CHEST

Official publication of the American College of Chest Physicians

CHEST ONLINE

American College of Chest Physicians Consensus Statement on the Respiratory Health Effects of Asbestos

Daniel E. Banks, Runhua Shi, Jerry McLarty, Clayton T. Cowl, Dorsett Smith, Susan M. Tarlo, Feroza Daroowalla, John Balmes and Michael Baumann

Chest 2009;135;1619-1627
DOI 10.1378/chest.08-1345

CHEST

Consensus Statement

American College of Chest Physicians Consensus Statement on the Respiratory Health Effects of Asbestos*

Results of a Delphi Study

Daniel E. Banks, MD, MS, FCCP; Runhua Shi, MD, PhD; Jerry McLarty, PhD; Clayton T. Cowl, MD, MS, FCCP; Dorsett Smith, MD, FCCP; Susan M. Tarlo, MBBS, FCCP; Feroza Daroowalla, MD, FCCP; John Balmes, MD, FCCP; and Michael Baumann, MD, MS, FCCP

Background: **The diagnosis of and criteria for the evaluation of asbestos-related disease impairment remains controversial after decades of research. Assessing agreement among experts who study pneumoconiosis, and diagnose and treat patients with asbestos-related respiratory conditions may be the first step in clarifying clinical and forensic/administrative issues associated with asbestos-related pulmonary conditions.**

Methods: **We conducted a Delphi study, an iterative method of obtaining consensus among a group of experts. An expert panel was identified using an objective, nonbiased algorithm, based on the number of asbestos-related disease publications authored during the preceding 10-year period. Identified experts were invited to participate by accessing an Internet site. Each expert was presented statements developed by the authors regarding the diagnosis or treatment of asbestos-related disease; experts then ranked their degree of agreement or disagreement utilizing an 11-level modified Likert scale for each statement. Each expert was asked to justify their selection and to suggest references in support of their opinion. The Wilcoxon signed rank test and the interquartile range were used to define "consensus." The results of the collective Likert rankings, deidentified comments, and suggested references as well as the initial consensus results were then provided to the participating experts. Each panel member then ranked their extent of agreement with a modified statement for which consensus was not achieved. The process was repeated three times.**

Results: **Consensus was achieved on all but 9 of 32 statements.**

Conclusions: **Consensus was not achieved for nine statements. These statements may be topics for future research.**

(CHEST 2009; 135:1619–1627)

Abbreviations: ACCP = American College of Chest Physicians; ATS = American Thoracic Society; HRCT = high-resolution CT; IQR = interquartile range

Executive Summary

Objective: **To provide expert-based consensus opinions for the diagnosis and documentation of asbestos-related lung disease, an area of occupational medicine that has remained controversial after decades of research. The American Thoracic Society published criteria for the diagnosis of asbestosis in 1986 and revised these criteria in 2004, yet the data still are not uniformly applied.**

Process: **Consensus opinions were derived using a systematic, iterative Delphi process. After developing strict criteria for inclusion, a panel of international experts was formed from an exhaustive literature search using a method that was intended to be as free of bias as practically possible. A set of 25 important statements about the diagnosis of asbestos-related disease was constructed by the American College of Chest Physicians (ACCP) with additional input from the Workers' Compensation Board**

of Alberta, Canada. These statements, which included sentinel topics central to the diagnosis and forensic assessment of asbestos-related respiratory disease, were ranked independently by panel members using a modified Likert scale. Seven more statements were added during the Delphi process as a result of suggestions from the expert panel. A rigorous statistical method was used to quantitate the degree of consensus.

***Outcome:* Consensus was reached on 23 of the 32 statements and formed the basis for this document. These statements included agreement on the associations between asbestos exposure and the development of radiographic pleural or parenchymal abnormalities, clinical associations between exposure based on a good environmental and occupational history and the development of disease, diagnostic utility of high-resolution CT scan of the chest, as well as increased risk of bronchogenic carcinoma and documented asbestos exposure even without documentation of asbestos fibers in respiratory tissue of the patient. Consensus was not attained regarding nine statements; these statements included questions of utility regarding chest radiographs and high-resolution CT scan of the chest, the relationship between asbestos exposure and pleural plaques, and the extent of risk for the development of lung cancer in the face of asbestos exposure.**

***Validation:* Consensus opinions were reviewed by the authors, the ACCP Occupational and Environmental Medicine NetWork Steering Committee, the ACCP Health and Science Policy Committee, and the Executive Committee of the ACCP Board of Regents.**

***Sponsors:* The ACCP and the Workers' Compensation Board of Alberta.**

In 1986, the American Thoracic Society (ATS) published criteria for the diagnosis of asbestosis,[1] yet these criteria are not typically uniformly applied. There is disagreement regarding a number of the health issues associated with respiratory exposure to asbestos.[2,3] Manuscripts showing diametrically opposite conclusions regarding asbestos-related exposure and impairments can be identified easily. For example, proponents of banning asbestos in all applications use peer-reviewed literature to buoy their arguments, yet others use objective data to support their opinion that the health risks of asbestos or

