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National Institute for Occupational Safety and Health General Industry Occupational Exposure Databases: Their Structure, Capabilities, and Limitations

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The passage of the Occupational Safety and Health Act of 1970 resulted in increased concern for the safety and health of workers in the United States. Early in 1971, a Hazard and Disease Task Force, formed by the Department of Health, Education, and Welfare, identified a need for more detailed information on the distribution of potential exposures of employees in industries regulated in the Occupational Safety and Health Act to chemical and physical hazards. To address this need, the National Institute for Occupational Safety and Health conducted two major national surveys as part of its hazard surveillance program. The first, conducted in 1972–1974, was called the National Occupational Hazard Survey. The second, conducted in 1981–1983, was called the National Occupational Exposure Survey. Each survey employed a stratified probability sample, and collected observational data on potential direct workplace exposures and also exposure to tradenamed products. Completed nearly a decade apart, the databases developed from these two surveys permit the identification of potential exposures by industry and occupational group. The database developed from the National Occupational Exposure Survey has the added advantage of providing gender information. These databases may be manipulated to derive exposure profiles for any of the observed agents by industry, occupational group, facility or exposure condition, or engineering control. Their usefulness as research and surveillance tools is expanded by linkage to a variety of external databases. The limitations of the databases include their lack of quantitative exposure data, the progressing age of the data, and the somewhat limited industry coverage. GREIFE, A.; YOUNG, R.; CARROLL, M.; SIEBER, W.K.; PEDERSEN, D.; SUNDLIN, D.; SETA, J.: NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH GENERAL INDUSTRY OCCUPATIONAL EXPOSURE DATABASES: THEIR STRUCTURE, CAPABILITIES, AND LIMITATIONS. APPL. OCCUP. ENVIRON. HYG. 10(4):264–269; 1995.

Early in 1971, a Hazard and Disease Task Force, formed by the Department of Health, Education, and Welfare, identified a need for more detailed information on the distribution of potential exposures of employees in industries regulated by the Occupational Safety and Health (OSH) Act to chemical and physical hazards. To address this need, the National Institute for Occupational Safety and Health (NIOSH) conducted two major national surveys as part of its hazard surveillance program. The first, conducted in 1972–1974, was called the National Occupational Hazard Survey (NOHS).[1] The second, conducted in 1981–1983, was called the National Occupational Exposure Survey (NOES).[1,2] These surveys were intended to describe health and safety conditions in the American workplace and to determine the extent of workers' exposures to chemical, physical, and biological agents. The sample of surveyed facilities was designed to permit projections to the national level based on survey results.

Completed nearly a decade apart, the databases developed from these two surveys permit the identification of potential exposures by industry and occupational group. Analysis of the data from both surveys provides information about trends in the occupational exposure distribution of observed agents, the distribution of in-plant health and safety services, and the utilization of exposure control technology. The databases provide unique information on the estimated numbers nationwide of employees by Standard Industrial Classification (SIC) codes potentially exposed to specified agents (1) by gender, NOES only), (2) the form (liquid, vapor, etc.) of the agent (NOHS only), (3) the duration (full- or part-time exposure) and extent of industrial hygiene and safety engineering services, (4) health care provisions, including physical examinations and screening tests for employees and extent of medical monitoring, (5) status of health records, (6) policies for and use of personal protective equipment and type of worker's compensation insurance, and (7) injuries and illnesses reported on Occupational Safety and Health Administration (OSHA) form 102 (NOHS) and OSHA form 200 (NOES). These databases are unique resources for associating potential health hazards with industries and occupational groups. It is possible, for example, to estimate the total number of people potentially exposed to a particular hazard or group of hazards, the percentage of that total who use personal protective equipment or other engineering controls, the percentage who receive periodic physical examinations of a particular type, and so forth.

