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SPECIAL ISSUE

Noise and hearing health: innovations and interventions

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Volume 31, Issue 2, 2025

SPECIAL ISSUE | Noise and hearing health: innovations and interventions

Contents

Editorial 53

Book Launch
In a Rain of Dust: Death, Deceit, and the Lawyer Who Busted Big Asbestos 54

Guest Editor Profiles
Goitsemang Keretetse 55
Liepollo Ntlhakana 56
Martha Chadyiwa 57

Original Research
Compensation claims for occupational noise-induced hearing loss in South African mineworkers: trends and determinants
D Njanjeni, J Levin, L Dzingwa, N Ndlovu 58

Noise exposure levels among aircraft technicians at an aviation maintenance organisation in Gauteng, South Africa
BAM Phakathi, W Utembe, J Manganyi 66

Audiometric screening results and knowledge of noise-induced hearing loss and hearing conservation practices among members of a South African army unit
C Ngobeni, L Pottas, M Soer, MA Graham 72

Technology-driven approaches to occupational noise-induced hearing loss management and hearing conservation programmes in Africa
K Khoza-Shangase 77

The interplay of occupational noise-induced hearing loss and middle ear disorders: towards comprehensive hearing conservation in Africa
K Khoza-Shangase, B Sebothoma 87

Opinion
Noise-induced hearing loss: what does the implementation of the standard threshold shift look like
L Ntlhakana 97

A rational approach to workplace drug and alcohol testing: scientific validity, legal defensibility, and ethical practice
JB Laurens 99

Sponsored
Smart technology preventing workplace hearing loss
Sedulitas 103

Legislation
Noise Exposure Regulations, 2024 and Physical Agents Regulations, 2024 promulgated under the Occupational Health and Safety Act No. 85 of 1993, as amended
W Mallon 104

Recent amendments to the Occupational Health and Safety Act – new Regulations
Webber Wentzel 106

Society Newsletters
SASOM 109
SAIOH 114
MMPA 119

From the Guest Editor



Dr Goitsemang Keretetse, Guest Editor

There is a renewed urgency in the way occupational noise is being addressed, reflecting both emerging evidence of its broader health impacts and an increasing commitment to regulatory reform and worker protection. As Guest Editor of this special issue on 'Noise and hearing health: innovations and interventions', I invite you to explore a timely collection of research and commentary that speaks to both the scientific advancements and regulatory momentum reshaping the field.

The publication of this issue coincides with a significant policy development through the launch of South Africa's new Noise Exposure Regulations, introduced by the Department of Employment and Labour on 11 April 2025. These updated Regulations, which will come into effect on 5 September 2026, represent a positive step in the revision of the 2003 Noise-Induced Hearing Loss Regulations. The Regulations introduce clearer and more enforceable thresholds, including a lower action level of 82 dBA, and a revised noise rating limit of 85 dBA for continuous noise and 137 dBC for impulsive noise.[1] They embed a structured approach to risk assessment, designate demarcation of noise zones, mandate regular medical surveillance, and impose meaningful consequences for non-compliance. In doing so, they signal a shift from passive management of occupational noise towards a more proactive, systems-based approach to worker protection.

Against this backdrop, the articles in this issue of *Occupational Health Southern Africa* reflect the current state and future direction of occupational noise. One compelling contribution is a study by Phakathi and colleagues, which focuses on noise exposure during aircraft maintenance operations, bringing attention to a critical, yet often under-recognised, worker group in the aviation industry. Aircraft maintenance personnel face unique noise hazards, arising from both routine and unscheduled tasks that require them to work in close proximity to equipment that generates excessive noise.[2] Unlike flight crew or terminal workers, maintenance personnel often operate in enclosed hangars or confined spaces where noise can reverberate and amplify, increasing both exposure intensity and duration.[3] Although noise exposure levels exceeded the noise rating limit of 85 dBA in Phakathi's study, differences in how aircraft maintenance technicians perceived the risk contributed to the inconsistent use of hearing protection devices (HPDs).

Other papers in this issue focus on hearing conservation practices; one such paper, by Ngobeni et al., describes a study of members in an army unit. The findings are of great concern, as they revealed that 50% of the study participants did not perceive noise to be a risk factor for noise-induced hearing loss (NIHL), and a similar proportion reported that they were not provided with HPDs. Khoza-Shangase and Sebothoma present a review on the relationship between occupational NIHL and middle-ear infections, which demonstrates a gap in hearing conservation programme (HCP) implementation in Africa.

In addition to studies on occupational noise exposure and gaps in HCP implementation, this issue includes timely insights into the use of technology for occupational NIHL management and HCPs. Real-time dosimetry, smart alert systems, AI-based solutions, and digital dashboards are no longer futuristic concepts; they are becoming accessible tools that can shift occupational noise management from reactive compliance to proactive intervention.[4] These technologies offer the potential to integrate exposure data into broader environmental, health, and safety frameworks, improving both accuracy and responsiveness. However, in Africa, issues of high costs, limited digital infrastructure, and data security persist as challenges to the adoption of such technologies.[5]

While clinical diagnoses and exposure assessments provide direct evidence, compensation claims data can reveal how frequently occupational NIHL leads to functional impairment that is significant enough to warrant legal or financial redress.[6] Moreover, rising or stagnant compensation claim rates, despite regulatory efforts, may signal the ineffectiveness of current HCPs, low use of hearing protection, and/or systemic exposure to hazardous noise levels. This is reflected in a paper by Njanjeni and colleagues.

What emerges clearly from this body of work is the need for occupational health professionals to lead a renewed response to noise – one that reflects current evidence, technological innovation, and a deeper understanding of the lived realities of workers. As the South African example shows, Regulations can provide a powerful foundation, but it is through our everyday practices, such as how we assess risk, implement controls, educate workers, and influence policy, that lasting change is achieved.

I wish to thank all the contributors, reviewers, and editorial team members who made this special issue possible. Your scholarship not only advances our field, but also provides the practical tools and critical reflections needed to protect workers better from the cumulative harms of occupational noise. My hope is that this issue will serve as both a resource and a catalyst for dialogue, innovation and, most of all, change.

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Thank you

We thank the Guest Editors of this special issue of *Occupational Health Southern Africa*, 'Noise and hearing health: innovations and interventions', for their contributions to the research papers, and their support to the editorial team. The profiles of Dr Goitsemang Keretetse, Dr Liepollo Ntlhakana, and Prof. Martha Chadyiwa – all research specialists in the field of occupational noise-induced hearing loss – can be found on pages 55–57 of this issue.

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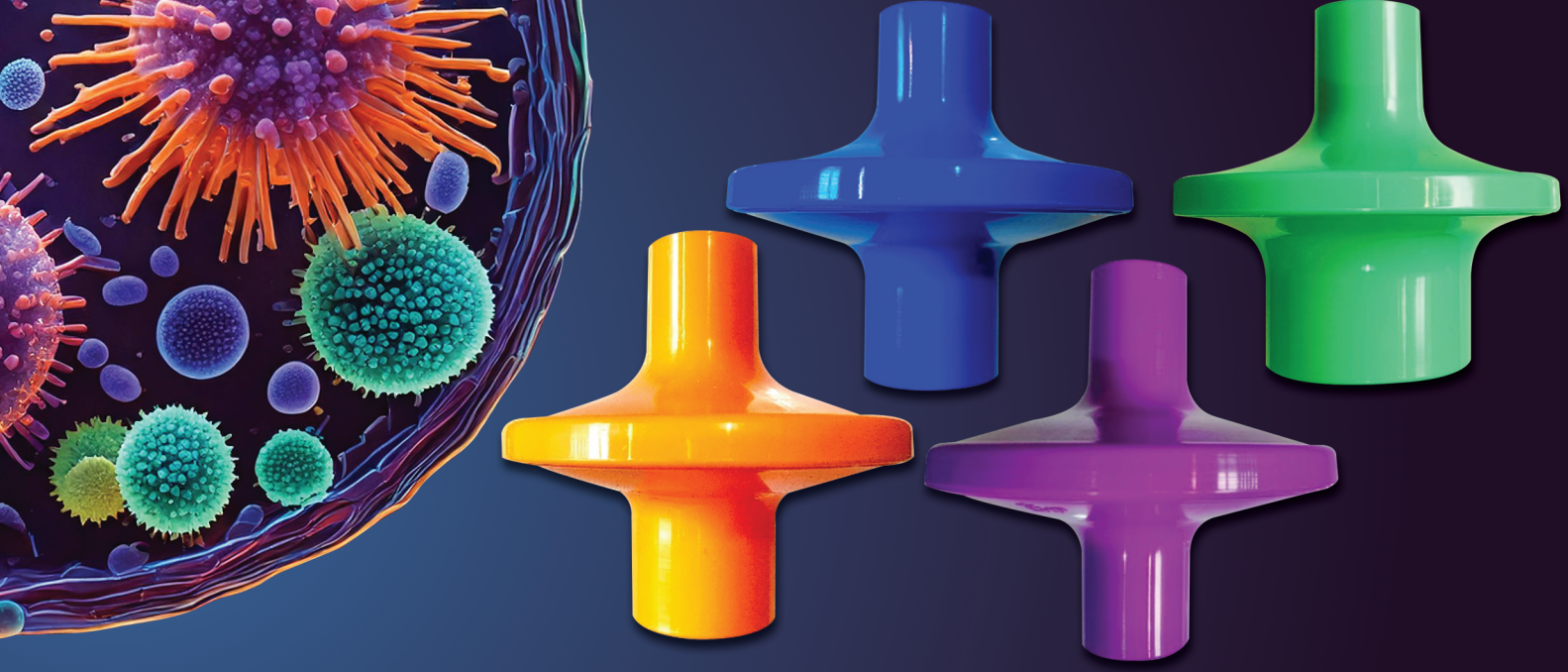
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In a Rain of Dust: Death, Deceit, and the Lawyer Who Busted Big Asbestos

12 June 2025 | Hosted by the National Institute for Occupational Health (NIOH)

Spo Kgalamono: Executive Director, NIOH
e-mail: spok@nioh.ac.za

The National Institute for Occupational Health (NIOH) hosted the launch of Prof. David Kinley's long-awaited book, *In a Rain of Dust: Death, Deceit, and the Lawyer Who Busted Big Asbestos*, on 12 June 2025. This hybrid event drew a national audience, with approximately 200 occupational health professionals attending either in person or online.

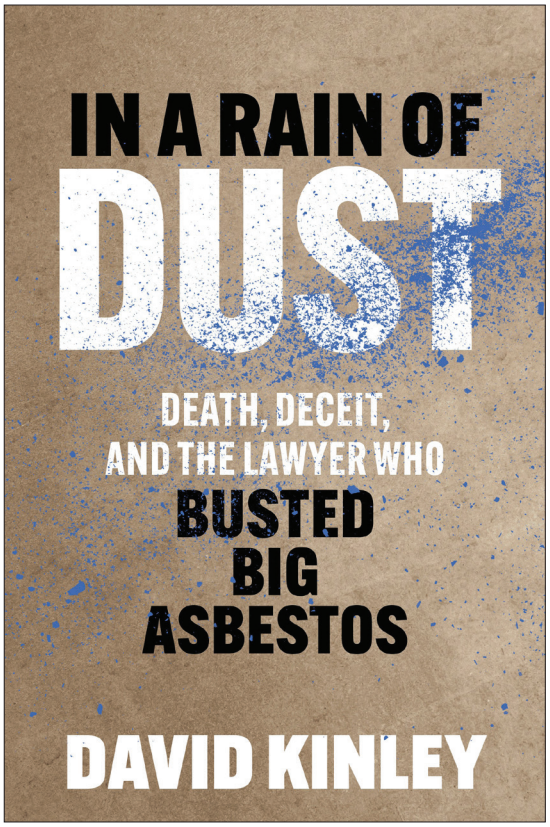
The Executive Director of the NIOH, Prof. Spo Kgalamono, delivered the opening remarks, setting a reflective and poignant tone. She described the book as, *"confronting a painful chapter in South Africa's history, one written not in ink, but in dust – the dust of asbestos"*. She paid tribute to the generations of South African workers who laboured in asbestos mines under dangerous conditions, often without protection or knowledge of the health risks.

