Thursday 8 November 2018
Welcome to the Faculty of Asbestos Assessment & Management Conference

Thank you to our sponsors & exhibitors
The first year

• 278 members
• Newsletter launched
• e-bulletins
• The first Professional Discussions (online) have been held
• Representation & presentation – industry forums / working groups
• A two day scientific conference
278 with a recognised professional status
The second year

• Membership expected to continue grow
• The development of position papers, guidance etc. as necessary
• Your chance to get involved
  • The first elections for the FAAM Board
  • PEP reviewers
  • Professional discussion interviewers
  • Articles, guidance etc.
  • Working groups
The GMB, a union representing workers, is calling for all asbestos to be removed by 2028. This is to protect future generations from the deadly effects of asbestos-related diseases. The call for action is part of a broader campaign to improve workplace health and safety. The GMB has been advocating for better regulations and higher standards to ensure the safe removal of asbestos.
Jeff Friar (1937 to 2018)

• HSE Superintendent Specialist Inspector
  • 1976 to 1997
• Consultant and Trainer (ARCA)
“In the early 70s HSE specialists were called out to a school which had a problem consisting of a cloud of blue dust clearly visible during playtime. We measured above the control limit in the open air and resolved the problem by concreting over the whole school playground which we believed to have been an abandoned tip.”

Dr Jeff Friar ex-HSE Superintendent Specialist Inspector
Mavis Nye. BCA
President

The
Mavis Nye Foundation
• Out to Guernsey in this.

Back Home in this.
Invitation to Talk to Influential people in Guernsey
Conference explains dangers of asbestos

A conferencing held last Tuesday explained the dangers of asbestos for woman who has it in her system for 25 years. Before it had symptoms, it was rare to find.

The event at St Peter Port Hotel included guest speakers, who had been affected by asbestos-related illnesses and helped raise awareness of the dangers.

One such speaker was Marie Nye, who was exposed to the substance in the workplace, only to find out the effects of asbestos 40 years later.

"My husband Ray worked in the docks in the 1970s, and we were cutting the steel," she said.

When we got married I tried to wash some clothes I'd had to wash, and it just didn't come off," she said.

"I thought it was just dust," she said.

"It wasn't until ten years ago that I found that I couldn't breath, my doctor contacted me about a scan I was having and he said I have a mass in my lung."

Then, I had scans for fluid.

My wife has since been diagnosed with lung cancer, mesothelioma, which is a rare cancer that is directly associated with exposure to asbestos.

I am here to agree that every single one of these people from all walks of life and they just don't use the dangers and it doesn't show until much later," she said.

There is always hope."

Many has started a foundation to raise money to give to scientists who are studying research into developing cure for mesothelioma.

"The worst is hearing from a variety of industries including insurance, surveyers, builders, and plumbers."

".event organiser, and owner of asbestos removal company, ASR, Paul Knight, said: "This is to give people a bit more knowledge."

It just through an awareness course, as a lot of people are misinformed and generally told the wrong thing."

"So I thought these speakers over to try and educate people on the planet and give them a bit more insight."

People are more aware now if you ask them, they know if you give them place."

The key thing today is to one person comes away taking something on board it's a success. If it's more, brilliant."
Diffuse mesothelioma payments

Overview

You may be able to get a payment if you’ve been diagnosed with the asbestos-related disease, diffuse mesothelioma.

There are 2 types of payment you can claim for:

- diffuse mesothelioma payments (the ‘2008 scheme’)
- the Diffuse Mesothelioma Payment Scheme (DMPS)

You can claim DMPS if you cannot find the employer responsible for your contact with asbestos, or their insurer.
Paul Knight ASR Supporter in Guernsey
2 Minutes of Silica Danger
Trade Unions' International Alliance "Chrysotile" Welcomes the Use of Chrysotile in the Space Industry
1st Person in the World to re Challenge

Immunotherapy
Comparison between beard stubble and hazardous fibrous materials under a microscope
Get a Face Fit Test
Oh dear! Demolition. I have a passion for Crowd Control. I see too many video`s Showing Bystanders covered in Dust.
Only things Left are Rubble and Damaged Lungs
Seen Recently in my Road
I could not believe my eyes
Education

Is he Educated
Me in my Dreams as I see Myself.

AS They see me!
The Mavis Nye Foundation will Issue its first grant for Research in March 2019
Thank you for Listening.

And now before I Close

• A little Jingle that Ray put together.
  • Enjoy
Do you know if your child's school has any asbestos in schools?

You can ask to see the Asbestos Register you know. It's not secret.
IOSH No Time to Lose campaign: working together to tackle asbestos-related cancer

#NTTLaasbestos

Jonathan Hughes
IOSH Vice-President
About the Institution of Occupational Safety and Health (IOSH)

www.iosh.com

Shaping the future of safety and health

We’re the Chartered body and leading membership organisation for safety and health professionals. Our focus is to support our members in creating workplaces that are safer, healthier and more sustainable. Through our training and resources, events and collaborations, we actively promote safety and health at work across industry sectors and around the world.
• Enhance
• Collaborate
• Influence

www.IOSHWORK2022.com
No Time to Lose: campaign on occupational cancer
At least 742,000 people die every year from a work-related cancer – more than one death every minute.

Source: ILO, Ministries of Finland and Singapore, WSH Institute Singapore, Finnish Institute of Occupational Health (FIOH), ICOH and EU-OSHA
The No Time to Lose campaign aims to:

- raise awareness of a significant health issue facing employees
- offer businesses **free practical, original materials** to help them deliver effective prevention programmes
- suggest **solutions** to tackle the problem
The four phases
IOSH commissioned Opinion to do a survey of 500 UK tradespeople to find out about their knowledge of asbestos.

15% have never been informed about asbestos risks.

Only three in five have the risks regularly reinforced.

Nearly one in five wouldn’t know what to do if they found asbestos.

A quarter say they have been exposed to asbestos; a further 42% say they may have been.

A third never check the asbestos register before starting work on a new site; with 15% of these not even been aware there is a register.
Free practical materials

All available from www.notimetolose.org.uk
Eight step asbestos risk prevention strategy

1. Know where it is
2. Record where it is
3. Complete a risk assessment
4. Create a management plan
5. Planning to work on asbestos-containing materials (ACMs)
6. Inform those who are potentially exposed
7. Train workers
8. Investigate asbestos incidents
Duty to Manage Asbestos

Step one

Do you own, manage or have maintenance responsibility for a building (premise), part of a building or structure? If your answer is YES, you have a legal duty to manage any asbestos in it. These two short step-by-step guides will help you understand what you should do.

**STEP ONE When was it built?**

**After 2007?**

Ensure you do not have any equipment or machines manufactured before 2000. If you are unsure, have them checked.

**Before 2007:**

If you don’t have older plant or equipment you do not need to take further action – but make a record.

**Before 2000? If you’re not sure, assume pre-2000**

You have a legal duty to identify and manage asbestos in your premises.

Do you know where your asbestos is?

- **No**.
  - Not sure.
  - Yes.

Locate your asbestos – you may need the help of a specialist.

Assure what you have, its condition, extent and risk.

**GO TO STEP TWO “How to manage asbestos”**

Step two

Create a record of your asbestos where it is situated and its condition.

