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Commentary

OccIDEAS: An Innovative Tool to Assess Past Asbestos Exposure in the Australian Mesothelioma Registry

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Malignant mesothelioma is an uncommon but rapidly fatal disease for which the principal aetiological agent is exposure to asbestos. Mesothelioma is of particular significance in Australia where asbestos use was very widespread from the 1950s until the 1980s. Exposure to asbestos includes occupational exposure associated with working with asbestos or in workplaces where asbestos is used and also 'take-home' exposure of family members of asbestos exposed workers. Asbestos exposure may also be non-occupational, occurring as a consequence of using asbestos products in non-occupational contexts and passive exposure is also possible, such as exposure to asbestos products in the built environment or proximity to an environmental source of exposure, for example an asbestos production plant. The extremely long latency period for this disease makes exposure assessment problematic in the context of a mesothelioma registry. OccIDEAS, a recently developed online tool for retrospective exposure assessment, has been adapted for use in the Australian Mesothelioma Registry (AMR) to enable systematic retrospective exposure assessment of consenting cases. Twelve occupational questionnaire modules and one non-occupational module have been developed for the AMR, which form the basis of structured interviews using OccIDEAS, which also stores collected data and provides a framework for generating metrics of exposure.

Key Words: Asbestos, Occupational exposure, Mesothelioma, Environmental exposure, Carcinogens

Introduction

Malignant mesothelioma is an uncommon cancer of the mesothelium, a membrane which forms a lining of the thorax, peritoneum and pericardium. Most mesotheliomas are associated with the pleural mesothelium, the lining of the lungs. About 80% of mesotheliomas in the developed world are in individuals known to have higher than background exposure to asbestos [1,2]. The possibility of unrecognised exposure exists in other cases [3,4]. Although mesothelioma is an uncommon tumour, it is aggressive and resistant to treatment and is uniformly and rapidly fatal [5-7].

Asbestos exposure is the principal etiological agent for mesothelioma. Asbestos is a naturally occurring mineral product and comes in a variety of forms, several of which have had commercial uses, including the serpentine mineral chrysotile ("white asbestos") and the amphibole minerals amosite ("brown asbestos"), crocidolite ("blue asbestos"), tremolite, anthophylite and actinolite. The earliest epidemiological evidence for an association between mesothelioma and asbestos was in relation to crocidolite, however, current consensus is that all forms of asbestos are carcinogenic, although the different mineral subtypes do not present equal risk [8-10].

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While the background incidence of mesothelioma is very low, the occurrence has been increasing since the 1950s and there is considerable inter-country variation, ranging from 7 per million (Japan) to 40 per million in Australia and this variation appears to be consistent with differences in historical asbestos exposure patterns [1,11]. Australia has one of the highest reported incidences of mesothelioma in the world, and this is consistent with the local history of high past asbestos use in occupational and environmental settings [3-5]. In countries where asbestos use has been phased out the increasing incidence over past decades can be expected to peak in the foreseeable future [1,11] and in Australia this peak is projected to occur around 2015-2020 [4,12].

The majority of mesotheliomas occur in males [13], and differences in exposure-profiles of men and women are likely to be important factors in this difference, with occupational exposure more common in males than females [14]. Analyses of mesothelioma incidence rates among residents and workers at a remote crocidolite mine and the associated mining town (Wittenoom) in Western Australia suggest that women may have a steeper dose-response curve than men [15].

Although it is well-established that asbestos is the main exposure relevant to the aetiology of mesothelioma, the very long latency of this disease (mean 40 years, range 15-97 years) [1] presents particular problems for exposure assessment. In general, retrospective assessment of occupational exposure in community-based studies has often been crude and subject to considerable misclassification [16]. Assessment of exposures in the very distant past is usually hampered by a lack of extant records of exposure measurement and in community-based studies exposure assessment must therefore often make use of information from the participants themselves [17]. This is especially problematic for a very long latency disease like mesothelioma.

The purpose of this paper is to provide an overview of asbestos exposure, particularly in the Australian population, and to describe how the OccIDEAS exposure assessment tool is being adapted for use in the Australian Mesothelioma Registry to retrospectively assess asbestos exposure among mesothelioma cases. OccIDEAS is a tool which can be used for exposure assessment in a wide variety of different research contexts, including studies of new exposure-disease combinations.

Sources of Asbestos Exposure

Sources of asbestos exposure can be classified into three broad categories. Firstly, occupational exposure is that which occurs in the workplace or in the course of work-related activities. Occupational exposure includes obvious exposures of workers who are using or handling asbestos fibre, manufacturing or using asbestos-containing products; it also includes passive exposures associated with working in an area where asbestos fibres are present. The second category of exposure is known as "take home" exposure and this occurs when an exposed worker's family experiences exposure to asbestos carried home on the worker's clothes. The third category is environmental (non-occupational) exposure. Like occupational exposures, environmental exposures may arise as a result of actual use of asbestos containing products outside the workplace, but the possibility also exists of passive environmental exposure, associated with being in environments where asbestos fibres are present, for example where asbestos building materials are present or proximity to asbestos mining or processing sites.