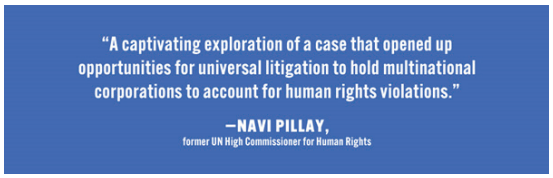
Prof. Kgalamono also acknowledged the significant contributions of Prof. Richard Meeran, one of the founding partners of Leigh Day's International Practice in London. A renowned human rights lawyer, Prof. Meeran has spent his career holding multinational corporations accountable for abuses across the globe. His work has had a profound impact in South Africa, most notably through:

- Representing South African asbestos victims in the landmark case against Cape PLC
- Playing a central role in litigation involving Thor Chemicals
- Leading silicosis class actions against Anglo American on behalf of former gold mineworkers

During the event, Profs. Kinley and Meeran shared insights into their involvement in the Cape PLC case, highlighting the devastating legacy of asbestos exposure and its impact on workers and the communities. The launch – a resounding success – served not only as a tribute to the resilience of those affected by occupational diseases, but also as a reminder of the ongoing importance of safeguarding worker health, advancing occupational justice, and promoting corporate accountability.

The book is on sale at Love Books in Johannesburg and at The Book Lounge in Cape Town.





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Goitsemang Keretetse

Dr Goitsemang Keretetse is a lecturer and course coordinator at the University of the Witwatersrand School of Public Health (Occupational Health Division), where she teaches occupational hygiene and exposure science courses and supervises master's students. Dr Keretetse joined the University of the Witwatersrand in 2015 as a lecturer and course coordinator for the Master of Public Health (MPH) programme in the field of Occupational Hygiene, as well as co-coordinator of the Postgraduate Diploma in Occupational Health. She was instrumental in the development of the new Master of Science programme (MSc in Medicine, in the field of Exposure Science), and a new field of study within the MPH programme (MPH in Exposure and Health). The two programmes – the first of their kind in Africa – were established in response to the evolving landscape of occupational hygiene and the shift towards exposome and exposure science. Advancements in exposure science underscore the importance of considering all exposures, whether consumer, residential, environmental, or occupational, across the entire human lifespan, encompassing contact with chemical, physical, or biological agents in diverse environments.

Dr Keretetse also worked as a resident occupational hygienist for one of South Africa's parastatal organisations. Prior to this, she worked for an occupational hygiene consulting company, servicing clients across various industries in Gauteng and other provinces of South Africa. She has more than 15 years of practical experience in occupational hygiene, covering both mining and non-mining industries. Her skills include developing occupational hygiene risk assessment and monitoring programmes for both chemical and physical hazards. She is registered with the Southern African Institute for Occupational Hygiene (SAIOH) as an occupational hygienist, and is the current SAIOH Chief Examiner. She is also a member of the SAIOH National Council and serves on the SAIOH Professional Certification Committee (PCC-ExCo).

As part of her contribution to developing occupational hygiene in the Southern African region, she co-facilitated Occupational Hygiene Training Association (OHTA) courses in Zambia, Mozambique, and South Africa, through the African Union Development Agency's (AUDA-NEPAD's) Southern African Tuberculosis and Health Systems Support (SATBHSS) project, which aimed to build professional capacity in the field of occupational hygiene.

Dr Keretetse was awarded a PhD in public health from the University of the Witwatersrand in 2023. Prior to this, she obtained her MSc degree from North-West University. Her research interests include exposure assessment, exposure pathway analysis, human health risk assessment, and the development of interventions to control exposure. For her Masters degree, she evaluated exposure of petrol attendants to volatile organic compounds (VOCs), and assessed DNA damage in the lymphocytes of African petrol attendants. Her PhD research focused on exposure of nail technicians to VOCs, emitted from nail products, in the formal and informal sectors of the beauty industry in Johannesburg.

Dr Keretetse has supervised a range of Master's research projects focused on occupational and environmental exposures, including air pollutants, hazardous chemical substances, and ergonomic



Dr Goitsemang Keretetse
Photograph: courtesy of Dr Goitsemang Keretetse

risks across diverse sectors such as waste management, energy production, healthcare, and mining. She is currently the Project Leader for a project funded by the South African Water Research Commission, focusing on characterising bioaerosols, VOCs, and odour emissions in wastewater treatment plants. She has made significant contributions to the field of occupational hygiene and exposure science through her publications in local and international scientific journals, as well as her presentations at local and international conferences.

Dr Keretetse has secured competitive funding for research and teaching equipment from the Wits Faculty of Health Sciences and the American Industrial Hygiene Association (AIHA) Developing World Outreach Initiative (DWOI). She has also received research grants from the National Research Found-ation (NRF), the Wits Early Career Academic Development (ECAD) Programme, and the Wits Chancellor's Female Academic Leaders Fellowship (FALF) fund. She has received multiple awards for her research and scientific communication, including the SAIOH awards for Best Poster and Oral Presentation (2017, 2023), the International Occupational Hygiene Association (IOHA) Best Poster Presentation Award (2021), and the Wits Faculty of Health Sciences Research Awards (2016, 2019). She also received accolades at the 2018 Wits Science Slam, where she presented her work during the National Science Week hosted by Wits for high school learners from around Gauteng. In 2008, she was awarded the SAIOH Occupational Hygiene Student and Research Paper of the Year.

Beyond her professional activities, she finds fulfilment in her roles as a devoted wife and mother of two precious children – a 14-year-old daughter and an eight-year-old son. Balancing her academic pursuits with family life, Dr Keretetse actively participates in her

children's extramural and sporting activities. During her leisure time, she enjoys participating in Parkruns, playing netball, and indulging in creative pursuits such as crocheting and crafting hand-made necklaces.

Her commitment to nurturing the next generation of scientists extends beyond the classroom, as she engages with young individuals to support their academic endeavours and future aspirations. Additionally, she is a dedicated Sunday school teacher, contributing to the spiritual growth of her community. Dr Keretetse embodies the essence of leader-ship, balancing professional excellence with personal fulfilment and community engagement.

Liepollo Ntlhakana

Dr Liepollo Ntlhakana (PhD) is a senior lecturer and the Head of Department (Audiology) in the School of Human and Community Development (SHCD), Faculty of Humanities, at the University of the Witwatersrand. She teaches theory and clinical courses across all years of undergraduate study and supervises postgraduate and undergraduate research. Her professional career in audiology spans more than 20 years and covers the health, education, and private practice sectors. Dr Ntlhakana's contribution to occupational health started in 2002 when she worked as a locum audiologist for Transnet, where she conducted audiometry medical surveillance for workers. Her passion for primary prevention of occupational hearing loss strategies for workers stemmed from her firm belief that, although this type of hearing loss is prevalent in various industries, it is preventable. Over time, her interest evolved into research during her postgraduate studies. She subsequently obtained a master's degree in Audiology, followed by a PhD in Public Health in 2021. She focused on hearing conservation programmes (HCPs) and risk assessment for the prevention of occupational noise-induced hearing loss (ONIHL) in mineworkers.

In 2010, Dr Ntlhakana joined the Medical University of South Africa, now Sefako Makgatho University, where her strong teaching and learning foundation was formed and firmly framed. There, she lectured in a theory course in occupational audiology and was also a clinical supervisor for the course. In 2014, she joined the University of the Witwatersrand's Department of Speech Pathology and Audiology.

Dr Ntlhakana is a guest lecturer in the Wits School of Public Health, where she teaches MPH and MSc exposure science postgraduate students about audiometry and medical surveillance. Her extensive teaching experience, which focuses on the prevention of ONIHL, risk assessment strategies for ONIHL, and the application of frameworks for hearing conservation – in both her undergraduate and postgraduate studies – solidified her research niche, which is the epidemiology of ONIHL. In her research publications, she has integrated outcomes aligned with the World Health Organization's Sustainable Development Goal 3: Good Health and Well-being. Dr Ntlhakana's publications, teaching, and clinical practice in audiometry and medical surveillance recently contributed to evidence-based knowledge and guidance for the South African mines' implementation of the revised NIHL Standards, specifically regarding how to integrate standard threshold shift (STS) calculations for the early identification of ONIHL. Since 2015, she has published more than 15 peer-reviewed journal papers and book chapters. Four of her publications were co-authored with students: three with undergraduate students and one with a postgraduate student.

Dr Ntlhakana's significant contribution to the audiology profession started when she signed up as a member of the South African Association of Audiologists (SAAA). She was nominated to serve



Dr Liepollo Ntlhakana
Photograph: courtesy of Dr Liepollo Ntlhakana

in various positions, including Chairperson of the occupational audiology portfolio, and member of the local organising committee for local and international conferences hosted by the Association (of significance being the 2018 World Congress of Audiology held in Cape Town). Later, she served as President Elect, President, and Past-President of the SAAA, between 2019 and 2023. She is currently a non-executive member of the SAAA, representing the Association at strategic stakeholder engagements, including the South African Bureau of Standards and Inter-Professional Rehabilitation Indaba.

Dr Ntlhakana has held leadership positions at various levels in the University of the Witwatersrand. In 2022, she was the Deputy Head and Acting Head of Department (Audiology). From 2022 to 2024, she was Chair of teaching and learning for the SHCD. Outside of the University, she serves in decision-making positions that foster growth and collaboration as an active member of the SAAA.

Dr Ntlhakana has received awards in teaching and learning, research, and academic citizenship, including:

- 2024: National Medical Awards: Healthcare Leadership Award for the profession of audiology in South Africa
- 2023: Grant by the Wits Writing Intensive (WWI) Board to redesign an undergraduate course and to collaborate with a writing fellow
- 2021: Best oral presentation and the 'VCCA Special Award' for

a paper delivered at the international Virtual Conference in Computation Audiology (VCCA) in the Netherlands: 'Examining the association of standard threshold shifts for occupational hearing loss among miners exposed to noise and platinum mine dust at a large-scale platinum mine in South Africa'
- 2014: Best oral presentation at a local conference in Cape Town, South Africa, for her master's degree thesis

Dr Ntlhakana's scholarship of teaching, research, and academic service contributions highlight her experience in occupational audiology and medical surveillance. Her collaborative work continues to show the importance of preventing occupational hearing loss for workers in various industries in South Africa.

Martha Chadyiwa

Martha Chadyiwa is an Associate Professor of Public Health at Sefako Makgatho Health Sciences University. Her multifaceted career spans academia, research, and international collaborations in the fields of environmental and occupational health.

Prof. Chadyiwa blends academic excellence with strategic leadership in her role as an environmental and occupational health expert. Her academic qualifications include an MBA from Twente University (the Netherlands), a PhD in Public Health from the University of the Witwatersrand, and a BEd Honours in Education Leadership and Management from the University of Johannesburg. Her leadership portfolio includes serving as Head of the Department of Environmental Health at the University of Johannesburg (2012–2017), where she spearheaded the development of the Master of Public Health (MPH) curriculum and pioneered the innovative MPH chatbot (https://uj-mph-chatbot.netlify.app/).

Her international influence is evidenced by her impactful tenure as a member of the Universitas 21 (U21), which is a global network of research-intensive universities that collaborate to enhance international education and research. As Vice Chair of the U21 Sustainable Development Goals Committee (2019–2024), she led international initiatives to shape health policy and sustainable development. She is a member of several prestigious international organisations, including the Horizon Europe Framework Programme, the Athens Institute for Education and Research, and the USA National Environmental Health Association.

A researcher and author, Prof. Chadyiwa has published in high-impact journals and contributed book chapters to significant works in her field. She serves as an editorial board member and reviewer for several prestigious academic journals, including the *Journal of Economic and Social Development, Water Resources Management, Health SA Gesondheid, Archives of Community Medicine and Public Health,* the *Malaysian Journal of Medicine & Health Sciences*, the *International Journal of Environmental Research and Public Health,* the *Journal of Medical Internet Research,* the *South African Medical Journal,* and *Occupational Health Southern Africa*.

As a principal investigator, she has secured research funding from organisations such as the South African Medical Research Council and the University of Johannesburg's Global Excellence and Stature 4.0 for Societal Impact Initiative.

Her scholarly excellence has been recognised in the many accolades she has received. She was named among South Africa's Inspiring Fifty women in STEM (2021), received the Black Women in Science Fellowship (2025), and was a recipient of the Olympus International Awards South Africa (OIASA2025), and of the University of Johannesburg's Special Recognition Award (2023).



