International Chrysotile Association

THE UNEP DOCUMENT ON ASBESTOS CONTAMINANTS

AN ANALYSIS BY THE

INTERNATIONAL CHRYSOTILE ASSOCIATION

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INTRODUCTION

In late February 2024, a paper titled "Options for addressing asbestos contaminants in products and the environment[1]" was distributed as an information document to the participants to the 6th session of the United Nations Environment Programme (UNEP)'s UN Environment Assembly (UNEA-6), which was held in Nairobi, Kenya, between February 26th and March 1st, 2024.

The 24-page document (hereinafter the 'UNEP document') was produced by the UNEP, in cooperation with the World Health Organization (WHO) and with input from the International Labour Organization (ILO), following a demand included in Resolution 5/7 adopted by the Fifth Session of the United Nations Environment Assembly UNEA-5) in 2021.

This document is a first as its scope goes beyond the usual focus on asbestos-related occupational and public health issues, to include potential environmental impacts. The coverage note by the UNEP Secretariat claims that it was intended '*to provide an overview of the foundational knowledge of asbestos, including its adverse impacts on human health and the environment, and the material flows along the life cycle.'* However, its authors somewhat mitigated their ambitions by expressly acknowledging that '*[t]he paper does not encompass an exhaustive review of all available information and references but is a summary of a rapid review*'[2].

Indeed, the International Chrysotile Association (ICA)'s review of the UNEP document reveals that its fancy presentation and extended scientific references also serve to hide serious fallacies and misrepresentations and that, contrary to its own title, it promotes just one single option to address the issue of asbestos contaminants: a worldwide ban of all form of asbestos.

It should be noted that the document was released in English only and not until a week before the start of UNEA-6, thus contravening to Rule of Procedure 12.3 whereby the Assembly can only include in its Agenda items duly communicated 42 days before the session in order to allow for proper review by all participants.

The present ICA analysis succinctly reviews the UNEP document's numerous shortcomings. Its first section provides an assessment of key issues that fundamentally skew the authors' approach and appraisals. The second section highlights specific issues that exemplify the depth and potential impacts of those approximations on the document's overall credibility and usefulness.

[1] https://documents.un.org/doc/undoc/gen/k24/003/25/pdf/k2400325.pdf

[2] Second paragraph of the document presented as an Annex to the Note by the UNEP Secretariat (part: 'About the document', Annex: page 2).

SECTION 1 – OVERALL REVIEW

1.1 - A fundamental bias

Up until now, the issue of asbestos has traditionally been addressed by various UN bodies as an issue of public health and of occupational safety. The UNEP document represent a first, as it attempts to update it as an issue of environmental hazard, through the prism of its impact on public health.

In view of this unprecedented nature of the UNEP document, the ICA finds especially worrisome that it was not able to trace the origin of the specific discussions that led to the addition of the demand to the list of requests grouped together in Resolution 5/7 voted by the 2021 UNEA-5; that no recognized independent experts or country representatives were involved with the document's preparation and; that the specific roles and contribution of its various authors remain unclear.

More fundamentally, the ICA finds particularly disturbing that throughout the document, produced with cooperation from the WHO, the UNEP choses to ignore not only a considerable amount of recent scientific research but also the 2007 World Health Assembly's resolution 60/26 that calls for a 'differentiated approach' of the various asbestos forms when designing national campaigns to address asbestos-related diseases[3].

Ignoring scientific facts and a previous UN sanctioned position emanating from the WHO's own governing body, the authors instead deliberately base their whole analysis on the provenly erroneous premise that all asbestos fiber types (amphiboles and chrysotile) could equally cause diseases. For a document pretending to provide the foundational knowledge on asbestos, it is to say the least puzzling and casts serious doubts about its quality and scientific robustness.

From the ICA's perspective, this fundamental distortion, which provides the basis for the entire document, should in itself suffice to completely discredit it.

1.2 - Confusion between hazards and risks

In a similar vein, it must be noted upfront that the document as a whole is marred by the unfortunately common lack of differentiation made by its authors between hazards and risks.

As the prism of public health is central to the UNEP document, readers should bear in mind that the International Agency for Research on Cancer (IARC), which is part of the WHO, classifies substances and habits as carcinogens based on some studies and conclusions about the certainty

[3] See: https://apps.who.int/gb/ebwha/pdf_files/wha60/a60_r26-en.pdf, paragraph 10. Last consulted March 2025

of their hazardousness, not their health risks. The WHO, through IARC, does not make any risk assessment, i.e. it does not make any evaluation of the possibility that a source of danger (hazard identification) turns into a harm. For this reason, different sources of danger such as tobacco, solar radiation, outdoor pollution, vinyl chloride, alcoholic beverages, wood dust, are all classified in the same Category 1 of carcinogenic products as all type of asbestos fibers. Risk management is dealt with by national governments through a myriad of measures such as information campaigns, consumer protection rules, or other, more restrictive, measures.

By again ignoring this fundamental fact, the UNEP document unfortunately contributes to further obfuscate issues while pretending to clarify them.

The two major distortions outlined above should have been sufficient to mandate a thorough, science-based and fact checked review of the UNEP document before its distribution.

Regrettably, the ICA's perusal of its "findings" on the impact of asbestos on human health and on the environment, of its socio-economic effects and life cycle, of existing regulations and – last but not least – on the existence of apparently safer alternatives brought to light numerous other flaws and fallacies. **While professing to offer options, the use and misuse of references that pepper the document inevitably lead to the conclusion that the only realistic one is the banishment of all forms of asbestos. It is as if the whole document was constructed with this sole objective in mind.**

While far from being exhaustive, the following section highlights some of the most blatant misconceptions and errors that further discredit the UNEP document.

SECTION 2 – SPECIFIC ISSUES

2.1 – The effects of asbestos on human health

Being the prism through which the whole document examines the various impacts of asbestos use, the way health-related issues are addressed in the UNEP document deserves attention. The ICA has produced a more detailed analysis of this specific issue which includes supplementary data. It can be consulted in the Addendum to the present document. The following paragraphs highlight its most important aspects.

An uninformed reading of the key findings that open the UNEP document creates a dire portrait. The statement to the effect that "[G]lobally, in 2016, occupational exposure to asbestos caused an estimated 209,481 deaths, which stands for more than 70 percent of all deaths from work related cancers" is particularly startling. But what is the truth behind these numbers?