Historical occupational exposure to asbestos in Australia has been well described elsewhere [18]. To summarize, exposures have been documented in mining and milling of asbestos ore, and in the production of asbestos textiles, cement building products, friction materials and gaskets. Exposure levels in various tasks in Australian industry have also been described and indicate levels of exposure many times greater than environmental levels [19].

The large gender imbalance in the incidence of mesothelioma probably reflects the historically low numbers of women working in most of the asbestos exposed industries, except perhaps in the textile industry. However, asbestos is also found in the community, arising from sources such as friction linings and building products such as cement sheeting in "fibro" houses. This results in an increased risk of exposure in people who are not in the traditional 'at-risk' jobs. In Australia, after World War II until the 1960s, 25% of new houses were clad in asbestos cement [18]. In recent years there has been a shift in asbestos exposure associated with phasing out the production and use of asbestos-containing products. Exposure since the mid-1980s has been limited primarily to the asbestos removal industry with a ban on all asbestos use in any commercial production since 2003.

The Australian Mesothelioma Registry (AMR)

AMR aims to assess exposure to asbestos from both environmental and occupational sources to identify emerging 'at risk' occupations and environmental exposures. The registry collects data on registered cases from the population-based cancer registries in each Australian state and territory. Because reporting of cancer cases in is mandatory in all Australian jurisdictions, the

state/territory registries have very high ascertainment of cases.

The AMR commenced in 1986 and initially collected detailed narrative histories of asbestos exposure from cases, but this was discontinued in 2004. Since that time, only incidence rates have been reported. In 2010, the Australian Government decided to expand the scope of the AMR by collecting exposure data from consenting cases. The data collection being undertaken is in two phases: a postal questionnaire covering job, school and residential histories followed by a structured telephone interview using the OccIDEAS exposure assessment tool. Exposure assessment of consenting AMR cases using OccIDEAS commenced in early 2011.

AMR operates under the primary ethcal approval of the New South Wales Population and Health Services Research Ethics Committee.

OccIDEAS – an Innovative Tool for Exposure Assessment

OccIDEAS is a web application which provides a streamlined way of undertaking expert assessment of occupational exposure including automation of some of the assessment steps [17]. Within OccIDEAS a research participant's full job history can be entered. Based on this job history, the researchers assign job-specific questionnaires (known as job specific module [JSM]s) to jobs which potentially involve exposure to asbestos. A structured interview is then conducted with the participant, usually by telephone, and the interviewer records the answers to the JSM questions in OccIDEAS. Exposure assessment rules can be programmed into OccIDEAS to produce exposure estimates automatically, based on the respondents' answers to JSM questions. Exposure assessment rules are flexible and may take a variety of forms to reach estimates of exposure probability (probable, possible or no exposure), intensity (high, medium or low) and frequency (hours per week, weeks per year). In essence, exposure rules are if/then statements relating to particular answers to questions in the JSMs [20]. The exposure rules may incorporate answers to several questions and can also take into account the historical period of the job being assessed and other known information about the exposure context.

For example, if a participant reported in response to an interview question that a particular job involved installing pipe-lagging, exposure rules could assign "probable" and "high"-level asbestos exposure. However, if the participant answered in a subsidiary question that certain respiratory protective equipment was used, then the exposure rules could modify the level of exposure to "medium" or "low" according to the known efficacy of the protective equipment in question. Likewise, if the job was in the period after which asbestos had been phased out in new pipe lagging, the exposure rules could be set to assign "no exposure" probability or, if the job was during the period when asbestos was being progressively phased out of new pipe lagging, the rules could assign "possible" probability of exposure. OccIDEAS exposure rules can also assign different exposure probabilities and levels to different temporal periods within the same job to provide accurate cumulative exposure assessment and this is particularly important for long duration jobs, during which exposure conditions may have changed considerably.

In this way the exposure rules can utilise other information known about exposure conditions, specific to the particular exposure context. Rules can also be updated as new information becomes available, enabling re-assessment of participants' exposure without necessitating re-interviewing. This may be a particular advantage for research on emerging exposure-disease combinations. OccIDEAS also allows for manual assessment and manual review of the rule-based assessment generated by OccIDEAS. Complex or rare situations which do not lend themselves to rule-based assessment can be set to demand an expert decision. Rule-based assessments can also be reviewed and may be over-ruled if necessary.

OccIDEAS is a flexible exposure assessment platform which enables an exposure assessment strategy to be tailored to particular research applications using automated rule-based assessments and, when necessary, incorporating expert input for complex, rare or unforeseen exposure situations.

OccIDEAS delivers the questions to the interviewer in an interactive on-screen format which displays the questions to be asked and provides appropriate spaces for answers to be entered by the interviewer. The format is based on a series of "parent" questions and subsequent "child" questions. Positive answers to "parent" questions trigger OccIDEAS to ask associated "child" questions. For example, if a participant answers "No" to the question, "Did this job involve repairing/servicing vehicles?", then OccIDEAS automatically skips over all the subsequent detailed "child" questions about automotive repair tasks. This dynamic process within the interview enables more efficient delivery of relevant questions to the participant, saving time by focusing on the most relevant questions and avoiding the need for the interviewer to identify and navigate around irrelevant questions.

