On 28 March 2023, a satellite workshop, as part of the South Africa Sweden University Forum (SASUF) Research and Innovation Week 2023, was held at the University of the Witwatersrand School of Public Health. Ninety-five participants attended online from South Africa and several countries, and 28 attended in person. Prof. Tobias Chirwa, Head of the School of Public Health, welcomed all attendees. The workshop presentations and issues raised are summarised under the four themes of the workshop.

Theme 1: What are the silica-related diseases and why are they important?

Chaired by Dr Spo Kgalamono, Executive Director: National Institute for Occupational Health, National Health Laboratory Service, South Africa

Prof. Gill Nelson from the Wits School of Public Health set the scene with a short presentation about silica dust and silica-related health effects.

Overview of silica-related health effects and magnitude of the problem

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Millions of people are exposed to silica dust, worldwide, from a variety of industries, and silicosis rates remain high. The risk of developing silicosis is life long and continues after exposure has ceased. Silicosis data are available for some large industries but not for smaller businesses (usually unregulated), and artisanal and informal workers, which include women and children.

Quartz is the most common form of crystalline silica and the most common mineral in the earth’s crust, so it is a component of most sand and rocks. Workers in many industries are exposed to silica dust. Aside from the well-known occupations, such as gold mining, construction, and artificial stone manufacture, those involved in tunnelling, denim jean production, jewellery production, hydraulic fracting, agriculture, and paint manufacturing (to name a few) are also potentially exposed to silica dust.

In the mining industry, silica dust is most prevalent in gold and coal mining, oil and gas mining, and shale and diatomaceous earth mining. Most affected are miners, drillers and crushing machine operators. In the construction industry, workers are exposed to silica dust from concrete, brick, granite, and tiles. Road working and stone working are also hazardous occupations. Exposure to silica flour is also a risk for silicosis as it comprises very fine grains of silica used in grouting, metal polish, abrasive cleaners, sandpaper, and toothpaste. Silica nanoparticles are produced on an industrial scale as additives to cosmetics, drugs, printer toners, varnishes, and food, and are being developed for biomedical and biotechnological applications such as cancer therapy, and drug delivery. Long-term toxicity due to accumulation of these nanoparticles is under investigation.

Although silicosis and silica-associated tuberculosis (TB) are the most common occupational lung diseases associated with silica worldwide, exposure also plays a role in connective tissue diseases, lung cancer, chronic obstructive pulmonary disease, and some types of pulmonary fibrosis and systemic diseases. All are preventable.

Challenges

• For some diseases, there is a clear dose-response relationship (e.g. simple silicosis). For others, the dose-response relationship is less clear (e.g. auto-immune diseases).
• All of the diseases, apart from silicosis, are associated with other exposures, e.g. chronic obstructive pulmonary disease (COPD) and cigarette smoking, TB, and HIV.
• For these other diseases, the association with silica dust exposure is often overlooked, e.g. chronic renal disease and rheumatoid arthritis.
• There are diagnostic challenges, particularly in distinguishing silicosis and TB.
• Many questions remain, e.g. what is the interactive effect of smoking and silica dust exposure on COPD and lung cancer?
Silicosis and tuberculosis — unanswered questions and research needs

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Although silicosis and tuberculosis were identified as closely related but distinct entities in the early 20th century, there are still many unanswered questions about their relationship and combined management. This brief overview is based on experience with gold miners from the South African mines, although the questions have global application.

**What is the silica dust concentration threshold for increased risk of TB?**
We do not know whether control of silicosis will also control the excess risk of TB due to silica.1 Cohort studies are needed, which control for radiological silicosis, measure silica exposure accurately, and control for other confounders.

**What is needed to better distinguish radiologically between silicosis, TB, and combined disease in individuals from populations with a high risk of both diseases?**
Training on the International Labour Organization (ILO) Pneumoconiosis Classification is necessary but not sufficient. Training is needed on taking an informed occupational history and on the radiological appearances of post-TB (fibrosis, nodulation, cystic changes/bronchiectasis, lung distortion, pleural sequelae) and of active TB.2 Development of training materials for involved clinicians and evaluation of such training are needed.

**What is the optimal TB treatment regimen for active TB combined with silicosis?**
Cohort studies have found a two-to-three times worse clinical outcome for silicotuberculosis than for TB alone.3,4 Past clinical trials offer conflicting evidence on the optimal regimen and period of treatment (e.g. five to nine months).5,6 Updated research using the latest regimens is needed.

