

Public health risks from asbestos cement roofing

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Abstract

There is no identified risk-free threshold exposure to asbestos. Based on epidemiology and toxicology, asbestos fiber dimensions have been implicated in causing asbestos-related diseases. Phase-contrast microscopy provides only a limited index of exposure to fiber dimensions implicated in mesothelioma induction. Installed asbestos-containing materials (ACMs) create an ongoing risk of intense exposure during natural disasters and remodeling, along with low-level exposure arising from the continual emission of airborne asbestos into the environment arising from weathering of installed ACM. Epidemiological studies have demonstrated a risk of disease associated with proximity to asbestos cement roofing (ACR), while ongoing environmental emissions of asbestos from installed ACR have also been demonstrated. Owing to the limitations of the available data, a precautionary approach is warranted; asbestos-free roofing materials should be used in new construction and existing ACR should be removed at the earliest opportunity.

KEYWORDS

asbestos cement roofing, dust diseases, environmental exposure, mesothelioma

1 | INTRODUCTION

The manufacture and installation of asbestos-containing building materials (ACM) inevitably result in exposure to asbestos for employees involved in the manufacture of ACMs and construction workers installing or remodeling ACMs. The serious risk of asbestos-related disease (ARD) for workers in these sectors is well recognized, having been established in numerous epidemiological studies.^{1,2} A large population continues to be at risk of exposure to asbestos from asbestos emitted into the environments from natural weathering of installed ACM.^{3,4}

Based on epidemiological and toxicological considerations, many bodies have concluded that all forms of asbestos are carcinogenic without a documented threshold exposure free from the risk of disease.⁵⁻⁸

The British Thoracic Society⁶ states that:

There is no evidence for a threshold dose of asbestos below which there is no risk. However, the risk at low levels of exposure is small.

Based on the limitations of epidemiological studies, Hodgson and Darnton⁹ considered that "Direct statistical confirmation of a threshold from human data is virtually impossible."

The Australian Faculty of Occupational Medicine guide on Occupational Cancer⁷ notes that nearly all cases of mesothelioma are asbestos-related and that:

The implication is that mesothelioma can arise from asbestos levels close to background levels (ie the low levels in the general environment to which all urban dwellers are exposed).

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It is sometimes claimed that ACMs in good condition poses no measurable risk to health.¹⁰ However, the measurability or not of risk gives no indication of the public health significance of the risk. There is a very large population of people who live or work around ACMs, and given the limited power of epidemiology to detect small increments in risk, a nonmeasurable risk to health may still have significance as a public health issue, particularly given the ongoing deterioration of some ACMs such as external asbestos cement roofing (ACR) and cladding.

2 | ASBESTOS FIBER DIMENSIONS FOR DISEASE AND LIMITATIONS OF EXPOSURE ASSESSMENT

Lippman has reviewed epidemiological and toxicological studies in an attempt to identify fiber dimensions most strongly implicated in causing ARD, which is summarized in Table 1.¹¹ There is also evidence that short fibers are relevant in ARD induction, with studies reporting that the majority of fibers found in lung or tumor tissue are shorter than 5 μm .^{12–14} Loomis found an association between lung cancer risk and exposure to asbestos fibers of all length classes (as measured by TEM), with the strongest association for exposure to fibers 20–40 μm in length. Owing to correlations between short and long fibers in the TEM samples, it was not possible to isolate the role of short fibers in lung cancer risk.¹⁵

Occupational exposure to asbestos is typically assessed using phase-contrast optical microscopy (PCOM) Using PCOM, it is possible to resolve fibers with diameters greater than about 0.25 μm (double the diameter of fibers implicated in mesothelioma induction), while fibers shorter than 5 μm are not counted.^{16,17} The selection of 5 μm as the cut-off for length for PCOM was chosen in the 1960s,¹⁸ while the diameter cut-off is an inherent limitation of PCOM. It follows from this that measurements of exposure made by PCOM are only a limited *index* of exposure to asbestos, and whatever role short thin fibers play in disease induction, exposure assessment by PCOM may not provide a meaningful measure of the exposure to the fiber dimensions involved in ARD risk. Figure 1 shows the fiber dimensions implicated in ARD induction and exposure assessment by PCOM.

It can be seen that none of the fibers implicated in mesothelioma induction are counted when PCOM techniques are used to assess exposure. This practical limitation of PCOM techniques to assess environmental exposure was demonstrated by Lanting and den Boeft¹⁹ who found that nearly all the chrysotile fibers detected in ambient air 400 m away from an asbestos cement plant were too small to be detected by PCOM.