The main features of OccIDEAS, which make it useful in the context of a mesothelioma registry are the way in which jobs are triaged as to their likelihood of exposure, the automatic delivery of relevant questions during the interview and the automatic rules for exposure assessment.

The triaging of jobs for likelihood of exposure, the assign-

Table 1. Job specific module (JSM)s developed for assessment of occupational exposure to asbestos for the the Australian Mesothelioma Registry

JSM name	Reported jobs for which this JSM may be applicable
Asbestos mining/milling	Jobs in asbestos mining, milling and primary processing jobs
Asbestos removalists	Specialised asbestos removalist jobs
Automotive component manufacture	Automotive component manufacturing jobs, automotive assemblers and related jobs
Cement factory workers	Cement and cement products manufacturing workers
Furnace industries	Jobs closely associated with furnaces and related fixed plant, including foundry, smelter, glassworks, brickworks, ceramic manufacture and power generation jobs with likely furnace related tasks
Insulators	Specialist insulation jobs, including insulators of buildings, ships, trains, boilers, etc.
Land transport	Drivers, mechanics & other vehicle repairers of land vehicles, military or civilian, passenger or freight
Textile worker	Textile and floor-covering manufacturing jobs
Tip worker	Tip/landfill or waste transfer jobs, including waste truck drivers and tip site workers
Trades	All trades not elsewhere classified, including metal, building, electrical, plumbing & mechanical trades and related workers, such as trades assistants, general maintenance workers, etc.
Water transport	Shipbuilders, ship repairers, seamen and waterside workers – military or civilian
Asbestos users not elsewhere classified	Jobs involving possible asbestos end-use not elsewhere classified, including laundry workers/drycleaners, bakers, industrial/factory cleaners, miscellaneous labourers and manufacturing workers

ment of questions specific to the type of job and industry and the automatic avoidance of irrelevant questions within interviews are particular advantages for interviewing mesothelioma cases, who are typically very ill and in a terminal phase of their condition, because these features minimise the interview time and focusing on questions relevant and specific to the case's own work history and the occupational exposure/s of interest.

Twelve JSMs have been developed specifically for assessing asbestos exposure. The JSMs have been developed to cover all categories of jobs likely to be reported by respondents and which have possible asbestos exposure in the Australian context. The development of JSM questions was based on the knowledge of occupational hygienists expert in the field and informed by published Australian data [19,21-23], and also on information from other relevant sources, such as the Australian Institute of Occupational Hygienists [24] and Safe Work Australia (formerly National Occupational Health and Safety Commission) [25]. The JSMs developed for the AMR are listed in Table 1.

Subjects' jobs are assigned JSMs according to the best match. Jobs with little probability of exposure are not assigned JSMs. The JSMs vary in length and most take only about 1-5 minutes to administer, depending on how many subquestions are triggered by the participant's responses. To keep the interview to a reasonable length, no more than 4-6 JSMs are assigned to a participant's job history, depending on the length of the JSMs involved. Where there are more than 4-6 jobs of interest reported, similar jobs can be assigned the same exposure estimates. It is important to note that JSMs do not ask participants to self-assess their own level of exposure to asbestos, as most workers do not have the breadth of experience to know what range of exposures are possible. The JSMs are comprised of questions seeking details about particular tasks and general workplace conditions. These questions relate to the determinants of exposure and from the answers to these questions exposure probability and level can be derived using the standard rules in OccIDEAS, supplemented with manual review as necessary.

In the case of mesothelioma, non-occupational exposure to asbestos is likely to be relevant and an exclusive focus on occupational exposure would be an important shortcoming. Therefore, in addition to the 12 occupational JSMs, we have also developed an environmental module which is used to assess likelihood of exposure to asbestos in non-occupational contexts. This module is delivered to all participants, irrespective of job history, and asks about residential exposure, including living in a house clad with asbestos cement building products; it also asks about home renovation activities, servicing automotive brakes/clutches, visits to asbestos mining towns and ever having lived with someone who came home with dusty clothing. Each of these possible exposure situations is represented by a stem question, a positive answer to the stem

question triggers a more specific set of questions to explore that particular exposure in more detail. The environmental module demonstrates the flexibility of the OccIDEAS platform to accommodate particular exposure assessment needs.

Conclusion

Asbestos exposure is an important historical exposure in the Australian context, which is expected to have health implications in this country for many years to come. Because of the long time lag between asbestos exposure and the onset of mesothelioma, systematic and rigorous retrospective assessment of exposure among mesothelioma cases is important in the context of the Australian Mesotheloma Registry. Given the rapidly fatal nature of the disease after the point of diagnosis, it is imperative to collect individual exposure data from patients quickly and efficiently and with as little inconvenience to the patients as possible.

OccIDEAS is a tool which enables exposure data to be collected in a rigorous way to inform exposure assessment without requiring long data collection interviews. The automated assignment of exposure assessments and the flexibility of the OccIDEAS tool are also strengths of the method in the context of the registry, which is seen as a very long-term project.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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