, 374)		
Heterogenous NHANES Occupation Groups ^{b,c} : Differential classification of asthmagens exposure across NCHS ^a job codes:		26
Engineers, architects and scientists (NCHS ^a 43—49, 53—59, 63—69, 73—79, 83)		Health service occupations (NCHS ^a 445—447) Other professional specialty occupations (NCHS ^a 163—169, 173—179)
Health diagnosing, assessing and treating occupations (NCHS ^a 84—89, 95—99, 103—106)		
Writers, artists, entertainers, and athletes (NCHS ^a 183—189, 193—195, 197—199)		Cleaning and building service occupations (NCHS ^a 448, 449, 453—455) Personal service occupations (NCHS ^a 456—459, 461—465, 467—469)
Protective service occupations (NCHS ^a 413—418, 423—427)		
Private household occupations (NCHS ^a 403—407, 466)		Farm operators, managers, and supervisors (NCHS ^a 473—477) Farm and nursery workers (NCHS ^a 479, 483, 484)
Related agricultural, forestry, and fishing occupations (NCHS ^a 485—489, 494—499)		
Vehicle and mobile equipment mechanics and repairers (NCHS ^a 505—509, 514—517)		Freight, stock, and material movers (NCHS ^a 875—878, 883) Laborers, except construction (NCHS ^a 889)
Textile, apparel, and furnishings machine operators (NCHS ^a 738, 739, 743—745, 747—749)		
Fabricators, assemblers, inspectors, and samplers (NCHS ^a 783—787, 789, 793, 795—799)		Motor vehicle operators (NCHS ^a 803, 804, 806, 808, 809, 813, 814) Other transportation and material moving occupations (NCHS ^a 823—826, 828, 829, 833, 834, 843—845, 848, 849)
Machine operators, assorted materials (NCHS ^a 703—709, 713—715, 717, 719, 723—729, 733—737, 753—759, 763—766, 768—769, 773—774, 777, 779)		
Other mechanics and repairers (NCHS ^a 503, 518, 519, 523, 525—527, 529, 533—536, 538, 539, 543, 544, 547, 549)		Other helpers, equipment cleaners, hand packagers and laborers (NCHS ^a 864—868, 874, 885, 887, 888)
Extractive and precision production occupations (NCHS ^a 613—617, 628, 634—637, 639, 643—647, 649, 653—659, 666—669, 674—679, 683, 684, 686—689, 693—696, 699)		Technicians and related support occupations (NCHS ^a 203—208, 213—218, 223—229, 233—235)
Construction trades (NCHS ^a 553—558, 563—567, 569, 573, 575—577, 579, 583—585, 587—589, 593—599)		Miscellaneous food preparation and service occupations (NCHS ^a 433, 434, 438, 439, 443, 444)

*Kennedy et al. (2000).

^aNational Center for Health Statistics (NCHS) Occupational Classification Source Codes are based upon the 1990 Census of Population Occupational Classification System source codes.^bDivision of Vital Statistics, National Center for Health Statistics. Instruction Manual Part 19: Industry and Occupation Coding for Death Certificates. U.S. Dept. of Health & Human Services, Centers for Disease Control & Prevention, National Center for Health Statistics, Hyattsville, Maryland, 1997.^cDivision of Vital Statistics, National Center for Health Statistics. Instruction Manual Part 19b: Alphabetical Index of Industries and Occupations. U.S. Dept. of Health & Human Services, Centers for Disease Control & Prevention, National Center for Health Statistics, Hyattsville, Maryland, 1997.^dStandard Occupational Classification (SOC)—1991, Statistics Canada, <http://www.statcan.gc.ca/subjects-sujets/standard-norme/soc-cnp/1991/soc-cnp91.menu-eng.htm>.^eIncludes: Supervisors, proprietors, and sales occupations (NCHS^a 243) and Interviewers (NCHS^a 316) both of which corresponded to more than one asthma-specific JEM job title, yet belong to occupation groups that have no exposure to asthmagens.

knowledge, skills, and abilities). Due to changes in the occupational landscape, O*NET periodically revises the taxonomy and the latest revision occurred in 2009. Furthermore, O*NET provides crosswalks between other occupational classification systems (e.g., Dictionary of Occupational Titles, SOC, Occupational Outlook Handbook) in order to facilitate cross-referencing of occupations [O*NET, 2009]. Researchers have successfully used O*NET data to examine possible health consequences of workplace exposures [Cifuentes et al., 2007; Meyer et al., 2009].