Survey Methods

NOHS

The NOHS was initiated in 1972 with a team of 20 extensively trained field surveyors (see Table 1). The survey sample

TABLE 1. Basic Survey Parameters

Basic Parameters	NOHS	NOES
Survey dates	February 1972–June 1974	January 1981–May 1983
Number of surveyors	20	15
Establishments surveyed	4636	4490
Employees surveyed	895,725	1,830,330
Metropolitan areas	67	98
Unique industries	639 (four-digit SIC)	523 (four-digit SIC)
Unique occupations	442	410
Unique hazards	8000	12,000
Unique trademarked products	86,000	100,000
Records in database	5 million	2.1 million

from which data were collected consisted of establishments representative of all nonagricultural businesses covered under the OSH Act of 1970, and employing eight or more persons. Businesses with less than eight employees were considered to be too numerous and transient to survey accurately.[1,3–5] Facilities were selected using a two-stage process involving stratification and systematic selection procedures. A complete walk-through inspection of each establishment was then undertaken, during which the surveyor recorded job titles for all employees, listed all potential exposure agents and the form of the agent (liquid, vapor, etc.), and noted duration of exposure and presence and type of engineering control(s) in place. Potential exposure to any agent was only recorded if the criteria for exposure guidelines were met.[1]

Potential exposures recorded during the survey were classified into one of two categories: tradename or actual exposures. If the surveyors were able to observe and identify a specific exposure agent during the survey, it was called an actual exposure. In cases where an exposure agent occurred as a formulated product labeled with a brand name, the ingredients were later identified. These were called tradenamed exposures. About 70 percent of the data collected in the NOHS was associated with tradenamed products.

Each surveyor was also equipped with a smoke tube for testing ventilation and a noise level meter for determining recordable noise exposures (≥85 dB), but the surveyor did not use chemical sampling techniques to measure ambient chemical concentrations. When the surveyor observed exposures to tradenamed products, the product name, manufacturer, and ingredients that were listed were recorded so that the information could be clarified further during subsequent survey analysis.

Before accurate statistics on workplace exposures could be developed from the survey, NIOSH had to determine the chemical components of any observed tradenamed products.[6,7] Considerable effort was expended in contacting the manufacturers and identifying ingredients. Special consideration was given to the preservation of confidential data to ensure more accurate reporting by the manufacturers.

For those products that were not resolved through interactions with the manufacturer, a generic resolution effort was undertaken. This generic resolution effort was done using all available literature on the general name of the product (e.g., "window cleaner") and the resolved trade-named products to develop a generic or common list of components for each product type.[8] This generic list of components was then substituted for the missing component lists of similar compounds.

NOES

The NOES was initiated in 1981 with a team of 15 extensively trained field surveyors (see Table 1). The NOES was similar in design and focus to the NOHS.[2] The most notable modification in the NOES was the additional collection of gender information. Approximately 70 percent of all chemical exposures resulted from exposure to tradenamed products. As in the NOHS, an extensive tradenamed product resolution effort was undertaken to identify the various agents within these observed tradenamed products.[9] To date, approximately 80 percent of the tradenamed products have been resolved. It is unlikely that this effort will continue due to limited resources and competing priorities within NIOSH.

Database Structure

The database file structure for both the NOHS and the NOES is hierarchical and data are retrieved sequentially. The basic unit is a facility within an industry. Within the facility are occupational groups or teams. The members of each team are potentially exposed to the same group of agents and each team may have a number of sets of exposure conditions. This type of file structure allows great flexibility in data retrieval, maximizing the field data collected. For several years, the database resided in machine-readable form on a mainframe computer. Efforts to downsize the files for maintenance in a personal computer environment are nearly completed.

The data from the two survey databases have been combined into six interactive data files for ease of retrieval. These files are:

1. Industrial classifications file – The SIC system was used to code the industries observed during each survey. The 1967 version of the SIC[5] was used to code the NOHS, and the 1972 version[10] was used to code the NOES. Translations of the 1967 codes to the 1972 codes have been completed. Coding the observed industries to the four-digit level resulted in 639 industries observed in the NOHS and 523 industries observed in the NOES.
2. Occupations file – The Bureau of the Census occupation codes were used to code the occupations observed in each survey. The 1970 version[11] was used to code the NOHS,

and the 1980 version[12] was used to code the NOES. There were approximately 442 different occupations observed in the NOHS and 410 different occupations observed in the NOES. Translation of the 1970 coding version to the 1980 coding version facilitates intersurvey comparisons.