*From the Department of Medicine (Drs. Banks, Shi, and McLarty), Louisiana State University School of Medicine, Shreveport, LA; the Divisions of Pulmonary & Critical Care Medicine, and Preventive, Occupational & Aerospace Medicine (Dr. Cowl), Mayo Clinic, Rochester, MN; the Department of Medicine (Dr. Smith), University of Washington School of Medicine, Seattle, WA; the Department of Medicine (Dr. Tarlo), University of Toronto, Toronto, ON, Canada; Stony Brook University Health Science Center (Dr. Daroowalla), Stony Brook, NY; the Department of Occupational and Environmental Medicine (Dr. Balmes), University of California at San Francisco, San Francisco, CA; and the Department of Medicine (Dr. Baumann), University of Mississippi Medical Center, Jackson, MS.

The questions were developed and revised for each round by the members of the working group as a whole. Drs. Shi and McLarty developed the Web site and the statistical analysis for each round. Drs. Banks, Shi, and McLarty wrote the manuscript with the approval of the members of the working group.
This work was performed at the Louisiana State University School of Medicine in Shreveport, LA. This project was commissioned by the ACCP and can be considered an "official" project of this organization. The ACCP provided a number of neckties embroidered with the ACCP logo to be distributed to participants who served on the expert panel in this study.
The Workers' Compensation Board of Alberta provided financial support of $25,000 to support the project. Vernon Lappi, MD, serves as the medical director of medical services at the Workers' Compensation Board of Alberta, Canada. The Feist-Weiller Cancer Center of the Louisiana State University School of Medicine in Shreveport provided computer support for this project.
Several physicians who participated in the Delphi project on asbestos have cared for patients, offered legal consultation, and/or testified in medical legal matters regarding asbestos-related diseases. Dr. Banks has served as a consultant for both plaintiffs and defendants regarding the pulmonary health effects of occupational dust exposure. He has provided no legal consulting regarding the health effects of asbestos exposure within the past 10 years. Dr. Cowl has evaluated and treated patients with asbestos-related lung disease but has not participated in any litigation or performed legal consulting work related to asbestos exposure or asbestos-related lung disease. Dr. Smith has evaluated > 1,000 patients with asbestos exposure and > 150 patients with mesothelioma. He has served as a legal expert witness on multiple occasions, testifying primarily for defendants. He has authored articles and book chapters related to asbestos-related disease; his latest publication was in 2005. Most recently, he has evaluated patients with asbestos exposure primarily for forensic aspects of workers' compensation systems in the northwestern United States. He has been a radiographic "B-reader" since 1980 and has read multiple radiographs with pneumoconioses. Dr. Tarlo has served as a clinical consultant for patients referred by their physicians or by the Ontario Workplace Safety and Insurance Board but has not been involved with litigation for asbestos-related diseases. Dr. Daroowalla has served as a clinical consultant for patients referred by their physicians but has not been involved with litigation for asbestos-related diseases. Dr. Balmes has served as a medical consultant for both plaintiffs and defendants, but primarily for plaintiff counsel, in the role of expert in the pulmonary health effects of occupational exposure to asbestos. However, he has performed no legal work regarding the topic of asbestos exposure or related disease in the past 5 years. Drs. Shi, McLarty, and Baumann have reported to the ACCP that no significant conflicts of interest exist with any companies/organizations whose products or services may be discussed in this article.
Manuscript received May 27, 2008; revision accepted February 25, 2009.

Correspondence to: Daniel E. Banks, MD, MS, Professor and Head, Department of Medicine, Louisiana State University School of Medicine, Room 6-203, 1501 Kings Hwy, Shreveport, LA 71130; e-mail: dbanks3@lsuhsc.edu
DOI: 10.1378/chest.08-1345

related fibers may be acceptable in certain situations.[4–6] There is disagreement regarding whether asbestosis must be present to attribute lung cancer to an asbestos effect,[7,8] how best to gauge the risk of asbestos-containing materials in schools and offices,[9,10] and if the presence of pleural plaques increases lung cancer risk[11–14] or whether other cancers outside of the respiratory tract are caused by asbestos exposure.[15,16] Finally, there remains substantial disagreement as to whether a profusion score of International Labor Organization category 1/0 is sufficient to make the diagnosis of asbestosis. For example, in the most recent ATS statement,[17] a "critical distinction is made between films that are suggestive but not presumptively diagnostic (0/1) and those that are presumptively diagnostic but not unequivocal (1/0)." Although some of these conclusions may have little direct bearing on the understanding of the health effects of asbestos exposure, a more systematic approach to answering these and other questions may be more relevant to understanding the risks associated with asbestos exposure and eventual administrative decisions reflecting equitable compensation to affected patients.

The goal of this study was to address these problems and to assess the health effects of asbestos exposure using the Delphi framework of consensus assessment using knowledge extracted from experts. This method promotes the resolution of "disputed" topics by iteratively polling experts and providing sequential feedback to all panel participants regarding the responses elicited from other experts. We hoped to draw consensus opinions regarding a variety of diagnostic, forensic, and administrative issues stemming from clarified statements associated with asbestos exposure health effects.