Firstly, one should keep in mind that this figure, as well as the fearmongering "disability-adjusted life years losts" quoted in the UNEP document are not factual recorded data but estimated forecast data, based on mathematical models and extrapolations. As detailed in the ICA's analysis (see Addendum), a review of the references cited by the UNEP document's authors provides no clear explanation of how this impressive number was determined. The WHO itself uses a slightly different one, that stems from the 2016 Global Burden of Disease (GBD) study.

Furthermore, the UNEP document is erroneously based on the assumption that current asbestos use, strictly limited to chrysotile fibers, is similar to the situation that prevailed in the middle of the XXth century, when extensive amounts of amphibole asbestos (amosite and crocidolite) were also used. Until the 1970s, little or no distinction was made between the use of amphibole asbestos and that of chrysotile. How can the UNEP authors ignore the fundamental fact that amphibole asbestos were banned in most of the Western world in the 1980s, and that similar actions were undertaken worldwide in the following decade?

For more than 30 years, a majority of scientists have refined their analysis of the different fibers' effects: to cite one recent example, Santos et al. (2022)[4] systematically reviewed the literature on asbestos exposure and malignant pleural mesothelioma and reported that the mean age of patients was approximately 66 years, with a mean latency period between the first exposure and diagnosis of approximately 42 years. In other words, the mesothelioma deaths occurring in 2016 were a result of exposures that occurred in the 1970s or even earlier.

Other, more defined studies had already reached similar conclusions. Gilham et al., 2015[5] reported that all mesothelioma in the UK could be accounted for from amosite exposure alone even though of the five million tons of UK asbestos imports since 1954, 4.45 million tons of chrysotile were imported (89 %), compared to 0.45 tons of amosite (9 %) and 0.1 tons of crocidolite (2 %). Their results confirmed that chrysotile exposure was not a factor in explaining the UK mesothelioma incidence.

More than 20 years ago, the U.S. Environmental Protection Agency (EPA) brought together a group of scientists to assess asbestos-related risk. Its report stated that *"The expert panelists unanimously agreed that the epidemiology literature provides compelling evidence that amphibole fibers have far greater mesothelioma potency than do chrysotile fibers—a finding reported both in the review document (Berman and Crump 2001) and a recent re-analysis of 17 cohort studies (Hodgson and Darnton 2000) that reported at least a 500-fold difference in potency. Two panelists commented further that the epidemiology literature provides no scientific support for chrysotile exposures having a role in causation of mesothelioma—an observation that is generally consistent with the meta-analysis in the proposed protocol, which failed to reject the hypothesis that chrysotile fibers have zero potency for mesothelioma".*[6]

[4] Cátia Santos, Maria dos Anjos Dixe, Ema Sacadura-Leite, Philippe Astoul, António Sousa-Uva; Asbestos Exposure and Malignant Pleural Mesothelioma: A Systematic Review of Literature. *Port J Public Health* 28 December 2022; 40 (3): 188–202.

[5] Gilham C, Rake C, Burdett G, et al. Occup Environ Med Published Online First: December 29 2015 doi:10.1136/oemed-2015-103074 See : https://oem.bmj.com/content/73/5/290

[6] See Report on the Peer Consultation Workshop to Discuss an proposed Protocol to Assess Asbestos-Related Risk, EPA, 2003

It should also be noted that the UNEP document or references cited therein provide no differential information on the potency of chrysotile alone at exposure levels that occur today. However, such information does exist: Schonfeld et al., 2017[7], reported on the airborne dust concentrations in one the largest chrysotile asbestos operation since the 1890's and still operating today at Uralasbest in Russia from over 90,000 dust measurements collected across six factories and a mine covering five decades. In 1950, the total dust concentration ranged from 50 to 1000 $mg/m^{3,}$ but as early as 2000, control measures reduced the concentration to a range of 0.5 to 8 mg/m^3 depending on activity. In a follow-up publication on cancer mortality at the same mine, Schüz et al. (2024)[8] presented in the supplementary data to the study[9] that no statistically significant difference was found for lung cancer in men based on chrysotile fibers/cm^3-years, even with the earlier high exposure levels.

Simply put, international scientific data provides overwhelming evidence that today, the use of chrysotile alone, without mixed amphibole exposures and at considerably lower exposure concentrations than those that occurred when many of the epidemiology studies cited in the UNEP document were performed, does not cause mesothelioma and certainly would not be associated "with 70 % of work-related cancers".

2.2 – Environmental Impacts

On the topic of asbestos related-environmental impacts, it is in itself very telling that the leading global authority in its area of expertise can only come up, in its document, with three meager paragraphs filled with approximative, if not downright spurious data. Which conclusions could one possibly draw from generic affirmations such as "[A]sbestos can remain suspended in the air (…) thus contaminating areas far away from source", or "[D]eterioration of ecosystems is evident in many asbestos sites, particularly closed/abandoned sites"?

Furthermore, after admitting that "[S]tudies on the impact of asbestos on wild fauna and flora is (sic) scarce", the UNEP document, in a revealing shift, then refers to unspecified and undocumented "various tests" on animals that involved inhalation and injections of various amphibole fibers, at concentrations nonexistent in natural conditions. The fact that the subjects exhibited tumors is nevertheless enough for them to declare that such results provide insight into the carcinogenic effects of asbestos "across different animal species".

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[7] Schonfeld SJ, Kovalevskiy EV, Feletto E, Bukhtiyarov IV, Kashanskiy SV, Moissonier M, Straif K, McCormack VA, Schüz J, Kromhout H. Temporal Trends in Airborne Dust Concentrations at a Large Chrysotile Mine and its Asbestos-enrichment Factories in the Russian Federation During 1951-2001. Ann Work Expo Health. 2017 Aug 1;61(7):797-808. doi: 10.1093/annweh/wxx051. PMID: 28810689; PMCID: PMC6005011.

[8] Schüz J, Kovalevskiy E, Olsson A, Moissonnier M, Ostroumova E, Ferro G, Feletto E, Schonfeld SJ, Byrnes G, Tskhomariia I, Straif K, Morozova T, Kromhout H, Bukhtiyarov I. Cancer mortality in chrysotile miners and millers, Russian Federation: main results (Asbest Chrysotile Cohort-Study). J Natl Cancer Inst. 2024 Jun 7;116(6):866-875. doi: 10.1093/jnci/djad262. PMID: 38247448;

[9] Supplementary data https://academic.oup.com/jnci/article/116/6/866/7577290#supplementary-data Accessed October 3rd 2024

Beyond the high school level, disputable nature of the amalgamation, it is also telling that the UNEP document ignores studies conducted with lab rats proving the low biopersistence of chrysotile fibers in the lungs[10]. This is coherent with the authors' decision not to differentiate between different types of fibers, despite the amount of scientific evidence that undoubtedly point in the opposite direction.