If you do not know what asbestos you have, or if you are unsure, seek specialist advice about arranging an asbestos survey.

If you intend to have major works that include invasive and/or demolition work, a survey will be required and need to be carried out by a competent person. Seek advice from a specialist asbestos consultant if you are unsure.

For demolishing a building, you will need to have the asbestos removed in advance. Removal of asbestos may also be required in advance of refurbishment works. Update your records once you have removed asbestos containing material from your premises.

**STEP TWO How to manage asbestos**

**Good condition – no visible damage**

Monitor the condition. This should be a regular visual inspection of your asbestos-containing materials (approximately yearly). Assess whether the asbestos or surrounding areas are likely to be disturbed. If the condition changes or the material gets damaged, follow the advice in the adjacent boxes. If the material is in good condition and unlikely to be disturbed it is usually safer to leave it.

You may be able to have the asbestos-containing material repaired, sealed or enclosed. If not then it must be removed. Update your records.

**Fair condition**

You must have the asbestos-containing material removed. Seek advice from a specialist asbestos consultant on the correct course of action. Update your records.

**Poor condition**

All work on or with asbestos requires strict controls, some also requires the services of a HSE-licensed contractor.

Everyone must be told where asbestos is before they start work, so site, especially maintenance workers or contractors doing invasive work of any kind.
There’s ‘No Time to Lose’ – get involved today
Support the campaign – join over 290 organisations
IOSH and BOHS collaboration
Pledge to take action – join more than 115 leading businesses

1. Assess the risks
2. Develop and deliver a prevention strategy
3. Brief managers
4. Engage employees
5. Demand the same standards from their supply chain
6. Report progress
Supporters and pledge signatories raising awareness of asbestos-related cancer

ASBESTOS DUST IS A KILLER
Worldwide, more than 200,000 people die a year from lung diseases caused by asbestos exposure.

Take action on #WorldLungCancerDay
Download free resources to prevent asbestos exposure at www.notimetrose.org.uk and www.asdoknowasbestos.org
CAMPAIGN HIGHLIGHTS – 4 YEARS ON
WORKING TOGETHER TO BEAT OCCUPATIONAL CANCER
www.notimetolose.org.uk
Follow the campaign at twitter.com/_NTTL

WORK-RELATED CARCINOGENS HAVE BEEN HIGHLIGHTED TO MORE THAN HALF A MILLION EMPLOYEES

OVER 120,000 VISITORS HAVE EXPLORED WWW.NOTIMETOLOSE.ORG.UK

290 ORGANISATIONS HAVE FORMALLY SUPPORTED THE CAMPAIGN AND HAVE AGREED TO RAISE AWARENESS OF OCCUPATIONAL CANCER

MEDIA COVERAGE HAS REACHED AN AUDIENCE OF OVER 67 MILLION

6 MILLION SOCIAL MEDIA IMPRESSIONS GENERATED

95,000 RESOURCES DOWNLOADED

38,000 FILM VIEWS

20,000 CAMPAIGN PACKS DISTRIBUTED

The campaign has been presented at 190 events

115 BUSINESSES HAVE PLEDGED TO MANAGE HARMFUL EXPOSURES AT WORK

The campaign won the GIPA ‘MARK OF EXCELLENCE’ AWARD 2018 IN THE BEST INTERNATIONAL CAMPAIGN CATEGORY
Thank you
• Asbestos Exposure & Risk Assessment: Making Sense of the Laboratory Data

Andrew Darnton, HSE (UK)
Andrey Korchevskiy, C&IH, Inc. (USA)
Andrew Darnton, MSc (UK)

- Statistician / Epidemiologist
- Health and Safety Executive (HSE), GB
- Collaborated on various epidemiological studies of asbestos-related disease:
  - Risk models for mesothelioma and asbestos-related lung cancer from meta-analyses
  - British asbestos workers cohort
  - British mesothelioma case-control and lung burden studies
  - National Statistics on mesothelioma mortality, including future projections
Andrey Korchevskiy, PhD, DABT, CIH

• Director of Research and Development at Chemistry & Industrial Hygiene, Inc. (Wheat Ridge, CO)
• Diplomate of American Board of Toxicology (DABT)
• Certified Industrial Hygienist (CIH)
• Distinguished lecturer of AIHA
• PhD in applied mathematics and doctorate in biology
• Chairman of the International Task Force for Children’s Environmental Health
• Chairman of the AIHA Standards Advisory Panel (SAP)
Goals of the Workshop

1. To discuss current state of science in asbestos risk assessment.
2. To outline possible challenges and opportunities for laboratory data interpretation.
3. To demonstrate case studies on asbestos data interpretation.
Risk assessment as a universal instrument for health and safety evaluation

When we need risk assessment:

• To evaluate and prioritize new and existing hazards
• To predict health effects for exposed individuals
• To establish occupational exposure limits (OEL) (“risk based standards”)
• To analyze complex and uncertain scenarios and their outcomes
Some example of asbestos data challenges

1. Asbestos risk assessment depends on fiber characteristics.
2. Significant part of asbestos data today will be “below detection limit” (“censored”)
3. Asbestos in soil is becoming a significant concern.
4. Definition of “asbestos” is expanding.
**Historical context: asbestos use and consequences**

- **2500 BC**
  - Artifacts and usage in ancient civilizations

- **1500 AD**
  - Introduction of asbestos in pottery and insulation

- **1800 AD**
  - Increase in usage for various industrial purposes

- **1900**
  - Widespread use in construction and insulation
  - First regulations to control exposure in UK

- **1950**
  - UK Asbestos Regulations (1970)

- **1960s**
  - Early epidemiological studies in UK and USA
  - Confirmation of mesothelioma risk, SA, 1960
  - Suspicions about lung cancer
  - Concerns about pulmonary fibrosis in factory workers, UK

- **1970s**
  - Decline in asbestos manufacturing in Western countries
  - Many other epidemiological studies: insulation workers, clockworks, manufacture of asbestos cement, textiles, friction products

- **1980s**
  - Clear evidence that both amosite and crocidolite are more potent causes of mesothelioma than chrysotile
  - Late 1980s: further confirmation of amphibole risk, SA, W Australia
UK disease burden: British asbestos imports, annual mesothelioma deaths and projections
What is asbestos?

...“asbestos” means the following fibrous silicates—
(a) asbestos actinolite, CAS No 77536-66-4;
(b) asbestos grunerite (amosite), CAS No 12172-73-5;
(c) asbestos anthophyllite, CAS No 77536-67-5;
(d) chrysotile, CAS No 12001-29-5 or CAS No 132207-32-0;
(e) crocidolite, CAS No 12001-28-4; and
(f) asbestos tremolite, CAS No 77536-68-6,

The Control of Asbestos Regulations 2012

What about:
Libby amphiboles (winchite and richterite),
glaucophane (blueschist) fluoro-edenite;
balangeroite;
fibrous erionite...

and other?
Two distinct mineral groups of asbestos

Serpentine fibers (represented by chrysotile):
- low in iron concentration,
- have distinct fiber morphology,
- typically comprised of clumps in the air,
- have magnesium hydroxyl groups on the surface, which allow decomposition in acid, generally cleared easily in the human lung (half-life on the order of weeks in the lung).