Drs. Banks, Shi, and McLarty prepared questionnaires and β-tested questions with their colleagues; they identified the panel of experts, built a project Web site, collected and undertook the statistical analysis of gathered data, and produced the documents after each round. In effect, they provided the leadership for the consensus statement project. The remainder of the authors served as an advisory committee to develop all aspects of the questionnaire, review results, change or develop new questions for each round based on the available data, and contribute to and edit the manuscript.

Materials and Methods

The Delphi Technique

An interactive technique known as the *Delphi method* is one systematic approach to maximize areas of agreement and minimize the areas of disagreement regarding fundamental beliefs or assumptions regarding the role of asbestos exposure and how it affects respiratory health. Consensus among experts is a central assumption of Delphi methodology. This approach is employed for problems that are difficult to solve with conventional techniques.[18–23] The Delphi method helps structure communication in a way that allows a group of individuals to deal with a complex problem by identifying consensus. It is a systematic process that can be clearly documented and involves a series of questions designed by a monitor group. The questions can be sent by e-mail in several rounds to a respondent group of experts who remain anonymous from one another. The anonymity of answers allows Delphi participants to express their personal views without face-to-face peer pressure. This method is particularly useful for topics on which there are strong differences of opinion or when high levels of uncertainty are present.

After each round, the results are summarized and assessed, then used to develop a questionnaire for the next round at which time all participants are asked to weigh in again. This forces experts to consider group opinion. The assessment document and revised questionnaire with supporting evidence (if available) is then sent out again to all who responded. A Delphi survey is considered complete when a convergence of opinion occurs or when a point of diminishing returns is reached. The reliability of the Delphi method depends largely on the selection of panel members, the size of the group, and the number of rounds.[18]

In the Delphi process utilized in this study, we first identified members of an international expert panel in an unbiased manner, described later. Key issues in asbestos-related diseases were then collected and reviewed for content and style by the American College of Chest Physicians (ACCP) Occupational and Environmental NetWork steering committee. Key issues identified by the committee were then presented as a survey to the expert panel through e-mail or internet Web pages. A total of 32 statements were evaluated by the expert panel. Each statement was ranked on a Likert scale by each panel member. An 11-category scale ranged from 0 (strong disagreement) through 10 (strong agreement), with a score of 5 indicating no opinion or not enough information to judge. A panel member was given the option of not weighing in on an issue if that topic was outside his or her respective area of expertise. Also, panelists were encouraged to supply references and other information in support of their opinion for each question. Results were compiled for each question and a quantitative measure of consensus (described in the next section) applied. The results were then distributed to the expert panelists and the ACCP steering committee. All information was maintained on the Web site developed for this protocol (http://www.sh.lsuhsc.edu/medicine/delphi/). The issues for which consensus of opinion were not reached were returned to the expert panelists, this time with the compiled results and supportive evidence. This process was repeated for three rounds. Some questions were modified for clarity in the second round, and some new questions were added after the first round. This proposal was submitted to and approved by the Louisiana State University School of Medicine Institutional Review Board.

Statistical Definition of Consensus

Various methods of consensus have been utilized in other Delphi studies, including one concerning pulmonary disease.[24] However, many of the methods are not statistically rigorous. We developed a statistically based definition of consensus and degree of consensus, based on probabilities (p value) and interquartile range (IQR). The Wilcoxon signed rank test was used to test the null hypothesis that there was an even distribution of scores throughout the range. Four degrees of consensus were defined: very good, $p \leq 0.05$ and $IQR \leq 2$; good, $p \leq 0.05$ and $IQR \leq 3$; some, $p \leq 0.05$ and $IQR \leq 4$; and none, $p > 0.05$ or $IQR > 4$.

Expert Panel Formation

Identification and selection of the expert group is critical to a consensus document because the experts' judgments form the basis of conclusions. The choices of expert participants for the Delphi inquiries were vetted extensively by the ACCP steering committee.

An attempt was made to identify, in an unbiased manner, individuals with significant numbers of recent first author publications (reviews or peer-reviewed manuscripts only) pertaining to asbestos-related disease. A PubMed search was conducted of publications related to asbestos disease for the approximate 10-year period from January 1, 1991, through May 15, 2002 (the initial date of the search). Only clinically relevant publications pertaining to asbestos were retrieved. Animal studies were excluded. The search yielded 1,106 references. We sorted this list by first author and counted the number of publications for each first author. Ninety-five individuals were the first author of ≥ 3 publications (some had as many as 13 publications). These 95 individuals represented a diverse panel from different countries and institutions. One author was known to be deceased, limiting the cohort of eligible experts to 94.

We invited 71 members from the expert pool with known e-mail addresses to participate. Although we concede a potential for bias in excluding those without e-mail access (such individuals without e-mail may be the most or the least knowledgeable), we considered this the most practical means of communicating with our international panel of experts. Participation was anonymous; none of the panelists knew the identity of the other panelists.

