

# Dust diseases and the legacy of corporate manipulation of science and law

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**Background:** The dust diseases silicosis and asbestosis were the first occupational diseases to have widespread impact on workers. Knowledge that asbestos and silica were hazardous to health became public several decades after the industry knew of the health concerns. This delay was largely influenced by the interests of Metropolitan Life Insurance Company (MetLife) and other asbestos mining and product manufacturing companies.

**Objectives:** To understand the ongoing corporate influence on the science and politics of asbestos and silica exposure, including litigation defense strategies related to historical manipulation of science.

**Methods:** We examined previously secret corporate documents, depositions and trial testimony produced in litigation; as well as published literature.

**Results:** Our analysis indicates that companies that used and produced asbestos have continued and intensified their efforts to alter the asbestos–cancer literature and utilize dust-exposure standards to avoid liability and regulation. Organizations of asbestos product manufacturers delayed the reduction of permissible asbestos exposures by covering up the link between asbestos and cancer. Once the decline of the asbestos industry in the US became inevitable, the companies and their lawyers designed the state of the art (SOA) defense to protect themselves in litigation and to maintain sales to developing countries.

**Conclusions:** Asbestos product companies would like the public to believe that there was a legitimate debate surrounding the dangers of asbestos during the twentieth century, particularly regarding the link to cancer, which delayed adequate regulation. The asbestos–cancer link was not a legitimate contestation of science; rather the companies directly manipulated the scientific literature. There is evidence that industry manipulation of scientific literature remains a continuing problem today, resulting in inadequate regulation and compensation and perpetuating otherwise preventable worker and consumer injuries and deaths.

**Keywords:** asbestos, mesothelioma, state-of-the-art, corporate corruption, MetLife, industry knowledge

## Introduction

In 1933, Merewether, the chief UK factory inspector, recognized that asbestos use should be prohibited if it caused disease with “slight” exposure.<sup>1</sup> Despite this early recognition of asbestos in the UK, and similar recognition within the industry in the US,<sup>2–4</sup> adequate asbestos regulation was delayed until well into the 1990s. After industry-sponsored experiments unexpectedly found cancer in mice in the 1940s, disguising the link between asbestos and cancer became a particular concern for the asbestos industry. The American Conference of Governmental Industrial Hygienists (ACGIH) set a precedent for regulation of carcinogens in 1953 when industry representatives identified nickel carbonyl as a carcinogen and immediately reduced its threshold limit value (TLV) to the limit of detection (0.001 ppm). At the 1956 ACGIH symposium, the members developed a consensus that

there was no safe level of exposure if a substance was a carcinogen, and yet the ACGIH “failed to include any acknowledgment of the known carcinogenicity of arsenic, chromates and asbestos.”<sup>5</sup> Owing to this scientific precedent, if asbestos was publicly recognized as a carcinogen, the permissible exposure level would have to be dramatically lowered to a level that would have threatened the production of most products, as manufacturing and use would have resulted in dangerous exposures.

Asbestos product companies would like the public to believe that there was a legitimate scientific debate surrounding the asbestos–cancer link during the twentieth century that delayed adequate regulation. We argue that there was no such legitimate debate, but that the asbestos product manufacturers directly manipulated the scientific literature. They purposefully designed a litigation defense strategy to confuse juries about what was known about the asbestos–cancer link and permissible exposure limits at given points in time.<sup>6</sup>

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This paper follows a previous article published in this journal which argues that Metropolitan Life Insurance Company (henceforth MetLife) had direct involvement in coordinating the industry efforts to manipulate science, law, and policy in the first half of the twentieth century. Associate Medical Director, Dr. Anthony J. Lanza,<sup>1</sup> and MetLife's corporate allies, most of which were members of the Industrial Hygiene Foundation (IHF), acted in concert to manipulate dust disease science and avoid legal liability for the injuries their products caused to workers, consumers, and their family members.

In this follow-up paper, we highlight the ongoing manipulation of science and law by the asbestos product manufacturers, primarily members of the IHF, the American Conference of Governmental Industrial Hygienists (ACGIH), and the Asbestos Information Association of North America (AIA). MetLife, Union Carbide Corporation (UCC), and Johns Manville.<sup>7-9</sup> By the mid 1940s, the international scientific community had recognized the link between asbestos and cancer.<sup>10-18</sup> In the first part of this paper, we discuss how the IHF and ACGIH delayed the recognition of the asbestos-cancer link in the United States. Once the decline in asbestos products sales became inevitable due to the reduction of the OSHA PEL during the 1970s, the companies turned their attention to concocting a litigation defense strategy to avoid legal liability, which we detail in second section. In the final section we conclude that the asbestos-cancer link was deliberately kept secret and discuss the ongoing manipulation of asbestos science.

### Manipulation of Science and "Safe" Standards after 1957: Asbestos Carcinogenicity What was the role of the TLV?

Two things should be noted about the ACGIH's role in delaying the lowering of the asbestos TLV.

First, many asbestos companies understood that the asbestos TLV was an "arbitrary" number based on the

silica TLV, and several of the lead companies, such as MetLife, understood since the 1930s that the original 5 mppcf level did not protect against asbestosis.<sup>19-21</sup> In 1967, I. C. Sayers of UCC studied the available evidence on asbestos health hazards and reported: "It is understood that the maximum dust level of 5 million particles per cubic foot (still adhered to by the U.K. Factory Inspectorate) was proposed by an engineer in 1938 as an interim guide. This figure was an arbitrary choice, and had no experimental foundation."<sup>21</sup>

Secondly, the ACGIH's asbestos TLV, like all such ACGIH guidelines, was not an official governmental, enforceable standard. The ACGIH itself explicitly stated that governmental standards should not be based on TLVs. In other words, industry did not have to follow non-governmental, unenforceable recommendations and government agencies that adopted the TLVs rarely enforced them.<sup>11</sup>

The companies rarely, if ever, relied on the asbestos TLV in an effort to protect workers and we have been unable to locate any instances of companies monitoring worker exposures that resulted from product use before 1965.<sup>23</sup> In 1968, Pittsburgh Corning was the first US company to measure consumer exposures to asbestos that occurred during product use. They found that exposures to its insulation product were as much as 80-fold higher than the 5 mppcf level.<sup>24</sup>

### The Braun-Truan report and its effect on the asbestos TLV

In 1957, Daniel Braun, medical director of the IHF, learned of several published articles that made the connection between asbestos and cancer.<sup>25</sup> This discovery led to the study known as the Braun-Truan report, which was extremely influential in promoting the viewpoint that asbestos was not a carcinogen.<sup>26,27</sup> The deliberate confusion of the asbestos-cancer relationship in the United States contributed to the delay in the reduction of the asbestos TLV by the ACGIH.<sup>28</sup>

The IHF conducted the study under contract from the Quebec Asbestos Mining Association (QAMA) between 1956 and 1957. This cross-sectional study looked at the rates of asbestosis and lung cancer in nearly 6000 miners, using the Quebec province mortality information as a control.