3. Chemical master file – This file contains the hazard code and its respective alphabetical description. The hazard code is a unique five-digit identifier, assigned by NIOSH, for every substance observed or included during the tradenamed component resolution process. Also included in this file is an extensive list of synonyms for the chemical agents observed during the surveys. Unique hazard codes were developed because many agents observed during the surveys had not been assigned codes by other conventions, such as a Chemical Abstracts (CAS) number or a Registry of Toxic Effects of Chemical Substances (RTECS)® number.[13] Cross-reference of hazard codes to CAS and RTECS numbers is also maintained on file.
4. Facilities file – This file contains all information collected for each facility surveyed except for the exposure data. This type of information includes the chief products and activities of each surveyed facility, the type of industrial hygiene, safety, health, and medical surveillance activities, and the presence of unions.
5. Exposure file – This file contains all the observations made by the surveyors during each facility walk-through. This type of information includes the use of personal protective equipment, engineering controls present, number of workers potentially exposed, gender of the potentially exposed workers (in the NOES only), and the occupations of the observed workers.
6. Tradenamed ingredients file – This file contains formulations of the products observed during each survey.

Data in the first five files contain the field observations made by the surveyors, and are retrieved using COBOL program language. The tradenamed data are maintained in two different database management systems. Each of these systems, however, allows for interaction with the field observation data.

During development of the NOHS database for the tradenamed data, several different database management systems were evaluated.[1] The database management system, SYSTEM 2000, met the selection criteria, which included size parameters, relationship capabilities, and technical development support. Prior to the development of the NOES database, extensive review of database management systems was again conducted to determine if other systems were available that would be more advantageous than SYSTEM 2000. ADABAS was selected as the system of choice for processing the NOES tradenamed data. The NOES database, unlike the NOHS database, does not contain generic resolution data for the unresolved tradenamed products. The development and use of generic data for the NOHS survey was considered to be rather resource intensive, and the quality of the resulting data was questionable. Therefore, generic resolution of the tradenamed data was not undertaken for the NOES. This lack of generic data in the NOES database resulted in a smaller overall total number of records: 2.1 million records in the NOES database compared with 5.0 million in the NOHS database.

Database Capabilities

The capabilities of the NOHS and NOES are essentially the same. Each database associates potential exposure agents with industry types, occupations, and observed conditions of exposure in surveyed facilities in an extremely flexible manner. In the NOES, the gender of the potentially exposed worker is also available.

The surveys did not provide direct information on health effects of the potential exposure agents; therefore, it was logical to link the file to the NIOSH RTECS, which provides extensive information on the results of toxicologic studies on many agents.[13] This enabled NIOSH to produce a model capable of systematically identifying high risk employee groups.[14,15] This model used RTECS data to create severity indices for NOHS agents, and to construct overall severity indices for particular occupations or industries based on the potential exposure agents associated with that group. The final output from this linking and modeling process was a list of industries or occupations ranked-ordered on the basis of potential health risk. The model was designed to permit liberal production of custom outputs based on criteria supplied by the researcher. It is possible, for example, to focus the model on only chronic health effects, or to combine all effects in a weighting scheme chosen by the researcher. The outputs from such a model have obvious value for those who wish to identify groups of workers with elevated potential for health risk from occupational factors, or to explain increases in disease outcomes among occupational groups. The NOES database can also be linked to RTECS, but a model such as that created for the NOHS data has not been developed.

The RTECS file contains data on an impressive array of agents. However, only a small percentage (about 25%) of the 8000 potential exposure agents recorded during NOHS were listed in RTECS at the completion of the survey. In an effort to expand the coverage of the NOHS-RTECS model, NIOSH developed a system designed to apply structure–activity principles to the NOHS compounds not listed in RTECS. This resulted in a predictive toxicology system that was capable of generating estimates of potential toxicity for four different end points (acute toxicity, carcinogenicity, teratogenicity, and mutagenicity) for chemical agents that can be described structurally and that meet certain other eligibility requirements.[14,15] This predictive toxicology system was used to estimate an agent's potential toxicity even before animal testing had been completed.

The NOHS data only were also linked to a national industrial demographic file in order to depict the presumed geographic location of occupational groups potentially exposed to selected agents.[16] The linkage of these two files allowed the production of computer-generated maps of the nation or selected states or regions, which would graphically portray county-specific potential exposure patterns. The output characteristics of these maps could be adjusted to show the geographic spread of establishments, employees, or population-based rates by county for potentially exposed groups. These heuristic techniques were intended for possible application in generating or testing hypotheses.