Despite the practical absence of meaningful measurements of ambient exposure to asbestos in the vicinity of asbestos factories, the association between residences close to asbestos factories and ARD is well-established. In 1965, the first reports were made of the increased incidence of mesothelioma in residents living in proximity to asbestos factories in London (UK).²⁰ Since then there have been similar reports in Hamburg (Germany),²¹ Broni (Italy), Amagasaki (Japan),²² Sibaté (Colombia).²³ Press reports highlighted many cases of ARD in residents

TABLE 1 Fiber dimensions and ARDs

ARD	Diameter (μm)	Length (μm)
Fibrosis	<3	≥ 5
Mesothelioma	<0.1	≥ 5
Lung Cancer	>0.15	>10

Abbreviation: ARD, asbestos-related disease.

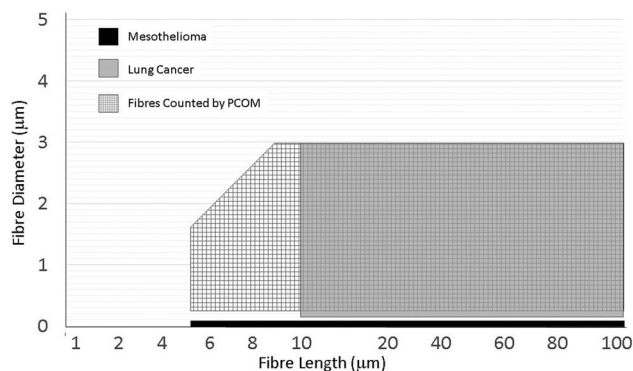


FIGURE 1 Fiber dimensions associated with mesothelioma and lung cancer induction and the limitation of exposure assessment by phase-contrast optical microscopy (PCOM)

who had lived around an asbestos cement factory in Sunshine North (Australia)²⁴; while cancer registry data supported an elevated incidence of mesothelioma around the factory, the registry only held data on residence at the time of diagnosis and would not have included cases who moved away after being exposed as children.²⁵

3 | ASSESSMENT AND CONTROL OF EXPOSURE IN OCCUPATIONAL ENVIRONMENTS

As asbestos is a carcinogen without a verified threshold exposure, asbestos exposure should be minimized to the maximum extent possible. Control of exposure to asbestos in occupational contexts should be based on the hierarchy of control.

Considering the ready availability of substitutes, substitution should always be considered the most appropriate control measure. Relatively effective engineering controls can be implemented in workplaces manufacturing ACM. However, it is very difficult to implement effective engineering controls and/or use PPE when ACMs are installed during construction work. Even with control measures in place, ACM manufacturing workplaces with airborne fiber levels compliant with exposure standards (as measured by PCOM) may still have significant levels of asbestos fibers with dimensions capable of inducing ARD; including mesothelioma. A full assessment of the effectiveness of control measures in occupational environments should involve the assessment of submicroscopic fibers using electron microscopy (Figures 2 and 3).

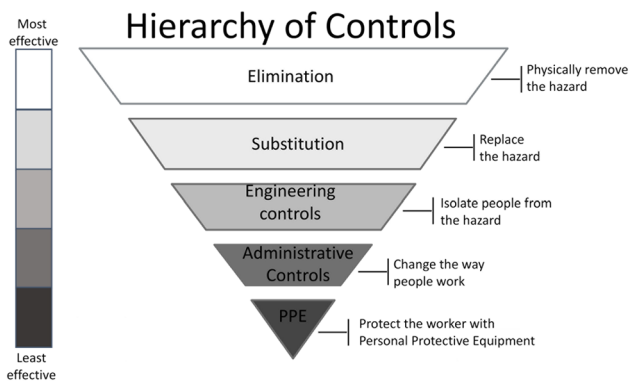


FIGURE 2 Hierarchy of control. Source: CDC

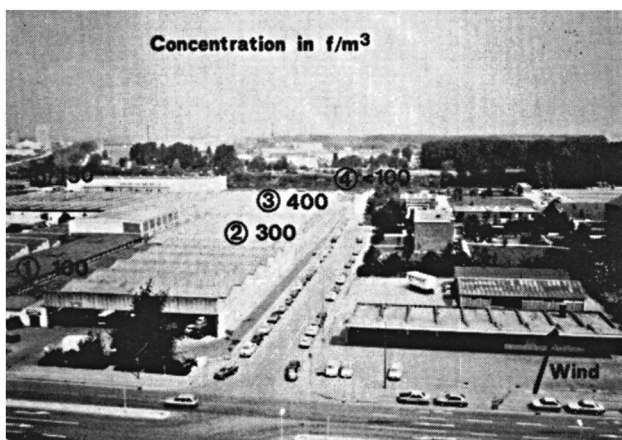


FIGURE 3 Elevated airborne asbestos fiber levels above an asbestos cement roof. Source: Teichert³⁰

