Questionnaires for Collecting Detailed Occupational Information for Community-Based Case Control Studies

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In case control studies, collection of information on the workplace environment has generally been limited to self-reports of exposures or to job title, type of employer, and the dates the jobs were held, supplemented sometimes by work activities. This information, however, may be insufficient to assess the potential and level of exposure accurately due to recall difficulties and the variability of exposures within a job. A solution to this problem is to use job-specific questionnaires. The organization of a series of such questionnaires developed for a case control study of brain tumors is described. Three types of questionnaires, or modules, were developed: task-based, industry-based, and modules based on jobs with nonspecific types of tasks (e.g., laborer). The format of these modules starts with questions on the general work environment (type of employer) and proceeds to questions on tasks. More detailed information is then gathered on materials and equipment used, sensory descriptions, dermal exposure, work practices, engineering controls, and personal protective equipment use. The questionnaires cover a wide variety of exposures including solvents, heavy metals, polycyclic aromatic hydrocarbons, machining fluids, electromagnetic frequency fields, and many other exposures and, therefore, can be used in other case control studies.

Keywords: case control studies, exposure, questionnaires

Community or hospital-based case control studies have an advantage over the cohort design for evaluating rare diseases and for collecting detailed information on a variety of occupational and nonoccupational risk factors, including potential confounders. In occupational research, however, the contribution of case control studies has historically been limited by inadequate exposure assessment due to the limited amount of information collected on occupational exposures. Case control studies have used two approaches to collect this type of information:[1] asking the respondent direct questions about exposures (e.g., "Were you ever exposed to benzene?") or asking generic questions on job title, employer, type of business, date of employment, and perhaps activities, materials, and equipment used. The first approach requires that the respondent be able to report his or her exposures (e.g., the chemicals with which he or she worked), but often workers do not know or cannot recall the names of the materials. Information collected by the second approach is generally likely to be more accurate than direct questions on exposures, but it may be insufficient to assess the potential and level of exposure accurately. In either approach, interviewers are usually unfamiliar with industrial hygiene principles and lack the expertise to probe for information needed by an industrial hygienist to accurately assess exposures. Moreover, use of a single, uniform, detailed questionnaire administered to all subjects, such as developed in nutritional epidemiology, is not possible because of the variability of the environment, tasks, and exposures across jobs and industries.

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In 1985 Siemiatycki and Gerin resolved this problem by developing procedures for a hospital-based case control study that included collection of detailed job-exposure information.[2] Study subjects initially completed a self-administered typical work history. This was reviewed by chemists who developed follow-up questions, which evolved into job-specific questionnaires to supplement the work histories. The approach provided a semistructured framework for obtaining specific and detailed information on a variety of jobs. It also included techniques to identify the variability of exposure among different individuals reporting the same job. Characterizing this interindividual variability within jobs is a critical advance over the traditional approach that assumes homogeneity of exposures within a job, and therefore, these procedures represented an important step in identifying workplace hazards using the case control design by reducing exposure misclassification and increasing statistical power.[3]

In an on-going case control study of brain cancer by the National Cancer Institute the questionnaires developed by Siemiatycki and Gerin were modified and several others were developed. In addition, the methods of Siemiatycki and Gerin were modified to incorporate the use of a computer-assisted personal interview (CAPI), which identifies to the interviewer possible job-specific questionnaires based on the generic work history information reported.[4] This system reduces the time spent reviewing the work histories by the industrial hygienist or chemist primarily to that of identifying questions about jobs for which no supplemental questionnaire has been developed. This report describes how the job-specific questionnaires, or job-specific modules (JSMs), developed for the brain cancer study are organized to enhance recall and to increase the detail and accuracy of the collected occupational information.

Background

The JSMs were developed for a multisite case control study of brain cancer.[4] Cases included patients with primary glioma, meningioma, or acoustic neuroma treated at any of three large hospitals in Boston, Phoenix, or Pittsburgh. Controls with nonmalignant neurosurgical or general surgical conditions from the same hospitals were frequency matched on hospital, age, sex, and proximity of residence to the hospital. Interviews were conducted in the hospital within 6 weeks of diagnosis for cases, or of admission for controls, by trained interviewers. Most interviews were done with the patient or the patient and a next of kin. About 5% were done with a next of kin alone.