These databases are unique surveillance tools. Data from the NOES and NOHS have been used for surveillance purposes to determine trends in exposure to hazardous agents. For exam-

ple, trends in occupational exposure to chemical agents reported as carcinogenic by the National Toxicology Program's Fifth Annual Report on Carcinogens: summary 1989 was examined using both databases.[17] This examination indicated that six chemical agents known to be carcinogens were introduced into the work environment since 1974, and that five of the six agents were pharmaceuticals. Overall, there was an increase in the proportion of workers exposed to occupational carcinogens in the NOES when compared with the NOHS. However, a greater proportion of workers in the NOES than in the NOHS were using one or more appropriate control measures to reduce exposure.

Another example of the usefulness of the databases in examining trends is in the area of use of hearing protection. Since 1983, any company exposing workers to noise levels in excess of 90 dB for an entire work shift (8 hours) has been required by OSHA standards to provide workers with hearing protection. Data recorded on hearing protector use during the NOES and NOHS were linked with data collected by OSHA in the 1989 Survey of Personal Protective Equipment Usage to examine trends in hearing protector usage in U.S. industry.[18] This examination indicated that in all establishment size categories, hearing protector usage among production employees exposed to noise increased from 4 percent in 1972 to 30 percent in 1989. This overall increased use in hearing protection was not uniform across all industries, however.

Another capability of the databases is their usefulness in the determination of current as well as historic numbers of workers potentially exposed to hazardous agents. For example, an effective prevention program for occupational bladder cancer should be based on an estimate of the number of workers previously and currently exposed to bladder carcinogens.[19] Estimates of the number of workers at increased risk of bladder cancer can be derived in two ways. Case control and census data may be used to identify industries and occupations at risk and the number of workers in these occupations. An alternative approach is to estimate the number of potentially exposed workers from existing hazard surveillance data. This latter approach utilized data from the NOES, the best available source for recent estimates of the number of workers potentially exposed to hazards, and the NOHS for past exposures. These data indicated an increase in the estimated number of workers potentially exposed to bladder carcinogens from the 1970s to the 1980s, and could be used to identify groups for which screening programs should be established. In addition, these data could also be used to estimate the magnitude of bladder cancer as a public health problem.

An additional capability of these databases is their use in epidemiologic research through the creation of a job exposure matrix (JEM).[4] The JEM is a three-level hierarchical subfile. Each level of classification is nested within the previous one, beginning at the industry level. Thus, the three levels of classification in the JEM are industry, occupation within industry, and potential exposure agent within occupation within industry. JEMs have been created using both the NOHS and NOES data. The NOHS JEM is particularly useful for the investigation of disease end points with long latencies, such as cancer. The NOES JEM file has been linked with other data sets such as the National Center for Health Statistics Household Interview Survey and the National Health and Nutritional Examination Survey.

Database Limitations

There are several limitations of the NOHS and the NOES databases which affect their usefulness.[1,2] The data are becoming progressively more dated, and as a consequence, less representative of some current exposure situations. The data do provide, however, valuable historic exposure information which is quite useful for the evaluation of diseases with long latencies such as cancer. Data from the NOHS are indicative of potential exposures more than 20 years ago. The data also offer a rich historic perspective on the early years of the OSH Act which cannot be duplicated elsewhere.

The scope of the survey universe was defined as general manufacturing or industrial facilities covered by the OSH Act, and reporting more than seven employees. Thus, by definition, all facilities engaged in agricultural production, any mining activity except oil and gas extraction, private households, and all federal, state, and municipal government facilities were excluded. In the NOES, facilities engaged in finance, insurance, and real estate were also excluded.

All exposure data collected were observational and must be considered potential exposures. There were no environmental levels of contaminants actually measured. The collection of industrial hygiene measurements in a survey of this magnitude was not feasible for several reasons. Principally, prior to the survey, information did not exist that could indicate the range of possible exposure agents the surveyors might encounter. Secondly, the cost of conducting industrial hygiene sampling in 4636 facilities in the NOHS and in 4490 facilities in the NOES was prohibitive. Thirdly, the additional time required to collect, analyze, and integrate these industrial hygiene measurements into the database would have greatly lengthened the entire survey time frame, resulting in extensive additional costs. Finally, sampling and analytic procedures do not exist for many exposure agents.