Amphibole asbestos fibers (such as amosite and crocidolite):
- higher in iron,
- more chemically resistant,
- more difficult for the body to clear (with half-lives in the human lung of decades).

Pictures courtesy of USGS
Fiber Types and Health-Based Endpoints

There are distinct differences in the propensity of the different asbestos fibre types to cause mesothelioma. Amphibole (amosite and crocidolite) asbestos is considerably more potent than chrysotile, and crocidolite is more dangerous than amosite.

*International Agency for Research on Cancer, “Pathology and Genetics of Tumors of the Lung, Pleura, Thymus and Heart” Lyon, IARC (2004).*
# Fiber Types and Health-Based Endpoints

<table>
<thead>
<tr>
<th>Wittenoom, Australia</th>
<th>Quebec, Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predominant crocidolite exposure.</strong></td>
<td><strong>Predominant chrysotile exposure.</strong></td>
</tr>
<tr>
<td>Average cumulative exposure 23 f/cc-years</td>
<td>Average cumulative exposure 600 f/cc-years</td>
</tr>
<tr>
<td>Cohort of 5173 men</td>
<td>Cohort of 9780 men</td>
</tr>
<tr>
<td>165 cases of mesothelioma</td>
<td>38 cases of mesothelioma</td>
</tr>
</tbody>
</table>


Fiber Sizes and Health-Based Endpoints

Relation of Particle Dimension to Carcinogenicity in Amphibole Asbestos and Other Fibrous Minerals

Meir F. Stanton,1,4 Maxwell Lydard,1,4 Andrew Tegeler,1 Eliza Miller,1 Margaret Mey,1,4
Elizabeth Morgan,1,4 and Ailey Smith1

ABSTRACT—With 72 experiments, durable minerals in the form of particles on respirable size and of sizes below and above structural limits, were subjected in the presence of cultured human Osmonde-Mendel rats for periods of one to 5 years. The incidence of induced malignant mesothelial neoplasms correlated well with the dimensional distribution of the particles. The probability of particle survival correlated best with the number of fibers that measured 0.95 um or less in diameter and more than 8 um in length, but relatively high corruptions were also noted with fibers in other size categories having diameters up to 1.5 um and lengths greater than 4 um. Morphologic observations indicated that short fibers and large-diameter fibers were involved in phagolysosomes and that exfoliation phagolysosomes of long, thin fibers occurred. The wide variety of compounds used in these experiments suggested that the carcinogenicity of fibers depended on dimension and duration rather than on physicochemical properties.

-JOCH 1981. 47:555-575

Work in several laboratories has indicated that diverse varieties of minerals are carcinogenic when applied directly to the pleural or the rat or hamster in the form of microscopically free, i.e., particles with dimensional aspect ratios of 3.1 or greater (1-9). The same minerals are much less carcinogenic when applied at equal weight in size in nonfibrillar form. Further, preliminary experiments indicate that carcinogenicity correlates better with increasing numbers of fibers having both diameters of 0.25 um or less and less than 0.8 um than with the correlation diminishes with fibers of greater diameter or lower length. Consequently, a reasonable conclusion is that the long, thin, fibrous structure is critical to the carcinogenicity of these minerals. Studies on fibrillar samples within very narrow dimensional ranges would be valuable in the establishment of this hypothesis, but these ideal samples are not available. Consequently, we are faced with the correlation of carcinogenicity with fiber samples of a range of varying built. The purpose of this report is to correlate our best estimate of fibrillar dimension with carcinogenicity for all those minerals that we have studied that are both durable and within the size range.

MATERIALS AND METHODS

Note of the methods were appreciable different from those described in earlier papers (4, 6, 9,11). Consequently, only modifications of methods are detailed here. A standard 0.5-g dose of particles uniformly dispersed in hand-sheared gelatin was applied by open thoracotomy directly to the left pleural surface of 12-15 25-week-old, outbred male Osborne-Mendel rats. In each experiment, 30-50 rats were exposed and followed for 2 years, at which time the survivors were killed. All rats were necropsied and all lesions examined histologically. A positive response was the occurrence of pleural sarcomas that resembled the mesothelial neoplasms of man, developing after the 1st year (12). Three types of controls were used: unexposed rats, rats that received thoracotomy but no pleural implant, and rats with pleural implants of nonfibrous material. There were two types of spontaneous tumors that could cause confusion: the fibromatoses of left mammary glands and the subcutaneous fibromatoses induced by uranin material. Vigilance and early surgical removal accounted for most mammary tumors; the use

Table 3.—Correlation coefficients of logit of tumor probability with common logarithm of number of particles per micrometer in different dimensional ranges

<table>
<thead>
<tr>
<th>Fiber diameter, um</th>
<th>Fiber length, um</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤0.05</td>
<td>&gt;0.05-0.40</td>
</tr>
<tr>
<td>&gt;0.05-0.10</td>
<td>-0.05</td>
</tr>
<tr>
<td>&gt;0.10-0.15</td>
<td>-0.45</td>
</tr>
<tr>
<td>&gt;0.15-0.20</td>
<td>-0.25</td>
</tr>
<tr>
<td>&gt;0.20-0.25</td>
<td>-0.05</td>
</tr>
</tbody>
</table>

ABBREVIATIONS: ABN = asbestos body number; ADN = amphibole diametric number; AS = amphibole; ATN = asbestos tissue number; CR = carcinogenic ratio; CRF = cancer ratio factor; CRFT = cancer ratio factor; CTN = cancer tissue number; CTN = cancer tissue number; DTN = diameter tissue number; E = electron microscopy; EM = electron microscopy; FE = fiber counting; FM = fiber counting; FN = fiber counting; FNT = fiber counting; G = graphite; GPA = graphite powder analysis; GTN = graphite tissue number; H = hematite; HMB = hematoxylin and eosin; I = iron; LM = light microscopy; M = melanoma; N = neoplasm; O = osmium tetroxide; P = pleurine; PM = pleural mesothelioma; Q = quartz; R = rat; S = sarcoma; T = tumor; TGF = tumor grading factor; U = uranium; X = x-ray; Y = year.

1 Received November 15, 1980; revised May 6, 1981; accepted June 6, 1981.
2 The guidelines for the care and use of laboratory animals were followed as set by the Committee on Revision of the Guide for Laboratory Animal Facilities, by the Guide for the Care and Use of Laboratory Animal Resources, by the National Research Council, and by the National Institute of Health.
3 Laboratory of Pathology, Division of Cancer Biology and Diagnosis, National Cancer Institute (NCI), National Institutes of Health, Public Health Service, U.S. Department of Health and Human Services, Bethesda, Md. 20205.
4 Present address.

Fig. 2. Hypothetical on the carcinogenic potency of a fiber as a function of the size with some data on "carcinogenicity factors" [11]. This three-dimensional model requires the fiber size of a sample to be divided into various categories. The size categories include three parameters: length, diameter, and the length-diameter ratio.