In his private report to QAMA, Braun stated that miners with *asbestosis* had a statistically significant increased risk for developing lung cancer.<sup>30</sup> However, in the published paper, the authors reported the exact opposite.<sup>31</sup>

<sup>1</sup> By the 1950s, Lanza was retired from MetLife but served on the IHF board of trustees and was a member of the IHF Research Advisory Council. He was a professor and later Director of the Institute of Industrial Medicine at New York University from 1947 to 1960, and maintained an official affiliation with MetLife until at least December 1948.<sup>29</sup> He still actively consulted for the companies and lobbied on behalf of continued use of asbestos. He was involved in the firing of Vorwald by Saranac Lab in 1953 and fired Dr. W.E. Smith at NYU for his interest in industrial carcinogens, particularly asbestos, in 1956.<sup>29</sup> W.C. Heuper of the National Cancer Institute wrote to NYU in 1955 complaining of Lanza's influence on his research on chromates and cancer: *Due to these lobbying activities of Dr. Lanza, not only my field studies have come to an end since 1951 but there was for some time serious interference even with my experimental work in the field of occupational cancer because I was not able to continue for some time my cooperative work with the Mutual Chemical Company on blood reactions in chromate manufacturers. It was only after a long delay that I finally succeeded in reactivating this problem... It is my belief, however, that through the intervention of Dr. Lanza, not only the interest of American industries with cancer hazards to workers employed in these industries, but of the American people at large, and of the American medical profession, was seriously damaged.* (W.C. Heuper (National Cancer Institute) to W.E. Smith (NYU) August 24, 1955.)

<sup>11</sup> There were a few pre-1971 exceptions where the federal government adopted a TLV in specific circumstances. A 1952 addition to the Walsh-Healy Public Contracts Act included a 5 mppcf asbestos TLV that applied to workers for government contractors with Federal Supply Contracts. The Department of Labor adopted the 5 mppcf standard for employers by 1960 (under the Longshoremen's Act). These were not enforced.<sup>22</sup>

The original secret report to the companies read:<sup>III</sup>

*On the basis of a careful and detailed study of what are believed to be complete and reliable data, it seems fair to conclude that the asbestos miners at Thetford Mines and Asbestos in the Province of Quebec do not have a significantly higher death rate from lung cancer than do comparable segments of the general population. Despite this, the results suggest that a miner who develops the disease asbestosis does have a greater likelihood of developing cancer of the lung than a person without this disease. We suspect, however, that under-reporting of asbestosis cases had led to a fallacious finding in this connection.* (Emphasis added)<sup>30</sup>

Authors Daniel Braun, the medical director of the IHF, and T. David Truan deleted the underlined sentences from the final published paper, thereby removing all references linking asbestosis to lung cancer:

*On the basis of what are believed to be complete and reliable data, it seems fair to conclude that the asbestos miners in the province of Quebec do not have a significantly higher death rate from lung cancer than do comparable segments of the general population.*<sup>31</sup>

Before the final publication, Dr. Kenneth Smith and Hugh Jackson of Johns Manville wrote that they agreed with the deletions in the report, but that it must be recognized “that this report will be subjected to criticism when published because all other authors today correlate lung cancer to cases of asbestosis.”<sup>33</sup>

The Braun–Truan paper played a crucial role in influencing other experts. On 20 January 1958, in his role as editor of AMA’s *Archives of Industrial Health*, Herbert Stokinger wrote to Braun that he “was particularly pleased to learn the main conclusion of the paper was against the association of lung cancer with asbestosis, for [he] had come to a similar conclusion on obviously far less information but was afraid to say so for this reason.”<sup>28</sup> In his seminal 1960 textbook on occupational diseases, Rutherford Johnstone wrote, “In the United States particularly since the studies of Braun and Truan, there was considerable conviction that asbestosis does not predispose to the development of lung cancer. Until further evidence is forthcoming, we have arbitrarily placed asbestos in the unproved or doubtful group...”<sup>26</sup> In 1961, Johnstone was the official American Medical Association consultant on occupational disease, and he was asked to respond to a question about the relationship between silica and asbestos and cancer.<sup>34</sup> Citing Lanza’s argument that there was a difference between the US and European

experience, he asserted that there was no evidence that asbestos was a carcinogen in the US.<sup>34,IV</sup>

As discussed above, the ACGIH had lowered the TLV of nickel carbonyl after evidence of its carcinogenicity emerged.<sup>37</sup> In the 1950s, Stokinger had argued that standards for carcinogens could protect workers if they were lowered by a factor of 100–500 (lowering by a factor of 500 is in the range of the current OSHA PEL. It is impossible to convert particle counts to fiber counts.).<sup>38</sup> If asbestos was considered a carcinogen, ACGIH could face pressure to lower the TLV to comport with its members’ views that there was no known “safe” exposure level for a carcinogen.<sup>5</sup>

### The OSHA PEL and the Industry Response

In the 1960s, the toll of asbestos cancer in addition to a growing body of work from independent researchers forced a broad recognition of asbestos carcinogenicity. The advocacy efforts of asbestos researcher Dr. Irving J. Selikoff were key to this greater publicity, spurred by his 1964 conference on the harmful effects of asbestos.<sup>39</sup> In the face of this evidence, in 1971 OSHA implemented its first asbestos standard, an emergency PEL of 5 f/cc with a 10 f/cc maximum.<sup>29</sup> In June of 1972, OSHA proposed a reduction of the PEL to 2 f/cc on an 8-hour, time-weighted-average basis, which was eventually implemented in 1976.<sup>29,40</sup> The ACGIH, on the other hand, did not officially accept that asbestos was a carcinogen until 1974.<sup>29,V</sup> After the carcinogenicity was acknowledged, the ACGIH dropped its TLV only six-fold, to 5 f/cc: enough to reduce, but not eliminate, asbestos-caused cancer.<sup>29</sup>

There is no doubt that by the time OSHA set the emergency PEL in 1971, many leaders in the industry understood that asbestos was a serious health hazard and that the ACGIH TLV was an “arbitrary” or “fictitious” standard.<sup>21,41</sup> In an example from that year, a distributor of Union Carbide asbestos wrote to German customers that “Asbestos dust endangers not only the producer of asbestos products, where it is doubted that the as yet fictitious TLV is regarded as reliable, but also can endanger the fabricator of asbestos products and even the population which lives in the neighborhood of the asbestos manufacturers and fabricators.”<sup>41</sup> However, the companies recognized that it would be difficult, if not impossible, to comply with the lower OSHA PELs. Henry E. Moreno, the Senior Operating Vice President of Johns Manville responsible for the company’s Industrial and International Divisions, noted that:

<sup>IV</sup> A few weeks later, another physician George Trimble wrote to JAMA and contested Johnstone’s assertion.<sup>35</sup> Johnstone rebutted Trimble, citing an absence of epidemiologic evidence.<sup>36</sup>

<sup>V</sup> Between 1970 and 1974, ACGIH only had a notice of intent to change the TLV to 5 f/cc.<sup>29</sup>

<sup>III</sup> Each copy of the report was numbered (we have “restricted copy 27”) and the companies’ practice was to ask that all the drafts be returned.<sup>32</sup>

...The cost of redesigning and building equipment to operate at Lomax dust levels increases exponentially – not in a linear fashion. **If the TLV were to be set at two fibers per cc, it would require capital expenditures of \$12 million and additional operating costs of \$5 million per year to bring our operations to the two fiber-per-cc level in those processes where we believe we could develop the capability to do so...**

...At the present time, approximately half of our present dust stations show consistent readings over two fibers per cc. Included in this group are five manufacturing plants, involving approximately 1100 workers. As we see it now, it would not be economically feasible for Johns-Manville to attempt to operate these plants at a standard of two fibers per cc. We estimate that 1100 workers would be out of jobs at those locations. And when you add supporting sales, clerical, research and administrative personnel, we are talking about a total of some 1600 employees who would have to join the unemployed. [Emphasis added]<sup>42</sup>