**Is TB preventive treatment (TPT) of individuals with silicosis realistic in low-resource settings?**
There is limited and mixed evidence of the effectiveness of TPT in silicosis and the period of treatment.7,8 South African national guidelines recommend TPT for persons with silicosis for three months (weekly rifapentine and isoniazid) or 12 months (daily isoniazid).9 The extent of local implementation is unknown and questions regarding regimen, acceptability, feasibility, and coverage remain, particularly among miners. Updated research using the latest shorter regimens is needed.

**How frequently should individuals be examined for silicosis and silicotuberculosis?**
Currently, active miners in South Africa are required by law to be examined annually while the Occupational Diseases in Mines and Work Act provides for ex-miners to be examined every two years. This latter provision has historically hardly been implemented in the case of black miners, many of whom do not live in South Africa.10 Even with these limitations of access, the Medical Bureau for Occupational Diseases (MBOD), the state agency responsible for certifying occupational lung disease in miners, has struggled with large backlogs in recent years.11 This raises the question of what frequency of examination of ex-miners is feasible, taking into account the need to determine eligibility for compensation in an impoverished population and to identify TB given a very high risk of active disease.

**In populations with high burdens of silicosis and TB, what is the role of sputum examination using GeneXpert or equivalent?**
Individuals with silicosis have four times the risk of TB than those with TB alone.1 In populations with both disease burdens, the diagnosis of active TB is confounded by chest X-ray (CXR) abnormalities and chronic respiratory symptoms attributable to silicosis and post-TB. On the other hand, half of individuals with active TB may have no symptoms.12,13 Xpert (and Xpert Ultra) have been shown to attain high sensitivity and specificity against TB culture.14 Protocols are needed for the threshold for sputum examination when examining individuals from such populations, and for rational empirical treatment in the case of negative sputum tests.12,14

**Can use of computer-aided detection systems for reading CXRs increase the ability to conduct such surveillance?**
Computer-aided detection (CAD) is recommended by the World Health Organization (WHO) for CXR screening for active TB in high-risk groups, which includes workers exposed to silica dust.15 Independently, CAD has been shown to achieve high performance metrics for identification of silicosis in miners.16 Acceptability, feasibility, and costing studies of application of CAD for TB and silicosis in low-resource settings are needed.17

REFERENCES
Silica-associated lung cancer

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Worldwide, lung cancer is one of the most commonly diagnosed malignancies and is the leading cause of cancer mortality; for example, in the USA, it comprises 21% of all cancer deaths.¹ In the general population, tobacco smoke is the main risk for lung cancer and there is evolving evidence of increased risks due to smoking combined with other lung carcinogens. However, what is less well appreciated, both by the medical profession and the general public, is the contribution of occupational factors. The population attributable fraction of occupational lung cancer is reported to be as high as 15%.² Of the occupational exposures, asbestos is the most common, but there are many other workplace carcinogens, including arsenic, radon, polycyclic aromatic hydrocarbons, and silica.

In 1997, the International Agency for Research on Cancer (IARC) designated silica as a carcinogen³ but, at that time, the carcinogenicity was questioned because of the absence of dose-response findings in studies, and the concern that confounding variables, in particular smoking, had not been adequately addressed.⁴ In 2012, the IARC performed an updated meta-analysis, which confirmed the carcinogenicity of silica and clearly demonstrated a positive exposure-response relationship.⁵ These findings greatly contributed to the lowering of the occupational exposure limit (OEL) to 0.05 by the Occupational Health and Safety Administration (OSHA) in 2016.⁶ However, a number of uncertainties remained, with implications for medical screening, prevention, setting of OELs, and lung cancer treatments. Is the presence of silicosis a necessary prerequisite to attribute lung cancer in an individual to silica exposure? What is the combined effect of silica and smoking? Is there a silica exposure threshold below which lung cancer will not occur? Is there an association with specific histological subtypes?