The study, initiated in response to public concern about the postulated link between cellular telephone use and brain tumor occurrence, is a comprehensive investigation of all major suspected occupational and nonoccupational risk factors for brain tumors in adults. Table I identifies some of the occupational exposures being investigated in the questionnaires. They include electromagnetic fields; organic solvents; heavy metals such as lead, mercury, and chromium; polycyclic aromatic hydrocarbons, including engine exhausts; machining fluids; and several other chemical and physical agents. Only the occupational component of the data collection is described here.

CAPI

The occupational component of the CAPI includes collection of a generic work history, a computerized search mechanism for matching jobs with JSMs, and a library of 63 JSMs. For each job, the interviewer first obtains the employer's name, the job title, and the dates of employment. When the reported job title is entered into the computer, a search of a synonym file is initiated to link the job with a JSM. For example, a secretary may report a job title as secretary, stenographer, typist, clerk, "does filing," or use a number of other words . Likely responses are identified in the synonym file with the office professional module. "What did (name of employer) make or do, that is, what did they make or what service did they provide?" is then asked. If a match occurs between the reported job title or industry and a synonym, the names of the JSMs associated with the synonym appear on the computer screen. The interviewer selects the best match and immediately asks the questions from the selected JSM. If there is no JSM match, three generic questions are asked: "What were your main activities?", "What kinds of chemicals or materials did you handle?", and "What kinds of tools and equipment did you use?". As each response is entered into the computer, a new search of the synonym file is made on the words in the most recent response and matches are displayed. If a JSM is selected by the interviewer, the remaining generic questions are not asked and the interviewer goes directly into the JSM. If no match has been made after all four generic questions have been asked, the interviewer repeats the process for the next reported job.

Description of JSMs

Three types of questionnaires were developed. The first (task-based JSMs) focus on frequently encountered jobs that usually entail performing specific tasks using identifiable materials across most industries in which that job is found, e.g., mechanics and electricians. A second type of questionnaire (nonspecific JSMs) is for jobs in which tasks and exposures vary substantially (e.g., laborers) from work site to work site and person to person. Often, exposures for these people arise from being in exposed areas rather than from performing a specific task (e.g., managers). A third type of questionnaire (industry-based JSMs) captures information on less frequently encountered jobs by collecting data on a variety of jobs within an industry or specific manufacturing process. This type of JSM determines where in the manufacturing process or support activities the person worked and then obtains information on the tasks he or she performed only in that part of the process. Examples of these questionnaires include steel manufacturing and dry cleaning. The questionnaires are significantly shortened if the interview respondent is a next of kin of the study subject.

Task-Based JSMs

For a number of jobs the primary sources of exposures are from performing tasks. Therefore, most of the exposures tend to be independent of the environment or the industry. In addition, the performance of these tasks is fairly uniform across industries. For example, many sheet metal workers install insulation, resulting in exposure to asbestos, and most painters have exposure to solvents from painting, regardless of the type of industry. Variation in exposures for these jobs may, however, occur. First, although most workers in these jobs may perform the primary task (e.g., riveting, painting), they may perform different secondary tasks. A painter, for example, may sand, strip paint chemically or by sand blasting, use wood putty, or apply varnishes or stains, in addition to painting. The hours spent performing these tasks, the materials used, and the availability of engineering controls and personal protective equipment may also vary. Second, other exposures may occur