Of further concern to asbestos companies was the National Institute of Occupational Safety and Health (NIOSH), formed by the same act that created OSHA, proposed warning or caution labels for asbestos products. The National Institute of Occupational Safety and Health originally proposed adding a label that included both the words “cancer” and “danger.”<sup>11</sup> At the OSHA hearings on the asbestos standard (the Goldberg Hearings) in 1972, Matthew Swetonic, who served in public relations for Johns Manville and later as Executive Secretary for the AIA, reported that:

*Such a label would surely spell the demise of a number of major product lines of the industry, including vinyl-asbestos floor tile, asbestos-pipe, and any other product that is sold directly to the consumer market. In addition, there is no doubt that our competitors will attempt to take advantage of the situation by encouraging the public to avoid asbestos-containing products because of the potential health hazards implied in the warning label, even though to the customer no such hazard exists.*<sup>42</sup>

The companies lobbied against the proposed label and the final OSHA standard did not include the words “cancer” or “danger” in the label regulation.<sup>11,51</sup>

During the next decade, the companies had significant debate both internally and during industry-sponsored conferences about what could be done about the asbestos problem. In a 1972 memo, Swetonic wrote to the AIA:

*Because of the generally reasonable regulations issued by OSHA and the 1976 effective date of the two fiber standard, the asbestos industry may be lured into a false sense of security and consider the OSHA battle to be over. This would be a most serious error to make. If we are to convince OSHA that the two fiber standard and other unfavorable sections of the regulations must be changed then we must begin now to develop the medical, technical*

*and economic evidence necessary to prove our point.* [emphasis added]<sup>43</sup>

Once again, the industry convened to challenge the OSHA regulations, avoid legal liability, and undermine negative publicity.

In a 1973 speech to the Asbestos Textile Institute, Swetonic summarized the industry’s fears about the publicity surrounding the efforts of Dr. Irving Selikoff to publicize asbestos-induced cancer: “If the industry permits this interpretation to be disseminated unchallenged, the consequences could be grave indeed.”<sup>44</sup> [emphasis added] Swetonic acknowledged that the insulation workers of Dr. Selikoff’s studies “have been dying from asbestos related disease at an appalling rate,” but instead of finding these consequences problematic for worker health, he continues: “This would be enough to cloud any man’s thinking.”<sup>44</sup> Swetonic did not allow it to “cloud” his own thinking, however, and his speech reflects the hope of the survival of asbestos within the industry:

*And now, having heard the bad side of the public relations problem, it’s time for the good news. And the good news is... despite all the negative articles on asbestos-health that have appeared in the press over the past half-dozen years, very few people have been paying attention.*<sup>44</sup> [emphasis added]

Swetonic went on to applaud the industry for their involvement in convincing OSHA to accept the industry position on 9 of the 11 main requirements in the standards.

However, as substitutes for asbestos, such as fiberglass and cellulose,<sup>29</sup> became more prevalent and the decline in asbestos sales was understood as inevitable, the industry was left primarily with the fear of legal liability. A 1975 memo between Union Carbide managers H.B. Rhodes and W.C. Thurber highlights this fear: “the courts will find a way to assign liability to the producer regardless of the type of warning labels and information dissemination that they have used.”<sup>45</sup> Rhodes’ opinion mirrors the concerns about legal liability evident at the first meeting of the Air Hygiene Foundation in 1935.<sup>46</sup>

In 1984, OSHA proposed new, more stringent regulations. That year, a Union Carbide memo discussed the impact the PEL would have on sales, finding that “we could expect a 31.5% loss in sales if the more stringent regulations [0.2 f/cc] were promulgated,” but that a PEL of 0.5 f/cc would not affect sales.<sup>47</sup> The author of the memo, G.L. Dickson, expressed a greater concern over the “additional adverse publicity which could result, and the possible action by other agencies, such as EPA and CPSC.”<sup>47</sup> It is noteworthy that in 1985 Union Carbide sold their asbestos mine.<sup>48</sup>

In 1986, OSHA did indeed lower the PEL to 0.2 f/cc – considered “the lowest level feasible” at that time.<sup>49</sup> OSHA estimated that cancer mortality

risk for lifetime exposures (45 years) at 0.2 f/cc would be 6.7 deaths per 1000 workers, and 3.36 deaths per 1000 workers at 0.1 f/cc.<sup>49</sup>

By the early 1980s asbestos-related litigation had also mushroomed, as workers exposed on the job began bringing suits against manufacturers. Johns Manville was the first asbestos company to declare bankruptcy due to suits in 1982.<sup>50</sup> In the following section we illustrate how the companies used the existence of the TLV to design a defense against legal liability for the asbestos-caused cancers that appeared after the 20–40 year latency period.

### *The development of the state of the art and TLV defenses*

*“It appeared among the problems common to all industries were the following: (1) the menace of ambulance chasing lawyers in combination with unscrupulous doctors... (2) The desirability of making various dust diseases compensable under properly drawn workmen’s compensation laws. One of the speakers stated that ‘the strongest bulwark against future disaster for industry is the enactment of properly drawn occupational disease legislation.’ Such legislation would (a) eliminate the jury and empower a Medical Board to pass upon the existence of the disease and the extent of the disability; (b) eliminate the shyster lawyer and the quack doctor... (c) permit the correcting of initial mistakes in the making of awards by providing for hearings to reduce or eliminate awards if proof could be adduced that the claimant was not disabled or that the extent of his disability had been overestimated.”*

-Vandiver Brown letter to M.F. Judd on the founding meeting of the IHF.<sup>51</sup>

### **Understanding the SOA and TLV Defense**

State of the art (SOA) is a legal concept that describes what was known or knowable by experts (manufacturers are considered to be experts by law) about the potential hazards of their product(s) at a point in time. (In other words: “Who should have known what when?”) An SOA argument must contextualize the information within the relevant *medical and scientific standards of the times* in which a product was produced in order to correctly interpret what was “known” about a hazard. State of the art is complicated because different people and entities often knew different things at different times. In most states, if a company can convince a jury that they should not have known about a hazard, it then has no duty to warn. “Failure to warn” is the lynchpin of most toxic tort cases.<sup>VI</sup>

In a 1987 seminar for defense attorneys entitled “State of the Art Defense: Is it Real?,” Henry Garrard, a defense attorney, described how defense

counsel should use the SOA defense in asbestos litigation:

*...Although OSHA is a creation of the 1970’s, the basic mindset of the general public is that the government has been involved intricately in control of workplace exposures almost forever. Most of the people today have not grown up in an atmosphere that did not include significant government involvement. This can become a play for state-of-the-art throughout... Probably the final thing to consider is the necessity to warn and the different timings of warnings is to attempt to get the jury to place themselves back in the 1960’s, 50’s, and 40’s with the realization that times were different and expectations were different. Human factors experts or historians in general may be experts that we as defense lawyers have overlooked which might be helpful in making these presentations. Additionally, industrial hygienists who are not medical doctors probably should be used to a greater extent than they are used now to show the newness of that field and how they in fact rely upon the threshold limit value concept in general. After all, the threshold limit value concept is probably the best thing the defense has in its arsenal.<sup>6</sup>*

The asbestos product manufacturer courtroom defense is also based on the argument that manufacturers and downstream companies that used or sold products had no duty to warn of hazards and thus have no liability if their products resulted in exposures were under the TLV. This defense tries to convince juries that the TLV was statutory rather than voluntary and that the government would have intervened to protect workers and the public had the industry’s products exceeded this limit.<sup>6</sup> Essentially they argue that mere existence of a proposed safe level (the TLV) allowed them to escape liability that resulted from injuries that occurred to workers who were exposed to asbestos or asbestos-containing products that the industries sold. However, because the TLV was not health protective for either asbestosis or lung cancer, the companies must also contest the historical acceptance of the asbestos–cancer relationship.