2.3 – Social and economic effects

On the issue of the social consequences of massive past amphibole asbestos uses, the UNEP document correctly focuses on the "burden for patients and their families", the "healthcare cost" and, last but not least, on the "costs arising from the victim's compensation and legal actions against (asbestos) companies". Again, this situation partly reflects the legacy of historical circumstances such as the extensive use of amphibole flocking in post WW2 reconstruction efforts.

The UNEP document however chooses not to point out that such very sad and unfortunate situations which occurred more than half a century ago have nothing to do with the current usage of chrysotile under well-established programs of controlled and responsible use. It fails to mention that today, 95 % of chrysotile asbestos used around the world is encapsulated in cement matrix used in the production of slate, flat sheets and pipes: even in the event of destruction, the chrysotile fibers simply couldn't be released into the environment in any significant concentration that could pose serious risk to public health.

Had proper consultations been conducted in the process of producing the UNEP document, its authors would also have been made aware of the damage done by the massive US asbestos litigation money-machine industry in which law firms and part of the judicial system use potential asbestos victims to raid insurance companies of long dead businesses, to the costs of hundreds of million dollars[11]. For that reason, uncontextualized data on health costs associated with amphibole asbestos such as the one presented in the UNEP document, especially with regards to the United States, do not constitute a realistic basis for assessing the extent of real costs, be it for individuals, the states' social-security nets or private companies.

On the economic front, the UNEP document devotes almost four pages to spread the false idea of asbestos (without distinction between fibers) flooding the world markets and threatening the population.

In this regard the use of the Zou et al. 2023 study and the figure 3 in page 8 are of particular significance. As indicated in the UNEP document, using the United Nations Comtrade database for the period 2004-2019, this study focusses on "46 chemicals or groups listed under the Rotterdam

[10] See for example https://pubmed.ncbi.nlm.nih.gov/18788018/ Consulted March 2025

[11] It is of interest to note that some actors of this US-based practice are currently attempting to broaden its reach both in European and other countries. Their brazenness is such that a reputable online trade publication, Legal Newsline, dedicates a whole section of its website to their excesses.

Convention to look into the continuing large-scale global trade and illegal trade of highly hazardous chemicals." Without any further explanation, the authors then declare that this data enabled them to produce the estimated top trade flows of both mineral asbestos and unspecified 'Fabricated asbestos fibres' for the year 2022, which was translated in the remarkably confusing coloured chart in Figure 3. This time, they use the opportunistic criteria of a customs classification (HS code 2524.90 covers 'asbestos other than crocidolite' but includes in the same category amphibole - except crocidolite- and chrysotile asbestos) to create the false assumption of high-volume asbestos trade under a unique '*Mineral Asbestos*' with a passing reference on the "chrysotile being dominant".

CRUDE APPROXIMATIONS

Images are worth a thousand words. The authors of the UNEP document have chosen to buttress their points with equally flawed and in some case downright fallacious figures and illustrations:

- None of the figures in the document differentiate between the different types of asbestos – amphiboles (amosite and crocidolite) and chrysotile.
- In Figures 1 and 2, under generic titles, the reader is confronted with an amalgamation of generic potential situations, ill-documented hypothetical impacts and in some case extreme contextual risks, which can only result in an overall feeling of impending doom bearing no relation whatsoever with any actual state of affairs.
- As explained above and in a similar fashion, undated trade flow data in Figure 3 is used to support generically presented actual flows.
- Last but not least, the authors chose to include an illustration (Figure 5) directly borrowed from the International Ban Asbestos Secretariat – raising further doubts about the consultation processes that lead to the production of the UNEP document.

2.4 – Life cycle

Legacy issues stemming from the extraction processes and flocking of amphibole asbestos fibers in the reconstruction boom that followed WW2 are well known: low density loose amphibole asbestos-containing materials were mostly used for insulation and fire protection purposes in residential and commercial buildings as well as in public facilities construction in Western Europe, North America and Japan.

The human health and environmental problems associated with those past practices are and must be measured, circumscribed and addressed. Collectively, we now have decades of experience in those matters that allow public officials and private organizations alike to do so, in the best interest of the populations they serve. Best practices must be shared and disseminated.

But on this topic as on the other issues addressed in this UNEP document, its authors, by ignoring the basic, fundamental fact that amphibole fibers extraction and use have long been banned and abandoned, once again create a biased picture which can only hinder efforts to not only correct mistakes from the past but also facilitate initiatives that today contribute to a better future for millions of fellow citizens.

Chrysotile fiber extraction processes are governed by strict safety and security standards that have become the norm around the world. As the authors themselves admit, albeit indirectly, encapsulated chrysotile asbestos is the only legally used fiber, mostly in the form of roof tiles, flat sheets and pipes, in which the asbestos content is about 10 per cent in cement-bound state. Even in the unlikely event of their destruction, such encapsulated fibers could not be released in the environment in any harmful concentration that could pose serious risks to human health. In addition, new, promising technologies are allowing for a safe and responsible use of serpentine tailings to produce much needed material such as magnesium ingots, offering communities new development opportunities while contributing to restoring the environment.

Empty sentences such as "[D]eteriorating asbestos-containing building materials and continuing use of asbestos in some countries will only add to this burden (…)" found in p. 9 of the UNEP document senselessly amalgamate past and present: they serve only to conceal a complex but promising reality. They have no purpose other than to promote the ban of chrysotile fibers.

2.5 – Regulations

The UNEP document provides an overview of various initiatives undertaken in Western countries to address legacy issues stemming from the past use of mostly amphibole asbestos. It is regrettable that these otherwise potentially useful examples suffer from a biased presentation highlighting and sometimes amplifying realities in order to serve the authors' overall purpose. Unsurprisingly, the real issues surrounding the Parties' refusal for the past 18 years to include chrysotile in the Rotterdam Convention's Annex III are obfuscated.

Data is also presented in ways that give an inflated image of issues: in the description of actions undertaken in Poland, for example, measurements of asbestos fiber concentrations in the air are presented in terms of the number of fibers per cubic meter, although the generally accepted standard for measuring fibers is counting fibers per cubic centimeter, 0.1 fiber per cubic centimeter of air being the standard threshold limit value.