TABLE I. Questionnaires Developed

Modules	Task-Based Modules[A]														
	Type of Questions									Exposures (Broad Categories Only)					
	Ind Exp	Tasks	Equip	Mats	Sens	Derm	Work P	Eng	PPE	Sol	Met	PAHs	MF	EMF	Other
Aircraft mechanic	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Barber or hairdresser	x	x	x	x										x	x
Bartender			x		x										x
Bus driver	x	x	x	x	x				x			x			x
Brick, block, and stonemason	x	x	x	x	x				x		x	x		x	x
Butcher/meat cutter		x	x	x			x		x					x	x
Cabinetmaker or bench carpenter		x	x	x	x	x	x		x	x				x	x
Carpenter	x	x	x	x	x	x	x	x	x	x				x	x
Concrete or terrazzo worker	x	x	x	x	x		x				x	x		x	x
Construction industrial or maintenance painter	x	x	x	x		x	x	x	x		x	x			x
Electrician	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Firefighter	x	x		x	x					x		x			x
Fisherman		x		x	x							x			x
Gas station attendant	x	x	x	x	x	x				x	x	x	x	x	x
Gardener or groundskeeper		x	x	x			x	x		x		x			x
General farm/rancher		x	x	x		x	x		x	x	x	x			x
General farm worker, crop/vegetable worker	x	x		x		x			x						x
Insulator	x	x	x	x	x	x			x	x	x		x	x	x
Janitor	x	x	x	x	x	x	x			x		x	x	x	x
Kitchen worker/dishwasher	x	x	x		x							x		x	
Knitter or weaver		x	x		x	x				x				x	x
Vehicle or mobile equipment mechanic	x	x	x	x	x	x	x		x	x	x		x	x	x
Machinist, woodworker, or metal worker	x	x	x	x	x	x	x		x	x	x		x	x	x
Nurse	x	x	x	x			x	x	x	x				x	x
Police officer or detective	x	x	x	x		x				x		x		x	x
Plumber, pipe fitter, or steamfitter	x	x	x	x	x	x			x	x	x	x	x	x	x
Repairer of industrial machinery	x	x	x	x	x	x			x	x	x			x	x
Roofer	x	x	x	x	x	x			x	x		x		x	x
Sheet metal worker	x	x	x	x	x	x	x			x	x	x	x	x	x
Taxicab/limo driver		x			x	x						x	x		x
Teacher		x	x	x						x	x		x	x	x
Tool and die worker	x	x	x	x	x	x	x		x	x	x		x	x	x
Truck or tractor trailer driver		x	x	x	x	x	x					x	x		x
Waiter/waitress	x	x			x							x			
Welder, cutter, or burner	x	x	x	x	x	x	x	x	x	x	x		x	x	x
	Nonspecific modules														
Laborer	x	x			x		x		x	x		x		x	x
Mail carrier	x	x	x	x								x	x		x
Manager, executive, or supervisor	x		x		x									x	x
Packing and filling operator	x	x	x	x	x		x			x				x	x
Production inspector, checker, or examiner	x	x	x		x									x	x
Office professional		x	x											x	
Traffic, shipping, and receiving clerk	x	x	x			x						x		x	x
	Industry-Based modules														
Dry cleaner/launderer	x	x	x	x	x	x				x				x	x
Shoemaker/repairer	x	x		x	x	x	x	x		x				x	x
Steel worker	x	x	x	x	x		x		x		x	x		x	x
Printing[B]	x	x	x	x	x	x	x	x		x	x			x	x
Pulp and paper[B]		x	x	x		x								x	x
Electroplating[B]		x	x	x			x	x	x	x	x			x	x

Notes: Nineteen other questionnaires were developed for electromagnetic field exposure only. Because they do not follow the organization described in this report, they are not identified. These are antenna repairer; computer operator; computer user; dentist; electrical/electronic engineer/technician/extremely low frequency jobs (e.g., assembler, textile workers, etc.); electrical power installer; electrical machinery/video display unit jobs (e.g., biological or chemical lab worker); fork lift truck operator; heating equipment operator; military occupation; miner; physician/health professional; railroad worker; radio operator; radar operator; radio and video display operator (e.g., dispatcher, guard, messenger); sales worker; and telephone line installer.

[A]Ind exp = indirect exposure; Equip = equipment used; Mats = materials used; Sens = sensory descriptions; Derm = dermal exposure; Work P = work practices; Eng = engineering controls; PPE = personal protective equipment; Sol = solvents; Met = metals; PAHs = polycyclic aromatic hydrocarbons; MF = machining fluids; EMF = electromagnetic frequency fields.

[B]Developed since the brain tumor study described in this article.

indirectly because the person is in a workplace where other operations are taking place; for example, silica exposure can be experienced by a mechanic in a foundry. These other exposures could be the raw materials, intermediate chemicals, or end or byproducts of the manufacturing process that the job is supporting.