Prof. Martha Chadyiwa
Photograph: courtesy of Prof. Martha Chadyiwa

As a dedicated mentor, Prof. Chadyiwa has supervised more than 30 master's students' research to completion. Her mentorship extends to creating pathways for the next generation of public health professionals. She is equally committed to community engagement, having developed and implemented numerous intervention programmes to address public health challenges in South African communities. Her work in community-based research has contributed significantly to environmental and occupational health issues in underserved populations.

With expertise spanning environmental impact assessment, occupational health and safety, and public health leadership, Prof. Chadyiwa continues to drive innovation in health education, through integrating technology solutions and developing frameworks for sustainable health outcomes in resource-challenged environments. Her career embodies a commitment to excellence in teaching, research, and community service, making her a transformative leader in public health education and practice across southern Africa.

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Compensation claims for occupational noise-induced hearing loss in South African mineworkers: trends and determinants

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ABSTRACT

Background: Workers with prolonged exposure to noise above the occupational exposure limit (OEL) of 85 dBA are at risk of developing occupational noise-induced hearing loss (ONIHL). In South Africa, ONIHL compensation in mining, metals, and construction is administered by Rand Mutual Assurance (RMA).

Objectives: To describe trends of ONIHL claims, and determinants of successful claims in the South African mining industry, from 2010 to 2019.

Methods: This was a repeat cross-sectional study. Mineworkers were assigned to homogeneous exposure groups (HEGs) by occupation at claim submission. Trends in annual proportions of ONIHL claims were assessed using the chi-square test. Binary logistic regression was used to identify factors associated with successful ONIHL claims, i.e. those that met employment and medical compensation criteria.

Results: From 2010 to 2019, 12 761 ONIHL claims were submitted to RMA. Claims decreased by 7.3/10 000 mineworkers per year, and successful claims decreased from 72.6% to 43.3%. Three-quarters (n = 9 585, 75.1%) of claimants were in HEG B (85–105 dBA). The HEG was not stated for 1 374 (10.8%) claimants. Compared to claimants with < 20 years of employment, those employed for 20–29 years had a 40% greater likelihood of success (adjusted odds ratios (AOR): 1.40, 95% CI 1.25–1.56). Compared to claimants in HEG B, those in HEG C (82–85 dBA) had a 33% lower likelihood of successful claims (AOR: 0.67, 95% CI 0.57–0.78 and AOR: 0.52, 95% CI 0.45–0.60, respectively).

Conclusion: Claim data provide useful information about ONIHL and compensation. Noise exposures above the OEL were common. Successful claims were associated with higher noise exposures and longer employment. The findings from this study highlight the need for noise prevention programmes to achieve the mining industry target of zero harm, and the usefulness of routine administrative data for research and monitoring of occupational diseases.

INTRODUCTION

Prolonged exposure to noise exceeding 85 dBA can lead to noise-induced hearing loss (NIHL).[1,2] It affects not only the hearing of workers, but also their social lives, cognitive wellbeing, and overall quality of life.[3,4] Efforts to mitigate occupational NIHL (ONIHL) are essential, particularly in developing regions where the burden is disproportionately high. Globally, in 2021 there were more than 3.8 million disability-adjusted life years (DALYs) in developing regions, compared to 0.3 million in developed regions of the world.[2] In South Africa, an estimated 30% of mineworkers experienced ONIHL in the period 2016–2017.[5]

The prevalence of ONIHL in mineworkers is a concern. In South Africa, the Mine Health and Safety Act No. 29 of 1996 (MHSA) was promulgated to protect the health and safety of mineworkers.[6] Regulation 22.9 of the MHSA deals specifically with occupational noise and sets the occupational exposure limit (OEL) to 85 dBA.[6] However, a study published in 2011 reported that 73.2% of South African mineworkers were exposed to noise levels above this OEL.[7]

While regulatory measures aim to limit exposures and prevent occupational diseases, compensation exists to support those affected. In South Africa, compensation for ONIHL in all industries, including the mining industry, is governed by the Compensation for Occupational Injuries and Diseases Act No.130 of 1993 (COIDA).[8] Claims from former mineworkers are adjudicated, based on their exit medical diagnostic audiograms.

According to Section 4 of Circular Instruction 171 of the COIDA, to be eligible for compensation, claimants must have documentary proof of workplace exposures to noise levels exceeding 85 dBA, of sufficient duration to cause NIHL.[9] Also required is a medical opinion supporting hearing impairment due to work-related noise exposure. Claimants' baseline and diagnostic audiograms are required to determine percentage loss of hearing (PLH).[8,9]

Rand Mutual Assurance (RMA) adjudicates ONIHL claims and pays out compensation according to the COIDA for the mining, iron, steel, metal, and related industries, on behalf of the Department of Employment and Labour.[8-10] The success of claims is dependent upon the submission of complete documentation and audiograms of good quality.[9,10]

Although compensation benefits claimants, prevention of ONIHL is key. The mining industry introduced milestones to reduce ONIHL in the industry in 2003, to be met by 2013, and again in 2014, to be met by 2024.[11,12] These targets are summarised in Table 1.

The mining industry has implemented preventive measures to reduce ONIHL, through Mining Industry Occupational Safety and Health (MOSH) initiatives to identify and adopt leading practices. Interventions include production of training manuals for the Hearing Protection Device: Training, Awareness and Selection (HPD TAS) tool, introduced in 2010,[14] and the Industry-Wide Buy and Maintain Quiet Initiative (IBMQI), introduced in 2014.[15,16] The IBMQI aims to reduce over-exposure to loud noise in mines, through purchase and maintenance of equipment that emits noise below 107 dBA.[15,16]

Despite these interventions, evidence suggests that gaps in the implementation of noise exposure limit regulations persist, leading to continued high noise exposure levels. An early study conducted in 2007, following the introduction of MHSC milestones, reported noise levels above the OEL in some work areas.[7] A more recent study (covering the period 2014 to 2017) showed that 85.5% of mineworkers, including workers as young as 21 years who were compensated for ONIHL, had been exposed to noise above the OEL.[17]

Occupational NIHL remains a prevalent occupational disease in South Africa. A review of South African occupational health and safety (OHS) statistics in annual reports of the Compensation Fund showed that, from 2001 to 2019, the incidence of ONIHL (53.4%) was higher than that of other occupational diseases.[18] Occupational NIHL accounted for 43.6% of all compensated occupational diseases in 2001, 50.8% in 2003, 70.7% in 2006, and 49.9% in 2017, consistently remaining the leading compensated occupational disease during this period.[18] However, in comparison to occupational injuries, ONIHL and other occupational diseases, such as those caused by mine dust, are often overlooked, despite their potential to cause lifelong disability, reduce quality of life for workers, and incur high compensation costs.[1,18,19]

Analysis of compensation claims may offer valuable insights into the burden of ONIHIL and the effectiveness of interventions. Temporal trend analysis of claim data can track progress towards reducing ONIHL in mineworkers, and provide insights about claims processes. Additionally, factors influencing successful claims remain poorly understood, and understanding these determinants may identify jobs and areas where noise reduction is needed. In this study, we analysed ONIHL compensation claims from 2010 to 2019 to describe trends, and identified the factors associated with successful claims, in the South African mining industry (SAMI).

METHODS

We conducted a repeated cross-sectional time trend analysis, using RMA's ONIHL compensation claims data from 2010 to 2019 – the data available at the time of the study. Data on all claims submitted to RMA for South African mineworkers were included, regardless of employment status at the time of claim. Information recorded in the database includes employment data at the time of claim submission (historical data are not recorded).

Demographic and compensation-related data from 2010 to 2019 were obtained from RMA in MS Excel format, and were exported to Stata (Statacorp version 16) for data management and analysis. Data integrity checks were conducted to confirm the absence of duplicates, inconsistencies, and missing entries. We performed a power calculation, using the comparison of two unpaired proportions method. Using all 12 761 records, there was 99% power to detect statistically significant differences of 1% in the proportions of ONIHL claims between any two years at the 5% level.

Rand Mutual Assurance adjudicates claims based on the criteria stipulated in Section 4 of Circular Instruction 171 of the COIDA.[9] The outcome-variable ONIHL claim was binary, viz. successful or unsuccessful. Successful claims were defined as those for which RMA had accepted liability after examination of submitted records. Unsuccessful claims were those that did not meet the compensation criteria, had no exposure data, had incomplete information, etc. Claims were categorised as gold, platinum, 'other', and 'not stated' according to the commodity in which the mineworker last worked when the claim was submitted to RMA. The mineworker was assigned to a homogenous exposure group (HEG) based on occupation at the time of claim submission (or last occupation before leaving the industry). Homogeneous exposure groups are used for monitoring exposures in the SAMI. Each HEG comprises mineworkers with similar average noise exposure levels, and enables estimation of individual exposures within that group.[20] The classification of ONIHL HEGs in the mining industry is shown in Table 2.

Ethics clearance for the study was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (ethics clearance certificate no. M210550).

Data analysis

Descriptive statistics were used to summarise continuous data (age, years employed, year of diagnosis) using means, standard deviations, and ranges. Categorical variables (sex, population group, HEG, commodity) were summarised using frequencies and proportions. We calculated the annual proportions of ONIHL claims using the total number of employed mineworkers as the denominator, as obtained from RMA.

Table 1. Mine Health and Safety Council milestones for occupational noise-induced hearing loss

2003 targets	2014 targets	2024 targets
Hearing conservation programmes implemented after December 2008 to guarantee that persons exposed to noise at work do not have hearing loss of more than 10%	By December 2016, no worker's mean STS, averaged at 2 000, 3 000, and 4 000 Hz in one or both ears, will differ by more than 25 dBA from baseline	By December 2034, according to current diagnostic techniques, there should be no new cases of NIHL among *"previously unexposed individuals"*, i.e. those who started work in January 2025
By December 2013, no location in any workplace to have a sound pressure level higher than 110 dBA due to equipment	By the end of December 2024, no equipment to produce more than 107 dBA of operating or process noise	By December 2034, no individual process equipment and employee-operated equipment to produce noise levels higher than the milestone sound pressure level of 104 dBA

NIHL: noise-induced hearing loss, STS: standard threshold shift
Sources: Mine Health and Safety Council, 2015,[11] Mamphitha, 2022,[12] Balfour, 2024[13]

The chi-square test was used to assess trends in annual total ONIHL claims and successful claims over time. Logistic regression modelling was used to identify factors associated with successful ONIHL claims, with odds ratios (ORs) as the measure of association. Univariable logistic regression was performed for each independent variable to assess its association with successful ONIHL claims. The explanatory variables in the univariable analyses were sex, age at diagnosis, population group, number of years employed in the company where the diagnosis was made, commodity and occupation at the time of diagnosis, and year of diagnosis. The category with the largest number of observations was used as the reference in the analyses.

Variables with a p value ≤ 0.20 in the univariable analysis were included in the multivariable logistic regression model. This cut-off was selected to allow inclusion of variables that may have insignificant associations at the univariable level, but could be significant when adjusted for other factors in the multivariable model. In the final multivariable logistic regression analysis, adjusted ORs (AORs) were estimated to account for the effects of multiple factors simultaneously. Age, population group, years employed, occupation, commodity, and year of diagnosis were significant in the univariable analysis (p ≤ 0.20) and were, therefore, included in the final multivariable model. Sex was excluded due to the small number of females in the dataset. Although claims with missing employment information are not processed by RMA, we included those with missing commodity and years of employment in the analysis, because discarding them would have introduced significant bias as these constituted a high proportion of the claims. The Hosmer-Lemeshow goodness-of-fit test was used to assess the model's fit to the data. A non-significant p value (p > 0.05) indicates a good fit, suggesting that the model's predicted probabilities align well with the observed outcomes.