Arguably, more detailed exposure assessments that address a host of occupational factors (e.g., timing and duration of exposure; current vs. longest held job) should be used when assessing workplace exposures. However, this is often not feasible and researchers must rely on other sources of information that may be more readily available on workers when health-effect studies are conducted. Although we were not successful in applying the asthma-specific JEM using large existing databases such as NHANES, they should not be entirely discounted as such databases allow for exploratory analyses. If the occupational coding in NHANES provided more detailed occupational titles and work responsibilities, these data could be better utilized by researchers to improve occupational surveillance efforts for purposes of improving the health and safety of workers.

In conclusion, NHANES is designed to represent the U.S. population, including those who work. However, we found the occupational data to be structured in a way that we could not fully explore injuries or illnesses due to workplace exposures. We recommend that improvements in the NHANES occupational data be made for purposes of better tracking the health of U.S. workers.

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REFERENCES

- Checkoway H, Pearce N, Kriebel D. 2004. Research methods in occupational epidemiology. 2nd edition. New York: Oxford University Press.
- Cifuentes M, Boyer J, Gore R, d'Errico A, Tessler J, Scollin P, Lerner D, Kriebel D, Punnett L, Slatin C, PHASE in Healthcare Research Team. 2007. Inter-method agreement between O*NET and survey measures of psychosocial exposures among healthcare industry employees. *Am J Ind Med* 50:545–553.
- Goldberg M, Kromhout H, Guenel P, Fletcher AC, Gerin M, Glass DC, Heederik D, Kauppinen T, Ponti A. 1993. Job exposure matrices in industry. *Int J Epidemiol* 22(Suppl 2):S10–S15.
- Kennedy SM, Le Moual N, Choudat D, Kauffmann F. 2000. Development of an asthma specific job exposure matrix and its application in the epidemiological study of genetics and environment in asthma (EGEA). *Occup Environ Med* 57:635–641.
- Kromhout H, Symanski E, Rappaport SM. 1993. A comprehensive evaluation of within- and between-worker components of occupational exposure to chemical agents. *Ann Occup Hyg* 37:253–270.
- Le Moual N, Kennedy SM, Kauffmann F. 2004. Occupational exposures and asthma in 14,000 adults from the general population. *Am J Epidemiol* 160(11):1108–1116.
- Messing K, Punnett L, Bond M, Alexanderson K, Pyle J, Zahm S, Wegman D, Stock SR, de Groenbois S. 2003. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. *Am J Ind Med* 43:618–629.
- Meyer JD, Warren N, Reisine S. 2009. Racial and ethnic disparities in low birth weight delivery associated with maternal and occupational characteristics. *Am J Epidemiol* 153(2):153–162.
- O*NET Resource Center. O*NET Database [Internet]. 2009. [cited 2009 Sept 30]. Available from: <http://online.onetcenter.org/find/>.
- U.S. Department of Health and Human Services (USDHHS). 2009. Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey (NHANES) Data [Internet]. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention; [cited 2009 May 10]. Available from: http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm.
- Zock JP, Cavalle N, Kromhout H, Kennedy SM, Sunyer J, Jaen A, Muniozguren N, Payo F, Almar E, Sanchez JL, Anto JM, Kogevinas M. 2004. Evaluation of specific occupational asthma risks in a community-based study with special reference to single and multiple exposures. *J Expo Anal Environ Epidemiol* 14:397–403.