As early as 1976, the AIA – an organization of asbestos product manufacturers and fiber suppliers – gathered to design the SOA defense. The defense was

<sup>VI</sup> As elucidated in *Borel v. Fibreboard Paper Products Corp.* 493 F.2d 1076. No. 72-1492, September 10, 1973 “...the manufacturer is held to the knowledge and skill of an expert. This is relevant in determining (1) whether the manufacturer knew or should have known the danger, and (2) whether the manufacturer was negligent in failing to communicate this superior knowledge to the user or consumer of its product. The manufacturer’s status as expert means that at a minimum he must keep abreast of scientific knowledge, discoveries, and advances and is presumed to know what is imparted thereby. But even more importantly, a manufacturer has a duty to test and inspect his product. The extent of research and experiment must be commensurate with the dangers involved. A product must not be made available to the public without disclosure of those dangers that the application of reasonable foresight would reveal. Nor may a manufacturer rely unquestioningly on others to sound the hue and cry concerning a danger in its product. Rather, each manufacturer must bear the burden of showing that its own conduct was proportionate to the scope of its duty”.

dependent upon the work that MetLife and others had previously done to cover up important cancer and TLV information.<sup>52</sup> The AIA formed a “Legal/Medical Research Program” and stated that “the primary purpose of the Legal/Medical Research Program is to improve the quality of defenses for asbestos companies involved in third party liability suits in tort.” [emphasis added]<sup>52</sup>

They hired Philip Enterline, a professor of biostatistics at the University of Pittsburgh, to conduct a literature review that could be used to contest the date of the acceptance of the asbestos–cancer relationship.<sup>52</sup> This paper would help the companies establish that their reliance on the TLV had been reasonable if they could show the medical and scientific community did not accept the relationship between asbestos and cancer until the 1964 Selikoff conference.<sup>39</sup> At the time the asbestos companies concocted this defense, it was known that exposures after 1964 would not have contributed to any pre-1980 mesothelioma cases due to the twenty-year latency period between exposure and disease manifestation.

By hiring Enterline, the industry successfully developed a SOA defense that only focused on public knowledge published in the United States, ignoring both the European consensus that asbestos was a carcinogen and the unpublished information about cancer that the companies hid from the public for decades.<sup>6</sup> In effect, the companies hired Enterline to “discover” what they could have known had they read the US literature during the time periods in question. The companies withheld all their own studies from Enterline, including the studies that Dr. Leroy Gardner conducted at the Saranac Laboratories in the 1930s. Detailed in our previous paper, Gardner’s experiments found an 81.8% tumor incidence in mice exposed to asbestos.<sup>37,53</sup> MetLife and the brake manufacturing companies agreed that this information should be deleted from the final publication of Gardner’s research (1951) after his death.<sup>37</sup> Despite the withheld information, Enterline’s original monograph, which was given to the AIA in 1978, but not published until 1991, stated that: “Few authors ever expressed doubt about the relationship between this rare tumor [mesothelioma] and asbestos exposure and by 1953, the issue was fairly well resolved.”<sup>54</sup>

However, Enterline’s 1978 published editorial “Asbestos and Cancer: the International Lag” concluded that although European scientists believed that asbestos was a carcinogen, there was no scientific consensus in the US because of “the attitude of leaders in the field of pneumoconiosis, particularly Vorwald, Lanza and Gardner. Their expressed concern was the lack of experimental [animal] data.”<sup>55</sup> Instead of noting the 1953 consensus on mesothelioma, he wrote

that experts in the US were not certain of the link between cancer and asbestos until positive epidemiological studies emerged in 1963 and 1964.<sup>55</sup>

Enterline’s original date of 1953 for the recognition of the asbestos–cancer relationship would have undermined the litigation defense that the US medical community did not generally accept the asbestos–cancer until 1964.<sup>54–56</sup>

After he was presented with the Gardner animal results at a deposition in 1991, Enterline retracted his opinion about any “European North American information lag” and signed an affidavit acknowledging that the scientists had the animal data:

*It is my opinion that if the Gardner findings of an 81.8% tumor incidence in mice exposed to asbestos had been published in a reputable scientific journal, it would have accelerated in this country the acceptance of a causal relationship between asbestos and cancer.*<sup>53</sup>

In 1991, Enterline published the complete version of his 1978 report of defense-funded work, this time including reference to the 1953 consensus on the asbestos–mesothelioma link.<sup>56</sup>

Asbestos companies continue to present Enterline’s earlier lung cancer conclusions to juries in order to cast doubt on the acceptance of the asbestos–cancer relationship. To buttress their argument that the asbestos–cancer relationship was in doubt, defendants cite downstream medical publications (i.e., Johnstone) that in turn had cited the corrupted Braun–Truan paper as evidence to question the acceptance of the asbestos–lung cancer relationship.<sup>26,36,VII</sup>

The SOA defense is used in almost every current asbestos tort suit in the United States.<sup>60</sup> The lead, tobacco, beryllium, chromates, benzene, pesticide, pharmaceutical, and medical device industries have also used their own TLV and SOA defenses in toxic tort suits and regulation.<sup>61–75</sup>

## Discussion and Conclusions

In this two part series, we illustrated how corporations utilized complex techniques to distort scientific literature and manufacture false knowledge to avoid liability and regulation. Through their concerted and often covert efforts, the corporations developed and supported powerful and well-organized networks of medical professionals and lawyers. They created organizations like the IHF and the AIA to use and sometimes manipulate prominent and ostensibly objective experts, including government scientists. The IHF and the AIA blocked the adoption of an adequate TLV, which as Merewether predicted in

<sup>VII</sup> Scientific doubt continued in a new form in the 1990s when the defendants began to use scientists to argue that some forms of asbestos (whichever asbestos form they used) had not been “proven” to cause mesothelioma.<sup>57–59</sup>

1933, would have required prohibition of the use of asbestos. A standard that finally met Stokinger's suggested criterion for asbestos carcinogenicity was not adopted until 1994, when OSHA lowered the asbestos PEL to 0.1 f/cc.<sup>29,76</sup> In the 1994 regulations, which remain in place today, OSHA estimated that lifetime exposures at 0.1 f/cc would reduce excess cancer risk to 3.4 per 1000 workers.<sup>77</sup>

In addition to manipulating the TLV, industry leaders and their lawyers concocted the TLV SOA defense to be used in tort litigation, putting a strategy first conceived in 1935 to use, beginning in the 1970s and continuing through today. The TLV SOA argument that relies on corrupted papers remains the bulwark of the defense long after the corruption has been exposed.<sup>19,78</sup> The litigation continues because the legacy of the corruption is manifested in new cases of fatal cancer that occur more than 40 years after exposure.

This is a classic example of companies foisting externalities of production onto the workers, consumers, bystanders, and family members of those who were sickened by exposure.