Table 2. Classification of HEGs, based on noise levels in the South African mining industry

HEG	Average dBA, LAeq, 8h*
A	≥ 105
B	≥ 85–< 105
C	≥ 82–< 85
D	< 82

*Equivalent continuous noise level over an 8-hour period
Source: Department of Minerals and Energy, 2002[21]

Table 3. Characteristics of occupational noise-induced hearing loss claimants, 2010 to 2019 (N = 12 761)

Variable	n	%
Sex		
Female	60	0.5
Male	12 701	99.5
Age group (years)		
≤ 30	97	0.8
31–40	580	4.6
41–50	3 007	23.6
51–60	7 923	62.1
> 60	1 153	9.0
Missing	1	0.0
Population group		
Black	7 702	60.4
White	2 068	16.2
Missing	2 991	23.4
Commodity		
Gold	5 412	42.4
Platinum	3 742	29.3
Other*	3 558	27.9
Missing	49	0.4
HEG		
A	0	0
B	9 585	75.1
C	725	5.7
D	1 077	8.4
Missing	1 374	10.8

* Coal, diamond, and other commodities

RESULTS

We analysed the records of 12 761 ONIHL claimants. As shown in Table 3, there were few female claimants (n = 60, 0.5%). Most claimants were black (n = 7 702, 60.2%). Population group was not stated for almost a quarter of the claimants (n = 2 991, 23.4%). The mean age of the study participants was 53.0 years (SD 6.9 years, range 23.0–82.0 years) with most claimants being older than 50 years (n = 9 076, 71.1%). Most were in HEG B, which had the highest noise exposure levels (n = 9 585, 75.1%), and the mean number of years employed was 24.0 (SD 10.9, range 1.0 to 66.0).

Most claimants were in HEG B, viz. 7 702 (83.2%) black claimants and 1 253 (60.6%) white claimants. A higher proportion of white than black claimants were in HEG D (n = 498, 24.1% and n = 248, 4.3%, respectively). A high proportion of gold and platinum mineworkers (56.5% and 41.5%, respectively) had been employed for more than 20 years, compared to 37.9% of those in the 'other' group; in 26.4%, duration of exposure was not stated. The proportion of claimants with no noise exposure information increased from 4.2% (n = 537) in 2010 to 19.5% (n = 2 486) in 2019.

The characteristics of the study population by ONIHL claim status are presented in Table 4. The differences in proportions of successful and unsuccessful claims were statistically significant (p < 0.05) for sex, age, population group, commodity, years employed, and noise exposure level. The highest proportion of successful claims was among those aged 41–50 years (61.6%), followed by those aged 51–60 years (57.2%). Gold mineworkers had the highest proportion of successful ONIHL claims (67.0%), followed by platinum mineworkers (60.7%). Those who had been employed for 30–39 years had a high proportion of successful claims (63.4%), while those employed for less than 20 years had the lowest proportion of successful claims (50.7%). Workers in HEG D had the lowest proportion of successful claims (40.3%), while those in HEGs C and D had more unsuccessful than successful claims.

Figure 1 shows the annual proportions of claims submitted from 2010 to 2019. Overall, the numbers and proportions of ONIHL claims submitted to RMA decreased from 1 635 (4.2 claims per 10 000 workers) in 2010 to 1 007 (2.9 claims per 10 000 workers) in 2019. The rate of decrease of 7.3 claims per 10 000 workers per year was statistically significant (p < 0.001).

More than half (n = 7 203, 56.5%) of submitted claims were successful. Figure 2 shows the proportions of successful claims per year. The numbers and proportions of successful claims decreased from 1 190 (72.6%) in 2010 to 436 (43.3%) in 2019.

Table 4. Characteristics of claimants by claim status (N = 12 761)

Variable	Successful claim		Unsuccessful claim		p value
	n	%	n	%	
Sex					
Female	20	33.3	40	66.7	< 0.001
Male	7 183	56.6	5 518	43.5	
Age group (years)*					
> 30	46	47.4	51	52.6	< 0.001
31–40	286	49.3	294	50.7	
41–50	1 852	61.6	1 155	38.4	
51–60	4 528	57.2	3 395	42.9	
> 60	491	42.6	662	57.4	
Population group					
Black	5 216	67.7	2 486	32.3	< 0.001
White	1 113	53.8	955	46.2	
Missing	874	29.2	2 117	70.8	
Commodity					
Gold	3 628	67.0	1 784	33.0	< 0.001
Platinum	2 270	60.7	1 472	39.3	
Other	1 284	36.1	2 274	63.9	
Missing	21	42.9	28	57.1	
Duration of employment (years)					
< 20	2 138	50.7	2 076	49.3	< 0.001
20–29	1 518	60.7	985	39.4	
30–39	1 505	63.4	868	36.6	
≥ 40	662	60.1	439	39.9	
Missing	1 380	53.7	1 190	46.3	
HEG					
A	0	-	0	-	
B	5 828	60.8	3 757	39.2	< 0.001
C	356	49.1	369	50.9	
D	434	40.3	643	59.7	
Missing	585	42.6	789	57.4	

* Missing = 1

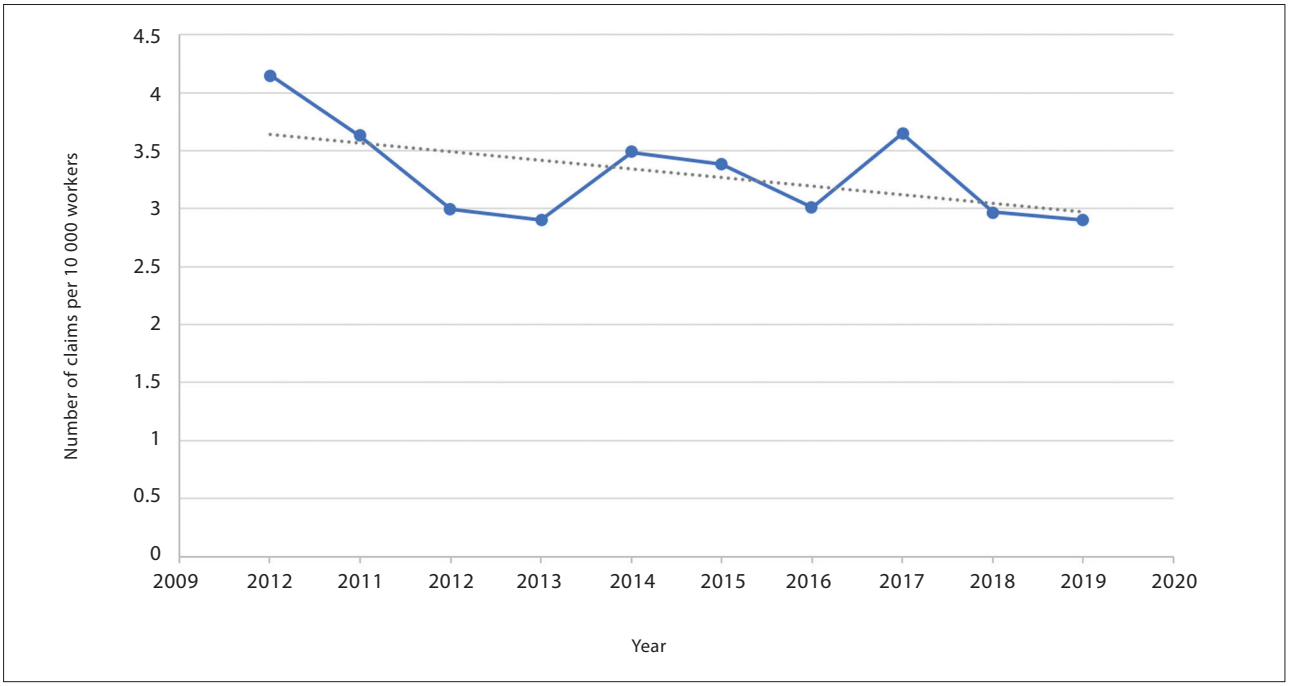


Figure 1. Proportions of occupational noise-induced hearing loss claims submitted to Rand Mutual Assurance, 2010–2019 (N = 12 761)

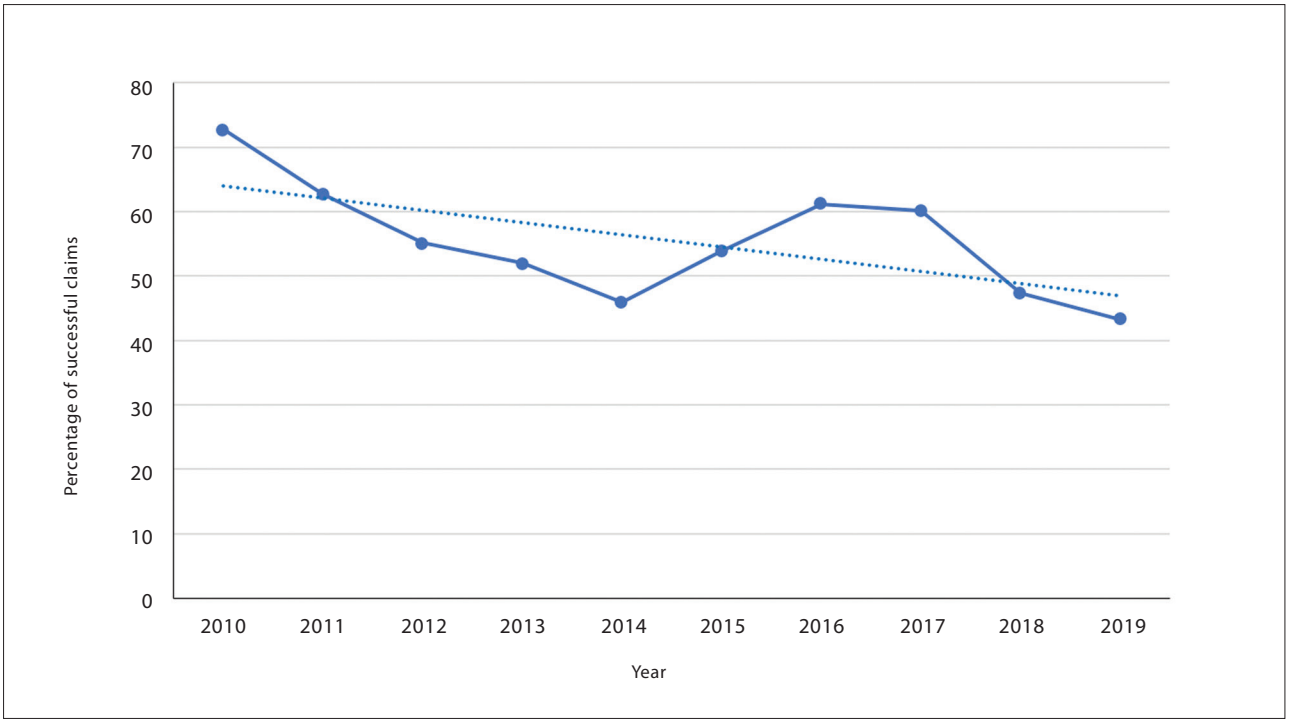


Figure 2. Proportion of successful occupational noise-induced hearing loss claims, 2010–2019 (N = 12 761)

Table 5. Factors associated with successful occupational noise-induced hearing loss claims, 2010–2019 (N = 12 761)

Variable	n	OR	p value	95% CI	AOR	p value	95% CI
Claim year		0.92	< 0.001	0.91–0.93	0.97	< 0.001	0.96–0.98
Age group (years)*							
≤ 30	97	0.68	0.056	0.45–1.00	0.76	0.213	0.49–1.17
31–40	580	0.73	< 0.001	1.62–1.86	0.72	0.001	0.60–0.87
41–50	3 007	1.20	< 0.001	1.10–1.31	1.09	0.093	0.99–1.19
51–60	7 923	Reference			Reference		
> 60	1 153	0.56	< 0.001	0.49–0.63	0.80	0.001	0.69–0.91
Population group							
Black	7 702	Reference			Reference		
White	2 068	0.56	< 0.001	0.50–0.61	0.84	0.002	0.75–0.94
Missing	2 991	0.20	< 0.001	0.18–0.22	0.28	< 0.001	0.25–0.31
Commodity							
Gold	5 412	Reference			Reference		
Platinum	3 742	0.76	< 0.001	0.70–0.83	1.03	0.592	0.93–1.13
Other	3 558	0.28	< 0.001	0.24–0.30	0.44	< 0.001	0.40–0.48
Missing	49	0.37	0.001	0.21–0.65	0.69	0.237	0.38–1.27
Duration of exposure (years)							
< 20	4 214	Reference			Reference		
20–29	2 503	1.50	< 0.001	1.35–1.65	1.40	< 0.001	1.25–1.56
30–39	2 373	1.68	< 0.001	1.52–1.87	1.43	< 0.001	1.28–1.60
≥ 40	1 101	1.46	< 0.001	1.28–1.68	1.31	< 0.001	1.12–1.52
Missing	2 570	1.13	0.018	1.02–1.24	1.15	0.011	1.03–1.28
HEG							
B	9 585	Reference			Reference		
C	725	0.62	< 0.001	0.54–0.72	0.67	< 0.001	0.57–0.78
D	1 077	0.44	< 0.001	0.38–0.50	0.52	< 0.001	0.45–0.60
Missing	1 374	0.48	< 0.001	0.43–0.54	0.84	0.008	0.74–0.95

OR: odds ratio, AOR: adjusted odds ratio
*One claimant had no stated age, but was retained in the regression model.