Each JSM begins with questions about the general work environment, followed by more detailed questions about tasks and exposures (Table I). The JSMs generally open with questions on the employer's business type, which provide general information about the work environment and suggest what indirect exposures may occur. Indirect exposures occur when emissions are released in the vicinity of a worker independent of the tasks being performed. Emission sources include process equipment (furnaces, mixers, etc.) or tasks being performed by other workers (e.g., demolition). A worker's indirect exposures may be relatively consistent from day to day because the job is stationary, or they may vary from day to day because the job is assigned to several different areas, such as maintenance workers in a chemical plant. For example, a mechanic may be exposed to grain dust in a grain mill when in the mill itself and to cutting fluids when in a maintenance shop. Questions are therefore asked of the mechanic about the number of hours spent in the production area (e.g., the grain mill) and in the maintenance shop. If work in a production area is indicated, the respondent is asked "What were other workers doing in the production area where you spent most of your time?". These questions give the industrial hygienist an indication of the type of exposure and the amount of time spent in areas where these indirect exposures can occur.

For each JSM the interviewer inquires about specific major tasks possibly associated with the job and the duration and frequency of each task because they provide qualitative and quantitative information on exposures. For instance, repairing brakes indicates probable low level asbestos exposure (compared with, for example, installing insulation). For all tasks reported affirmatively, detailed questions are asked about the type of equipment and materials used if the task was performed for a minimum amount of time.

Other details associated with tasks are obtained as needed for specific jobs and exposures, including equipment ("What type of machining equipment did you use"?); sensory descriptions (of noise, dust, and odor levels); dermal exposure "How many hours a week did you have (agent) on your hands?"; work practices ("Please describe how you degreased parts."); engineering controls ("How was the air ventilated where you sanded?"); and use of personal protective equipment.

Nonspecific JSMs

A second type of questionnaire was developed for jobs with tasks and exposures that vary across industry, such as managers, laborers, and packagers. For these jobs it is not possible to develop a single set of questions applicable to all industries and individuals. Instead, these modules are fairly general and provide a basis for asking follow-up questions in a short second interview.[4]

JSMs for these jobs use the same approach for getting information on the type of employer as the task-based JSMs. Detailed questions on indirect exposures, equipment used, and sensory descriptions follow these questions. For jobs that may have been located in several identifiable areas, a question is asked about the amount of time spent in each area to obtain information on possible indirect exposures. For example, a traffic clerk or material handler is asked the number of hours spent in an office, in a warehouse, and in a production area. Questions regarding types of equipment used (e.g., video display units for managers after 1975) and sensory descriptions are asked where appropriate.

Industry-Based JSMs

Many other jobs than those already described are reported in case control studies that have specific identifiable exposures generated in the performance of their tasks or arising from specific identifiable process equipment. It is, however, impractical to develop JSMs for all possible job/industry combinations, particularly because many jobs are rarely reported (e.g., a sawyer in a saw mill or a reactor operator in a formaldehyde producing plant). The frequency of an industry being reported, however, is higher. Modules were therefore developed to capture information relevant to specific industrial processes. These modules tend to be less detailed than those developed for the specific job modules, because they attempt to cover all jobs in the industry. Examples of these modules are the steel manufacturing and the dry cleaning industries.

For these modules closed-ended questions are asked regarding the process with which the subjects were associated, with possible responses identified (because the respondent is unlikely to know what specific type of information is being sought), to characterize the industrial process. In the steel manufacturing module, for example, response options include coal receiving, the coke plant, the steel mill itself, and the rolling mill. Once the part of the process is identified, the general function the job—for example, maintenance, quality control, production, utilities, engineering, administration, shipping and receiving, research, environmental (air, water, and waste), or other—is asked. An affirmative response to any one of these functions is followed by more specific questions on tasks. (If a task-based JSM is available for a particular job, however, that module, rather than the industry module, would be selected because it is more detailed.) For nonproduction jobs the respondent is asked how many hours per week were spent in the production area. If a production job is indicated, the respondent is asked to identify from a list which of the major steps of the manufacturing process the subject performed. For each process step, questions are asked concerning the number of hours spent per week (and weeks per year if applicable) performing a short list of tasks specific to the manufacturing step. Questions on the materials used (e.g., water-based and solvent-based adhesives when gluing leather in shoe manufacturing), sensory descriptions, types of equipment used (e.g., basic oxygen, electric arc, or induction furnace), work practices (e.g., "Was the coke discharged from the ovens in batches or continuously?"), and engineering controls are also asked where appropriate.