Historians working in occupational and environmental health have rightly attended to the way in which the broader historical contexts shaped the understanding and contestation of industrial diseases. However, sensitivity to historical context should not obscure the fact that corporate scientists, such as those discussed here, knowingly and purposefully manipulated science to suit the companies that employed them. Therefore, some conflict over science cannot be properly understood as sincere debates over health effects where all parties shared the goal of protecting workers. It is precisely this view that defense attorneys and corporate scientists would like juries to adopt.

The companies discussed here *consciously* manipulated science, even by contemporaneous standards, and influenced the fundamental principles used to determine cause-effect relationship. Our critical examinations in this paper and the one prior offer evidence to the argument that corporate power and influence is what ultimately delayed scientific output and influenced policies on worker rights and industrial regulation in the asbestos and silica industries.

Our paper is largely based on documents and depositions that companies produced in tort litigation in the US. The use of corporate documents produced in litigation provides a useful perspective on industry practices and reflects general industry practices. Corporate executives and their medical consultants generated these documents, which reflect contemporaneous opinions that the authors never expected would become public. Lawyers for MetLife and the other companies have mentioned and cross-examined one of the authors (David Egilman) at

numerous trials and depositions, and it is unlikely that they have withheld exculpatory materials. However, our search may have missed relevant documents. Those who wrote or produced documents that we referenced often did not have an opportunity to comment on the documents or explain their context. Some were deposed and we have had the opportunity to read many of these depositions.

During the last several decades, researchers in a wide spectrum of fields have documented the direct and purposeful efforts of corporations to disguise public health concerns and affect government policies, particularly in the tobacco, alcohol, silica, and asbestos industries, and more recently, the pharmaceutical, chemical, and ultra-processed food and drink industries.<sup>79,73</sup> Corporate-funded "objective science" leading to the corruption of scientific literature remains a major problem.<sup>65,68,69,71,73,75,80-86</sup> Like MetLife and the efforts of the IHF and AIA, companies in other industries have spawned "scientific controversies" that are rarely legitimate debates; rather, they are the result of fabricated scientific evidence and manufactured arguments about the relative importance and legitimacy of various types of evidence (like epidemiology, mechanistic understanding, pathology, etc).<sup>61-75</sup> Unfortunately, such fabricated debates are the bulwark of defenses that permit corporations to shift the cost of injuries they create onto individuals.

The manipulation of the science surrounding asbestos still continues. Public health researchers, journalists, and activists have documented efforts on the part of asbestos producing and using companies to retain scientists with the purpose of producing papers and lectures that meet industry litigation goals sources.<sup>117,119</sup> We and others have reported instances in which industry-hired authors did not disclose the fact that they were funded by the industry.<sup>117,119-121</sup> Frequently, these consultants make the old argument that asbestos is safe if exposures are kept under the TLV.<sup>122</sup> During the last decade, the companies and their law firms have created a cottage industry of scientific studies that purport to replicate and estimate exposures that occurred between 1930 and 1985.<sup>59,67,87-116</sup> These studies are often performed under idealized conditions, employing methods that are misrepresentative of those seen in the field.<sup>67</sup> Recently (2013) defense lawyers have been involved in the production of studies, the sole purpose of which is to impact litigation. For example, it has been alleged that Georgia Pacific entered into a special employment relationship with Stewart Holm, its Director of Toxicology and Chemical Management.<sup>117</sup> Separate from his regular duties, Mr. Holm confidentially performed research projects under the auspices of its in-house counsel, who also was involved in the pre-publication review process.<sup>117</sup> When studies are

conducted for corporate counsel, the results do not have to be produced during legal discovery and this allows the companies to selectively publish favorable results.<sup>117</sup> In some cases companies have funded “dose-recreation” studies in which the researchers recreate products that have not been sold for over 40 years in an effort to estimate past exposures.<sup>67</sup> These published studies always conclude that exposures were below the ACGIH TLV. However, had the companies actually relied on the TLV, they would have measured exposures contemporaneously and could produce these actual contemporaneous test results in court.<sup>VIII</sup> Companies use this research to argue that countries should not ban asbestos as it has been in Europe and many other locations.<sup>123</sup>

While many countries have now banned asbestos, seven (Russia, Ukraine, Kazakhstan, Kyrgyzstan, India, Zimbabwe, and Vietnam) opposed the listing of chrysotile asbestos at the 2013 Rotterdam Convention conference. The Rotterdam Convention merely requires asbestos suppliers to warn countries of the risks of their products and obtain consent before exporting those products. The asbestos companies hired toxicologist David Bernstein to produce a paper designed to influence the Rotterdam process.<sup>119</sup> Bernstein did not disclose this in his paper.<sup>124</sup>

This continuing corruption of science translates into hundreds of thousands of additional asbestos injuries and deaths worldwide and the accompanying individual and human toll that results.

A 2011 NIOSH report estimated that from 1999 to 2007, there were 23 878 deaths from malignant mesothelioma and 12 794 deaths from asbestosis in the United States alone.<sup>125</sup> The mortality from asbestos-related lung cancer is estimated to be even greater; the ratio of deaths from lung cancer to mesothelioma is at least 1 : 1 and has been suggested to be as high as 7 : 1.<sup>126</sup> The epidemic of asbestos-caused disease in workers persists outside of the United States as well; the annual number of cancer deaths attributable to asbestos in workers worldwide is estimated to be 100 000–140 000.<sup>127</sup>

If we are to improve public, consumer, and worker health it is vital to consider how corporate power is direct, concerted, and often hidden within the structure of scientific society, including the design and output of research, the perceived “experts,” historic accounts, law, policy, and SOA defense.

Through the release of previously confidential documents and depositions, tort suits have opened windows to corporate manipulation of literature on

many other products and some drugs. However, the pharmaceutical and medical device industries have successfully kept many of their secrets.<sup>IX</sup> They have done so by taking the position that all of their documents, study drafts, emails, and depositions are “trade secrets,” including documents that have served as the basis of criminal convictions for violations of FDA regulations. This effectively seals these documents from public view and scrutiny. The courts and plaintiff lawyers willingly agreed to these secrecy agreements, without seeking their clients approval, we agree with Supreme Court Justice Louis Brandeis: “Sunlight is the best disinfectant.” But like any preventive intervention it must be applied as early as possible.

## Disclaimer Statements

**Funding** none

**Conflicts of interest** David Egilman has consulted in asbestos litigation at the request of injured workers and asbestos product mining and manufacturing companies. Tess Bird and Caroline Lee were employed by Dr. Egilman. This study was not funded.