Dose-Response Models for Asbestos

Cumulative risk of dying of mesothelioma in the absence of other causes among N American asbestos insulation workers

Quantitative risk models for mesothelioma and asbestos-related lung cancer

**Specific past high exposure contexts**

Observations of mesothelioma and lung cancer in highly exposed worker populations

- Eg. Miners, product manufacture, insulators etc.
- Stable working environment: exposures of a number of years, similar sort of tasks each day (Typically 5 years duration, 10-100 f/ml.yrs cumulative exposure)
- Exposures form majority of worker’s lifetime dose

**Generalised risk models**

Risk model for *lifetime risk* of mesothelioma in terms of cumulative asbestos exposure (f/ml.yrs)

**Application to new situations of interest today**

Usually involves substantial extrapolation:
1. Much lower cumulative exposures
2. Much shorter durations

- Eg. Exposure intensity somewhat higher than control limit for a few hours?
- Exposure being considered is likely to be only a small part of a person’s lifetime dose

Account for fibre type, age first exposed, duration of exposure, industrial context
Hodgson, Darnton model (2000, 2010)

- Developed by HSE team (GB);
- Contains two parts, considered linear and non-linear model by cumulative exposure (f/cc-years);
- Used modified Peto model for age-related mesothelioma and lung cancer calculations;
- Allowed to account for fiber type and size;
- Separates calculations for pleural, peritoneal mesothelioma and lung cancer, if needed.
Mesothelioma risk by fibre type

Source: Hodgson and Darnton 2000 - Figure 2
A Meta-Analysis of Asbestos-Related Cancer Risk That Addresses Fiber Size and Mineral Type

D. Wayne Berman
Aegaeus, Inc., Albany, California, USA

Kenny S. Crump
Louisiana Tech University, Ruston, Louisiana, USA

Quantitative estimates of the risk of lung cancer or mesothelioma in humans from asbestos exposure made by the U.S. Environmental Protection Agency (EPA) make use of estimates of potency factors based on phase-contrast microscopy (PCM) and obtained from cohorts exposed to asbestos in different occupational environments. These potency factors exhibit substantial variability. The most likely reasons for this variability appear to be differences among environments in fiber size and mineralogy not accounted for by PCM.

In this article, the U.S. Environmental Protection Agency (EPA) models for asbestos-related lung cancer and mesothelioma are expanded to allow the potency of fibers to depend upon their mineralogical types and sizes. This is accomplished by posting exposure metrics composed of non-overlapping fiber categories and assigning each category its own unique potency. These category-specific potencies are estimated in a meta-analysis that fits the expanded models to potencies for lung cancer ($K_L$) or mesothelioma ($K_M$) based on PCM that were calculated for multiple epidemiological studies in our previous paper (Berman and Crump, 2008). Epidemiological study-specific estimates of exposures to fibers in the different fiber size categories of an exposure metric are estimated using distributions for fiber size based on transmission electron microscopy (TEM) obtained from the literature and matched to the individual epidemiological studies. The fraction of total asbestos exposure in a given environment respectively represented by chrysotile and amphibole asbestos is also estimated from information in the literature for that environment. Adequate information was found to allow $K_M$’s from 15 epidemiological studies and $K_L$’s from 11 studies to be included in the meta-analysis.

### Potency factors for selected metrics

<table>
<thead>
<tr>
<th>Category</th>
<th>Mesothelioma ($K_M \times 10^8$, 95 % CI)</th>
<th>Lung cancer ($K_L \times 10^2$, 95 % CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Thin” fibers: Width &lt;0.4 μm, length &gt;10 μm</td>
<td>30.8 (16.5, 61.5)</td>
<td>7.7 (1.6, 26.6)</td>
</tr>
<tr>
<td>“All width” : Width &lt;3 μm, length &gt;10 μm</td>
<td>13.8 (3.5, 26.3)</td>
<td>2.7 (0.56, 9.9)</td>
</tr>
</tbody>
</table>
Pooled PCME potency factors for chrysotile and amphiboles

<table>
<thead>
<tr>
<th></th>
<th>Mesothelioma $K_M*10^8$ (95% CI)</th>
<th>Lung cancer $K_L*10^2$ (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphiboles</td>
<td>8.5 (3.5, 19)</td>
<td>1.4 (0.23, 5.9)</td>
</tr>
<tr>
<td>Chrysotile</td>
<td>0.009 (0, 0.16)</td>
<td>0.20 (0, 0.55)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>No. studies</th>
<th>I^2</th>
<th>K^2</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Quebec mines and mills</td>
<td>19</td>
<td>64.1</td>
<td>0.13 (0.04, 0.22)</td>
<td></td>
</tr>
<tr>
<td>2 Italian mine and mill</td>
<td>11</td>
<td>67.4</td>
<td>0.18 (0.04, 0.33)</td>
<td></td>
</tr>
<tr>
<td>3 Connecticut friction products mfr</td>
<td>9</td>
<td>68.5</td>
<td>0.19 (0.03, 0.35)</td>
<td></td>
</tr>
<tr>
<td>4 South Carolina textile plant</td>
<td>5</td>
<td>73.7</td>
<td>0.36 (0.10, 0.61)</td>
<td></td>
</tr>
<tr>
<td>5 North Carolina textile plant</td>
<td>3</td>
<td>84.4</td>
<td>0.56 (0.12, 1.00)</td>
<td></td>
</tr>
<tr>
<td>6 Swedish cement plant</td>
<td>2</td>
<td>88.4</td>
<td>0.55 (0.11, 0.99)</td>
<td></td>
</tr>
</tbody>
</table>

Effect measure estimates for the relation between lung cancer and asbestos exposure vary strongly between studies. It has been suggested that differences in fiber dimension distributions across industries may account for this variation. The use of better quality exposure assessments allows for the estimation of a steeper slope for the lung cancer–asbestos exposure relationship.
British mesothelioma case-control and asbestos lung burden study

Occupational, domestic and environmental mesothelioma risks in the British population: a case-control study

C Rake1, C Gilham2, J Hatch2, A Darnton2, J Hodgson2 and J Pete3,4,5

1Institute of Cancer Research, Sutton, Surrey SM2, SNG, UK; 2Epidemiology Unit, Health and Safety Executive, Beeston, Mansfield NG16 6TG, UK; 3Department of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London, UK; 4Department of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK

We obtained lifetime occupational and residential histories by telephone interview with 622 mesothelioma patients (512 men, 110 women) and 1,420 population controls. Odds ratios (ORs) were converted to lifetime risk (LR) estimates for Britain born in the 1940s. Male ORs (95% confidence interval (CI)) relative to low-risk occupations for >10 years of exposure before the age of 30 were 50.4 (25.8–96.8) for carpenters (LR 1 in 17), 17.1 (10.3–27.6) for other construction workers, 15.3 (9.0–26.2) for other recognized high asbestos areas encountered. The LR was similar in apparently approximately doubled in exposed workers’ relatives (OR 2.05, 95% CI 1.42–2.97). In all, 41% of male and 62% of female cases were attributable to exposure of the male cases were construction workers, and only four had been British Journal of Cancer advance online publication, 3 March 2009, © 2009 Cancer Research UK

Keywords: mesothelioma; case-control; asbestos

Pleural mesothelioma and lung cancer risks in relation to occupational history and asbestos lung burden