Table 5 shows the results of the univariable and multivariable logistic regression analyses. Most of the crude odds ratios (ORs) were significant in the univariate logistic regression analysis. In the multivariable analysis, the chances of successful claims declined by 3% per year (AOR = 0.97, 95% CI 0.96–0.98). Mineworkers aged 31–40 years were 28% less likely to have a successful claim than those aged 51–60 years (AOR = 0.72, 95% CI 0.60–0.87). Black claimants were 16% more likely to have successful claims than white claimants (AOR = 0.84, 95% CI 0.75–0.94). Those employed in the mining industry for 20–29 years were 40% more likely to have successful claims compared to those employed for less than 20 years (AOR = 1.40, 95% CI 1.25–1.56). Similarly, those with 30–39 years of employment were 43% more likely to have successful claims (AOR = 1.43, 95% CI 1.28–1.60). Mineworkers in HEG C were 33% less likely to have successful claims than those in HEG B (AOR = 0.67, 95% CI 0.57–0.78). There was no significant difference in claim success between gold and platinum mineworkers (AOR = 1.03, 95% CI 0.93–1.13, p > 05).

DISCUSSION

In this study, we sought to determine the trends and determinants of ONIHL compensation claims in the SAMI from 2010 to 2019. The key findings were the decreasing numbers and proportions of claims submitted to RMA annually and the decreases in successful claims. Determinants of successful ONIHL claims were claimant age, population group, number of years employed, commodity, and noise exposure levels.

The number of ONIHL claims received by RMA gradually decreased from 1 635 in 2010 to 1 007 in 2019, which may be the result of shrinkage of the mining labour force, from 518 519 in 2010 to 468 988 in 2019,[22,23] resulting in fewer claims. It may also be due to the implementation of effective occupational noise exposure and hearing loss reduction interventions, which include several regulatory and industry-led initiatives such as MOSH, hearing conservations programmes (HCPs), the HPD TAS tool, and the MHSC milestones. These interventions align with global best practices to reduce occupational noise exposures.[12,17]

More than half of the claims received and adjudicated during the study period were successful (56.4%). This proportion is lower than that in a study conducted in Australia, where 81.2% of ONIHL compensation claims submitted from 1998 to 2008 were successful.[24] The Australian study did not investigate determinants of successful claims – they investigated yearly incidence rates of ONIHL claims – therefore, it is not possible to make further comparisons between the studies.

In the review period, no changes were made to the claim submission or adjudication processes that could have affected the success of claims. Our findings suggest that the incomplete information submitted with claims could have led to them being unsuccessful. The proportion of claims with incomplete ONIHL exposure information increased from 4.2% in 2010 to 19.5% in 2019. This might explain the decreasing success rates, as complete exposure information is required for claim adjudication.[9] The submission of claims with incomplete information results in delays in the process, or rejection of claims. This was also found in a study in the United States of America, in which claim success rates were significantly reduced due to incomplete noise exposure histories and inadequate medical records.[25] In our study, the RMA data did not allow us to investigate the completeness of medical records.

In recent years, RMA has introduced educational drives to educate stakeholders about the requirements for compensation claims, in order to improve the quality of claims submitted (Dr L Dzingwa, personal communication, 14 March 2023). Analysis of more recent data will show if the interventions have been successful.

Most claimants were in the older age categories, i.e. ≥ 50 years (71.2%). This finding is similar to that from other studies on ONIHL compensation claims, in which most of the claimants were in the age group 50–59 years.[25,26] However, in our study, most of the successful claims were for mineworkers aged 41–50 years (61.6%). This might be because mineworkers older than 40 years had sufficient cumulative noise exposure to meet the criteria for ONIHL. When adjudicating claims for older mineworkers (> 50 years), hearing loss may be attributed to aging rather than occupational noise exposure, potentially leading to lower claim approval rates. Hence, the proportions of successful claims were lower in those older than 60 years. This is consistent with evidence that both noise-induced and age-related hearing loss often co-occur, but the ability to distinguish them diagnostically diminishes with age.[27] Our findings are also similar to those from other studies, where claimants aged 40–59 years had the highest proportion of successful compensation claims.[26,28]

Younger mineworkers (aged 31–40 years) were 28% less likely to have successful claims than those aged 51–60 years. Noise-induced hearing loss progresses slowly and is usually detectable within 12–15 years of exposure.[4,26] Thus, it may be more difficult to prove occupational noise exposure as the cause of hearing loss in claimants with short exposures.

Most claims were received from gold (42.4%) and platinum (29.3%) mineworkers. In a South African study published in 2012, most ONIHL claims were received from gold mineworkers (n = 1 179), followed by platinum mineworkers (n = 396).[26] These findings are explained by the fact that, historically, the gold mines employed the largest numbers of mineworkers, and studies have reported that the highest noise exposure levels are in gold mines.[7,26] In South Africa, gold and platinum mines are typically underground mines, where work is performed in confined spaces, resulting in higher noise levels.[7,26] This might explain the high number of ONIHL compensation claims from mineworkers working in these sectors.

There was no significant difference in the likelihood of successful claims between gold and platinum mineworkers. However, the group 'other' had a 56.3% significantly lower odds of successful claims than gold mineworkers. Further analysis of the data showed that 62.2% of claims in this group had short work durations (only 37.8% had more than 20 years of employment), and for more than a quarter (26.4%), duration of employment was not stated. These factors probably lowered the chances of claim success.

As expected, none of the claimants were in HEG A (noise levels ≥ 105 dBA). No mineworkers should be exposed to occupational noise levels at, or above, 105 dBA due to sector-wide noise-reduction initiatives, which include the MHSC milestone 2024 target of a maximum permissible equipment noise level of 107 dBA, and MOSH's IBMQ initiative that seeks to manage noise emissions at source (from mining equipment).[12-16] Three-quarters (75.1%) of the claimants worked in occupations in the highest noise exposure group (HEG B), with exposures of 85–105 dBA. Claims from mineworkers in this HEG were likely to be successful, as high noise exposure is a criterion for compensation.

The strength of the study is the large number of ONIHL claims, which enabled the analysis of trends and determinants. A major limitation of the study is missing data – a common feature of routinely collected administrative data. While the large proportion of claimants with missing population group has no bearing on the adjudication of claims, the large proportion of claims with missing HEG (occupation) information would have implications for compensation. Although difficult to interpret, the retention of claimants with missing information in the analysis reduced selection bias. The assignment of HEGs, based on occupation at the time of claim submission, may have introduced misclassification as previous noise occupational exposures in the mining industry and elsewhere were not considered. Rand Mutual Assurance attempts to obtain missing information during claims processing to enable adjudication of claims. However, this analysis indicates that the information gathered is not captured, hence, there may be misclassification of unsuccessful claims. The claimants' PLH and audiograms were not provided in the dataset, which prevented us investigating the relationship between the severity of ONIHL and the success of claims.

Recommendations

This analysis of OHNIHL claims provides useful insights into the compensation claim process and the quality of data in the RMA database, and provides a baseline for future similar analyses. Employers should ensure that submitted claims contain all required information to prevent delays in processing and unsuccessful claims. Rand Mutual Assurance roadshows to inform occupational medical practitioners, employers, and employees about the requirements for ONIHL compensation should improve the quality of submitted claims. An important lesson, for all organisations collecting routine administrative data, is to ensure that records are updated as information becomes available, to improve the quality and completeness of electronic records for operational and research purposes.

CONCLUSION

This analysis provides insights into the magnitude of ONIHL in the SAMI. Although we did not estimate the prevalence of ONIHL, the analysis of the numbers of claims indicates high noise exposures, above the OEL, in the study period. Despite the decrease in claims over time, the need for enhanced noise control, through targeted prevention programmes, to achieve the target of zero harm to workers persists.

KEY MESSAGES

1. The analysis of ONIHL compensation claim submissions provides an important mechanism to monitor noise exposures and the effects of interventions implemented in the mining industry.
2. Employment duration, noise exposure, and age of claimants are important determinants of successful claims.
3. Employers should ensure submission of complete claims, as claims with incomplete information are more likely to result in unsuccessful claims and the denial of compensation.
4. Routine administrative data are useful for research and monitoring, but require regular updating to ensure optimum quality.

DECLARATION

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conception and design of the study: DN, JL, NN
Data acquisition: DN, NN
Data analysis: DN
Interpretation of the data: DN, JN, NN
Drafting of the paper: DN, NN
Critical revision of the paper: DN, JL, LD, NN

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Noise exposure levels among aircraft technicians at an aviation maintenance organisation in Gauteng, South Africa

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ABSTRACT

Introduction: The aviation industry relies on the expertise of aircraft maintenance technicians (AMTs) to ensure aircraft airworthiness. However, the noise produced by airport maintenance activities and tools poses a potential risk of noise-induced hearing loss (NIHL) to AMTs.

Objective: The objectives of the study were to assess noise perceptions and the use of hearing protective devices (HPDs), and to measure personal occupational noise exposure levels among AMTs involved in aircraft maintenance operations in Gauteng province, South Africa.

Methods: Self-administered questionnaires were used to collect sociodemographic data and perceptions about noise exposure from 208 AMTs. The associations between participants' perceived noise levels and some socio-demographic factors were assessed using descriptive statistics. The associations between participants' socio-demographic characteristics and their perceptions of personal noise exposure and use of HPDs were analysed, using binary logistic regression. Personal noise exposures were measured in a subset of 30 AMTs across three maintenance areas (minor, line, and base maintenance), using a QUEST Technologies noise dosimeter. One-way analysis of variance (ANOVA) was performed on log-transformed mean personal noise exposure levels, to compare exposure across the three areas.

Results: Most of the study participants were male (n = 135, 64.9%). A large proportion (n = 171, 82.2%) perceived that they were exposed to high noise levels. The majority of participants (n = 200, 96.2%) reported being supplied with HPDs, while a smaller proportion (n = 181, 87.0%) indicated that they had received training. The logistic regression analysis showed that being an apprentice (p = 0.032) was the only significant predictor of perceiving exposure to loud noise. The AMTs employed to do line maintenance were exposed to the highest 8-hr time-weighted average (TWA) daily noise levels of 95.7 ± 7.5 dBA; both minor and base maintenance workers were also exposed to high noise levels (92.3 ± 6.0 dBA and 92.1 ± 3.8 dBA, respectively). However, there were no statistically significant differences in mean exposure levels.

Conclusion: Being an apprentice was the only socio-demographic variable associated with perception of noise exposure. Not all study participants were issued with HPDs and provided with training on their use. Aircraft maintenance workers are exposed to noise levels that exceed the 85 dBA noise rating limit and are, therefore, at risk of NIHL. A comprehensive hearing conservation programme with targeted interventions, based on tasks and work environments, is essential for AMTs.