Subsequent research has shed light on these uncertainties. First, the risk of lung cancer is elevated in both those with and without radiological signs of silicosis,⁷ and the effect of smoking is likely multiplicative⁸ (see Figure 1). With regard to histological type, some studies have suggested an increased risk of all types of lung cancer,⁹ while others have reported a strong association with small cell carcinomas⁵ – subtypes that are less responsive to therapy than adenocarcinomas.¹⁰

As a result of relatively recent advances in lung cancer management, the outlook has shifted from one of nihilism to cautious optimism.¹¹ Subsequent to research conducted in the USA that showed that screening with low-dose computed tomography (LDCT) substantially reduced lung cancer mortality,¹² programmes targeted at current and former smokers have been widely instituted in well-resourced settings. There are no official screening programmes for lung cancer in South Africa. However, the South African Thoracic Society made broadly similar recommendations in 2019 with pointers to guide interpretation,¹³ given the high local prevalence of tuberculosis. With regard to treatment, molecular profiling of tumours, undertaken in sophisticated pathology laboratories, is resulting in targeted, individually tailored therapy.¹⁰

There are several important implications for the management of silica-exposed populations in South Africa. Chest radiographs are the most widely used modality for silicosis diagnosis – but they not only miss half the cases of pulmonary silicosis using autopsy as the gold standard,¹³ but also do not meet the requirements for lung cancer screening.⁴ Studies are necessary to clarify the efficacy
of LDCT screening in populations in which silicotuberculosis is not infrequent. Research directed at treatment should include a focus on the cells and genes activated by silica exposure to identify potential therapeutic targets. Primary prevention should aim not only to reduce exposure to silica, but also carcinogens, particular tobacco smoke. For workers with lung cancer, clear criteria for compensation need to be established. Finally, research is needed to evaluate the burden of silica-associated lung cancer in both mining and non-mining populations.

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THREE 2: SILICOsis ELIMINATION PROGRAMMES

Chaired by Dr Vanessa Govender, Director: Masakhane Health, South Africa

Silicosis elimination programmes in the non-mining sector: a global context

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Background
Elimination of silicosis has been on the global agenda since the 1930s. In 1995, the ILO/WHO Joint Committee on Occupational Health recommended countries to place elimination of silicosis high on their priority lists. In the same year, the Global Programme for the Elimination of Silicosis (GPES) was initiated. Following this, countries such as Brazil, China, Chile, India, Thailand, Vietnam, and South Africa joined the programme and formed their own National Programmes for the Elimination of Silicosis (NPEs).

Methods
A scoping review was conducted to explore silicosis elimination programmes in the non-mining industry, globally, through an extensive search for both scientific and grey literature.
Food for thought

- Is the WHO and ILO target to eliminate silicosis by 2030 achievable?
- What are the best silicosis elimination strategies for the African non-mining industry, including the informal sector?
- What lessons can the non-mining industry draw from the mining industry?
- How can we translate strategies/experiences from countries such as Belgium and Switzerland to suit the southern African context?

Acknowledgements

Ntombizodwa Ndlovu, Thireshni Chetty, Nelisiwe Fakudze, Taile Kgoete, and Lebogang Mogongoa (School of Public Health, University of the Witwatersrand); Edward Sepiriwa and Odette Volmink (National Institute for Occupational Health); and the Department of Employment and Labour (South Africa).

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Moving abroad, Prof. Anna-Carin Olin (University of Gothenburg), who was visiting South Africa for the SASUF Research and Innovation Week, described the current situation with regard to silica dust exposure in Sweden.
Silica exposure in South Africa — past and current perspectives

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The exposure pattern to silica dust has changed dramatically in Sweden during the last decade. The mining sector has changed from having more than 1 000 small mines back in history; the number is now down to 15. Quarrying also used to be a big industry, employing more than 7 000 workers, but has decreased in size and currently employs around 1 200 workers. Much of the stonework is now exported, mainly to China, where poor working conditions have been described. Initiatives have been taken to strengthen procurements to include standards for the work environment for imported stone, but many anomalies still probably exist.

Moving back to South Africa, Jabulile Mhlophe (Department of Employment and Labour) gave an update on the silica dust and silicosis milestones.

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In 2004, the Department of Employment and Labour initiated the National Programme for the Elimination of Silicosis. Two years later, in 2006, the National Working Group (NWG) and Provincial Working Groups (PWGs) were established to manage the programme, but lack of baseline data on the prevalence of silicosis in South Africa made it difficult for the working groups to achieve their mandates.