Concentrations expressed according to scientific standards in fact reveal that extremely low concentrations of up to 0.0004 fibers/cm3 were registered in approximately 38 percent of measurement points, very low concentrations (from 0.0004 to 0.001 fibers/m3) were observed in 44 percent of them and that concentrations exceeding 0.001 fibers/cm3, still far below standards, were found in the remaining 18 percent. What those measurements tell us is that even in places having "high" concentrations, those are in fact very low and correspond to the content of asbestos fibers in the natural environment.

Once again, the risks associated with past use of amphibole fibers must be taken seriously. But in view of the innumerable, dire and often life-threatening environmental issues faced by our collectivities, shouldn't we take a step back and examine our priorities?

SECTION 3 – SAFER ALTERNATIVES

The UNEP document is refreshingly honest in its acknowledgement of the need for rigorous scientific analysis of so-called safe alternatives to asbestos. Its warnings are worth underscoring:

> *"As in any case of chemical substitution, supplementary research (including life-cycle assessments (LCA)) and monitoring of the asbestos alternatives is warranted to avoid any unintended health and environmental consequences and regrettable substitutions. To make well-informed decisions on asbestos replacement, it is essential to conduct a LCA of potential alternatives. (…) However, only some of the substitute materials have been assessed for health hazards, and health hazard data has not been sufficient in many cases. The examination of alternatives in a study conducted by Park (2018) concluded that initiatives should be undertaken to reduce workers' exposure to replacement materials devoid of asbestos.*
>
> *According to patent data from the United States and Europe, fibrous materials may be considered as an alternative to asbestos. There are many kinds of fibrous materials, which can be classified into synthetic and natural fibres. However, recent studies brought to lights evidence on health hazards, including links to cancers, of fibrous materials used as asbestos substitutes."*

One can only regret that the scope of this recognition is again truncated by the authors' decision to never differentiate between amphiboles and chrysotile fibers.

CONCLUDING THOUGHTS

The UNEP document represents the first attempt by a UN body to examine issues related to asbestos fibers impacts from an environmental perspective, albeit mostly through the prism of its effects on human health. Unfortunately, the result should not be considered acceptable by the very UN standards its authors should have respected.

It is not the ICA's role to weight the extent to which the document's ideological preconceptions stem from the collaboration its authors received from the WHO and, to a lesser extent, from the ILO. But the UNEP's decision to ignore, in its own paper, the World Health Assembly's 2007 resolution calling for a differentiated approach of the various asbestos forms, along with decades of scientific research that supported and have since buttressed their motion, introduces a fundamental bias that simultaneously distorts and discredits their work. On the issue of human health alone, the consequences are so far-reaching that the ICA attaches a more detailed analysis of the UNEP document's shortcomings. It will be for the reader to judge.

Legacy impacts of the use of amphibole fibers are real. They take numerous forms and must be addressed. To do so effectively, we need dispassionate analyses of the most recent scientific findings, collaborative, non-ideological approaches, thorough research and identification of best practices and their tireless dissemination. We must also bear in mind that resources needed to reach our objectives will be competing with other, emerging and perhaps far more considerable risks. What should we make of the recent and still very sketchy recognition of the extensive dangers to human health and the environment associated with the pervasive use of perfluoroalkyl and polyfluoroalkyl substances (PFAS), the so-called forever chemicals that, according to recent studies[12], have now found their way in the blood of 98 per cent of Americans?

Angling as the UNEP document does for the complete ban of chrysotile fibers under the guise of various options is at best naïve, and most likely hypocritical. Chrysotile fibers are an asset that we cannot afford to ignore, especially where the critical health and sanitary needs of citizens from emerging or fragile economies warrant the use efficient, durable and safe material devoid of long-term risks.

[12] See: https://www.atsdr.cdc.gov/2019-annual-report/php/pfas.html?CDC_AAref_Val=https://www.atsdr.cdc.gov/2019atsdrannualreport/stories/pfas.html Consulted March 7th 2025.

ADDENDUM

THE TRUTH BEHIND NUMBERS – AN ICA ANALYSIS OF A UNEP DOCUMENT - IMPACTS OF ASBESTOS FIBERS ON HUMAN HEALTH

Highlights

- **A document published by the UNEP in February 2024[1], with the collaboration of the WHO and the ILO, estimated that in 2016 asbestos caused 209,481 deaths, which stands for more than 70 per cent of all deaths from work related cancers.**
- **The document's estimate was based on mixed exposures which occurred in the last century when amphiboles were often used – not today when only chrysotile is used.**
- **This estimate does not provide any indication of the risk associated with the current exclusive use of chrysotile.**
- **While the UNEP document takes potency differences between chrysotile and amphibole asbestos into account, especially for mesothelioma, the final risk assessment uses combined estimates across all asbestos types due, as was claimed, to the mixed nature of reported exposures over several decades. Separate risk estimates for chrysotile vs amphiboles fibers were not presented in the final exposure-risk relationship table.**
- **There is strong evidence today that chrysotile does not cause mesothelioma.**
    - **Data presented in a recent epidemiology study of the largest and oldest chrysotile mine has shown that chrysotile does not cause lung cancer.**
    - **As presented (in the supplementary data) in this epidemiology study on workers from this chrysotile mine in Russia, no statistically significant association with lung cancer in men based on chrysotile fibers/cm3-years was observed even with earlier high exposure levels.**
- **The UNEP calls for studies on alternative to chrysotile which we fully support. These studies should be conducted on an equivalent fiber exposure basis.**

Context

Early in 2024, a paper titled "Options for addressing asbestos contaminants in products and the environment" was distributed as an information document to the participants to the 6th session of the United Nations Environment Programme (UNEP)'s UN Environment Assembly[13], which was held in Nairobi, Kernya, between February 26th and March 1st 2024. In it, the authors stated that in 2016, asbestos caused an estimated 209,481 deaths, which stand for more than 70 percent of all deaths from work-related cancers.

The ICA's analysis of the information concerning asbestos in the UNEP document does not provide any indication on the risk of using chrysotile only today. For chrysotile, the UNEP's estimate has

[13] UNEP in cooperation with the World Health Organization (WHO) and with input from the International Labor Organization (ILO)) prepared the paper following a request from the participants to the 5th Session of the UN Environment Assembly of the UNEP.

no validity based on current scientific publications and data. In fact, the current use of chrysotile alone has little, if any, contribution to workplace mortality today.