Discussion

Typically, in community or hospital-based case control studies generic questions on job title, type of employer, and dates of employment have been collected to evaluate occupational exposures. There is a growing recognition that sole reliance on the traditionally collected information (i.e., job titles and type of employer) is inadequate to accurately characterize exposures. This is because this very general information is usually insufficient to allow a complete understanding of the inherent variability of exposures among individuals with the same job. Questionnaires specific to the job, on the other hand, can be used to assess this variability, but only a few investigators have attempted to use such questionnaires.[5,6]

The use of detailed questionnaires raises the issue of whether subjects can provide such information. A respondent's ability to recall job characteristics depends on the recency of the job, the number of jobs held, the duration of time the job was held, and the years since the job was held.[7–10] A coherent, logical method

is needed, therefore, to enhance retrieval of this information that may not have been recalled for many years. In the development of these questionnaires several principles underlying recollection of distant events are used. First, the subject's memory is "primed" by describing his or her entire work history before revisiting the jobs for more detailed information.[11] Second, retrieval of memory is enhanced by providing respondents with cues about the jobs by using language with which the subject is familiar.[11] Also, responses to quantitative questions on frequency of events (such as tasks) are decomposed into days per week and weeks per year to reduce errors in addition or multiplication and to increase response time.[12]

In spite of these attempts to enhance recall, it is not known how well subjects can provide detailed occupational information. Most evaluations of recall of occupational data have been focused on more generic types of questions, such as job title and dates of employment. Studies comparing subjects' reports of jobs to jobs in employers' records have produced estimates of agreement ranging from 50–95%, depending on which jobs were evaluated (all, most recent, etc.).[7,9,10,13–15] Dates have been found to be reported with an accuracy rate of 50–80%, depending on the criteria for defining agreement.[7,10] Thus, the jobs identified in response to the generic questions in this study should meet the level of accuracy reported in these studies.

The more detailed information asked for in this study, however, is likely to be less accurate. Results of comparisons of self-reports of specific chemical exposures to employer evaluations have varied widely, but in general they have been lower than agreement rates for jobs. For a chemical used in large quantities in an industry, accurate reporting is likely to be higher than for a chemical that is used in smaller quantities.[9,16–18] General classes of chemicals (e.g., oils and greases) may also be more easily reported.[17] Specificities of not reporting an exposure are usually high (> 0.95), but that may be more a function of low prevalence than of knowledge of exposures. Differences in reporting exposures are likely due to the actual knowledge of the subject (components of a material such as a spot cleaner used by dry cleaners are not likely to be known); the variability of use and the volume of the chemical used (in the dry cleaning industry, a single chemical, such as perchloroethylene, is usually used in large amounts in dry cleaning machines over many years); or the familiarity of the chemical name ("oils" or "greases" are more familiar than "imidazoline"). In part, however, the differences may be due to the structure of the question.

A concern about using closed-ended questions for specific chemicals is the possible differential recall among cases and controls, although whether such bias occurs is not clear. Differential recall is of concern in case control studies because of its effect on disease odds ratios. However, in a study of mental retardation and parents' occupations, little evidence of this type of bias was found for reports of a variety of exposures.[19] Differential recall of cases and controls is likely to be of less concern when one is asking questions about tasks or process information, or even, perhaps, chemical exposures within the context of detailed probing of a job, such as was done in this study.

If such bias exists, one possible mechanism is to minimize it by asking open-ended questions. Teschke et al.[20] examined the effect of the question structure by evaluating responses from a group of saw filers in a sawmill using open- and closed-ended questions. When asked open-ended questions, sensitivities of self-reports to industrial hygiene measurements and material safety data sheets were very low for specific exposures (generally 0.0), but somewhat higher for broad classes of substances such as coolants (0.69) and grinding wheel dust (0.85). Specificities were moderate to high for specific exposures (0.84 – 1.00) and low for the broader classes of exposures (0.6 – 0.75). In contrast, for closed-ended questions exposure sensitivity was higher for the broad classes of chemicals (> 0.85) than for the specific chemicals (0.0 – 0.58). In this study closed-ended questions were used to probe for use of exposures of interest to the study hypothesis to ensure the greatest sensitivity of reporting. For other exposures, lower sensitivities were accepted because they are of less interest to the study hypothesis.