Questionnaire Development

A major task in planning the use of the Delphi method in assessing the health effects of asbestos was to identify and select issues that could benefit from formal consensus of expert judgments. Issue identification and selection was based on a broad review with a goal of addressing a comprehensive slate of topics. We emphasized selection of a broad subject, rather than beginning with a limited list and defending the omission of issues after the fact. We invited comments from members of the ACCP Occupational and Environmental NetWork Steering Committee and the Workers' Compensation Board of Alberta, Canada, individuals with expert knowledge about the health problems of asbestos. After a reasonable assurance that the list of issues was complete, we identified 25 statements later incorporated into the panel survey. After the first round, it was apparent that three questions needed clarification, and seven new statements were added in response to expert panel and steering committee suggestions. Six statements were adapted directly from the 1986 ATS diagnostic guidelines document.[1] A complete list of the 32 statements considered for consensus appears in Tables 1, 2, and 3.

Results

Figure 1 illustrates the Delphi process for one opinion statement for which consensus was reached after three Delphi rounds. In this case, the expert consensus was to disagree with the statement. Overall, the results showed some degree of consensus on 23 statements. Seven of the 25 questions achieved consensus in the first round. Seven new statements were added after round 1, and three were modified for clarity. Twelve of the remaining 25 questions achieved consensus in the second round, and 4 of the remaining 13 questions in the third round reached consensus. There was no consensus reached for nine statements.

Tables 1 and 2 contain the 17 statements for which consensus with agreement was reached and the 6 statements of consensus with disagreement by the expert panel, respectively. Table 3 lists the nine statements for which no consensus was achieved. A variable number of experts participated in each round and each statement, as follows: 34 experts voted in round 1; 29 experts voted in round 2; and 24 experts voted in round 3. Within each round, experts were given the option of not evaluating some statement, although most voted on all questions.

Discussion

The expert panel agreed with the provisions of the 1986 ATS position statement on the diagnosis of asbestos-related disease[1] with good or very good consensus. This project was underway prior to the publication of the second 2004 ATS statement, *Diagnosis and Initial Management of Nonmalignant Diseases of Asbestos.*[17] There are several aspects of these reports that invite comparison with the Delphi process findings. The authors of the second ATS statement[17] comment that "a profusion of irregular opacities at the level of 0/1 is the boundary between normal and abnormal in the evaluation of the film, although the measure of profusion is continuous and there is no clear demarcation between 0/1 and 1/0. When radiographic or lung function abnormalities are indeterminate, HRCT [high-resolution CT]scanning is often useful in revealing characteristic parenchymal abnormalities." In this report, experts agreed that in the setting of a category 1/0 radiograph, the high-resolution CT (HRCT) scan would increase the specificity of these radiographic findings. In both this report and the second ATS statement, there is recognition that asbestosis can develop without impairment.

Although the authors of the second ATS statement[17] characterized the role of asbestos as a cause of airways obstruction as controversial, they provide evidence to show that asbestos exposure has long been associated with obstructive physiologic abnormality. The experts in this report were unable to reach a consensus when asked to agree or to disagree with the statement "A decline in small airway flow rates in a nonsmoker can be attributed to asbestos exposure." In fact, the experts seem evenly divided on the issue and the results did not change substantially from round to round. This resistance to change due to the Delphi process may be indicative of firmly

Table 1—*Consensus Statements Showing Agreement*

Statement No.	Consensus Statement	Median	IQR	p Value
1	Workers with asbestos exposure and pleural plaques or diffuse pleural thickening (in the absence of fibrosis) are at increased risk of mesothelioma	9.5	3	0.0001
2	Asbestos exposure can cause diffuse pleural thickening	10	0	0.0001
3	Asbestos exposure can cause pleural plaques	10	0	0.0001
4*	. . . a reliable history of exposure	10	1	0.0001
5*	. . . an appropriate time interval between exposure and detection	9	2	0.0001
6†	. . . . chest roentgenographic evidence of "s," "t," "u" small irregular opacifications of a profusion of 1/1 or greater	6.5	4	0.0112
7†	. . . a restrictive pattern of lung impairment with a FVC below the lower limit of normal	7	3	0.0474
8†	. . . a diffusing capacity below the lower limit of normal	7	3	0.0074
9†	. . . bilateral late or pan inspiratory crackles at the posterior lung bases not cleared by cough	6	3	0.0471
10	A history of asbestos exposure of sufficient duration, dose and latency is likely the cause of interstitial fibrosis in the absence of other explanations	9	2	0.0001
11	Asbestos exposure causes other neoplasms in addition to lung cancer and mesothelioma	7	3	0.0114
12	Identification of asbestos fibers in lung specimens is integral to the histological diagnosis of asbestosis	8	4	0.0175
13‡	. . . chest radiographic changes of profusion 1/1 small irregular opacities or greater or high-resolution CT scanning images in the prone position at lung bases indicating interstitial fibrosis are of value in detecting asbestosis.	8	3	0.0001
14‡	. . . chest radiographic changes of a profusion level 1/0 small irregular opacities are a good screening tool, but lack specificity for an accurate diagnosis of asbestosis. HRCT scanning should be performed to increase the specificity of these chest radiographic findings	7	4	0.0091
15	In an asbestos-exposed worker without asbestosis and with lung cancer, the recognition of asbestosis among coworkers with similar exposures is sufficient to attribute the worker's lung cancer to asbestos exposure	8	1	0.0037
16	Compared to the chest radiograph, an HRCT scan is a more sensitive method for detecting asbestos-related pleural and parenchymal disease	9	2	0.0001
17	Workers who have significant asbestos exposure (but who do not have asbestosis) are at increased risk of bronchogenic carcinoma	9	2	0.0001