Clare Gilham1, Christine Rake1, Garry Burdett2, Andrew G Nicholson2, Leslie Davison3, Angela Franchini1, James Carpenter1,5, John Hodgson6, Andrew Darnton2, Julian Pete1

ABSTRACT

Background: We have conducted a population-based study of pleural mesothelioma patients with occupational histories and measured asbestos lung burdens in occupationally exposed workers and in the general population. The relationship between lung burden and risk, particularly at environmental exposure levels, will enable future mesothelioma risk assessment in 1985 who never worked as a miner or shipyard worker. In 1985, we measured asbestos levels in lung samples obtained from 133 patients with mesothelioma and 262 patients with lung cancer. ORs for mesothelioma were converted to lifetime risks, respectively. Lifetime mesothelioma risk is approximately 0.2% per 100 asbestos fibres per gram of dry lung tissue over a more than 100-fold increase, from 1 to 4 in

What this paper adds

• People born before the 1960s have the highest mesothelioma mortality in the world, reflecting high occupational asbestos exposure in men and widespread environmental exposure in both sexes before 1980, when asbestos use virtually ceased in Britain.
• The risk to younger people from asbestos still present in many buildings is not known but could be substantial.
• We have shown that lifetime mesothelioma risk is approximately 0.2% per 1000 asbestos fibres per gram of dry lung tissue over a more than 100-fold increase, from 1 to 4 in

Original article

Past and current asbestos exposure and future mesothelioma risks in Britain: The Inhaled Particles Study (TIPS)

Clare Gilham1, Christine Rake1, John Hodgson2, Andrew Darnton2, Garry Burdett3, James Peto4, Michelle Dewar5, Andrew G Nicholson2, Leslie Davison3, Mike Shires6, Tom Treasure7 and Julian Pete1

1London School of Hygiene and Tropical Medicine, London, UK; 2Health and Safety Executive, Beeston, UK; 3Health and Safety Laboratory, Bootle, UK; 4Department of Cardiovascular Sciences, University of Leicester, UK; 5Department of Histopathology, Royal Brompton and Harefield Hospitals NHS Foundation Trust, and National Heart and Lung Institute, Imperial College, London, UK; 6Department of Cellular Pathology, Leeds Teaching Hospitals NHS Trust, Leeds, UK; 7Leeds Institute of Cancer and Pathology, University of Leeds, UK and 8Clinical Investigation Research Unit, University College Hospital, London, UK

Corresponding author: Faculty of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK, E-mail: julian.pete@lshtm.ac.uk

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# Mesothelioma case-control study

<table>
<thead>
<tr>
<th>Duration in job category before 30 years of age</th>
<th>Non-construction high risk</th>
<th>Construction</th>
<th>All other jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carpenters</td>
<td>Plumbers, electricians, painters</td>
<td>Medium-risk industrial</td>
</tr>
<tr>
<td>None</td>
<td>4/15 (2.8 (0.9, 8.9))</td>
<td>3/10 (3.1 (0.8, 11.8))</td>
<td>6/12 (5.2 (1.8, 14.9))</td>
</tr>
<tr>
<td>&lt;5 years</td>
<td>52/59 (9.8 (5.9, 16.2))</td>
<td>9/12 (8.2 (3.2, 20.9))</td>
<td>13/34 (4.0 (1.9, 8.3))</td>
</tr>
<tr>
<td>5–9 years</td>
<td>42/25 (18.3 (10.0, 33.7))</td>
<td>11/5 (24.4 (8.0, 74.9))</td>
<td>24/22 (12.3 (6.3, 24.2))</td>
</tr>
<tr>
<td>≥10 years</td>
<td>55/39 (15.3 (9.0, 26.2))</td>
<td>66/15 (50.0 (25.8, 96.8))</td>
<td>69/46 (17.1 (10.3, 28.3))</td>
</tr>
<tr>
<td>Lifetime risk for ≥10 years duration*</td>
<td>1.8%</td>
<td>5.9%</td>
<td>2.0%</td>
</tr>
</tbody>
</table>
Mesothelioma risk in relation to asbestos lung burden

Figure 2  Mesothelioma ORs (95% floating CIs) in men using resected lung cancers as controls, and asbestos lung burden: upper graph linear axes, lower graph logarithmic axes. When the lung cancer risk caused by asbestos is ignored the fit of the linear model is significantly worse (p=0.02; dashed line).

Fitted models

Solid line:
Mesothelioma risk ∝ lung burden
Lung cancer RR = 1 + 2.55 x lung burden

Dashed line:
Mesothelioma risk ∝ lung burden
(lung cancer risk ignored)

Fitted models

Solid line:
Mesothelioma risk ∝ lung burden
Lung cancer RR = 1 + 2.55 × lung burden

Dashed line:
Mesothelioma risk ∝ lung burden
(lung cancer risk ignored)
National mesothelioma mortality and average amphibole asbestos lung burdens in Britain by year of birth (fibres/mg longer than 5 microns)
Risk assessment calculator for asbestos exposure

Different fiber types

Exposure distribution (f/cc)

Three major methods of risk modeling

Mesothelioma and lung cancer risk

Exposure onset age (years)

Exposure duration (years)

Combined Monte Carlo risk forecast (excess lifetime cases per 1,000,000)
Asbestos Risk Calculations: Simplified Method Based on Inhalation Unit Risk (IUR)

\[
\text{Risk} = \text{Concentration (f/cc)} \times \text{Inhalation Unit Risk (IUR)} \times \text{Size of population of interest (people)}
\]

where

Risk – total lifetime excess cancer cases,
Concentration (f/cc) is a exposure concentration, averaged for lifetime,
IUR – a coefficient for inhalation exposure (f/cc)\(^{-1}\)

<table>
<thead>
<tr>
<th>Fiber type</th>
<th>Inhalation unit risk (IUR), f/cc(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>0.23*</td>
</tr>
<tr>
<td>Libby amphiboles</td>
<td>0.17*</td>
</tr>
<tr>
<td>Chrysotile</td>
<td>0.0072**</td>
</tr>
<tr>
<td>Crocidolite</td>
<td>1.34**</td>
</tr>
<tr>
<td>Amosite</td>
<td>0.46**</td>
</tr>
</tbody>
</table>

* U.S. EPA  
** Based on Hodgson, Darnton method (2000, 2011)
Case study: short-term work that involves disturbing AIB

- What sort data might we have about potential exposure to workers?
- PCM data based on personal sampling over several hours?

Think about 1 particular day:
4 workers with 4-hour PCM measurements as follows...