**Ethics approval** None required.

## References

- 1 Merewether ERA. A memorandum on asbestosis. *Tubercle*. 1933;15:109–18.
- 2 Hobart, G, Letter to V. Brown. Hobart and Minard, Newark New Jersey, Dec. 15. 1934.
- 3 Smith W. Proof of death statement of the employer and attending physician, metropolitan life insurance company. Charleston, SC: Standard Certificate of Death, State of South Carolina, Bureau of Vital Statistics, State Board of Health; 1934.
- 4 Gardner L. Outline of proposed monograph on asbestos, Saranac Laboratory Study under Grant from Asbestos Association. 1943.
- 5 Cook WA. Introduction to ‘symposium on threshold limits.’ *Am Ind Hyg Assoc*. 1956;7(3):273–274.
- 6 Garrard HG. State of the art as a defense – is it real? Chicago: Defense Research Institute; 1987.
- 7 Walmer CR. Foundation facts. *Trans Bulletin*, 22nd Annual Meeting of the Industrial Hygiene Foundation, Pittsburgh, Pa: October 30–31, 1957.
- 8 Industrial Hygiene Foundation of America. Members of the Industrial Hygiene Foundation; 1959. Annual Report.
- 9 Industrial Hygiene Foundation of America; 1968. Annual Report.
- 10 Unknown. Environmental cancer. *JAMA*. 1944;126:836.
- 11 Noro L. Occupational diseases. Helsinki: Otava; 1945.
- 12 Macklin MT, Macklin CC. Does chronic irritation cause primary carcinoma of the human lung? *Arch Path*. 1940;30:924–55.
- 13 Wolff A. Asbestosis pulmonum. *Nordisk Hyg Tidskr*. 1940;21:1–40.
- 14 Lecoeur J. L’Etude des cancers professionnelles. *Presse Med*. 1942;50:415–8.
- 15 Levin ML. Epidemiology of cancer. *Am J Public Health*. 1944;34:611–20.
- 16 Tabershaw IR, Bowditch M. Industrial hygiene in 1944. *New Engl J Med*. 1944;231:706–10.
- 17 Heuper WC. Industrial management and occupational cancer. *Occup. Med*. 1946;2:190–200.
- 18 Luton P, Champeix J. Study of asbestosis. *Arch Mal. Profess*. 1946;7:365–78.
- 19 Egilman D, Reinert A. The origin and development of the asbestos threshold limit value: scientific indifference and corporate influence. *Int J Health Serv*. 1995;25(4):667–96.

<sup>VIII</sup> In the case of joint compounds, Kaiser Gypsum actually studied contemporaneous exposures (in 1974) and found that they exceeded the OSHA PEL.<sup>118</sup>

<sup>IX</sup> As an example, see New York Times reports on Zyprexa: <http://www.nytimes.com/2006/12/17/business/17drug.html?pagewanted=all>

- 20 Clark WI, Drinker P. Industrial medicine. New York: National Medical Book Company, Inc.; 1935.
- 21 Sayers, Ian; "Asbestos as a Health Hazard in the United Kingdom." Union Carbide UK Internal Report, 1967.
- 22 Dodson RF, Hammar SP, editors. Asbestos: risk assessment, epidemiology and health effects, 2nd edn. Boca Raton, FL: CRC Press, Taylor & Francis Group; 2011.
- 23 Responses of Defendant Manville Corporation Asbestos Disease Compensation Fund to Plaintiffs' Interrogatories. Virginia: In the Circuit Court for the City of Newport News. D. Garland Moore and William L. Kelley, Plaintiffs, v. H. K. Porter Company, Inc., et al. Defendants. 1994.
- 24 Balzer L, B. Tebbens, and C. C. Report to Health and Safety Committee National Insulation Manufacturers Association. 1971.
- 25 Braun DC. Letter to Hugh Jackson, Industrial Health Program, Johns-Manville; 1957.
- 26 Johnstone RT, Miller SE. Occupational diseases and industrial medicine. Philadelphia: W.B. Saunders Company; 1960.
- 27 Egilman D, Reinert A. Letter to the editor. Arch Environ Health. 2000;55(1):75-6.
- 28 Stokinger HE. Letter to D. C. Braun. Cincinnati: Archives of Industrial Hygiene and Occupational Medicine; 1958.
- 29 Castleman BI. Asbestos: medical and legal aspects, 5th edn. Austin, Boston, Chicago, New York: Aspen Publishers; 2005.
- 30 Braun DC. An Epidemiological Study of Lung Cancer in Asbestos Miners for Quebec Asbestos Mining Association, Quebec, Canada, July, 1956 to July, 1957, Industrial Hygiene Foundation of America, 1957.
- 31 Braun DC, Truan TD. An epidemiological study of lung cancer in asbestos miners. AMA Arc Ind Health. 1958;17(6):634-53.
- 32 Brown V. Letter to Kelly, Executive Vice-President of American Brake Block Division of American Brake Shoe Company, New York, NY; 1943.
- 33 Smith K. Letter to I. Sabourin. Johns-Manville: New York; 1957.
- 34 Johnstone RT. Silicosis and cancer. J Am Med Assoc. 1961;176:1.
- 35 Trimble G. Letter to the Editor. J Am Med Assoc. 1961;178(3):352-353.
- 36 Johnstone R. Letter to the editor from jama consultant. JAMA. 1961;178(1):353.
- 37 D. Egilman TB, C. Lee. MetLife and its corporate allies: dust diseases and the manipulation of science, IJOEH. 2013;19(4):287-303.
- 38 Stokinger HE. Standards for safeguarding the health of the industrial worker. Public Health Rep. 1955;70:1-11.
- 39 Greenberg M. Biological effects of asbestos: New York Academy of Sciences 1964. Am J Ind Med. 2003;43(5):543-52.
- 40 Occupational Safety & Health Administration (OSHA). Occupational exposure to asbestos. Regulatory History. United States Department of Labor. [Cited 2013 October 30]; Available from: [https://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=PREAMBLES&p\\_id=775](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=PREAMBLES&p_id=775)
- 41 Degussa. Letter to German customers. Translated by J. Goddard, 1972 June 14; 1971.
- 42 Public Hearing In the Matter of: Standard for Exposure to Asbestos Dust, Proposed Rule Making, before A. M. Goldberg, Hearing Examiner. Washington, D.C. US Department of Labor 1972 March 16).
- 43 Swetonic M. 1972 June 12, Memo. Asbestos Information Association.
- 44 Swetonic M. Speech to Asbestos Textile Institute. 1973 June 7.
- 45 Rhodes H. B. Memo to W. C. Thurber. 1975 May 30.
- 46 Hitchins, RA. Report and recommendation of the temporary organization committee which was elected at the Symposium on Dust Problems; 1935 January 15; Pittsburgh, PA.
- 47 Dickson GL. Internal memo to J. T. Kelly. Union Carbide Corporation. 1983 October 20.
- 48 Union Carbide Corporation's Responses to Plaintiffs' First Set of Interrogatories and Requests for Production. Charles R. Latham et al. Plaintiffs, v. Garlock, Inc., et al. Defendants. In the District Court of Brazoria County, Texas, 23rd Judicial District; 2001.
- 49 Occupational Safety & Health Administration (OSHA). Occupational exposure to asbestos, tremolite, anthophyllite, and actinolite; Final Rules. Federal Register, June 20 1986;51(119). United States Department of Labor.
- 50 Johns Manville. Company History; 2013 [Cited 2013 December 30]. Available from: <http://www.jm.com/corporate/56.htm>
- 51 Brown V. Letter to M. F. Judd. Re: Mellon Institute of Industrial Research Symposium on Dust Problems. 1935 January 22.
- 52 Asbestos Information Association (AIA) Board of Directors Meeting minutes, Mayflower Hotel, Washington DC; 1976.
- 53 Affidavit of Philip E. Enterline, 1991 March 31. State of Florida; 1991.
- 54 Enterline P. Asbestos and cancer: the first thirty years (Unpublished Draft); 1978.
- 55 Enterline PE. Asbestos and cancer: the international lag. Am Rev Respir Dis. 1978;118(6):975-8.
- 56 Enterline P. Changing attitudes and opinions regarding asbestos and cancer 1934-1965. Am J Ind Med. 1991;20:685-700.
- 57 McDonald JC, McDonald AD. Chrysotile, tremolite, and mesothelioma. Science. 1995;267(5199):776-7.
- 58 Proctor DM, Panko JP, Liebig EW, Paustenbach DJ. Estimating historical occupational exposure to airborne hexavalent chromium in a chromate production plant: 1940-1972. J Occup Environ Hyg. 2004;1(11):752-67.
- 59 Paustenbach DJ, Finley BL, Lu ET, Brorby GP, Sheehan PJ. Environmental and occupational health hazards associated with the presence of asbestos in brake linings and pads (1900 to present): a 'state-of-the-art' review. J Toxicol Environ Health B Crit Rev. 2004;7(1):25-80.
- 60 Hoffman S, Radcliff T. Personal Communication with D. Egilman, 2011 June 30.
- 61 Rosner D, Markowitz G. A 'gift of God'? The public health controversy over leaded gasoline during the 1920s. Am J Public Health. 1985;75(4):344-52.
- 62 Rosner D, Markowitz G. Deadly dust: silicosis and the politics of occupational disease in twentieth-century America. Princeton, NJ: Princeton University Press; 1991.
- 63 Markowitz GE, Rosner D. Deceit and denial: the deadly politics of industrial pollution. Berkeley, CA: University of California Press; 2002.
- 64 Markowitz G, Rosner D. The limits of thresholds: silica and the politics of science, 1935 to 1990. Am J Public Health. 1995;85(2):253-62.
- 65 Pneumoconiosis Case Summaries from the Vorwald Archives, Armed Forces Institute of Pathology, Bethesda, MD. 1952.
- 66 Egilman DS, Bohme SR. A brief history of warnings. In: Wogalter MS, editor. Handbook of warnings. Mahwah, NJ: Lawrence Erlbaum Associates; 2006. p. 11-8.
- 67 Egilman DS, Ardolino EL, Howe S, Bird T. Deconstructing a state-of-the-art review of the asbestos brake industry. New Solutions. 2011;21(4):545-71.
- 68 Egilman D, Bagley S, Connolly S. Anything but beryllium: the beryllium industry's corruption of safety information. Am J Ind Med. 2002;42(3):270-1.
- 69 Egilman DaS, Egilman, D, Scout. Corporate corruption of science - the case of chromium(VI). Int J Occup Environ Health. 2006;12(2):169-76.
- 70 Egilman D. Manipulated data in Shell's Benzene Historical Exposure Study. Int J Occup Environ Health. 2007;13(2):222-32.
- 71 Egilman D. The Beryllium 'double standard' standard. Int J Health Serv. 2003;33(4):769-812.
- 72 Bohme SR, Zorabedian J, Egilman DS. Maximizing profit and endangering health: corporate strategies to avoid litigation and regulation. Int J Occup Environ Health. 2005;11(4):338-48.
- 73 Krumholz HM, Ross JS, Presler AH, Egilman DS. What have we learnt from Vioxx. Br Med J. 2007;334(7585):120-3.
- 74 Ong E, Glantz S. Constructing 'sound science' and 'good epidemiology': tobacco, lawyers, and public relations firms. Am J Public Health. 2001;91:1749-57.
- 75 Michaels D. Doubt is their product: how industry's assault on science threatens your health. Oxford University Press: New York; 2008.
- 76 Occupational Safety and Health Administration (OSHA). Asbestos (all forms). United States Department of Labor. [Cited 2013 June 6]; Available from: [http://www.osha.gov/dts/chemicalsampling/data/CH\\_219600.html](http://www.osha.gov/dts/chemicalsampling/data/CH_219600.html)
- 77 Occupational Safety & Health Administration (OSHA). Occupational exposure to asbestos. Federal Register 1994 October 8;59. United States Department of Labor.