INTRODUCTION

The aviation industry is vital to global transportation, and maintenance personnel are directly responsible for the safety and efficiency of aircraft operations. Among the various hazards to which aircraft maintenance technicians (AMTs) are exposed, noise is the most concerning. They are often subjected to high noise levels from operating equipment.[1]

Noise exposure is the leading cause of preventable hearing loss, globally.[2] Reports indicate that occupational noise exposure causes 16% of cases of disabling hearing loss.[3] In addition to noise-induced hearing loss (NIHL), other health issues associated with noise exposure include tinnitus, hyperacusis, cardiovascular disease, discomfort, performance issues, and sleep problems, which can undermine both quality of life and professional performance.[4,5] Noise-induced hearing loss is the most frequently reported occupational health issue in both developed and emerging economies, such as South Africa.[6] In the USA, Europe, and Australia, 14–20% of workers are exposed to hazardous noise and 16% of those exposed develop significant hearing impairment.[7] An estimated 18% of sub-Saharan African workers are exposed to excessive noise levels.[8]

Noise-induced hearing loss is the most prevalent occupational health condition across different industries.[9] In South Africa, studies on noise exposure and NIHL have been conducted in several occupational settings, such as the mining, and iron and steel industries.[10-12] However, only a few studies have investigated this issue in aviation maintenance settings, globally.[13-15] Some of the noisy activities in

these settings are moving aeroplanes, testing engines, and the use of powered tools and equipment.[16] Aircraft maintenance technicians are, thus, exposed to excessive noise during maintenance work in hangars and station aprons.[17,18] In South Africa, several studies have investigated noise exposure in communities living near airports or aerodromes, and have highlighted concerns regarding environmental noise pollution and its effects on human health and wellbeing. For example, Nchemanyi (2006) focused on communities near Cape Town International Airport. Residents frequently reported sleep disturbances, communication interference, and reduced quality of life due to persistent aircraft noise.[19] Similarly, Seabi et al. (2013) in a study in Durban, South Africa, found that children exposed to chronic aircraft noise experienced significant disturbances in their school activities and reported higher levels of annoyance, even after the relocation of the airport.[20] Van der Merwe and Von Holdt reported on aircraft noise management at Cape Town International Airport in 2005.[21]

To our knowledge, no studies have addressed noise exposure in aircraft workers in South Africa. We investigated perceptions about noise exposure in the workplace and the use of hearing protection devices (HPDs) – to assess personal hearing protection practices – by AMTs in an aviation organisation in Gauteng province, South Africa. We also measured noise exposure levels in a subset of AMTs that performed different maintenance activities.

METHODS

This cross-sectional study was conducted among aircraft maintenance technicians (AMTs) in an aircraft maintenance organisation (AMO) in Gauteng province, South Africa, from July 2021 to January 2022. The company employs 212 AMTs in avionics, mechanics, jet engine overhauling, components, and aircraft structures. Technicians undertake maintenance activities in hangars, engine testing bays, aircraft moving zones (airside), and workshops,[9] in three aircraft maintenance departments, viz. line maintenance, minor maintenance, and base maintenance were included in the study. Line maintenance involves routine inspections and repairs of aircraft while on the ground. Minor maintenance involves detailed checks and component replacements that require short-term aircraft downtime, and base maintenance entails comprehensive overhauls, often involving disassembly and extended aircraft grounding.[22]

The study population of 208 participants comprised both full-time and part-time AMTs, who were at least 18 years old and had a minimum of six months of experience. Technicians with known medical hearing conditions or self-reported previous SARS-CoV-2 infection were excluded.

Due to logistical challenges and time constraints, it was not possible to conduct personal noise exposure measurements for the entire sample; a subset of 30 participants was selected using purposive sampling; 10 from each of the three maintenance categories. This sample size is supported by the central limit theorem (CLT), which posits that a sufficiently large sample, commonly 30 or larger, yields a sampling distribution of the mean that approximates normality, regardless of the population distribution.[23]

Questionnaire

We developed a self-administered, structured questionnaire that consisted of single and multiple-response questions to collect socio-demographic and work-related data (age, sex, job type, years of experience, and family history of hearing loss) and perceptions of noise exposure in the workplace. Information regarding the type and use of HPDs was also collected. The questionnaire was piloted on 10 employees from the Aircraft Maintenance Organisation Production Control section, to assess its feasibility, reliability, and efficiency.

Personal noise exposure measurements

Personal noise was measured according to the SANS Code of Practice 10083, 2023.[24] The noise measurements from the 30 participants were collected over 30 days. Each measurement was taken during an eight-hour day shift, using a calibrated QUEST Technologies noise dosimeter. The noise dosimeter was set at an exchange rate of 3 dB, a criterion level of 85 dB, a criterion time of eight hours, and with the threshold level switched off. At the start of the working shift, the dosimeter was attached to the worker's collar close to the ear; it was removed at the end of the shift.

Data analysis

The questionnaire data were entered into SPSS (Statistical Package for the Social Sciences, IBM, Version 29) for analysis. Continuous variables were summarised as means and standard deviations (SDs). Categorical variables were summarised as frequencies and percentages. Binary logistic regression was used to analyse the associations between participants' socio-demographic characteristics and their perceptions of personal noise exposure. The binary outcome variable (perceptions of personal noise exposure) was based on responses to the question, *"Do you believe you are regularly exposed to high levels of occupational noise?"*. The variables sex, job type, years of experience, and family history were considered for inclusion in the multivariable logistic regression model. Variables with p values of < 0.2 for odds ratios in the bivariate analysis were included in the multivariable analysis. Association between key variables were also tested using chi-square tests.

One-way analysis of variance (ANOVA) was used to compare log-transformed mean personal noise exposure measurements between base, minor, and line maintenance technicians. To allow comparisons with the South African legislated noise rating limit, the 8-hr time-weighted average (TWA) $L_{Req,8h}$ was calculated using the following equation:

$$L_{Req,8h} = L_{Req,Ts} + 10 \log \frac{Ts}{8}$$

where:

$L_{Req,8h}$	equivalent continuous 8-hour rating level
$L_{Req,Ts}$	equivalent continuous rating level, determined over the duration of the work shift
Ts	total duration of the work shift, in hours
$8h$	total duration of the reference time interval, in hours

The 8-hr TWA personal noise exposure levels were compared to the 85 dBA legislated noise rating limit.

The study was approved by the Research Ethics Committee (REC) of the Faculty of Health Sciences at the University of Johannesburg (clearance number: REC-898-2021). Permission to conduct this study was granted by the management of the aircraft maintenance organisation. Only workers who provided written informed consent were included in the study. Unique study numbers were assigned to participants to maintain anonymity and confidentiality.

RESULTS

Socio-demographic characteristics of participants

Questionnaires were completed by 208 AMTs. Most of the participants perceived themselves as being exposed to occupational noise (n = 171, 82.2%), as shown in Table 1.

Table 1. Socio-demographic characteristics and perceptions of noise exposure of study participants by (N = 208)

Characteristic	Perceived noise exposure			
	yes (n = 171)		no (n = 37)	
	n	%	n	%
Age group (years)				
20–30	12	7.0	18	48.6
31–40	45	26.3	11	29.7
41–50	80	46.8	8	21.6
51–60	34	19.9	0	0
Sex				
Male	114	66.7	21	56.8
Female	57	33.3	16	43.2
Job type				
Apprentice	2	1.2	5	13.5
Qualified technician	33	19.3	20	54.1
Senior technician	65	38.0	11	29.7
Licensed technician	71	41.5	1	2.7
Experience (years)				
1–5	40	23.4	27	73.0
6–10	24	14.0	3	8.1
> 10	107	62.6	7	18.9
Family member with hearing loss				
Parent: yes	26	15.2	2	5.4
no	145	84.8	35	94.6
Sibling: yes	4	2.3	2	5.4
no	167	97.7	35	94.6

Perceptions of noise

Most of the study participants reported that they were bothered by noise at work (n = 168, 80.8%); 166 (79.8%) said they were exposed to loud noise in their work environments. Few reported having hearing problems (n = 9, 4.3%) or communication difficulties (n = 10, 4.8%).

Hearing protection devices

Two hundred (96.2%) of the participants reported that they were provided with HPDs; most had been trained on their use (n = 181, 87.0%). The most common HPDs were disposable ear plugs (n = 88, 42.3%), followed by earmuffs (n = 69, 33.2%), and David Clark aviation headsets (n = 51, 24.5%). Most of those who were provided with David Clark aviation headsets found them comfortable to wear (n = 41, 80.4%). Lower proportions of participants found ear plugs and earmuffs comfortable (n = 60, 68.2% and n = 44, 63.8%, respectively).

Factors associated with perceived noise exposure

Although age was found to be significantly associated with perceptions of noise in the bivariate model (OR 0.06–0.44, p < 0.001), it was excluded from the multivariate model because it was strongly associated with years of exposure. Sex and siblings' history of hearing loss were also excluded as the p values were > 0.2. Sex and parents' history of hearing loss were not significantly associated with noise perceptions in the crude analysis, but were included in the adjusted multivariable model as the p values were < 0.2. As shown in Table 2, only one factor (job type: apprentice) was significantly associated with not perceiving loud noises at work (AOR 0.09, p = 0.032).

Table 2. Socio-demographic factors associated with noise exposure perceived by study participants (N = 208)

Characteristic	n	OR	95% CI	p value	AOR	95% CI	p value
Age group (years)[a]							
20–30	30	0.16	0.06–0.44	< 0.001			
31–40	56	Reference					
41–50	88	2.44	0.92–6.52	0.074			
51–60[b]	34	-	-	-			
Sex							
Male	135	1.16	0.55–2.41	0.700			
Female	73	Reference					
Job type							
Apprentice	7	0.09	< 0.00–0.78	0.028	0.090	0.01–0.81	0.032
Qualified technician	53	Reference			Reference		
Senior technician	76	3.04	1.29–7.15	0.011	1.45	0.29–7.04	0.646
Licensed technician	72	18.00	3.95–81.99	< 0.001	7.64	0.79–73.7	0.079
Experience (years)							
1–5	67	Reference			Reference		
6–10	27	5.07	1.38–18.55	0.014	2.42	0.37–15.74	0.354
> 10	114	8.4	3.52–20.07	< 0.001	2.27	0.41–12.69	0.348
Family member with hearing loss							
Parent: yes	28	3.14	0.71–13.85	0.131	1.97	0.42–9.29	0.393
no	180	Reference			Reference		
Sibling: yes	6	0.42	0.07–2.38	0.326			
no	202	Reference					

CI: confidence interval, OR: odds ratio, AOR: adjusted odds ratio

[a] Age group excluded from the adjusted model because of statistically significant association with years of exposure (p = < 0.001)

[b] Age group 51–60 all reported perceiving noise, thus, the analysis did not produce meaningful results.

Personal noise measurements

Mean individual personal noise exposure level measurements by maintenance area are presented in Table 3.

The highest mean noise levels were measured among AMTs working in line maintenance (95.7 ± 7.5 dBA), followed by those working in minor (92.3 ± 6.0 dBA), and base (92.1 ± 3.8 dBA) maintenance areas. There were no statistically significant differences in mean noise levels between the three groups.

DISCUSSION

In this study, we investigated perceived noise exposure, HPD use, and personal occupational noise exposure levels among AMTs over an eight-hour work shift in an aircraft maintenance organisation. The high prevalence of perceived noise exposure aligns with findings from other studies; these have shown that maintenance personnel are routinely subjected to hazardous noise levels during daily operations.[25,26] Employers need to address noise exposure to improve the overall work environment and enhance workers' quality of life, regardless of reports of adverse health effects.[27-29]

Perception of noise risk influences compliance with hearing conservation practices, such as the consistent use of HPDs.[30] The variation in perception among participants may reflect differences in work environments, tasks performed, or awareness of noise-related health risks. These findings underscore the importance of targeted noise awareness and hearing conservation training, particularly for those who may underestimate their exposures.[31] There was a notable discrepancy between the provision of HPDs and training on the correct use of devices. While an overwhelming majority of participants (96.2%) reported being supplied with HPDs, a smaller proportion (87.0%) indicated that they had received training. This gap suggests that, although protective equipment is widely available, the supporting educational component necessary for its effective use may be inconsistently provided. Other researchers have emphasised that the effectiveness of personal protective equipment is poor when not accompanied by adequate training, as improper use can fail to mitigate occupational hazards.[25] The fact that 13.0% of respondents reported receiving no training, compared to the 3.8% who were not provided with HPDs, points to systemic issues in safety protocol implementation. These results highlight the critical need for integrated hearing conservation programmes that prioritise both equipment provision and behavioural training, to ensure compliance and enhance worker protection.[32]

The data on the provision and comfortability of HPDs highlight a critical balance between availability and user acceptability. Although David Clark aviation headsets were the least-frequently distributed HPDs (24.5%), they had the highest comfortability rating. In contrast, disposable earplugs, despite being the most commonly provided (42.3%), had a notably lower comfort rating, with nearly one-third of users reporting discomfort. Earmuffs, provided to a third of respondents, had the highest rate of discomfort (36.3%) of all HPD types.

These findings reinforce the importance of considering not only the functional performance of HPDs, but also user comfort, which significantly influences compliance and long-term use.[25,33] Research has shown that discomfort is a key barrier to consistent HPD use, and devices perceived as uncomfortable are often used incorrectly or removed during exposure, thereby reducing their protective efficacy.[32] The favourable comfort profile of aviation headsets, despite their limited availability, suggests a missed opportunity to improve compliance through more user-centred protective equipment policies.