3.1 | Ongoing exposure from installed ACMs

Wherever ACM has been installed, their very presence creates an ongoing risk of exposure to asbestos and consequent ARD. Relatively high levels of exposure can occur during direct active disturbance to ACM during the remodeling of structures²⁶ or following natural disasters.²⁷

In Sri Lanka, asbestos-roofing material has been extensively used since the 1960s. Following the December 2004 tsunami in Sri Lanka, many workers involved in the large-scale clearing of debris were exposed to large quantities of damaged ACM. Wickramatillake et al. screened 230 self-selected asbestos-exposed workers, including construction workers, tsunami debris clearing workers, and demolition workers. Lung fibrosis was observed in 6 out of 8 tsunami debris workers and 6 out of 12 building demolition workers.²⁸ It is very difficult to implement effective control measures in remodeling and disaster situations as the presence of ACM may not have been identified and/or the implementation of effective control measures may hamper urgently required humanitarian works.

In addition to intense exposure from active disturbance to ACM, the weathering of installed ACR results in ongoing passive emission of asbestos into the environment and exposure to members of the

public. The ongoing contamination of ambient air from the weathering of ACR was first demonstrated in 1979,²⁹ and has been reported on many occasions since.^{3,30–34}

Spurny measured asbestos fiber levels by scanning electron microscope and measured fiber emission rates from wind erosion of up to 14,000,000 f/m²/h for fibers >5 μm long; most of the fibers would not have been visible using PCOM.^{31,32} In addition to weathering by wind erosion, significant quantities of respirable asbestos fibers are dispersed by runoff after rainfall events. This leads to local contamination of soils and hard surfaces. On drying, fibers can be re-aerosolized from hard surfaces, while asbestos-contaminated soil can be tracked indoors.

Emissions of asbestos from weathering of ACR have been estimated for each administrative district in South Korea; and it is calculated that each year, such weathering releases almost a million tonnes of asbestos fibers into the environment.³⁵ Chrysotile fibers released by weathering has not been significantly altered,³⁶ and in animal testing weathered chrysotile fibers from asbestos cement retain their carcinogenic potential.³⁷

4 | HEALTH RISKS FROM PASSIVE ENVIRONMENTAL EMISSIONS

There are a number of epidemiological studies that indicate that there is a measurable risk to health from ACR materials. In 2000, Magnani reported a statistically significant increased risk of mesothelioma for people domestically exposed to asbestos, including six cases where the only apparent source of exposure was from residing in a home with an ACR.³⁸ In 2001, Magnani reported an elevated risk of mesothelioma for living in a home with ACR, the elevated risk approached statistical significance.³⁹ The cases included in this study were different from the earlier 2000 Magnani study. Ferrante has reported a statistically significant increase in the risk of mesothelioma for living in a building with an ACR, or for living near large asbestos cement-clad buildings.⁴⁰ The cases included in this study were not included in the two studies by Magnani. The implications arising from the increased risk of mesothelioma reported in these studies are somewhat unclear, as all three studies took place in regions that had previously had asbestos cement manufacturing plants.

In 2018, Kang et al. demonstrated an association between living in an area with a high density of asbestos roofing and lower lung fibrosis and pleural disease; however, this study was not controlled for potential confounders.⁴¹ The studies on environmental health risks from proximity to ACR make no reference to the condition or disturbance of the ACM, and it is likely that the predominant exposure from ACR would have arisen from natural weathering.

5 | CONCLUSION

Over 60 countries have banned the new use of all types of asbestos.⁴² However, there remain countless residential, commercial, and industrial structures with ACR that will continue to deteriorate and emit

fibers into the environment an which also have the potential to generate high airborne fiber levels during remodeling or during recovery following natural disasters. Research to date has demonstrated an increased risk of disease to residents likely to be affected by emissions from ACR. While some studies are complicated by the presence of other potential sources of exposure, given the demonstrated extent of environmental emissions of asbestos caused by the weathering of asbestos roofing and the absence of a verified threshold for ARD induction; it is biologically plausible that asbestos roofing can cause ARD in members of the general public. There appears to be limited opportunity to control the environmental emissions of asbestos roofing. Based on the precautionary principle,⁴³ asbestos-free roofing should be used for new construction and existing ACR should be removed under controlled conditions at the earliest opportunity.

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CONFLICTS OF INTEREST

Michael Kottek has prepared expert reports and given expert testimony for plaintiffs with asbestos-related disease and defendant companies in asbestos litigation. Man Lee Yuen declares no conflicts of interest.

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John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

Michael Kottek conceived the article. Michael Kottek and Man Lee Yuen draft reviewed and approved the article.

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary references.

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