On the other hand, the UNEP document does address the important issue of assessing alternatives to chrysotile fibers, as ICA has long been advocating. Those issues are summarized below.

Key issues

In the opening page of the UNEP document, the authors state that "Globally, in 2016, occupational exposure to asbestos caused an estimated 209,481 deaths, which stands for more than 70 percent of all deaths from work-related cancers." A review of the references cited by its authors[14] provides no clear explanation of how this impressive number was determined other than that it represents a cumulative sum of mesothelioma, trachea, bronchus, lung, ovary, and larynx cancers.

This number raises questions. The WHO itself uses a slightly different number: the WHO Global Health Estimates, stemming from the 2016 Global Burden of Disease (GBD) study[15], state that there were 218,827 asbestos attributed cancer deaths. It must be noted that in the same way, the ICA's review revealed that the number of deaths from mesothelioma worldwide in 2016, which has been historically associated with amphibole asbestos exposure, was reported by WHO to be 23,104, while in the GBD study estimates this number was 27,612.

It also seems that the UNEP document presupposes that current asbestos use, strictly limited to chrysotile fibers, is similar to the situation that prevailed in the middle of the XXth century when extensive amounts of amphibole asbestos (amosite and crocidolite) were also used.

The use of amphibole asbestos in the last century may still result in mesotheliomas today, but those diseases are not a result of the current use of chrysotile. To cite but one example, Santos et

[14] Mandrioli et al. 2018 WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of occupational exposure to dusts and/or fibres and of the effect of occupational exposure to dusts and/or fibres on pneumoconiosis. Environ Int. 2018 Oct;119:174-185. doi: 10.1016
- European Commission 2022. Commission staff working document impact assessment. Proposal for a Directive of the European Parliament and of the Council amending Directive 2009/148/EC on the protection of workers from the risks related to exposure to asbestos art work. https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CONSIL:ST_12863_2022_ADD_2&qid=1673446822849&from=EN. Accessed October 2023
- Schlünssen, et al. 2023. The prevalences and levels of occupational exposure to dusts and/or fibres (silica, asbestos and coal): A systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury. Environment International 107980.

[15] See table 1 of GBD 2016 Occupational Carcinogens Collaborators. Global and regional burden of cancer in 2016 arising from occupational exposure to selected carcinogens: a systematic analysis for the Global Burden of Disease Study 2016. Occup Environ Med. 2020 Mar;77(3):151-159. doi: 10.1136/oemed-2019-106012. PMID: 32054819; PMCID: PMC7035689.

al. (2022)[16] systematically reviewed the literature on asbestos exposure and malignant pleural mesothelioma and reported that the mean age of patients was approximately 66 years, with a mean latency period between the first exposure and diagnosis of approximately 42 years. Thus, the mesothelioma deaths occurring in 2016 were a result of exposures that occurred in the 1970s or even earlier and are not the result from any possible current exposures to chrysotile.

Until the 1970s, little or no distinction was made between the use of amphibole asbestos and that of chrysotile. Amphibole asbestos, need it be repeated, were banned in most of the Western world in the 1980s, and similar actions were undertaken worldwide in the following decade.

The UNEP document states that of the 209,481 deaths, 177,614 were from lung cancers, which its authors attributed to asbestos exposure. This derivation appears to be based on a ratio of mesothelioma to lung cancers in cohorts heavily exposed decades ago to both amphibole and chrysotile asbestos[17]. A search of the GBD Study database for risk factors associated with asbestos exposure shows three citations as the basis for their determination (Lentes et al., 2011; Goodman et al., 1999; Camargo et al.,2011). The oldest exposures cited in these publications range from 1904 to 1939, a period when exposures were exceedingly high and when there was little, if any, differentiation between amphibole and chrysotile asbestos.

As only chrysotile is used today, extrapolating asbestos-related deaths from mixed exposures at high exposure concentrations is meaningless. Gilham et al., 2015[18] reported that all mesothelioma in the UK could be accounted for from amosite exposure alone even though of the five million tons of UK asbestos imports since 1954, 4.45 million tons of chrysotile were imported (89 %), compared to 0.45 tons of amosite (9 %) and 0.1 tons of crocidolite (2 %). Their results confirm that chrysotile exposure was not a factor in explaining the UK mesothelioma incidence.

Another publication (McCormack et al., 2012)[19] estimated the asbestos-related lung cancer burden from mesothelioma mortality: it included 68 risk estimates drawn from 55 studies, in which excess cancer deaths were calculated for each cohort based on observed minus expected deaths, based on national/regional age- and sex-specific rates, to obtain Standardized Mortality Ratios (SMR)[20].

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[16] Cátia Santos, Maria dos Anjos Dixe, Ema Sacadura-Leite, Philippe Astoul, António Sousa-Uva; Asbestos Exposure and Malignant Pleural Mesothelioma: A Systematic Review of Literature. *Port J Public Health* 28 December 2022; 40 (3): 188–202.

[17] UNEP used an asbestos impact ratio (AIR) approach where the AIR was defined as the excess deaths due to mesothelioma observed in a population divided by the excess deaths in a hypothetical population heavily exposed to asbestos (without differentiating chrysotile form amphibole asbestos).

[18] Gilham C, Rake C, Burdett G, et al. Occup Environ Med Published Online First: December 29, 2015. doi:10.1136/oemed-2015-103074 See: https://oem.bmj.com/content/73/5/290

[19] McCormack V, Peto J, Byrnes G, Straif K, Boffetta P. Estimating the asbestos-related lung cancer burden from mesothelioma mortality. Br J Cancer. 2012 Jan 31;106(3):575-84. doi: 10.1038/bjc.2011.563. Epub 2012 Jan 10. Erratum in: Br J Cancer. 2014 Dec 9;111(12):2381. PMID: 22233924; PMCID: PMC3273352.

[20] The Standardized Mortality Ratio (SMR) is a statistical measure to compare the mortality rate of a study group to that of a standard population.