In 2009, the Council for Scientific and Industrial Research (CSIR) was commissioned to conduct a literature review on silica dust exposures of workers in the non-mining industry, especially in South Africa. The review revealed that there was no information regarding the most frequently recorded occupations where silicosis was listed as a contributory cause of death in the South African non-mining sector, although, from 1999 to 2004, the Occupational Medicine Clinic at the National Institute for Occupational Health (NIOH) diagnosed silicosis in workers from foundries and potteries, and from the refractory, engineering, stone crushing, construction, chemical, and glass industries. The authors also stated that “Lack of a comprehensive programme on worker exposure to silica dust and a commitment from the management on this type of programme is a problem in the non-mining industries”. The same group collected 300 personal dust samples, using gravimetric dust sampling in six non-mining industries in Gauteng province. Silica dust exposures in the sandstone, ceramics, refractory, and foundry exceeded the OEL of 0.1mg/m³.

In the same year (2010), the Department of Employment and Labour embarked on an inspection of 208 silica dust producing companies in all the provinces to determine compliance with silica dust levels in terms of the Occupational Health and Safety Act of 1993. Only 54 companies (26%) were found to be compliant.

In October 2020, the CSIR and the Wits Health Consortium were funded by the Department of Employment and Labour to conduct a study on the prevalence of silicosis in the non-mining sectors in South Africa, which is underway. The objectives of the study are:

1. To determine the prevalence of (and the number of workers diagnosed with) silicosis across industries from 2012 to 2018
2. To establish trends in the number of deaths from silica-related diseases per industry from 2012 to 2018
3. To develop a strategy and occupational health programmes that should be put in place to reduce exposure to respiratory silica dust and to eliminate silicosis in South Africa by 2030

References


Jabulile Mphlope was followed by Dr Thuthula Balfour (Minerals Council South Africa), who brought the audience up to date on the mining industry’s progress on silicosis elimination.

Silicosis elimination in the South African mining industry

**Thuthula Balfour**: Head of Health, Minerals Council South Africa  
e-mail: tmbalfour@mineralscouncil.org.za

The elimination of silicosis remains a priority in the South African mining industry as evidenced by the number of cases that are still reported annually. Although cases of silicosis declined by 86.5% from 2008 to 2021, there were still 240 cases reported in 2021. This is a significantly high number.

It is ironic that the first international conference on silicosis was convened by the ILO and the Transvaal Chamber of Mines, and paved the way to the adoption of a 1934 ILO convention that recognised silicosis as an occupational disease. Over the years, South Africa has led research on silicosis. In a seminal study conducted in 2004, Gavin Churchyard et al. found an 18.3–19.9% prevalence of silicosis in 520 gold miners with mean service of 21.8 years, at quartz levels of 0.053 mg/m³. With this and other evidence, better performance regarding the elimination of silicosis in the country would have been expected.

This irony is well articulated by Jock McCulloch in his book, *South Africa’s Gold Mines and the Politics of Silicosis*, in which he states: “The history of silicosis in South Africa is filled with paradoxes. The Rand mines were the first in the world to invest heavily in dust extraction technologies and instruments, such as the konimeter, to reduce risk. South Africa was the first state to recognise silicosis and tuberculosis as occupational diseases, and the gold mines were the first to use radiography to screen workers. Yet South Africa was unsuccessful in making the mines safe or in providing adequate compensation. The major paradox is between the intensity of public debate about silicosis and the invisibility of the disease burden.”

There have been concerted industry initiatives from both the Mine Health and Safety Council (MHSC) and the Minerals Council South Africa to eliminate silicosis and other pneumoconioses. In 2003, through the MHSC, the industry adopted milestones, which were re-emphasised in 2013:

1. By December 2024, 95% of all exposure measurement results will be below the milestone level for respirable crystalline silica (RCS) of 0.05 mg/m³.
2. By December 2024, 95% of all exposure measurement results will be below the milestone level for coal dust respirable particulate of 1.5 mg/m³ (< 5% crystalline silica).
3. Using current diagnostic techniques, no new cases of silicosis, pneumoconiosis, or coal worker's pneumoconiosis will occur amongst previously unexposed individuals who joined the industry in 2009.

In 2007, the Minerals Council developed the Mining Occupational Safety and Health (MOSH) leading practice adoption system and rolled out several leading practices in mines, such as the fogger dust suppression system, footwall and sidewall treatment, scraper winch covers, multistage filtration system, and continuous real-time monitoring of airborne pollutants. The Minerals Council also established a milestone reporting system in 2015 to monitor progress towards achieving the milestones.

Consequently, the mining industry is on target to meet the milestone on RCS. In 2022, 6.3% of exposures were higher than 0.05 mg/m³, lower than the aspirational target of 7%. A few cases of silicosis have, however, been diagnosed in novices who joined the industry after 2009. This is a cause for concern as it indicates previous high levels of exposures.