*Based on 1986 ATS guidelines.[1] This statement was preceded by "In the absence of pathologic examination of lung tissue, the diagnosis of asbestosis is a judgment based on a careful consideration of all relevant clinical findings. In our opinion, it is necessary that there be."
†This statement was preceded by "These clinical criteria are of recognized value."
‡This statement was preceded by "With a reliable history of exposure and an appropriate time interval between exposure and detection [and in] the absence of pathologic examination of lung tissue."

held diverse opinions. Further, the probability of no consensus was large for this question (p = 0.76).

In the second ATS statement,[17] the authors report that the presence of plaques is associated with a greater risk of lung cancer compared to individuals with similar exposure without such radiographic findings. In this report, there is strong disagreement with that conclusion. Weiss[25] reviewed this issue in

Table 2—*Consensus Statements Showing Disagreement*

Statement No.	Consensus Statement	Median	IQR	p Value
1	Chest radiographs are a sensitive method to diagnose interstitial disease attributable to asbestos exposure	2	3	0.0009
2	Chest radiographs are a sensitive method to measure pleural abnormalities attributable to asbestos exposure	3	2	0.0001
3	Pleural plaques alter lung function to a clinically significant degree	2	3	0.0003
4	Workers with asbestos-induced pleural abnormalities are at increased risk for lung cancer compared to workers with similar exposures without these pleural abnormalities	1	2	0.001
5	Asbestos exposure (in the absence of interstitial fibrosis) leads to COPD	3	4	0.0001
6	A decline in small airway flow rates in a smoker can be attributed to asbestos exposure	2	3	0.0001

Table 3—*Statements Without Expert Panel Consensus*

Statement No.	Statement	Median	IQR	p Value
1	A heavy asbestos exposure (sufficient to cause asbestosis) with sufficient latency is necessary to establish asbestos exposure as causative for lung cancer (clarified from round 1)	2.5	7	0.0994
2	The extent of asbestos exposure correlates with the presence and extent of pleural abnormalities	6	4	0.325
3	A reasonable scheme can be developed to apportion the individual attributability of smoking and exposure in a cigarette smoking asbestos-exposed worker with lung cancer	5	5	0.5907
4	A decline in small airway flow rates in a nonsmoker can be attributed to asbestos exposure	6	6.5	0.7637
5	BAL is a technique for accurately establishing lung fiber burden	5	4	0.252
6	CT scanning of the chest should be used to screen populations at risk for asbestos-related diseases	5	3	0.2445
7	There should be initiatives to develop protocols to attempt therapy for asbestosis	5	5	0.0209
8	Nonsmoking workers with significant asbestos exposure (without asbestosis) have at least double the risk of bronchogenic carcinoma compared to nonsmoking workers with low-level exposure	7.5	4	0.0609
9	Workers who smoke cigarettes and have significant asbestos exposure (without asbestosis) have at least double the risk of bronchogenic carcinoma compared to nonexposed smokers	9	5	0.0031

detail and concluded that lung cancer risk is not elevated among individuals with asbestos-related pleural plaques in the absence of asbestosis.

Issues that remain contentious generally fit into the following several categories: the value of HRCT scanning for screening; the feasibility of protocols for therapy of asbestosis; pleural changes related to asbestos exposure; and the issue of attributable risk for lung cancer due to smoking or asbestos exposure. Of these statements, only one is addressed in the second ATS report. Data were cited showing that large studies of workers with pleural plaques had approximately a 5% mean decline in FVC compared to asbestos workers without pleural plaques. In this report, the experts concluded that the presence of pleural plaques did not decrease lung function to a significant extent.

We suggest that the conclusions reported in Tables 1 and 2 are reasonable and can form a starting point of agreement on the issues regarding the health effects of asbestos exposure. We suggest that there is uniform agreement with the conclusions presented in the first ATS statement[1] regarding the diagnosis of nonmalignant respiratory disease attributable to asbestos exposure.