Data were not collected during the NOHS on the demographies of the exposed populations beyond occupational titles, making the investigation of gender- or ethno-specific hazards extremely difficult. Gender data were not collected during the NOHS because it was felt that collection of this information would put an unnecessary burden on the industries being surveyed. It must be noted that during the early 1970s, gender information was not routinely collected and maintained by industry in the same manner it is today.

Detailed component information was obtained on approximately 65 percent of the tradenamed products observed during the NOHS and on approximately 80 percent of the tradenamed products observed during the NOES. Additional resolution efforts are not anticipated at this time. Given the size of the original data file, this degree of resolution adds substantial data to the file. Less than 100 percent resolution, however, does limit the completeness of the database.

Different versions of the same coding systems for industry and occupations were used in the NOHS and NOES. This limits direct comparison of these two parameters between the surveys, and requires conversion of one survey's codes to the other. Conversion of the SIC codes and census occupation codes used in the NOHS and NOES to other coding schemes

such as the Department of Labor's Standard Occupational System or the Department of Transportation's job codes is possible, but has only been completed for the 1970 and 1980 census industry coding schemes. In addition, a classification scheme grouping exposure agents or structure has yet to be fully developed.

The uncertainty or standard error associated with estimates of the total numbers of employees or facilities has previously been published in Volume III of each database series.[1,2] These values were calculated using the balanced repeated replication technique, in which values are calculated for many subsamples and results are averaged. Standard errors for proportions of those totals have been calculated. A description of the method and a list of coefficients of variation to be used with the estimate are available. The equation, which may be used to determine standard errors for estimates of proportions of numbers of employees or numbers of facilities where potential exposure may occur, takes the form:

$$\log(\text{coefficient of variation}) = 1.422925 - 0.26758 * \ln(\text{estimate}) + \exp[-0.000518 * \ln(\text{estimate})]$$

where: ln is the natural logarithm.

Standard errors associated with low estimated values (less than 500) are greater than 50 percent of the estimate. Interval estimates for such low estimates should range between one and the estimate plus two standard errors. Any estimate whose standard error is greater than 25 percent of the estimate itself (as when the estiamte is less than 8000) should be considered unreliable and interval estimates should be documented.

Conclusions and Future Needs

The NOHS and NOES databases are unique resources for associating potential health hazards with industries and occupational groups. The NOES database can also associate these potential health hazards with gender. The sample of establishments in each survey was designed to permit the development of national estimates based on survey data.

Because the majority of all potential exposure agents which were recorded in the field occurred in the form of a trade-named product, it was necessary to contact the respective product manufacturers and obtain ingredient information on those products. This effort produced unique files which, in addition to their ability to clarify the NOHS and NOES exposures, are a useful hazard surveillance tool in their own right.

One of the largest uses of the database continues to be in estimating the number of workers potentially exposed. Current estimates of the number of exposed workers, however, might be qualitatively determined by comparing the degree and direction of change in the estimated number of workers from one survey to another. Another approach might be to compare estimates from the NOHS and NOES with contemporary estimates from the Bureau of the Census. Current estimates from the census could also be used to qualitatively suggest the direction and degree of change in the number of workers since the NOES. Caution must be exercised when using these or other approaches, however, to ensure that the same universe of SICs are included in any comparison.

The continued usefulness of these databases as research or surveillance tools depends in part on the acquisition of more current data. A third survey of this magnitude is not currently planned. Therefore, alternative sources of data are being explored. Finally, exposure assessment has always been an integral function of the various NIOSH field activities. To this end, quantitative exposure data need to be integrated with the existing observational exposure data, permitting assessments of risk based on magnitude as well as extent of exposure. The integration of NOHS and NOES exposure data and exposure assessment data from NIOSH and other sources would enhance the value of these observational exposure databases.

Current access to the database, for external research, is available through the NOHS/NOES JEM and its related subfiles. In addition, NIOSH frequently prepares specific subfiles of the database for use by external researchers.

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