<table>
<thead>
<tr>
<th>Worker</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker 1</td>
<td>0.099 f/ml</td>
</tr>
<tr>
<td>Worker 2</td>
<td>0.036 f/ml</td>
</tr>
<tr>
<td>Worker 3</td>
<td>&lt;0.01 f/ml</td>
</tr>
<tr>
<td>Worker 4</td>
<td>&lt;0.01 f/ml</td>
</tr>
</tbody>
</table>
Simplified exposure distribution during the day

<table>
<thead>
<tr>
<th>Worker 1</th>
<th>Worker 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>min</td>
<td>f/ml</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>30</td>
<td>0.1</td>
</tr>
<tr>
<td>60</td>
<td>0.01</td>
</tr>
<tr>
<td>137</td>
<td>0.001</td>
</tr>
<tr>
<td>240</td>
<td><strong>0.099 (4-hr TWA)</strong></td>
</tr>
</tbody>
</table>
Simplified exposure distribution during the day

<table>
<thead>
<tr>
<th>min</th>
<th>f/ml</th>
<th>Contribution to total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>44.0</td>
</tr>
<tr>
<td>5</td>
<td>0.1</td>
<td>22.0</td>
</tr>
<tr>
<td>60</td>
<td>0.01</td>
<td>26.4</td>
</tr>
<tr>
<td>173</td>
<td>0.001</td>
<td>7.6</td>
</tr>
</tbody>
</table>

**Worker 3**

<table>
<thead>
<tr>
<th>min</th>
<th>f/ml</th>
<th>Contribution to total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
<td>16.4</td>
</tr>
<tr>
<td>30</td>
<td>0.01</td>
<td>49.3</td>
</tr>
<tr>
<td>209</td>
<td>0.001</td>
<td>34.3</td>
</tr>
</tbody>
</table>

**Worker 4**

<table>
<thead>
<tr>
<th>min</th>
<th>f/ml</th>
<th>Contribution to total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
<td>16.4</td>
</tr>
<tr>
<td>30</td>
<td>0.01</td>
<td>49.3</td>
</tr>
<tr>
<td>209</td>
<td>0.001</td>
<td>34.3</td>
</tr>
</tbody>
</table>

240 **0.0095 (4-hr TWA)**

240 **0.0025 (4-hr TWA)**
Risk estimation

Risk = Concentration (f/ml) \times Inhalation Unit Risk (IUR) \times Size of population of interest (people)

**Worker 1:**
0.099 f/ml for 8 hour shift for 4 weeks, amosite
Risk = \frac{0.099 \times 8 \times 5 \times 4}{75 \times 24 \times 7 \times 52} \times 0.46 \times 1,000,000 = 11
Cases per million

**Worker 3:**
0.0095 f/ml for 8 hour shift for 6 months, amosite
Risk = \frac{0.0095 \times 8 \times 5 \times 24}{75 \times 24 \times 7 \times 52} \times 0.46 \times 1,000,000 = 6
Cases per million

<table>
<thead>
<tr>
<th>Fiber type</th>
<th>Inhalation unit risk (IUR), f/cc⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>0.23*</td>
</tr>
<tr>
<td>Libby amphiboles</td>
<td>0.17*</td>
</tr>
<tr>
<td>Chrysotile</td>
<td>0.0072**</td>
</tr>
<tr>
<td>Crocidolite</td>
<td>1.34**</td>
</tr>
<tr>
<td>Amosite</td>
<td>0.46**</td>
</tr>
</tbody>
</table>

* U.S. EPA
** Based on Hodgson, Darnton method (2000, 2011)
Risk estimation

\[
\text{Risk} = \text{Concentration (f/ml)} \times \text{Inhalation Unit Risk (IUR)} \times \text{Size of population of interest (people)}
\]

**Worker 1:**
0.099 f/ml for 8 hour shift for 4 weeks, amosite

\[
\text{Risk} = \frac{0.099 \times 10 \, m^3 \times 5 \times 4}{75 \times 20 \, m^3 \times 7 \times 52} \times 0.46 \times 1,000,000 = 16
\]
Cases per million

**Worker 3:**
0.0095 f/ml for 8 hour shift for 6 months, amosite

\[
\text{Risk} = \frac{0.0095 \times 10 \, m^3 \times 5 \times 24}{75 \times 20 \, m^3 \times 7 \times 52} \times 0.46 \times 1,000,000 = 9
\]
Cases per million

<table>
<thead>
<tr>
<th>Fiber type</th>
<th>Inhalation unit risk (IUR), f/cc(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
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</tr>
<tr>
<td>Libby amphiboles</td>
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</tr>
<tr>
<td>Amosite</td>
<td>0.46**</td>
</tr>
</tbody>
</table>

* U.S. EPA

** Based on Hodgson, Darnton method (2000, 2011)
Effect of age of exposure onset

\[
\frac{(80 - 0)^4}{(80 - 30)^4} = 6.6
\]

\[
\frac{(80 - 10)^4}{(80 - 30)^4} = 3.84
\]

\[
\frac{(80 - 20)^4}{(80 - 30)^4} = 2.07
\]
Dealing with censored data sets

What is my data point is “less than LOD”?

1. Elaborate statistical methods can be used:
   - Maximum Likelihood Estimation (MLE)
   - robust MLE
   - Kaplan-Meyers
   etc.
2. In many cases, replacing the data point with LOD/2 is helpful.

3. “Highly censored data sets” are difficult to work with (but possible!).

4. Problems with asbestos: sometimes LOD are in the “risk zone” themselves.
Thank you for your attention!
We will continue after a break.
Asbestos Exposure & Risk Assessment: Making Sense of the Laboratory Data

Andrew Darnton, HSE (UK)
Andrey Korchevskiy, C&IH, Inc. (USA)
The Problem
The problem: A site redevelopment project risk assessment (UK)

1. Site redevelopment project is planned for a former household and commercial waste deposit location.
2. Asbestos risk assessment is required to evaluate potential exposure of site personnel and residents.
3. Asbestos in soil and air samples are collected.

What can be done for an effective data interpretation?

Data courtesy to RSK
## Asbestos soil sampling results

<table>
<thead>
<tr>
<th>Sample N</th>
<th>Fiber type</th>
<th>Asbestos concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Chrysotile</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>5</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Chrysotile</td>
<td>0.002</td>
</tr>
<tr>
<td>9</td>
<td>Amosite</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>10</td>
<td>Chrysotile</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>11</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Chrysotile</td>
<td>0.006</td>
</tr>
<tr>
<td>13</td>
<td>Chrysotile</td>
<td>0.001</td>
</tr>
<tr>
<td>14</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Chrysotile</td>
<td>0.003</td>
</tr>
<tr>
<td>16</td>
<td>Tremolite</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>17</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>NAD</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Chrysotile</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>21</td>
<td>Amosite</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

NAD – No asbestos detected. Polarized Light Microscopy Testing Method

### The challenges:

1. Soil data should be recalculated to airborne concentrations.
2. Dataset is “heavily censored” (most of the data points are lower than LOD/LOQ).
3. Asbestos fiber type should be taken into account.
4. Collected air samples analyzed by PCM (Phase Contrast Microscopy); no fiber type information available.
Methodology
General Methodological Solutions

• A special procedure applied to censored data points to derive actual statistical values

• Soil-to-air concentrations recalculation performed based on the asbestos fiber weight coefficient

• Air sampling (PCM) results used for method calibration

• “Risk calculator” (C&IH in collaboration with Andrew Darnton and Wayne Barman) utilized

• Monte Carlo simulation applied to calculate exposure level and cancer risk distribution (Oracle Crystal Ball and Golden Software Surfer utilized)
What we do with non-detects and censored data points?

1. The laboratory testing was carried out in accordance with the HSE document HSG248 with the limit of quantification being 0.001%.

2. For samples where no asbestos was detected, a value of “less than 0.0001 %” was assigned to each in accordance with the HSE indication that a level of 1 ppm of asbestos in soil can be recognised by the preliminary Polarised Light Microscopy analysis of asbestos samples.