Again, the studies included high exposures that occurred many years ago. The authors estimated fiber-specific ratios which characterize the overall asbestos-related lung cancer to mesothelioma relationship across different exposure circumstances and over a long period of time. In these studies, there was a marked correlation between lung cancer SMR and mesothelioma cohorts exposed to the amosite asbestos (amphibole). For amphibole asbestos, estimates suggest there was between a 6 % and 10 % increase in lung cancer deaths for every mesothelioma death in 1,000 deaths. Chrysotile cohorts had a wider range of estimates, resulting from little correlation between excess lung cancers and mesotheliomas. When present, the authors state that it appears that many of the mesotheliomas were actually due to amphibole exposure. The authors state that "for chrysotile, widely consumed today, asbestos-related lung cancers cannot be robustly estimated from few mesothelioma deaths and the latter cannot be used to infer no excess risk of lung or other cancers". Their analysis does not exclude a lung cancer effect from these older cohorts but mentions that smoking can be a major contributor.

The UNEP document or the references cited therein provide no differential information on the potency of chrysotile alone at exposure levels that occur today.

But such information does exist: Schonfeld et al., 2017[21], reported on the airborne dust concentrations in one of the largest chrysotile asbestos operation since the 1890's and still operating today at Uralasbest in Russia from over 90,000 dust measurements collected across six factories and a mine covering five decades. In 1950, the total dust concentration ranged from 50 to 1,000 mg/m^{3}, but as early as 2000, control measures reduced the concentration to a range of 0.5 to 8 mg/m^{3} depending on activity. In a follow-up publication on cancer mortality at the same mine, Schüz et al. (2024)[22] presented in the supplementary data to the study that no statistically significant difference was found for lung cancer in men based on chrysotile fibers/cm^{3}-years even with the earlier high exposure levels. The study's abstract[23] and pages 4-6 of the supplementary data[24] (Table 4) from the Schüz et al., (2024) publications are included in Annex 1 and 2 of the present document.

Currently, as only chrysotile is used in controlled environments, no cancer mortality would be expected.

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[21] Schonfeld SJ, Kovalevskiy EV, Feletto E, Bukhtiyarov IV, Kashanskiy SV, Moissonier M, Straif K, McCormack VA, Schüz J, Kromhout H. Temporal Trends in Airborne Dust Concentrations at a Large Chrysotile Mine and its Asbestos-enrichment Factories in the Russian Federation During 1951-2001. Ann Work Expo Health. 2017 Aug 1;61(7):797-808. doi: 10.1093/annweh/wxx051. PMID: 28810689; PMCID: PMC6005011.

[22] Schüz J, Kovalevskiy E, Olsson A, Moissonnier M, Ostroumova E, Ferro G, Feletto E, Schonfeld SJ, Byrnes G, Tskhomariia I, Straif K, Morozova T, Kromhout H, Bukhtiyarov I. Cancer mortality in chrysotile miners and millers, Russian Federation: main results (Asbest Chrysotile Cohort-Study). J Natl Cancer Inst. 2024 Jun 7;116(6):866-875. doi: 10.1093/jnci/djad262. PMID: 38247448;

[23] See : https://academic.oup.com/jnci/article/116/6/866/7577290 Accessed March 2025

[24] Supplementary data https://academic.oup.com/jnci/article/116/6/866/7577290#supplementary-data Accessed October 3rd 2024.

There is clear evidence provided in the scientific literature that today, the use of chrysotile alone without mixed amphibole exposures and with considerably lower exposure concentrations (than which occurred when many of the epidemiology studies cited were performed) does not cause mesothelioma and certainly would not be associated "with 70 % of work-related cancers".

About alternatives

The need for rigorous database referencing and differentiation between fiber types is especially important in light of increasingly vocal calls for using alternatives to the chrysotile fiber. The UNEP document is remarkably honest in its remarks on the lack of scientific data on health hazards related to so-called "safer alternatives"[25]:

> "*As in any case of chemical substitution, supplementary research (including life-cycle assessments (LCA)) and monitoring of the asbestos alternatives is warranted to avoid any unintended health and environmental consequences and regrettable substitutions. To make well-informed decisions on asbestos replacement, it is essential to conduct a LCA of potential alternatives. (…) However, only some of the substitute materials have been assessed for health hazards, and health hazard data has not been sufficient in many cases. The examination of alternatives in a study conducted by Park (2018) concluded that initiatives should be undertaken to reduce workers' exposure to replacement materials devoid of asbestos.*
> *According to patent data from the United States and Europe, fibrous materials may be considered as an alternative to asbestos. There are many kinds of fibrous materials, which can be classified into synthetic and natural fibres. However, recent studies brought to lights evidence on health hazards, including links to cancers, of fibrous materials used as asbestos substitutes.*"

The ICA welcomes this recognition by UNEP of the need for more research on alternatives to chrysotile and hopes that its call will be heard within the WHO, the ILO as well as by all parties to the Rotterdam Convention. The ICA encourages authorities to evaluate the potential toxicity of all fibers, including alternatives, based on equal fiber number exposure.

[25] See https://documents.un.org/doc/undoc/gen/k24/003/25/pdf/k2400325.pdf pp. 14-15. Accessed October 3rd 2024.

Annex 1

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Article

Cancer mortality in chrysotile miners and millers, Russian Federation: main results (Asbest Chrysotile Cohort-Study)

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Abstract

Background: We investigated mortality in workers of the world's largest chrysotile mine and enrichment factories located in the town of Asbest, Russian Federation.

Methods: This historical cohort study included all workers employed for at least 1 year between 1975 and 2010 and follow-up until the end of 2015. Cumulative exposure to dust was estimated based on workers' complete occupational history linked to dust measurements systematically collected from the 1950s. Exposure to chrysotile fibers was estimated using dust-to-fiber conversion factors. Relative risks (RRs) and 95% confidence intervals (CIs) were estimated as mortality rate ratios in Poisson regression models.

Results: A total of 30 445 (32% women) workers accumulated 721 312 person-years at risk and 11 110 (36%) died. Of the workers, 54% had more than 30 years since their first exposure. We found an exposure-response between cumulative dust and lung cancer mortality in men. No clear association with dust exposure but a modest increase in the highest category of fiber exposure was seen for lung cancer in women. Mesothelioma mortality was increased (RR = 7.64, 95% CI = 1.18 to 49.5, to at least 80 fibers per cm^3 years and RR = 4.56, 95% CI = 0.94 to 22.1, to at least 150 mg/m^3 years [dust]), based on 13 deaths. For colorectal and stomach cancer, there were inconsistent associations. No associations were seen for laryngeal or ovarian cancer.