- 78 Castleman BI, Ziem G. Corporate influence on threshold limit values. *Am J Ind Med.* 1998;13:531–59.
- 79 Moodie R, Stuckler D, Montiero C, Sheron N, Neal B, Thamarangsi T, et al. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. *Lancet.* 2013;381:670–79.
- 80 Egilman D, Howe S. Against anti-health epidemiology: corporate obstruction of public health via manipulation of epidemiology. *Int J Occup Environ Health.* 2007;13(1):118–24.
- 81 Egilman D, Kim J, Biklen M. Proving causation: the use and abuse of medical and regulatory negligence inside the courtroom – an epidemiologist’s critique of the judicial interpretation of the Daubert ruling. *Food Drug Law.* 2003;58(2):223–50.
- 82 Egilman D, Mailloux C, Valentin C. Popcorn-worker lung caused by corporate and regulatory negligence: an avoidable tragedy. *Int J Occup Environ Health.* 2007;13(1):85–98.
- 83 Egilman DS, Bohme SR. Chevron-Texaco’s science. *Int J Occup Environ Health.* 2005;11(4):456–7.
- 84 Egilman DS, Ehrle LH. Handling conflicts of interest between industry and academia. *JAMA.* 2003;289(24):3240; author reply 3240–1.
- 85 Egilman DS, Presler AH. Report of specific cardiovascular outcomes of the ADVANTAGE trial. *Ann Intern Med.* 2006;144(10):781.
- 86 Egilman DS, Walta M. Breast implant verdicts resulted from corporate misconduct and legitimate science. *Am J Public Health.* 1999;89(11):1763–4.
- 87 Paustenbach DJ, Richter RO, Finley BL, Sheehan PJ. An evaluation of the historical exposures of mechanics to asbestos in brake dust. *Ann Occup Hyg.* 2003;18(10):786–804.
- 88 Paustenbach DJ, Sage A, Bono M, Mowat F. Occupational exposure to airborne asbestos from coatings, mastics, and adhesives. *J Expo Anal Environ Epidemiol.* 2004;14(3):234–44.
- 89 Mowat F, Bono M, Lee RJ, Tamburello S, Paustenbach D. Occupational exposure to airborne asbestos from phenolic molding material (Bakelite) during sanding, drilling, and related activities. *Ann Occup Hyg.* 2005;2(10):497–507.
- 90 Mangold C, Clark K, Madl A, Paustenbach D. An exposure study of bystanders and workers during the installation and removal of asbestos gaskets and packing. *Ann Occup Hyg.* 2006;3(2):87–98.
- 91 Paustenbach DJ, Finley BL, Sheehan PJ, Brorby GP. Re-evaluation of the size and type of free particulates collected from unused asbestos-containing brake components as related to potential for respirability. *Am J Ind Med.* 2006;49(1):60–1; author reply 2–4.
- 92 Paustenbach DJ, Madl AK, Donovan E, Clark K, Fehling K, Lee TC. Chrysotile asbestos exposure associated with removal of automobile exhaust systems (ca. 1945–1975) by mechanics: results of a simulation study. *J Exposure Sci Environ Epidemiol.* 2006;16(2):156–71.
- 93 Williams PR, Phelka AD, Paustenbach DJ. A review of historical exposures to asbestos among skilled craftsmen (1940–2006). *J Toxicol Environ Health B Crit Rev.* 2007;10(5):319–77.
- 94 Madl AK, Clark K, Paustenbach DJ. Exposure to airborne asbestos during removal and installation of gaskets and packings: a review of published and unpublished studies. *J Toxicol Environ Health B Crit Rev.* 2007;10(4):259–86.
- 95 Williams P, Paustenbach D, Balzer JL, Mangold C. Retrospective exposure assessment of airborne asbestos related to skilled craftsmen at a petroleum refinery in Beaumont, Texas (1940–2006). *J Toxicol Environ Health A.* 2007;70(13):1076–107.
- 96 Finley BL, Richter RO, Mowat FS, Mlynarek S, Paustenbach DJ, Warmerdam JM, et al. Cumulative asbestos exposure for US automobile mechanics involved in brake repair (circa 1950s–2000). *J Exposure Sci Environ Epidemiol.* 2007;17(7):644–55.
- 97 Madl AK, Scott LL, Murbach DM, Fehling KA, Finley BL, Paustenbach DJ. Exposure to chrysotile asbestos associated with unpacking and repacking boxes of automobile brake pads and shoes. *Ann Occup Hyg.* 2008;52(6):463–79.
- 98 Murbach DM, Madl AK, Unice KM, Knutsen JS, Chapman PS, Brown JL, et al. Airborne concentrations of asbestos onboard maritime shipping vessels (1978–1992). *Ann Occup Hyg.* 2008;52(4):267–79.
- 99 Pierce JS, McKinley MA, Paustenbach DJ, Finley BL. An evaluation of reported no-effect chrysotile asbestos exposures for lung cancer and mesothelioma. *Crit. Rev. Toxicol.* 2008;38(3):191–214.
- 100 Madl AK, Gaffney SH, Balzer JL, Paustenbach DJ. Airborne asbestos concentrations associated with heavy equipment brake removal. *Ann Occup Hyg.* 2009;53(8):839–57.
- 101 Hollins DM, Paustenbach DJ, Clark K, Mangold CA. A visual historical review of exposure to asbestos at puget sound naval shipyard (1962–1972). *J Toxicol Environ Health B Crit Rev.* 2009;12(2):124–56.
- 102 Richter RO, Finley BL, Paustenbach DJ, Williams PR, Sheehan PJ. An evaluation of short-term exposures of brake mechanics to asbestos during automotive and truck brake cleaning and machining activities. *J Exposure Anal Environ Epidemiol.* 2009;19(5):458–74.
- 103 Franke K, Paustenbach D. Government and Navy knowledge regarding health hazards of asbestos: a state of the science evaluation (1900 to 1970). *Inhal Toxicol.* 2011;23:1–20.
- 104 Donovan EP, Donovan BL, Sahmel J, Scott PK, Paustenbach DJ. Evaluation of bystander exposures to asbestos in occupational settings: a review of the literature and application of a simple eddy diffusion model. *Crit Rev Toxicol.* 2011;41(1):52–74.
- 105 Finley BL, Pierce JS, Phelka AD, Adams RE, Paustenbach DJ, Thuett KA, et al. Evaluation of tremolite asbestos exposures associated with the use of commercial products. *Crit Rev Toxicol.* 2012;42(2):119–46.
- 106 Berman DW, Sheehan PJ, Bogen KT, Holm SE. More on the dynamics of dust generation: the effects of mixing and sanding chrysotile, calcium carbonate, and other components on the characteristics of joint-compound dusts. *Ann Occup Hyg.* 2012;56(7):852–67.
- 107 Bernstein DM, Decker U, Gaering S, Kunzendorf P, Chevalier J, Holm SE. A Biopersistence study following exposure to chrysotile asbestos alone or in combination with fine particles. *Inhal Toxicol.* 2008;20:1009–28.
- 108 Bernstein DM, Rogers RA, Sepulveda R, Donaldson K, Schuler D, Gaering S, et al. The pathological response and fate in the lung and pleura of chrysotile in combination with fine particles compared to amosite asbestos following short-term inhalation exposure: interim results. *Inhal Toxicol.* 2010;22(11):937–62.
- 109 Bernstein DM, Rogers RA, Sepulveda R, Donaldson K, Schuler D, Gaering S, et al. Quantification of the pathological response and fate in the lung and pleura of chrysotile in combination with fine particles compared to amosite-asbestos following short-term inhalation exposure. *Inhal Toxicol.* 2011;23(7):372–91.
- 110 Brorby GP, Sheehan PJ, Berman DW, Greene JF, Holm SE. Re-creation of historical chrysotile-containing joint compounds. *Inhalation Toxicol.* 2008;20:1043–53.
- 111 Brorby GP, Sheehan PJ, Berman DW, Bogen KT, Holm SE. Potential artifacts associated with historical preparation of joint compound samples and reported airborne asbestos concentrations. *J Occup Environ Hyg.* 2011;8:271–8.
- 112 Brorby GP, Sheehan PJ, Berman DW, Bogen KT, Holm SE. Exposures from chrysotile-containing joint compound: evaluation of new model relating respirable dust to fiber concentrations. *Risk Anal.* 2012.
- 113 Sheehan PJ, Berman DW, Bogen KT, Holm SE. Chamber for testing asbestos-containing products: validation and testing of a re-created chrysotile-containing joint compound. *Ann Occup Hyg.* 2011;55(7):797–809.
- 114 Jones SB. Development and evaluation of a semi-empirical two zone dust exposure model for a dusty construction trade. *J Occup Environ Hyg.* 2011;8:337–48.
- 115 Jones SB. Comparing two-zone models of dust exposure. *J Occup Environ Hyg.* 2011;8:513–9.
- 116 Simmons JB. Factors influencing dust exposure: finishing activities in drywall construction. *J Occup Environ Hyg.* 2011;8:324–36.
- 117 Matter of New York City Asbestos Litigations 2013 NY Slip Op 04127, Decided on 2013 June 6, *Weitz & Luxenberg P. C., Plaintiffs, Respondents v. Georgia-Pacific LLC, Defendant-Appellant*, (2013).
- 118 Sheehan JS. J. S. Sheehan (Antioch R & D) to G. B. Kirk (Oakland). Kaiser Gypsum Company, Inc. Inter-Office Memorandum, 1974 March 1.
- 119 Videotape Deposition of Bobby Joe Pigg. 2013 June 18. *Ronald C. Nelson and Joanna Nelson vs. Allied Packing & Supply Inc, et al.* In the Superior Court of the State of California in and for the County of Alameda.