3. For censored data points (<LOQ), the value of LOQ/2 was assigned to each of the samples. More rigorous (Maximum Likelihood Estimation) would be needed for “less censored” data set!
Conceptual Model to Predict Airborne Asbestos Concentrations Based on Soil Content

Source of data:
- Emission factors
- Sampling
- Simulation
- Modeling (CFD)

Distribution of respirable dust concentrations (μg/m³)

Weight of asbestos fibers (g) in ml (cc) of air

Asbestos fraction in respirable dust by weight - %

Asbestos fibers per gram of asbestos

Distribution of the number of fibers (f) per ml (cc) of air (f/cc)

Source of data:
- Average weight of fibers
- Published estimations (Nicholson, 1986 etc.)

Addison, 1988: direct simulation of soil-to-air coefficients

Distribution of asbestos in soil (weight-%)

Source of data:
- Site assessment
A formula to calculate airborne exposure concentration based on weight-% in soil

\[
C_{\text{asbestos, airborne}} \text{ (f/cc)} = C_{\text{respirable dust}} \text{ (\(\mu g/m^3\))} \times \\
\text{Asbestos Fraction in Soil (\%)} \times \\
x \text{Coefficient (f/cc in 1 mg/m}^3\text{))/100/1000}
\]

where

\[C_{\text{asbestos, airborne}}\] – calculated airborne concentration of asbestos (f/cc),
\[C_{\text{respirable dust}}\] – concentration of respirable dust in the breathing zone (\(\mu g/m^3\)),
Asbestos fraction in soil - weight -% of fibers in soil,
Coefficient - demonstrates number of fibers per cc (ml) in 1 mg/m\(^3\) of asbestos fibers (f/cc in 1 mg/m\(^3\)).
Advantages of Monte Carlo simulation in risk assessment

- Incorporates various distributions for different input parameters (concentrations, exposure scenarios, dose-response parameters)

- Hundred of thousands tests performed to replicate combinations of values

- Allows to evaluate sensitivity of outputs to changes of input variables

- Effective way to visualize the level of confidentiality in risk prediction

... and in the US, it is recommended by the regulators.
Example of Monte Carlo assumption

If you have asbestos concentration ranking “from 0.005 to 0.05 f/cc...”

... you can utilize log-normal distribution for the risk assessment instead:
Let’s look closer

Probability density function (log-normal distribution)
Results
### Example of the Transformed Data: Chrysotile

<table>
<thead>
<tr>
<th>Sample N</th>
<th>Fiber type</th>
<th>Asbestos concentration (%)</th>
<th>Sample N</th>
<th>Fiber type</th>
<th>Asbestos concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td>12</td>
<td>Chrysotile</td>
<td>0.006</td>
</tr>
<tr>
<td>2</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td>13</td>
<td>Chrysotile</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td>14</td>
<td>Chrysotile</td>
<td>0.00005</td>
</tr>
<tr>
<td>4</td>
<td>Chrysotile</td>
<td>0.0005</td>
<td>15</td>
<td>Chrysotile</td>
<td>0.003</td>
</tr>
<tr>
<td>5</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td>16</td>
<td>Chrysotile</td>
<td>0.00005</td>
</tr>
<tr>
<td>6</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td>17</td>
<td>Chrysotile</td>
<td>0.00005</td>
</tr>
<tr>
<td>7</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td>18</td>
<td>Chrysotile</td>
<td>0.00005</td>
</tr>
<tr>
<td>8</td>
<td>Chrysotile</td>
<td>0.002</td>
<td>19</td>
<td>Chrysotile</td>
<td>0.00005</td>
</tr>
<tr>
<td>9</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td>20</td>
<td>Chrysotile</td>
<td>0.0005</td>
</tr>
<tr>
<td>10</td>
<td>Chrysotile</td>
<td>0.0005</td>
<td>21</td>
<td>Chrysotile</td>
<td>0.00005</td>
</tr>
<tr>
<td>11</td>
<td>Chrysotile</td>
<td>0.00005</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average:** 0.00078 %  
**Standard Deviation:** 0.0014 %
Chrysotile in Soil, weight-% (Kriging Map)
## Example of the Transformed Data: Amosite

<table>
<thead>
<tr>
<th>Sample N</th>
<th>Fiber type</th>
<th>Asbestos concentration (%)</th>
<th>Sample N</th>
<th>Fiber type</th>
<th>Asbestos concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Amosite</td>
<td>0.00005</td>
<td>12</td>
<td>Amosite</td>
<td>0.00005</td>
</tr>
<tr>
<td>2</td>
<td>Amosite</td>
<td>0.00005</td>
<td>13</td>
<td>Amosite</td>
<td>0.00005</td>
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<tr>
<td>3</td>
<td>Amosite</td>
<td>0.00005</td>
<td>14</td>
<td>Amosite</td>
<td>0.00005</td>
</tr>
<tr>
<td>4</td>
<td>Amosite</td>
<td>0.00005</td>
<td>15</td>
<td>Amosite</td>
<td>0.00005</td>
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<td>0.00005</td>
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<td>21</td>
<td>Amosite</td>
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</tr>
<tr>
<td>11</td>
<td>Amosite</td>
<td>0.00005</td>
<td></td>
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</tr>
</tbody>
</table>

Average: 0.00009 %

Standard Deviation 0.00013 %
Example of the Transformed Data: Tremolite

<table>
<thead>
<tr>
<th>Sample N</th>
<th>Fiber type</th>
<th>Asbestos concentration (%)</th>
<th>Sample N</th>
<th>Fiber type</th>
<th>Asbestos concentration (%)</th>
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<tbody>
<tr>
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<td>14</td>
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<td></td>
</tr>
</tbody>
</table>

Average: 0.00007 %
Standard Deviation: 0.00009 %
Assumption: Log-normal Distributions for Asbestos in Soil Fraction (%). Chrysotile asbestos.

Average: 0.00078
Standard Deviation 0.0014
Assumption: Log-normal Distributions for Asbestos in Soil Fraction (%). Amosite asbestos.

Average: 0.00009
Standard Deviation 0.00013
Assumption: Log-normal Distributions for Asbestos in Soil Fraction (%). Tremolite asbestos.

Average: 0.00007
Standard Deviation: 0.00009
Assumption: Respirable Dust Concentration at the Site (\(\mu g/m^3\))

Geometric mean: 190 \(\mu g/m^3\)
Geometric Standard Deviation 1.6
(Site assessment information)
Assumption: How many fibers/cc per 1 mg/m³ of asbestos?

Range 6 to 200, likeliest value 33 (data from Nicholson, 1986).

Assumption: How many fibers/cc per 1 mg/m$^3$ of asbestos?

Range 33 to 2,580, likeliest value 296 (data from Addison et al., 1988)

Assumption: How many fibers/cc per 1 mg/m^3 of asbestos?

