

LETTER TO THE EDITOR

# Letter to the Editor: “Comparing milled fiber, Quebec ore, and textile factory dust: Has another piece of the asbestos puzzle fallen into place?” by D. Wayne Berman

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We read with interest Dr. Berman’s article “Comparing milled fiber, Quebec ore, and textile factory dust: Has another piece of the asbestos puzzle fallen into place?” (Berman, 2010). We agree with Dr. Berman’s conclusion that sizes of airborne asbestos fibers encountered in asbestos textile mills are very different and might entirely explain the discrepancy in the findings between the studies of the textile workers and miners. However, we do not agree with Dr. Berman’s analyses of our transmission electron microscope (TEM) data for the Charleston, South Carolina, asbestos textile plant to support his conclusion that airborne fiber size distributions within a given industrial sector (e.g., textiles, friction products, cement, etc.) vary little by operation. We believe this conclusion is not consistent with known effects of asbestos textile production operations, is not supported by prior studies, and is not consistent with results of studies of asbestos textile mills in South Carolina and North Carolina.

A review of asbestos textile processes would not lead one to conclude that airborne fiber characteristics would be the same across departments. The *Handbook of Asbestos Textiles* (ATI, 1961) provides a detailed description of asbestos grades and processes involved with production of asbestos textiles. With regard to Grade 3 chrysotile used by Dr. Berman in his experiments, the ATI publication states that these fibers were “... passed through a vertical opener or rotating toothed cylinder known as a willow that effects finer fiberization. After additional treatment by means of specifically designed opening equipment and further screening to remove fibers too short for textile purposes, the fibers are ready for blending and mixing purposes.” Carding further opens the fibers by application of energy through

the teasing action of needle-pointed wires that cover the machine cylinders. It is clear that additional short fibers are removed during processing of the Grade 3 fibers used by Dr. Berman.

Additionally, Dr. Berman’s conclusion is not consistent with prior studies, including the 1938 study of North Carolina asbestos textile plants (Dreessen et al., 1938). These authors commented on the highly variable gross and microscopic appearance of airborne dusts collected in the various textile departments. Fibers were counted and sized in the Owens jet samples by optical microscopy using an oil immersion lens to increase microscope resolution. The percentage of fibers in the dusts range from 1% in fiber preparation (crushing) to 26% in weaving and mean fiber length ranged 7.0  $\mu\text{m}$  in fiber preparation (willowing) to 16.3  $\mu\text{m}$  in weaving.

Lynch and Ayer (1966) measured total fibers, fibers  $>5 \mu\text{m}$ , and fibers  $>10 \mu\text{m}$  by phase-contrast optical microscopy in US asbestos mills and found the ratio of concentrations of fibers  $>10 \mu\text{m}$  to total fibers to progressively increase from preparation to weaving. In fiber preparation, fibers  $>10 \mu\text{m}$  accounted for only 18.6% of airborne fibers counted by phase-contrast microscopy (PCM), whereas 38.7% of total PCM fibers were longer than 10  $\mu\text{m}$  in weaving. Although these prior studies did not have the advantage of TEM analyses, the weight of the evidence is not consistent with Dr. Berman’s conclusion that airborne fibers across textile departments share a common size distribution.

Finally, Dr. Berman’s analyses and results are not consistent with results of our studies of asbestos textile mills in South Carolina (the Charleston plant) and North Carolina. For the epidemiologic studies of South Carolina and North Carolina

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asbestos textile workers, we developed airborne fiber size-specific exposure estimates based on TEM analyses of archived membrane filters (Dement et al., 2008, 2009). Our TEM protocol was based on modifications of the ISO direct transfer method (ISO, 1995; Dement et al., 2008). TEM analyses were both time-consuming and expensive; therefore, we made an a priori decision to combine TEM samples within a given department (exposure zone) in order to arrive at overall estimates of department-specific bivariate diameter/length distributions. We also included as many samples as possible within a department in order to minimize the effects of sample-to-sample variability. Given the extremely varied density of fibers on each filter and three counts by fiber size for each filter (all structures, structures  $>5 \mu\text{m}$ , and structures  $>15 \mu\text{m}$ ), we developed procedures for combining the data across counting strata that did not depend on fiber density (Dement et al., 2008).