In conclusion, South Africa has the knowledge and ability to eliminate silicosis and all efforts should be directed at this task.

**REFERENCES**


**THEME 3: OCCUPATIONAL EXPOSURE LIMITS**

*Chaired by Prof. Cas Badenhorst, Anglo American and North-West University, South Africa*

More technical presentations followed, starting with an online discussion by Prof. Derk Brouwer (University of the Witwatersrand), who pertinently asked the question: “Should the current statutory OEL for silica be reduced to 0.05 mg/m³?” This question was further debated by Prof. Cas Badenhorst (North-West University) as he explained the challenges in reducing the statutory RCS OEL in the SA mining industry.

**Will reducing the statutory OEL for silica to 0.05 mg/m³ prevent new silicosis cases?**

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OELs aim to protect workers from developing diseases due to a working lifetime of exposure to hazardous substances. Such limit values can be derived from toxicological animal studies where an outcome or point of departure is used as a starting point for extrapolation to human exposure, or from epidemiological studies. The first type of OEL assumes a ‘standard worker and scenario’, such as a 70 kg male performing light activities for 40 years for 40 hours per week. The second type of OEL uses (aggregated lifetime) exposure-disease outcome relationships to calculate a cut-off point as a limit value concentration. However, there is always a residual risk – partly due to the uncertainties associated with the methods. This means that exposure to the substance at the OEL...
Challenges in reducing the statutory RCS OEL in the SA mining industry

OELs play a crucial role in assessing workplace exposures and their potential health risks. Ever since Kobert introduced the table of acute exposure limits in 1912, numerous organisations worldwide have contributed to the global effort of establishing OELs. These limits serve as invaluable tools in understanding and managing occupational hazards.

The widespread adoption of OELs has led to a complex landscape of guidelines, influenced by various factors and organisations. The process of developing and setting OELs involves evaluating scientific data on health impacts, which can differ between bodies and jurisdictions. One significant factor contributing to variations in OELs is the consideration of feasibility, with health-based OELs being more

Table 1. Early history of institutional OEL development

<table>
<thead>
<tr>
<th>Decade first published</th>
<th>Type of OEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910s</td>
<td>US and South African limits (for crystalline silica/quartz only)</td>
</tr>
<tr>
<td>1920s</td>
<td>US Bureau of Mines exposure limits International Critical Tables</td>
</tr>
<tr>
<td>1930s</td>
<td>German exposure limits USSR Ministry of Labour MACs</td>
</tr>
<tr>
<td>1940s</td>
<td>American Conference of Governmental Industrial Hygienists (ACGIH) maximum allowable concentrations of atmospheric contaminants (preceding threshold limit values) American National Standards Institute standards</td>
</tr>
<tr>
<td>1950s</td>
<td>People's Republic of China's Provisional Hygienic Standards for the Design of Industrial Premises</td>
</tr>
<tr>
<td>1970s</td>
<td>US Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) National Institute for Occupational Safety and Health (NIOSH) recommended exposure limits (RELs) Nordic Expert Group (NEG) for Criteria Documentation of Health Risks from Chemicals Deutsche Forschungsgemeinschaft (DFG) Maximale Arbeitsplatz-Konzentration (MAKs)</td>
</tr>
<tr>
<td>1980s</td>
<td>American Industrial Hygiene Association (AIHA) workplace environmental exposure limits (WEELs)</td>
</tr>
<tr>
<td>1990s</td>
<td>European Scientific Experts Group (now Scientific Committee on Occupational Exposure Limits [SCOEL]) binding occupational exposure limit values (BOELVs) and indicative occupational exposure limit values (IOELVs)</td>
</tr>
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</table>

*Source: Deveau et al. 2015"
Current practices to reduce dust exposure in the South African mining industry

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Vijay Nundlall focused on current practices in the South African gold mining industry to reduce exposure to silica dust. He described the processes that generate silica dust, and how the transportation of the broken rock influences where silica settles and how it is transported via the mine ventilation system. Some of the key interventions discussed were footwall treatment to keep dust trapped on the footwall, and dust filtration systems to remove silica from the ambient air and during rock tipping (transportation) processes. Watering down and the tools available, including automated spray systems, were also elaborated upon. The use of real-time dust monitors for trouble shooting problem areas, and for re-engineering work processes, was highlighted. Vijay emphasised the importance of awareness and education of employees about the dangers of silica dust, the control measures in place, and what employees can individually do to reduce their exposure to silica dust. He concluded with a description of internal dust management awards – created to influence behaviour – and the trends in silica dust exposure reduction over time with all interventions in place.