We suggest that issues regarding asbestos-related pulmonary disease that failed to achieve consensus by the expert panel include the following: the value of HRCT scanning for screening; the feasibility of protocols for therapy for asbestosis; pleural changes related to asbestos exposure; the recognition that a decline in small airway expiratory flow rates in a nonsmoker without asbestosis or COPD cannot be reliably attributed to asbestos exposure; and the issue of attributable risk for lung cancer due to smoking or asbestos exposure. In our group of questions without consensus, a median score at or near the midpoint of the Likert scale, in this instance a score of 5, implies that the experts were unable to either agree or disagree, perhaps in some instances due to the recognition that insufficient information was available to make an informed decision.

Of particular interest is the failure of experts to agree on whether asbestos exposure or asbestosis is the cause of the increased risk of lung cancer in asbestos workers. To begin, the facts that most asbestos-associated cancers occur in those who are cigarette smokers, that smoking represents the strongest identifiable lung cancer risk among many others, and the fact that lung cancer is a relatively common malignancy in industrialized societies make an analysis of the relationship between smoking and asbestos exposure complex.[26] The arguments were initially framed by Mereweather,[27] who showed that lung cancer occurred in 35 of 235 of deaths in which the persons were autopsied (13.2%) where asbestosis was identified. In 1955, the first mortality study of a cohort of asbestos-exposed workers showed that among 105 deaths, lung cancer was found in 18 instances, 15 times in association with asbestosis. In the three instances without asbestosis, the latency periods were 2, 12, and 11 years.[28] Conclusions from these and other reports were crystallized by Browne,[29] who reported there was sufficient evidence to justify the hypothesis that lung cancer in asbestos-exposed workers was due to asbestosis and

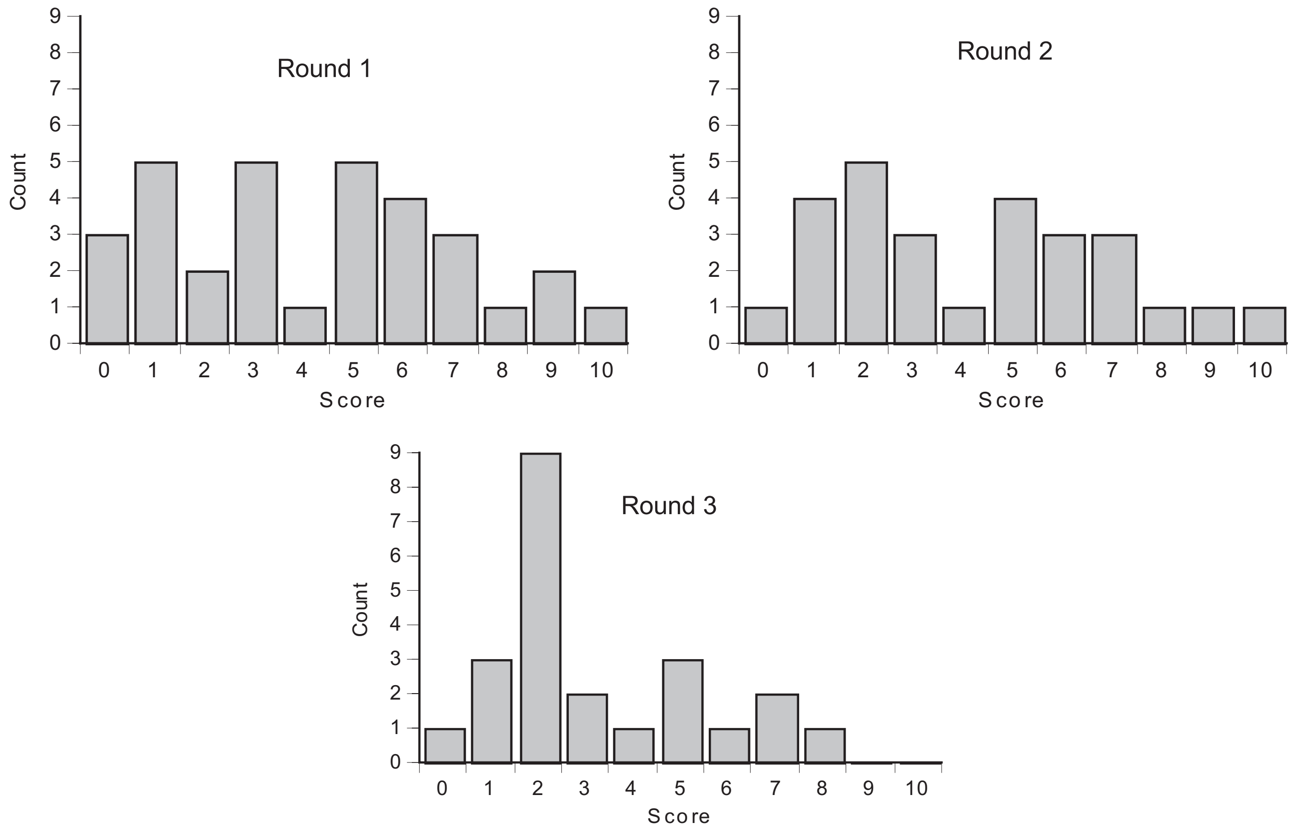

FIGURE 1. The progression of agreement after three Delphi rounds on the statement "Chest radiographs are a sensitive method to diagnose interstitial disease attributable to asbestos exposure." Possible opinion ratings range from 0 (strongly disagree) to 5 (no opinion) to 10 (strongly agree). After three rounds, the median score was 2; the IQR, 3; and the p value 0.001. The expert panel consensus was to disagree with this statement.