Conclusion: In this large-scale epidemiological study in the world's largest active asbestos mine, we confirmed an increased risk of mesothelioma with high fiber exposure and an increasing mortality for lung cancer in men with increasing dust exposure. Less clear-cut increased lung cancer mortality was seen in the women. Continued mortality follow-up is warranted.

Annex 2

Supplementary Data

Supplementary material to: Schüz, et al., Cancer mortality in chrysotile miners and millers, Russian Federation: main results (Asbest Chrysotile Cohort-Study). J Natl Cancer Inst. 2024 Jun 7;116(6):866-875. doi: 10.1093/jnci/djad262. PMID: 38247448;

https://academic.oup.com/jnci/article/116/6/866/7577290#supplementary-data Accessed October 3rd, 2024.

Supplementary Table 4. Mortality rate ratios (RR) and 95% confidence intervals (CI) for categories of cumulative dust exposure and cumulative fibre exposure, by deaths from different causes and cancer sites, by applying lag times of 10 years and of 20 years, by sex, adjusted for age and time since last employment

NOTE: Mortality rate ratios (RR) are considered statistically significant only when the 95% confidence interval (CI) does not include 1.0. Specifically, for a mortality rate ratio to be statistically significant, the lower limit of the 95% CI must be greater than 1.0. For Lung Cancer Fibers/cm^3-years all values are not statistically significant.

Supplementary Table 4. Mortality rate ratios (RR) and 95% confidence intervals (CI) for categories of cumulative dust exposure and cumulative fibre exposure, by deaths from different causes and cancer sites[a], by applying lag times of 10 years and of 20 years, by sex, adjusted for age and time since last employment

Dust category (mg/m^3-years)	Men				Women			
	10-year lag		20-year lag		10-year lag		20-year lag	
	N deaths	RR (CI)	*N* deaths	RR (CI)	*N* deaths	RR (CI)	*N* deaths	RR (CI)
	All deaths				All deaths			
0[b]	536	1.10 (0.99–1.23)	1595	0.94 (0.87–1.01)	76	0.79 (0.59–1.05)	303	0.96 (0.82–1.14)
>0–20	2208	1.00	2097	1.00	506	1.00	512	1.00
≥20–65	2261	0.94 (0.89–1.00)	2096	0.92 (0.86–0.98)	823	1.03 (0.92–1.15)	768	0.99 (0.89–1.11)
≥65–150	2079	0.90 (0.84–0.96)	1513	0.93 (0.86–1.00)	821	0.94 (0.84–1.05)	708	0.93 (0.83–1.05)
≥150	1186	0.98 (0.90–1.06)	969	1.00 (0.92–1.09)	614	1.01 (0.89–1.14)	549	1.01 (0.89–1.14)
p for trend		0.11		0.83		0.77		0.96
	All cancers (main ICD group C)				All cancers (main ICD group C)			
0	44	1.20 (0.87–1.67)	161	1.04 (0.86–1.27)	15	0.90 (0.50–1.61)	67	1.03 (0.73–1.45)
>0–20	285	1.00	323	1.00	97	1.00	99	1.00
≥20–65	435	1.06 (0.91–1.24)	468	1.06 (0.91–1.22)	169	1.09 (0.85–1.41)	145	1.04 (0.81–1.35)
≥65–150	494	1.10 (0.94–1.29)	362	1.13 (0.96–1.34)	137	0.88 (0.67–1.15)	121	1.03 (0.78–1.36)
≥150	268	1.14 (0.95–1.37)	212	1.12 (0.93–1.36)	117	1.13 (0.85–1.50)	103	1.24 (0.93–1.66)
p for trend		0.17		0.20		0.79		0.26
	Lung cancer				Lung cancer			
0	13	1.14 (0.63–2.05)	54	1.03 (0.74–1.44)	1	1.49 (0.17–13.08)	6	4.02 (1.09–14.90)
>0–20	95	1.00	116	1.00	7	1.00	4	1.00
≥20–65	161	1.19 (0.92–1.55)	177	1.12 (0.88–1.43)	10	0.74 (0.28–1.95)	9	1.25 (0.38–4.06)
≥65–150	190	1.34 (1.02–1.76)	135	1.27 (0.97–1.67)	11	0.65 (0.25–1.70)	10	1.33 (0.41–4.31)
≥150	105	1.44 (1.06–1.95)	82	1.31 (0.97–1.79)	12	1.07 (0.42–2.75)	12	2.34 (0.75–7.38)
p for trend		0.01		0.06		0.78		0.07
	Laryngeal cancer[c]				Ovarian cancer			
0	2	2.46 (0.50–12.18)	3	0.47 (0.14–1.67)	1	0.61 (0.07–5.12)	5	0.81 (0.26–2.59)
>0–20	8	1.00	15	1.00	10	1.00	10	1.00
≥20–65	18	1.41 (0.61–3.29)	11	0.46 (0.21–1.03)	10	0.65 (0.26–1.58)	7	0.58 (0.22–1.56)
≥65–150	9	0.63 (0.23–1.71)	13	0.83 (0.37–1.88)	9	0.70 (0.27–1.83)	8	1.08 (0.39–2.95)
≥150	9	1.21 (0.44–3.35)	4	0.44 (0.14–1.39)	5	0.64 (0.21–2.01)	5	1.01 (0.32–3.20)
p for trend		0.72		0.29		0.45		0.77

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	Stomach cancer				Stomach cancer			
0	6	1.12 (0.45–2.80)	22	1.02 (0.57–1.81)	5	2.01 (0.66–6.13)	11	0.90 (0.39–2.08)
>0–20	30	1.00	34	1.00	15	1.00	18	1.00
≥20–65	54	1.33 (0.84–2.12)	57	1.33 (0.85–2.06)	24	1.00 (0.52–1.92)	18	0.74 (0.38–1.44)
≥65–150	64	1.55 (0.96–2.51)	49	1.69 (1.04–2.74)	13	0.55 (0.26–1.20)	11	0.56 (0.26–1.23)
≥150	33	1.54 (0.90–2.66)	25	1.45 (0.83–2.54)	14	0.91 (0.42–1.94)	13	0.94 (0.44–2.00)
p for trend		0.06		0.08		0.38		0.47
	Colorectal cancer				Colorectal cancer			
0	3	1.59 (0.46–5.54)	12	1.54 (0.74–3.21)	1	0.44 (0.05–3.81)	6	0.72 (0.24–2.13)
>0–20	18	1.00	20	1.00	14	1.00	13	1.00
≥20–65	41	1.36 (0.78–2.40)	41	1.23 (0.71–2.13)	22	0.94 (0.48–1.84)	19	0.96 (0.47–1.95)
≥65–150	43	1.09 (0.61–1.95)	35	1.23 (0.68–2.21)	22	0.83 (0.42–1.65)	24	1.27 (0.63–2.56)
≥150	29	1.35 (0.72–2.51)	26	1.53 (0.82–2.85)	18	0.99 (0.48–2.04)	15	1.12 (0.52–2.41)
p for trend		0.65		0.18		0.90		0.66