The underlying assumption of these questions is that the respondent originally had the knowledge and therefore can provide valid information. If the respondent is a next of kin, however, the information may never have been known or is much more difficult to retrieve because the data were known secondhand and, therefore, accurate reporting by these types of respondents is likely to be lower.[21–28] For this reason the next of kin were asked only very general questions. It may be more appropriate, however, to ask the next of kin to identify a co-worker of the subject to obtain detailed workplace information.[20] This approach was used in a case control study of embalmers.[29] Presumably, the limitation of this approach would not lie in the ability of the co-worker to provide good workplace information, but rather in the success of finding the co-worker.

The questionnaires in this study were developed specifically for the brain tumor study, but the jobs for which the questionnaires were developed were selected from case control studies of cancer of the lung and brain, leukemia, and lymphoma, and the exposures cover those of interest in many other studies also. Because the number of conceivable job/industry combinations is enormous, it is not feasible to develop a detailed questionnaire for each possible combination. For the brain tumor study only 63 questionnaires were developed, but these have covered 80% of the reported jobs (n = 683 for the first 127 subjects) in the study.[4] (The 80% includes the jobs that received the EMF modules. In 15% of these a second interview was necessary to obtain information on other exposures. Expansion of these JSMs to cover other exposure would reduce this follow-up need.) Further, it is estimated that about 60% of industries of interest to disease investigations could be covered in about 100 questionnaires. Although the latter questionnaires would not be as detailed as the job modules, the authors believe the addition of industry-based questionnaires could make a substantial improvement toward the understanding of most workplace environments. Thus, with a limited effort, most situations that are likely to be encountered in a case control study in the United States could be covered. In fact, since the development of these questionnaires other modules have been developed. In any case, when a job with exposures of interest is encountered that does not have a questionnaire, a supplemental approach to obtaining detailed information can be used.[1,4]

Although the use of detailed questionnaires to collect information on jobs is a substantial improvement over the more traditional approach of collecting only generic information, more needs to be done to improve exposure assessment in community or hospital-based case control studies. First, the questionnaires should be validated to determine whether they do, in fact, elicit accurate information. Validating historical jobs identified through typical population-based case control techniques is almost impossible because of the feasibility in identifying a large enough number of workers across a variety of jobs, industries, and exposures who have been monitored historically. It appears more feasible to obtain the cooperation of a small number of employers and assess current exposures of employees using typical case control data collection techniques. A validation effort should assess several different types of jobs, industries, exposures, and questionnaires and could include assessments based on each of the following levels of

exposure information: the job title and type of industry only of these employees (as has traditionally be done); a generic work history that includes the job title, industry, dates, activities, and materials and equipment used; the generic work history supplemented by the JSMs; air monitoring of the employees under study; and finally, biologic samples of exposure markers of these employees. In addition, a second administration of the questionnaire would be useful to assess the reliability of the reported information. The authors are exploring whether this type of study is feasible. Such a study is likely to be difficult in the United States,[30] but in some countries it may be possible to obtain the requisite cooperation of employers. It must be recognized, however, that even if the questionnaires are not perfect, if they prove to provide more valid assessments than the current practice of basing assessments on job and industry title alone, investigators should consider this technique when designing population-based case control studies.

In addition, if the JSMs provide reasonable exposure assessments, they should be standardized.[31] Standardization of the questionnaires would accomplish two things: it would reduce start-up costs of future studies, and it would increase comparability of findings across studies (although changes in technology and variation in processes would require slight differences across countries). The authors envision that in the future, investigators could obtain a set of questionnaires that have been reviewed by experts in the field and cover most exposures of interest. Investigators could then simply delete those questions not applicable to their studies.

The questionnaires in this study are the first step toward this goal. Other questionnaires are expected to be developed for future studies. The authors encourage the sharing of questionnaires among investigators. A copy of the questionnaires described here can be obtained from the first author.

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