not asbestos exposure per se. A metaanalysis by Weiss[30] provided support for this hypothesis. Yet, because few studies cited by Weiss were designed to test the interaction among asbestos exposure, asbestosis, and lung cancer, these studies could be reasonably criticized.[31] Overall, the great majority of surveys that have serially evaluated sufficiently exposed populations over an adequate time have shown that both asbestosis and lung cancer occur at a rate commensurate with exposures, making separation of the duration of exposure and the development of clinically recognizable disease difficult.

The Delphi process used for this consensus document was unique in at least three ways, as follows: the selection of the expert panel was done in an objective manner based on clinically relevant publications using the extensive online database of the National Library of Medicine, PubMed; the survey was conducted via the internet using e-mail and a Web site; and a statistical definition of consensus was developed and used to minimize subjectivity in the interpretation of results. The use of the World Wide Web and e-mail in this context is novel and adds considerable power to the technique by eliminating the need for face-to-face expert panels. The study was conducted internationally, with very little cost. Finally, to our knowledge, a quantitative statistical method of interpreting consensus has not been used in previous applications.

Because the diagnosis of asbestos-related disease is complex and often contentious, we believed it imperative to make the process used in this research as transparent as possible. To this end, all of the original data, including questions, voting results and analysis, expert panel comments, and recommended references are available on the Web site for all three rounds of voting. In addition to providing openness regarding this approach, we hope that making our process so readily available will encourage other investigators to consider using the Delphi process in their research. The Web site address is http://www.sh.lsuhsc.edu/medicine/delphi.

Limitations of the study included the potential for nonresponse bias. The expertise of the panel members is without question, and the mixture of experts from different countries and backgrounds seemed appropriate. However, it is not possible to judge how a different pool of experts would have judged the issues. It is possible that face-to-face discussions might also have achieved different results. It is possible that more iterations of the Delphi process may have achieved a consensus of opinions on all of the statements, but it would have been impractical to do so. Furthermore, some experts were excluded because of their lack of an e-mail address or our inability to locate their e-mail address. We are not certain whether this could affect the outcome of the questions that were posed.

Conclusion

Consensual, independent, and qualitative assessment of clinical topics associated with the health affects of asbestos exposure was utilized after identifying international experts. The Delphi method was employed to provide a systematic approach to achieve consensus on disputed issues in asbestos-related disease. Questions of interest still remain unresolved and indicate areas for future research.

ACKNOWLEDGMENT: We acknowledge the important contributions of our expert panel and thank them for their participation.

Appendix

The following experts agreed to be recognized: Nabil Al Jarad, PhD, Bristol Royal Infirmary, Bristol, UK; Jacques Ameille, MD, Versailles University, Garches, France; Alex Burdorf, PhD, Erasmus MC, University Medical Center, Rotterdam, the Netherlands; Edmond Chailleux, MD, Centre Hospitalier Universitaire de Nantes, Nantes, France; Andrew Churg, MD, University of British Columbia, Vancouver, BC, Canada; Mark R. Cullen, MD, Yale University School of Medicine, New Haven, CT; Paul De Vuyst, MD, PhD, Université Libre de Bruxelles, Brussels, Belgium; Murray M. Finkelstein, PhD, MD, Ontario Ministry of Labour, Toronto, ON, Canada; Kirsti Husgafvel-Pursiainen, PhD, Finnish Institute of Occupational Health, Helsinki, Finland; Matti S. Huuskonen, MD, Finnish Institute of Occupational Health, Helsinki, Finland; Bengt Järvholm, MD, PhD, Umea University, Umea, Sweden; David W. Kamp, MD, Northwestern University Feinberg School of Medicine, Chicago, IL; James Leigh, MBBS, MD, PhD, MSc, MA, School of Public Health, University of Sydney, Sydney, NSW, Australia; Jeffrey L. Levin, MD, MSPH, The University of Texas Health Science Center at Tyler, Tyler, TX; Robert N. Jones, MD, Tulane University School of Medicine, New Orleans, LA; Silvano Neri, MD, Catania University Polytechnic, Catania, Italy; Jean-Claude Pairon, MD, PhD, Centre Hospitalier Intercommunal de Creteil, Creteil, France; Kirsti Husgafvel-Pursiainen, PhD, Finnish Institute of Occupational Health, Helsinki, Finland; William N. Rom, MD, MPH, New York University School of Medicine, New York, NY; Joachim Schneider, Dr Med, der Justus-Liebig Universität, Geissen, Germany; and Xiaorong Wang, PhD, The Chinese University of Hong Kong, Hong Kong, People's Republic of China.