- 120 Noorden RV. Toxicologist denies wrong-doing in asbestos case. Nature News Blog, 2013 Oct 8. [Cited 2013 Oct 30]; Available from: <http://blogs.nature.com/news/2013/10/toxicologist-denies-wrong-doing-in-asbestos-case.html>
- 121 Toxicology I. Corrigenda. *Inhalation Toxicol.* 2012;24:80.
- 122 Galvao A, Coelho E. Researchers absolve asbestos used in Brazil. *O Estado de Sao Paulo*. 1999.
- 123 Morris J. Exporting an epidemic: human toll reaches millions as asbestos industry expands worldwide. 2010 July 21,. [Cited 2013 October 12]; Available from: <http://www.publicintegrity.org/2010/07/21/3401/exporting-epidemic>
- 124 Bernstein D, Dunniga J, Hesterberg T, Brown R, Velasco JAL, Barrera R, et al. Health risk of chrysotile revisited. *Crit Rev Toxicol.* 2013;43(2):154–83.
- 125 Bang KM. Asbestosis and malignant mesothelioma mortality in the united states: an update. American Public Health Association Annual Meeting; 2011; Washington, DC.
- 126 LaDou J. The asbestos cancer epidemic. *Environ Health Perspect.* 2004;112(3):285–90.
- 127 Ramazzini C. Asbestos is still with us: repeat call for a universal ban. *Int J Occup Environ Health.* 2010;16: 351–5.

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