Average between Nicholson, 1986 and Addison, 1988

Example of airborne concentration calculation

\[ C_{\text{asbestos, airborne}} \ (\text{f/cc}) = C_{\text{respirable dust}} \ (\mu g/m^3) \times \text{Asbestos Fraction in Soil} \% \times \text{Coefficient} \ (\text{f/cc in } 1 \text{ mg/m}^3)/100/1000 \]

where

- \( C_{\text{asbestos, airborne}} \) – calculated airborne concentration of asbestos \((\text{f/cc})\),
- \( C_{\text{respirable dust}} \) – concentration of respirable dust in the breathing zone \((\mu g/m^3)\),
- Asbestos fraction in soil - weight -% of fibers in soil,
- Coefficient - demonstrates number of fibers per cc (ml) in 1 mg/m^3 of asbestos fibers \((\text{f/cc in } 1 \text{ mg/m}^3)\).

**Assumptions:**

- \( C_{\text{respirable dust}} \) 212 \(\mu g/m^3\)
- Asbestos Fraction in Soil 0.00068 %
- Coefficient 390 \((\text{f/cc in } 1 \text{ mg/m}^3)\) (average between Nicholson and Addison data)

**Approximated average exposure concentration:**

\[ 212 \mu g/m^3 \times 0.00068 \times \frac{390}{100/1000} = 0.00056 \text{ f/cc} \]
Forecast: Airborne asbestos concentrations at the site (all fiber types, f/cc)
Exposure forecast. Comparison between calculated asbestos air concentrations with airborne asbestos PCM samples on the site.

**Modeled (f/cc)**

Mean 0.00063, 95th percentile 0.00225

**Observed (f/cc)**

Mean 0.00063, 95th percentile 0.00158
Assumption: Exposure Scenario

1. 300 to 340 days of activity per year (uniform distribution).
2. 10 to 12 hours per day (uniform distribution).
3. Duration of the project: 2 to 4 years (uniform distribution).
4. Exposure onset age: birth (zero) (assumed constant)
Risk assessment calculator for asbestos exposure

Different fiber types

Exposure distribution (f/cc)

Exposure onset age (years)

Exposure duration (years)

Combined Monte Carlo risk forecast (excess lifetime cases per 1,000,000)

Three major methods of risk modeling

Mesothelioma and lung cancer risk
Forecast: Excess Cancer Cases (per 1,000,000 per lifetime)

Total cancer, Hodgson, Darnton, linear model
Forecast: Excess Mesothelioma Cases (per 1,000,000 per lifetime)

Background range: 70 to 210 cases per 1,000,000 per lifetime

Mesothelioma, Hodgson, Darnton, linear model
Sensitivity of the risk assessment results (Rank correlation)
Mapping of the Risk Assessment Results (Total Excess Cancer Cases, per 1,000,000)
Approaches to further improve the models

Computational fluid dynamics (CFD) modeling of respirable dust concentration at the site

Elutriator or fluidized bed methods to determine soil-to-air coefficients
Asbestos Risk Calculations: Simplified Method Based on Inhalation Unit Risk (IUR)

Risk = Concentration (f/ml) \times \text{Inhalation Unit Risk (IUR)} \times \text{Size of population of interest (people)}

where

Risk – total lifetime excess cancer cases,
Concentration (f/cc) is a exposure concentration, averaged for lifetime,
IUR – a coefficient for inhalation exposure (f/cc)-1

<table>
<thead>
<tr>
<th>Fiber type</th>
<th>Inhalation unit risk (IUR), f/cc⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>0.23*</td>
</tr>
<tr>
<td>Libby amphiboles</td>
<td>0.17*</td>
</tr>
<tr>
<td>Chrysotile</td>
<td>0.0072**</td>
</tr>
<tr>
<td>Crocidolite</td>
<td>1.34**</td>
</tr>
<tr>
<td>Amosite</td>
<td>0.46**</td>
</tr>
</tbody>
</table>

* U.S. EPA
** Based on Hodgson, Darnton method (2000, 2011)
Example of risk calculation

\[ \text{Risk} = \frac{\text{Concentration (f/cc) \times Inhalation Unit Risk (IUR) \times Size of population of interest (people)}}{24 \times 365 \times 75} \]

where

- Risk – total lifetime excess cancer cases,
- Concentration (f/cc) is a exposure concentration, averaged for lifetime,
- IUR – a coefficient for inhalation exposure (f/cc)^{-1}

Assumptions (worst case):
- 0.00225 f/cc mixed fiber exposure, 340 days, 4 years, 12 hours per day, starting at birth
- IUR = 0.23 (mixed fibers)
- Exposure concentration, averaged for lifetime:
  - \[ \frac{0.00225 \text{ f/cc} \times (12 \times 340 \times 4)}{24 \times 365 \times 75} = 0.000056 \text{ f/cc} \]

\[ \text{Risk} = 0.000056 \times 0.23 \times 1,000,000 = 12.9 \] (cases per 1,000,000)
Example of risk calculation

\[
\text{Risk} = \text{Concentration (f/cc)} \times \text{Inhalation Unit Risk (IUR)} \times \frac{\text{Size of population of interest (people)}}{24 \text{ hours} \times 365 \text{ days} \times 75 \text{ years}}
\]

where

Risk – total lifetime excess cancer cases,
Concentration (f/cc) is a exposure concentration, averaged for lifetime,
IUR – a coefficient for inhalation exposure (f/cc)$^{-1}$

**Assumptions**

0.0002 f/cc amosite exposure, 365 days per year, 24 hours per day, lifetime, starting at birth
IUR = 0.46 (amosite)

**Exposure concentration, averaged for lifetime:**

\[
0.0002 \text{ f/cc} \times \frac{24 \text{ hours} \times 365 \text{ days} \times 75 \text{ years}}{24 \text{ hours} \times 365 \text{ days} \times 75 \text{ years}} = 0.0002 \text{ f/cc}
\]

Risk = 0.0002 x 0.46 x 1,000,000 = 92 (cases per 1,000,000)
Example of risk calculation

Assumptions:
Average exposure of industrial plumbers 0.009 f/cc for amosite, 0.049 for chrysotile, 40 years occupational exposure.

IUR = 0.46 (amosite)
IUR = 0.0072 (chrysotile)

Exposure concentration to amosite, averaged for lifetime:
0.009 f/cc x (10 m³ x 5 days per week x 50 weeks x 40 years)/(20 m³ x 365 days x 75 years) = 0.0016 f/cc

Risk = 0.0016 x 0.46 x 1,000,000 = 736 (cases per 1,000,000)

Exposure concentration to chrysotile, averaged for lifetime:
0.049 f/cc x (10 m³ x 5 days per week x 50 weeks x 40 years)/(20 m³ x 365 days x 75 years) = 0.0089 f/cc

Risk = 0.0089 x 0.0072 x 1,000,000 = 64 (cases per 1,000,000)
Conclusions
Conclusions

1. Laboratory data about asbestos in soil and air can be effectively interpreted from the risk assessment prospective.
2. Major approaches that can be involved to the data interpretation process include censored data methods, statistical analysis and Monte Carlo simulation, asbestos risk calculations, and mapping.
3. Asbestos risk assessment paradigm opens additional opportunities for effective organization of data collection, analysis and utilization.
Acknowledgments

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• Daniel Hall, Eric Rasmuson, Jim Rasmuson, C&IH
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+1(303)420-8242
Thank you for your attention!