The logistic regression analysis identified that being an apprentice was a significant predictor of perception of excessive noise exposure. Apprentices may not perceive hazardous situations in the same manner as experienced workers, and they have been shown to have a higher risk of exposure to occupational hazards than their older co-workers, due to their increased vulnerability associated with their novice status and workplace learning.[34,35] Age was not associated with perceptions of exposure to loud noise, although this was anticipated because of age differences in underlying biological, behavioural, and/or occupational exposures.[36] However, many more participants aged 31–50 years were bothered by high noise levels than those aged 20–30 years (47% and 6%, respectively). All 30 AMTs were exposed to noise above 85 dBA during an eight-hour work shift, putting them at risk of NIHL. Noise levels varied by the nature of the maintenance duties and the area in which they operated, suggesting that individual targeted interventions could be appropriate.

The personal noise measurements reflect the equivalent continuous noise level normalised to an eight-hour workday, providing an objective assessment of each participant's daily noise exposure. Noise levels to which AMTs performing line and minor maintenance were exposed frequently exceeded the noise rating limit of 85 dBA, as defined by South African standards and legislation.[24] Measured

Table 3. Personal noise levels of study participants (N = 30)

Line maintenance		Minor maintenance		Base maintenance	
Participant	$L_{Req,8h}$(dBA)	Participant	$L_{Req,8h}$(dBA)	Participant	$L_{Req,8h}$(dBA)
1	94.6	11	86.6	21	86.9
2	96.2	12	90.0	22	73.6
3	84.5	13	86.7	23	75.6
4	96.3	14	80.1	24	88.8
5	96.1	15	83.5	25	66.3
6	90.9	16	84.0	26	87.8
7	85.2	17	78.1	27	79.4
8	88.7	18	90.0	28	93.1
9	89.2	19	87.1	29	79.8
10	87.6	20	93.3	30	87.3
Mean	95.7	Mean	92.3	Mean	92.1
SD	7.5	SD	6.0	SD	3.8
Range	84.5–96.3	Range	78.1–93.3	Range	66.3–93.1

SD: standard deviation

noise levels were as high as 96 dBA, which is consistent with previous research showing that aviation and manufacturing sectors often report exposure above legislated limits.[37] There is, therefore, a need for effective noise hazard identification and the implementation of effective hearing conservation programmes in this sector.[38]

It is evident that hearing conservation strategies in the aviation sector should be tailored to specific job functions and worker profiles. Programmes should include regular noise assessments, routine audiometric testing, awareness campaigns, and fit-testing for HPDs to reduce noise exposure levels to below 85 dBA. Moreover, organisational policies should ensure that new employees, particularly those in high noise exposure departments, receive adequate training – at induction and regular intervals.[24,39]

Limitations

The study had several limitations, including the relatively small sample size for which individual noise exposure levels were measured. The findings may, therefore, not be generalisable to South African aircraft maintenance organisations. We relied on self-reported data obtained through questionnaires, which are subjective and may be affected by recall bias. As self-reported perceptions do not constitute objective measures of noise exposure, this should be considered when interpreting the findings. Nonetheless, the findings underscore the importance of personal measurements when assessing noise exposure.

CONCLUSION

This study contributed to the limited research on occupational noise exposure in South Africa's aviation maintenance sector. The majority of study participants were bothered by noise, which highlights the importance of targeted training and awareness of workplace hazards. Not all participants used HPDs and not all were trained on their use. Most of the study participants were exposed to levels above 85 dBA and were, therefore, at risk of NIHL. Implementing a comprehensive hearing conservation programme, informed by objective data, is essential to ensure compliance with relevant legislation, and to reduce the risk of hearing loss amongst AMTs.

KEY MESSAGES

1. The 8-hr TWA noise exposure levels among AMTs often exceeded the legislated noise rating limit of 85 dBA.
2. Targeted interventions should form part of a comprehensive hearing conservation programme.
3. Being an apprentice was a significant predictor of perceiving exposure to loud noise; age, job type, years of experience, sex, and family history of hearing loss were not associated factors.

DECLARATION

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Conception and design of the study: BAMP, JM
Data acquisition: BAMP
Data analysis: BAMP
Interpretation of the data: BAMP, WU, JM
Drafting of the paper: BAMP, WU, JM
Critical revision of the paper: BAMP, GM, WU, JM

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Audiometric screening results and knowledge of noise-induced hearing loss and hearing conservation practices among members of a South African army unit

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ABSTRACT

Background: Military personnel are exposed to high noise levels during training and deployment missions. Interventions to reduce noise exposure levels and the prevalence of noise-induced hearing loss (NIHL) are necessary. When planning such interventions, workers' knowledge should be taken into consideration.

Objective: The objective of the study was to describe knowledge about NIHL and hearing conservation practices, and referral threshold shifts (RTSs) using audiometric screening results, among members of a South African army unit.

Methods: In this cross-sectional study, 38 army unit members were purposively sampled from a study population of 631. Demographic data, NIHL knowledge, and hearing conservation practices were collected using a questionnaire, and analysed using descriptive statistics. Audiometric screening data were analysed for army unit members who had been employed for two or more years and had two audiograms (baseline and periodic). The Wilcoxon signed-rank test (WSR) was used to compare participants' baseline and periodic hearing thresholds.

Results: Most participants were male (n = 37, 97.4%), aged 26–35 years (n = 31, 81.6%), and permanently employed (n = 33; 86.8%). Around half lacked knowledge that exposure to noise is the main risk factor associated with NIHL (n = 21, 55.3%); only two (5.3%) knew that NIHL cannot be treated with medicine. Almost half of the participants (n = 18, 47.4%) reported that they were only sometimes provided with hearing protection devices (HPDs); 10 were never or almost never provided with HPDs (26.3%). There was a significant RTS at high frequencies from the baseline and periodic screening examinations (p = 0.012 and p = 0.002 for the right and left ear, respectively).

Conclusion: The participants' RTS from baseline serves as early indication of those at risk for NIHL. A limited understanding of the primary risk factor for NIHL highlighted knowledge gaps. Education and training about NIHL should be provided to army unit members. Provision and correct use of suitable HPDs, to prevent NIHL, should be mandatory for military personnel for the promotion of effective hearing conservation practices.

INTRODUCTION

Noise-induced hearing loss (NIHL) is a concern in many occupational settings.[1] High prevalence rates of occupational NIHL (ONIHL) have been reported in the mining, construction, and military employment sectors.[2] Military personnel are exposed to high-intensity noise from firearms, explosives, radios, sirens, aircraft, and military vehicles, which exceeds the regulated limit of 85 dB $LA_{eq\ (8h)}$ and increases the risk of developing ONIHL.[2-4] A decrease in hearing thresholds at 3–6 kHz and a typical noise-notch at 4 kHz (defined as NIHL)[5] has been attributed to specific military equipment and job types, highlighting the importance of context-specific hearing conservation programmes (HCPs) to prevent ONIHL among military employees.[6] Hearing conservation programmes play an important role in mitigating the harmful effects of noise.[3] Research in the military sector, mainly in the United States of America, has highlighted the potential benefits of effective HCPs, including components such as audiometric monitoring, hearing protection, and HCP education.[3]

The South African National Standard (SANS: 10083, 2021) is the South African guideline for all industries where occupational noise exposure surpasses the noise rating limit (85 dB $LA_{eq\ (8h)}$), for the implementation of company-specific HCPs.[7] Employers are mandated to implement noise control measures as one of the HCP pillars.[7] In addition, adherence to relevant legislation such as the Compensation for Occupational Injuries and Diseases Act of 1993 (COIDA), which addresses compensation for employees who acquire occupational diseases, including NIHL, is imperative.[8] While much research on NIHL and HCPs has been conducted in the major industrial sectors in South Africa, there is a dearth of literature on the implementation of noise controls within HCPs in the South African military sector.

Audiometry assessments, as part of medical surveillance in HCPs, are used to evaluate the efficacy of such HCPs.[9] These assessments enable a comparative analysis of baseline audiograms and periodic screening results, described as the referral threshold shift (RTS).[7] An RTS is regarded as any deviation of more than 15 dB in hearing frequencies of 0.5 kHz to 8 kHz when audiometry is conducted annually, or 20 dB when it is conducted biennially.[7] Increased hearing thresholds of workers in the military – mostly in the high frequencies of 3–6 kHz has been reported.[2] In South Africa, the calculation of RTS in audiometry assessment was recently recommended in the SANS 10083 (2021), in an extended high frequency range (3–8 kHz).[7]

Other calculated values, such as the percentage loss of hearing (PLH), which is essential for compensation of NIHL, are drawn from audiometry assessments.[2,7]

Although RTS interpretations provide evidence for worker-specific hearing deterioration, there is a lack of evidence-based, tailor-made interventions, such as investigations about the potential causes of the threshold shifts, the effectiveness of hearing protection, and the proper fit and use of hearing protection devices (HPDs) in the military workforce. In addition, early identification of hearing loss, through periodic audiometric screenings and analysis of RTS, are essential for the education and training programmes tailored for the army members.[10] Thus, active and ongoing audiometric surveillance is imperative for the army members, since they are exposed to gunshots or other explosives.[7] Effective planning of HCP interventions, including education and training, requires workers' knowledge of NIHL, HPDs, hearing screening and health education, and hearing conservation practices.[7,11]

The objective of the study was to describe knowledge about NIHL and hearing conservation practices, and referral threshold shifts (RTSs), among members of a South African army unit.

METHODS

This was a cross-sectional study design, which included an analysis of audiometry data. The study population consisted of 631 military members of a South African army unit, aged 18 to 55 years (to mitigate age-related hearing effects)[12] and employed for two or more years. For inclusion in the study, they needed to have had at least two audiograms – a baseline audiogram and a recent periodic audiogram. These members are deployed for missions in South Africa and outside of the country, where they are exposed to noise from shooting and aircrafts, and to barometric pressure. Thirty-eight participants were selected for inclusion in the study, using purposive sampling.

The data were collected in two phases in June 2023. Face-to-face interviews were conducted during the first phase of the study, using an adapted knowledge, attitude, and practices (KAP) questionnaire (validated in previous studies)[13,14] to assess participants' knowledge about their work environment, noise exposure, NIHL, and hearing conservation practices (the availability and use of HPDs, and the education, training, and hearing screenings in which they participated).

After testing the questionnaire in a pilot study, the dichotomous response options of 'yes' and 'no' were expanded to include 'do not know'. Internal consistency of the questionnaire was assessed using Cronbach's alpha coefficient.[15]

Table 1. Characteristics of study participants (N = 38)

Characteristic		n	%
Sex	Male	37	97.4
	Missing	1	2.6
Age group (years)	18–25	1	2.6
	26–35	31	81.6
	36–45	4	10.5
	46–55	2	5.3
Employment type	Permanent	33	86.8
	Casual/temporary	3	7.9
	Missing	2	5.3
Employment duration (years)	2–4	1	2.6
	5–8	13	34.2
	9–13	14	36.8
	≥ 14	7	18.4
	Missing	3	7.9

Table 2. Knowledge about the causes, symptoms, treatment, and prevention of NIHL (N = 38)

Knowledge item	Yes		No		Do not know	
	n	%	n	%	n	%
Ear infections can cause HL	27	71.1	1	2.6	10	26.3
The use of some medicines is likely to cause HL	5	13.2	9	23.7	24	63.2
Hobbies like diving may cause hearing loss	18	47.4	2	5.3	18	47.4
Have you ever heard of HL due to noise exposure?	18	47.4	19	50.0	1	2.6
Noise exposure is the main risk factor associated with permanent hearing loss	6	15.8	21	55.3	11	28.9
The risk of HL may be higher if an individual drinks alcohol and works in a noisy environment	17	44.7	5	13.2	16	42.1
The risk of HL may be higher if an individual smokes and works in a noisy environment	17	44.7	3	7.9	18	47.4
Poor hearing of conversational speech may be a sign of HL	30	78.9	1	2.6	7	18.4
Ringing in the ears may be a sign of HL	27	71.1	2	5.3	9	23.7
HL due to noise exposure can be treated with medication	14	36.8	4	10.5	20	52.6
When one stops working in high noise levels, hearing may improve	15	39.5	7	18.4	16	42.1
Using earplugs and/or earmuffs during noise exposure can prevent HL	35	92.1	3	7.9	0	-
Reduced working hours can prevent HL due to noise exposure	14	36.8	9	23.7	15	39.5
Enclosing noise-generating machines can prevent HL	23	60.5	1	2.6	14	36.8
There are laws and legislations to protect workers from exposure to high noise levels	22	57.9	2	5.3	14	36.8

HL: hearing loss

The second phase of data collection entailed a review of the participants' audiometric data. Baseline audiograms and the most recent periodic screening audiograms (conducted in 2022 and 2023) were reviewed. We ensured that the audiograms met the requirements of the South African Standard (SANS 10083, 2021).[7] Referral threshold shift was determined by comparing the average hearing thresholds for mid-level and high frequencies (0.5–2 kHz and 3–6 kHz, respectively) of the baseline and the periodic screening audiograms.