Staying in the mining industry, Dr Dipalesa Mokoboto (Department of Mineral Resources and Energy) asked, and responded to the question: “Have the silicosis milestones for SA mining been achieved?”

Summary on achievement of silicosis milestone in the South African mining industry

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The Mine Health and Safety Inspectorate (MHSI), and Mine Health and Safety Council (MHSC) – an entity of the MHSI – were both established in terms of the Mine Health and Safety Act (MHSA) No. 29 of 1996 as amended. Occupational lung diseases (OLDs) such as silicosis and tuberculosis are reported to the MHSI in terms of the Mine Health and Safety Act (MHSA) No. 29 of 1996 as amended. Occupational lung diseases (OLDs) such as silicosis and tuberculosis are reported to the MHSI in line with the requirements of the MHSA. The MHSC, on the other hand, is responsible for setting milestones through its tripartite structures, during summits. Milestones on elimination of OLDs were set at a health and safety summit in 2014. The MHSC is responsible for monitoring and reporting on progress made on the milestones.

The milestones covered occupational hygiene and occupational medicine.1
1. By December 2024, 95% of all exposure measurement results will be below the milestone level for RCS of 0.05 mg/m³ (these results are individual readings and not average results).
2. Using present diagnostic techniques, no new cases of silicosis, pneumoconiosis, or coal worker’s pneumoconiosis will occur amongst previously unexposed individuals (‘previously unexposed individuals’ were regarded as those unexposed to mining dust prior to December 2008, i.e. persons entering the industry in 2009).

In terms of monitoring the occupational hygiene milestone to determine if 95% of the RCS measurements were below 0.05 mg/m³, there was an improvement from 82.75% in 2014 to 91.1% in 2020. Thus, the milestone has not yet been reached; however, it is anticipated that 95% of all RCS measurements will be below 0.05 mg/m³ by 2024.
For the occupational medicine milestone, six cases of silicosis were reported to the MHSI, which were confirmed as novice workers. The Medical Bureau for Occupational Diseases (MBOD) certified two of the cases as silicosis. Two additional cases were further investigated by the Minerals Council South Africa and silicosis was excluded in both. One was found to have miliary TB and the other had community acquired pneumonia.

A holistic review of the remaining two novice cases needs to be conducted to verify the diagnosis of silicosis. The validity of the diagnosis is influenced by the experience of the reader of the CXR, and the results of other examinations. Although the silicosis milestones for the South African mining industry have not yet been met, great achievements have been made.

REFERENCE


THEME 4: DETECTION AND MONITORING OF SILICA-RELATED DISEASES

Chaired by Dr Thuthula Balfour, Minerals Council South Africa

Three presentations were delivered under this theme. Dr Zodwa Ndlovu discussed the challenges and opportunities of the national silicosis surveillance programme. Prof. Emeritus David Rees from the Wits School of Public Health and Prof. Anna-Carin Olin from the University of Gothenburg spoke about the use of biomarkers in the diagnosis of lung fibrosis and silicosis.

National surveillance of silica-exposed workers – challenges and opportunities

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The concept of surveillance is well established. It is a systematic and ongoing process – not a one-off event. Occupational surveillance systems collect data on exposure measurements, disease, and demographic and occupational characteristics. Nowadays, these data are usually available in computerised, administrative databases. The data are analysed, interpreted, and disseminated to stakeholders for the prevention and control of adverse exposures and occupational diseases. Occupational disease surveillance is useful for the detection of exposures and disease, the monitoring of trends, the identification of workers who are at risk of developing disease, the provision of alerts or warnings of high risk, the provision of information to evaluate or monitor the effects on interventions, and for stimulating research.

The use of routine, administrative, compensation data for surveillance was illustrated using the example of the National Institute for Occupational Health’s (NIOH’s) Pathology Automation System database (PATHAUT). The database contains diagnoses of OLDs, including silicosis and TB, in deceased South African miners. Although the data are collected for autopsy compensation, they are used for OLD surveillance. The PATHAUT database is the only source of long-term data for OLD surveillance in South African mine workers. The surveillance information is contained in annual reports dating back to 1975, which are available on the NIOH website (https://www.nioh.ac.za/pathology-division-surveillance-reports/). The PATHAUT data have also been used extensively for research. Studies have described the magnitude and factors associated with silicosis trends and alerted the industry to the risk of silicosis in platinum miners and female gold miners.