References

1 American Thoracic Society, Medical Section of the American Lung Association. The diagnosis of nonmalignant diseases related to asbestos. Am Rev Respir Dis 1986; 134:363–368
2 Kern DG, Christiani DC, Kelsey KT, et al. Asbestos-related diseases. N Engl J Med 1991; 324:195–197
3 Mossman BT, Gee JB. Asbestos-related diseases. N Engl J Med 1989; 320:1721–1730
4 Camus M. A ban on asbestos must be based on a comparative risk assessment. Can Med Assoc J 2001; 164:491–494
5 LaDou J, Landrigan P, Bailar JC III, et al. A call for an international ban on asbestos. Public Health Rev 2001; 29:241–246
6 Siemiatycki J. Should Canadian health care professionals support the call for a worldwide ban on asbestos? Can Med Assoc J 2001; 164:495–497
7 Weiss W. Asbestosis: a marker for the increased risk of lung cancer among workers exposed to asbestos. Chest 1999; 115:536–549
8 Asbestos, asbestosis, and cancer: the Helsinki criteria for diagnosis and attribution. Scand J Work Environ Health 1997; 23:311–316
9 Oliver LC, Sprince NL, Greene R. Asbestos-related disease in public school custodians. Am J Ind Med 1991; 19:303–316
10 Weill H, Hughes JM. Asbestos as a public health risk: disease and policy. Annu Rev Public Health 1986; 7:171–192
11 Hessel PA, Gamble JF, McDonald JC. Asbestos, asbestosis, and lung cancer: a critical assessment of the epidemiological evidence. Thorax 2005; 60:433–436
12 Hillerdal G, Henderson DW. Asbestos, asbestosis, pleural plaques and lung cancer. Scand J Work Environ Health 1997; 23:93–103
13 Levin SM, Selikoff IJ. Radiological abnormalities and asbestos exposure among custodians of the New York City Board of Education. Ann N Y Acad Sci 1991; 643:530–539
14 Weiss W. Asbestos-related pleural plaques and lung cancer. Chest 1993; 103:1854–1859
15 Browne K, Gee JB. Asbestos exposure and laryngeal cancer. Ann Occup Hyg 2000; 44:239–250
16 Newhouse ML, Gregory MM, Shannon H. Etiology of carcinoma of the larynx. IARC Sci Publ 1980:687–695
17 American Thoracic Society. Diagnosis and initial management of nonmalignant diseases of asbestos. Am J Respir Crit Care Med 2004; 170:691–715
18 Lindstone HA, Turoff M. The Delphi method: techniques and applications. Reading, MA: Addison-Wesley, 1975
19 Fink A, Kosecoff J, Chassin M, et al. Consensus methods: characteristics and guidelines for use. Am J Public Health 1984; 74:979–983
20 Monteagudo JL, Guillen C. Priorities for health professionals in education and training in information technologies: results of a Delphi survey. Paper presented at: First European Conference on Health Telematics Education; September 5–8, 1996; Corfu, Greece
21 Goodman CM. The Delphi technique: a critique. J Adv Nurs 1987; 12:729–734.
22 Dalkey N, Helmer O. An experimental application of the Delphi method to the use of experts. Management Sci 1963; 9:458–467
23 Loughlin KG, Moore LF. Using Delphi to achieve congruent objectives and activities in a pediatrics department. J Med Educ 1979; 54:101–106
24 Baumann MH, Strange C, Heffner JE, et al. Management of spontaneous pneumothorax: an American College of Chest Physicians Delphi consensus statement. Chest 2001; 119: 590–602

25 Weiss W. Asbestos-related pleural plaques and lung cancer. Chest 1993; 103:1854–1859
26 Henderson DW, Rodelsperger K, Woitowitz H-J, et al. After Helsinki: a multidisciplinary review of the relationship between asbestos exposure and lung cancer, with emphasis on studies published 1997–2004. Pathology 2004; 36:517–550
27 Mereweather ERA. Asbestosis and carcinoma of the lung. In: Annual report for the chief inspector for the year 1947. London, UK: Her Majesty's Stationery Office, 1949; 79–81
28 Doll R. Mortality from lung cancer in asbestos workers. Br J Ind Med 1955; 12:81–86
29 Browne K. Is asbestos or asbestosis the cause of increased risk of lung cancer in asbestos workers ? Br J Ind Med 1986; 43:145–149
30 Weiss W. Asbestosis: a marker for the increased risk of lung cancer among workers exposed to asbestosis. Chest 1999; 115:536–549
31 Banks DE, Wang M-L, Parker JE. Asbestos, asbestosis, and lung cancer. Chest 1999; 115:320–322

American College of Chest Physicians Consensus Statement on the Respiratory Health Effects of Asbestos

Daniel E. Banks, Runhua Shi, Jerry McLarty, Clayton T. Cowl, Dorsett Smith, Susan M. Tarlo, Feroza Daroowalla, John Balmes and Michael Baumann

Chest 2009;135; 1619-1627
DOI 10.1378/chest.08-1345