Fibre category (f/cm³-years)	Men				Women			
	10-year lag		20-year lag		10-year lag		20-year lag	
	N deaths	RR (CI)	*N* deaths	RR (CI)	*N* deaths	RR (CI)	*N* deaths	RR (CI)
	All deaths				All deaths			
0[b]	536	1.10 (0.98–1.22)	1595	0.93 (0.86–1.00)	76	0.79 (0.59–1.06)	303	0.95 (0.81–1.12)
>0–12	2256	1.00	2248	1.00	524	1.00	545	1.00
≥12–40	2621	0.94 (0.89–1.00)	2524	0.90 (0.85–0.96)	916	1.03 (0.92–1.15)	870	0.98 (0.88–1.09)
≥40–80	2064	0.86 (0.80–0.92)	1341	0.88 (0.81–0.95)	758	0.92 (0.82–1.03)	622	0.90 (0.80–1.01)
≥80	793	0.97 (0.89–1.06)	562	1.02 (0.92–1.12)	566	0.95 (0.84–1.07)	500	0.98 (0.87–1.11)
p for trend		0.01		0.16		0.17		0.63
	All cancers (main ICD group C)				All cancers (main ICD group C)			
0	44	1.14 (0.82–1.57)	161	0.97 (0.80–1.17)	15	0.91 (0.51–1.64)	67	1.01 (0.72–1.43)
>0–12	309	1.00	374	1.00	95	1.00	103	1.00
≥12–40	495	0.98 (0.85–1.14)	557	0.95 (0.83–1.09)	179	1.10 (0.86–1.42)	163	1.04 (0.81–1.33)
≥40–80	489	1.00 (0.86–1.17)	295	0.92 (0.78–1.09)	134	0.95 (0.72–1.24)	111	1.02 (0.78–1.35)
≥80	189	1.13 (0.93–1.36)	139	1.18 (0.96–1.46)	112	1.12 (0.84–1.48)	91	1.17 (0.87–1.57)
p for trend		0.34		0.57		0.75		0.51
	Lung cancer				Lung cancer			
0	13	1.03 (0.57–1.85)	54	0.94 (0.68–1.31)	1	1.86 (0.21–16.64)	6	5.76 (1.38–24.01)
>0–12	106	1.00	135	1.00	6	1.00	3	1.00
≥12–40	183	1.07 (0.83–1.36)	214	1.01 (0.81–1.27)	12	1.02 (0.38–2.71)	12	2.14 (0.60–7.61)
≥40–80	187	1.17 (0.90–1.52)	109	1.03 (0.78–1.37)	9	0.74 (0.26–2.10)	9	2.00 (0.54–7.47)
≥80	75	1.36 (0.99–1.86)	52	1.32 (0.94–1.86)	13	1.49 (0.56–3.97)	11	3.36 (0.92–12.22)
p for trend		0.04		0.24		0.44		0.05

		Laryngeal cancer[c]				Ovarian cancer		
0	2	1.65 (0.35–7.73)	3	0.45 (0.13–1.55)	1	0.59 (0.07–4.96)	5	0.69 (0.23–2.12)
>0–12	12	1.00	17	1.00	10	1.00	12	1.00
≥12–40	16	0.74 (0.34–1.57)	12	0.39 (0.18–0.84)	10	0.60 (0.25–1.46)	7	0.43 (0.17–1.10)
≥40–80	9	0.41 (0.16–1.01)	10	0.71 (0.30–1.68)	9	0.72 (0.28–1.85)	10	1.09 (0.44–2.66)
≥80	7	0.89 (0.34–2.37)	4	0.73 (0.23–2.28)	5	0.60 (0.19–1.84)	1	0.16 (0.02–1.32)
p for trend		0.33		0.47		0.42		0.25
		Stomach cancer				Stomach cancer		
0	6	1.05 (0.43–2.59)	22	0.96 (0.55–1.69)	5	1.79 (0.59–5.38)	11	0.84 (0.37–1.92)
>0–12	33	1.00	39	1.00	17	1.00	20	1.00
≥12–40	60	1.19 (0.76–1.84)	73	1.30 (0.87–1.95)	22	0.75 (0.40–1.43)	18	0.61 (0.32–1.16)
≥40–80	70	1.55 (0.98–2.46)	40	1.40 (0.85–2.29)	15	0.60 (0.30–1.23)	14	0.72 (0.35–1.46)
≥80	18	1.18 (0.64–2.17)	13	1.25 (0.64–2.42)	12	0.68 (0.32–1.46)	8	0.57 (0.24–1.34)
p for trend		0.14		0.27		0.22		0.13
		Colorectal cancer				Colorectal cancer		
0	3	1.75 (0.50–6.13)	12	1.39 (0.68–2.82)	1	0.43 (0.05–3.70)	6	0.76 (0.25–2.25)
>0–12	17	1.00	24	1.00	15	1.00	13	1.00
≥12–40	46	1.46 (0.83–2.57)	51	1.11 (0.68–1.83)	24	0.90 (0.47–1.72)	23	1.08 (0.55–2.15)
≥40–80	44	1.21 (0.67–2.19)	25	0.82 (0.45–1.49)	20	0.80 (0.40–1.58)	21	1.33 (0.65–2.69)
≥80	24	1.91 (1.00–3.66)	22	1.98 (1.07–3.66)	17	0.94 (0.46–1.91)	14	1.22 (0.56–2.64)
p for trend		0.16		0.13		0.78		0.60

[a] ICD codes for cancer sites are: lung, C33–C34; larynx, C32; ovary, C56; stomach, C16; colon and rectum, C18–C21.

[b] Because the 10-year or 20-year lag time was applied, some workers had no occupational exposure to dust or fibres; as the counting of risk time started with first exposure, they are kept as a separate group and displayed only for the purpose of completeness (see Materials and Methods)

[c] Only 1 case of laryngeal cancer in women; therefore, analysis for women was not carried out.