There are other institutions that collect silicosis disease and silica exposure data that could be used to establish a national silicosis surveillance system for both the mining and non-mining industries. This will require collaboration among the relevant stakeholders. However, experience has shown that sustained commitment determines the success or failure of a surveillance system. Therefore, long-term commitment to provide adequate human and financial resources is key to the development of a sustainable national surveillance system.

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Biomarkers for the detection of pathophysiological responses to silica

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Medical surveillance of workers for silicosis – fibrosis of the lung due to RCS – is typically done using CXRs. This method is imperfect because subradiological silicosis (disease unapparent on the X-ray) is common and, once apparent, shows incurable and established disease. Consequently, markers of pathophysiological responses to silica using methods other than CXRs have been of interest for decades. These markers are broadly termed biomarkers or screening tests; meaning indicators of excessive exposure or the body’s negative reaction to the exposure, or tests that provide a presumptive diagnosis of disease.
Can we detect early adverse effects of inhaled respirable silica?

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Silica dust exposure is deposited in the very distal part of the small airways (i.e. airways < 2 mm in diameter). Here, silica induces a low-grade inflammatory response as the normal defence system cannot handle the long quartz structures. Long-standing inflammatory changes may slowly develop into silicosis in susceptible individuals, or into cancer.

The small airways have long been known as the ‘silent zone of the lung’. This is based on the fact that early pathological changes are asymptomatic and, moreover, are not detected by routine clinical measures such as spirometry or CXRs. This explains why silicosis often goes undiagnosed, as shown in several studies, and susceptibility for silicosis and coal-worker’s pneumoconiosis: a comprehensive review. J Toxicol Environ Health. 2006; Part B 9: 357-395. doi: 10.1080/15287390500196537.

A test that excluded silicosis (high negative predictive value) among exposed individuals would enable selection of only those with a risk of the disease to undergo chest imaging. In resource-scarse settings (informal mining, for instance) this targeting would be beneficial.

5. Identifying susceptible individuals

Only a proportion RCS-exposed people develop silicosis. Identifying those susceptible might stimulate interventions to prevent disease development.

All biomarkers and screening tests investigated so far have flaws and there are reservations about their use. Nevertheless, their potential benefits are substantial and the search for reliable tests should continue.

REFERENCES

A method has been developed and validated in which a small amount of fluid is retrieved from the airway linings in the lung, in exhaled air: the PExA method™ (particles in exhaled air: www.pexa.se). Pathological processes in the small airways of the lung have been shown to alter the composition of the lining fluid. Hence, the sample provides a valid source of biomarkers for diseases affecting the small airways. Using the PExA method, a number of protein biomarkers have been identified for smoking-induced lung disease and, in post-COVID-19 patients, a profile of surfactant lipids has been identified that is suggestive of the development of lung fibrosis. More recently, preliminary findings in tunnel workers exposed to silica dust show that their lipid profiles in PExA samples are altered, proposing a ‘pro-fibrotic’ profile. As the PExA method is non-invasive, it is suitable for screening for the detection of early disease.

REFERENCE
Unanswered questions
1. Is there a need for medical surveillance in the stone and sand industries?
2. What is the relevance of tuberculin skin testing in silica-exposed individuals? Is tuberculosis preventive treatment effective for silicosis in southern Africa?
3. What RCS OEL is protective against increased tuberculosis risk?
4. Should we spend resources on lung cancer surveillance and research in silica-exposed workers?
5. How can we address silica dust exposure and silicosis in artisanal and illegal mine workers?

Quotes from the workshop
1. “We are all swimming in the same pool. Can we learn to be life savers and prevent exposed workers from developing silicosis?” – Jabulile Mhlophe, Department of Employment and Labour
2. “240 cases of silicosis are 240 too many.” – Thuthula Balfour, Minerals Council South Africa
3. “We have known about silicosis for more than 150 years… let us not take another 150 years to eliminate it.” – Gill Nelson, Wits School of Public Health
4. “Silicosis is not the only disease caused by silica dust exposure, and the lungs are not the only organs affected.” – Gill Nelson, Wits School of Public Health

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