Dr. Berman performed a number of statistical analyses of the Charleston plant samples that violated our study design and draws into question validity of his analyses and conclusions. First, Dr. Berman attempted to calculate bivariate size distributions for *each* of the 83 TEM samples. As discussed previously, our a priori study design required that individual samples within a department be combined in order to reasonably estimate the bivariate size distributions (Dement et al., 2008). Dr. Berman chose to ignore our study design in his analyses, which accounts for *individual* samples with zero structure counts for some combinations of diameter and length commented on by Berman numerous times in his article. We do not believe calculation of bivariate size distributions on these *individual* samples is a valid statistical exercise.

Dr. Berman argues that the various departments within the Charleston textile mill do not differ significantly with regard to airborne fiber size based on his simulation study, in which the 83 samples were randomly regrouped into 10 new “hypothetical” zones. This exercise is problematic for several reasons. First, it appears that the samples within these then new “hypothetical zones” discussed by Dr. Berman were combined based on his fiber density method (described on p. 162). Using his procedure, filters with very high fiber loading would be given much more weight and would have a much more profound influence on the resulting size distributions. We chose not to use the density method for this reason. Secondly, Dr. Berman apparently combined all diameter categories within a given fiber length category in his analyses (p. 176 and Table 7) and he used numerous two-sample Mann-Whitney tests for most of his analyses; thus he never actually conducted an overall test of differences in bivariate size distributions. A more appropriate statistical test to compare differences in bivariate size distributions across departments is a likelihood-ratio chi-square based on a multinomial distribution, which strongly rejects the null hypothesis ( $p < .001$ ).

A final argument against Dr. Berman’s conclusions lies in the results of the analyses of lung cancer risk by TEM

fiber size (Stayner et al., 2008). In these analyses, fiber size-specific exposure estimates were used in risk models to explore asbestosis and lung cancer risk by fiber size category. Although all fiber size categories were found to be significant predictors of risk, longer and thinner fibers were found to be stronger risk predictors. If Dr. Berman’s conclusion that airborne fibers in textile operations are not different in size characteristics, use of our size-specific estimates should have simply introduced more noise and mask differences by fiber size—which did not occur. Similar results have now been obtained in studies of three asbestos textile plants in North Carolina (Dement et al., 2009; Loomis et al., 2009).

Although Dr. Berman’s Modified Elutriator Method offers a potentially useful tool for exploring relatively large differences in size distributions between industry sectors, this method cannot detect size differences within a given sector without additional considerations. Dr. Berman has not convincingly shown that airborne fibers sizes across textile departments are the same and it is difficult to see how the current elutriator method could be used to study operations like friction or cement products where the raw asbestos fibers are incorporated into a solid matrix. In these industries dust characteristics in the initial mixing and blending operations of raw fiber would be expected to be different from those experienced in cutting, drilling, and sanding operations where high levels of energy are applied to fibers embedded in a solid matrix.

We do not wish to convey the impression that Dr. Berman’s elutriator method is without merit for further studies that seek to investigate differences in airborne fiber characteristics and their association with health effects. It was appropriate and very informative to use these methods in his study to elucidate differences in the fiber size distribution between bulk samples from the Quebec mines and those used in the textile industries. However, it is important that both strengths and weaknesses in this approach be recognized. Airborne fiber characteristics are best determined using filter samples from the industries in question; however, this may not always be possible or feasible. Variability in bivariate airborne size distributions may well be greater between industries compared to within industries; however, additional research is needed for this determination.

## Declaration of interest

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