The study was approved by the Research Ethics Committee of the Faculty of Humanities of the University of Pretoria (HUM017/0422) and the Military Hospital Research Ethics Committee (Ref: 02.10.2022). Permission to conduct the study was obtained from the South African army unit, and informed consent was obtained from the participants.

Data analysis

The Statistical Package for the Social Sciences (SPSS) Version 27.0 was used to analyse the questionnaire data. Descriptive statistics (frequencies and percentages) were used to describe participants' knowledge about NIHL, hearing conservation education and training, and practices regarding the use of HPDs and hearing screening.

The audiometric data were tested for normality, using the Shapiro-Wilk test. As the data were not normally distributed, they were summarised as medians and interquartile ranges (IQRs). The non-parametric Wilcoxon signed-rank test (WSR) was used to test for differences between the baseline and periodic audiometric data.[16]

RESULTS

Demographic characteristics

Table 1 summarises the demographic and work-related characteristics of the study participants. Most were male (n = 37, 97.4%), and aged 26–35 years (n = 31, 81.6%). Most were permanent employees (n = 33, 86.8%) and had been employed for five to 13 years (n = 27, 71.1%).

Knowledge about NIHL

Although most participants knew that ear infections lead to hearing loss (n = 27, 71%), few knew that noise exposure is the main risk factor associated with permanent hearing loss (n = 6, 15.8%), as shown in Table 2. Half of the participants indicated that they had never heard of hearing loss due to noise exposure (n = 19, 50.0%). More than half of the participants (n = 20, 52.6%) were not sure if hearing loss due to noise exposure could be treated using medicine. However, most participants (n = 35, 92.1%) knew that wearing HPDs when being exposed to noise can prevent hearing loss.

Practices regarding HPDs, hearing screening, and health and safety training

More than half of the study participants (n = 28, 73.7%) reported that they were provided with earplugs, at least sometimes; six (15.8%) stated that they never or almost never wore HPDs in noisy environments (Table 3). Most (n = 20, 52.6%) reported they had never received training on the use of HPDs (n = 24, 63.2%), and eight (21.1%) reported that they had provided their own HPDs. Seven of the participants (18.4%) reported that they did not regularly participate in annual hearing screening examinations.

Audiometric characteristics

The RTS was calculated from the baseline and periodic screening audiogram results. There was a significant bilateral RTS between the baseline and periodic screenings (Table 4); the high frequencies were the most affected, in both ears (p = 0.012 and p = 0.002 for the right and left ears, respectively).

Table 3. Practices regarding hearing protection devices, hearing screening, and health and safety training (N = 38)

Practice item	Never/almost never		Sometimes		Always/almost always	
	n	%	n	%	n	%
I undergo annual hearing screening to determine my hearing status	7	18.4	10	26.3	20	52.6
I inform my supervisor when my earplugs/earmuffs are damaged	14	36.8	5	13.2	18	47.4
I wear HPDs when working in noisy environments	6	15.8	15	39.5	17	44.7
My audiometric test results are shared with my employer by the tester	19	50.0	6	15.8	12	31.6
My audiometry test results are shared with the health and safety representative of the institution by the tester	11	28.9	9	23.7	17	44.7
I received information from the health and safety committee on noise control at my workplace	16	42.1	7	18.4	14	36.8
I wear earplugs/earmuffs outside of the workplace when I am exposed to high noise levels	21	55.3	7	18.4	10	26.3
I am provided with approved earplugs/earmuffs at my workplace	10	26.3	18	47.4	10	26.3
There are posters in sections where it is required to wear earplugs/earmuffs at my workplace	12	31.6	16	42.1	10	26.3
I had to buy my own earplugs/earmuffs for use at my workplace	16	42.1	13	34.2	8	21.1
I attended organised training on HPDs at my workplace	24	63.2	7	18.4	7	18.4

HPD: hearing protection device

Table 4. Referral threshold shifts from baseline to periodic screening

Laterality	Audiometric frequency	Screening				p value
		Baseline		Periodic		
		Median	IQR	Median	IQR	
Right ear	Mid	6.7	8.3	8.3	6.7	0.170
	High	8.3	5.0	11.7	12.1	0.012
Left ear	Mid	6.7	5.8	9.2	6.7	0.075
	High	7.5	6.7	10.0	10.0	0.002

DISCUSSION

The findings from this study suggest that there is a lack of knowledge about risk factors for and management of NIHL among army unit members, inconsistent provision of HPDs, and hearing deterioration at high frequencies, shown as RTS from baseline.

Knowledge about NIHL

Workers' knowledge about HCP measures, such as education and training, which are essential for reducing the risk of NIHL, may be linked to positive uptake and compliance for HPD usage. Some of our study participants had some knowledge about NIHL risks, such as the effects of ear infections on hearing, and knew that the use of HPDs can prevent hearing loss, and that having problems hearing conversational speech was one of the early signs of hearing loss. Similar findings have been reported in the forestry sector.[17] The differences in knowledge about the HCP measures could be attributed to work-related factors, such as duration of work experience and types of jobs in the military. Other research has shown that British soldiers demonstrate adequate knowledge of the cause of hearing loss and the risk of noise exposure, although the same study reported noncompliance with HPD usage.[18] Education and training programmes, intended to improve knowledge about NIHL risks, are not necessarily enough to ensure compliance. It is essential to integrate all the pillars for an effective HCP in the military.

Contrary to beliefs that workers are knowledgeable about the effects of excessive noise exposure, only a small proportion of participants in our study knew that noise exposure is a risk factor for permanent NIHL. This and the belief that NIHL can be treated with medication indicate a general lack of knowledge about NIHL. This could be due to a lack of education and training; other studies have shown that NIHL awareness education and training for workers is often not prioritised.[19] Health knowledge may positively affect workers' behaviour in owning their health. Our findings highlight the need for the military to implement education and training, as stipulated in the South African Standard (SANS 10083, 2021).[7]

The practices regarding the provision and use of HPDs, health and safety training, and hearing screening

Although most study participants reported that they were provided with HPDs, they did not receive training on their use. According to the South African Standard (SANS 10083, 2021), employees must be issued with certified personal HPDs, at no cost, when working in noise zones, as well as receive education and training on the correct use and maintenance of HPDs.[7] The reported inconsistent provision and use of HPDs might not be a true reflection of the HCP in the army unit. Some reports have indicated that the reason for non-compliance with the use of HPDs, in a military setting, is the difficulty with communication and hearing commands, and discomfort while wearing HPDs.[18] Similar findings have been reported in other industries, such as the iron and steel manufacturing industry.[11]

Workers' knowledge of work-related health risks may be linked to their poor uptake of interventions put in place by employers to address health and safety risks.[17,19,20] There may be a connection between participants' knowledge of the risks associated with NIHL and the use of HPDs. Therefore, future research in the military could investigate these linkages to enhance hearing conservation practices, alongside investigations focused on individual workers' knowledge of work-related health risks.

Not all the study participants underwent regular hearing screening. Those who do not undergo hearing screening regularly may not be aware of their hearing function, and this may influence their use of HPDs to prevent NIHL, which may further lead to deterioration of hearing.[21] Nyarubeli et al. (2020), in a study on hearing loss prevention practices in iron and steel workers, reported that more than half of the employees changed their safety habits regarding noise exposure – both at work and outside work – as a result of undergoing annual hearing testing.[11] The South African Standard (SANS 10083, 2021) requires that employees who are exposed to gunshots or other explosives, such as those in the army unit, should participate in audiometric surveillance every six months.

Audiometric characteristics

The need for investigations into factors related to RTS is warranted. Any deviation from the baseline audiogram's hearing thresholds suggests a decline in hearing, requiring early interventions to minimise the risk of permanent hearing loss. Our findings revealed a statistically significant RTS at high frequencies. This highlights the importance of frequency-specific hearing loss over a period of time, which is associated with NIHL. The study findings are consistent with those reported by Moore in 2020.[2] Early evaluation of potential contributing factors associated with, and interventions to prevent, NIHL should be explored. One intervention that might target high-frequency noise exposure and improve communication is the selection of appropriate HPDs, designed with spectral impulse insertion loss, specifically for workers in the military.[22] The use of HPDs might be a feasible preventive control measure against harmful noise exposure for this group of workers. Routine provision and consistent use of appropriately selected HPDs that accommodate both communication needs and user comfort should be considered.

Limitations

Non-probability sampling was used and the sample size was small. Thus, the findings may not be generalised to all South African army units. Furthermore, the time interval between the baseline audiometry and subsequent periodic audiograms was not recorded during the audiometric data review. Therefore, the duration of military noise exposure from the time of the baseline audiometry testing could not be determined.

Recommendations

Future research on HCPs is needed in the military sector, using larger sample sizes and probability sampling methods, for generalisability to other army units in South Africa. Effective audiometry surveillance is needed for workers in the military, and future studies could investigate this to provide evidence for hearing health of members in the military in South Africa. Future studies could also investigate the association between the use of HPDs and development of NIHL in the military.

CONCLUSION

Participants in this study lacked the knowledge necessary to protect their hearing and prevent NIHL. The high-frequency RTS from baseline highlights early signs of NIHL-associated risks for this group of workers. Hearing conservation education and training on noise hazards, NIHL risks, and the use of appropriate HPDs are important. More research needs to be done to fill the gap in research on NIHL in the South African military sector.

KEY MESSAGES

1. Noise-induced hearing loss education and training programmes are essential to improve knowledge about NIHL and use of HPDs in the army unit.
2. There was evidence of hearing deterioration in the study participants, which suggests that army employees are at risk of NIHL.
3. Implementation of early interventions are necessary to mitigate the risk of hearing loss.

DECLARATION

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conception and design of the study: CN, MS, LP, MAG
Data acquisition: CN
Data analysis: CN, MAG
Interpretation of the data: CN, MS, LP, MAG
Drafting of the paper: CN, MS, LP, MAG
Critical revision of the paper: CN, MS, LP, MAG

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Technology-driven approaches to occupational noise-induced hearing loss management and hearing conservation programmes in Africa

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ABSTRACT

Background: Occupational noise-induced hearing loss (ONIHL) is a major public health concern in Africa, particularly in high-risk industries such as mining, manufacturing, and construction. While hearing conservation programmes (HCPs) exist, their effectiveness is often limited by poor enforcement, inadequate infrastructure, and low adoption of emerging technologies. Advancements in fourth industrial revolution (4IR) technologies – such as artificial intelligence (AI), tele-audiology, mobile health (mHealth), and the internet of things (IoT) – offer new opportunities for ONIHL prevention. However, their integration into occupational hearing healthcare in Africa remains limited.

Objective: To explore technology-driven approaches to ONIHL management and HCPs in Africa, highlighting advancements, barriers, and opportunities for integrating digital solutions into occupational health frameworks.

Methods: For this narrative review, PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, and African Journals Online (AJOL) were searched for relevant articles. The selected studies were categorised as highly or moderately relevant. Thematic analysis was conducted to synthesise key findings on AI-driven audiology, tele-audiology and mHealth, IoT-integrated hearing conservation, and regulatory challenges.

Results: A total of 1 147 publications were identified, of which 55 were evaluated for relevance; 22 were included in the review. Ten were considered to be highly relevant and 12 to be moderately relevant. AI-based solutions show promise for early detection and predictive analytics in ONIHL management, but face barriers such as high costs and limited digital infrastructure. Tele-audiology and mHealth interventions can improve access to hearing healthcare in underserved areas, yet connectivity and data security challenges persist. IoT-enabled hearing protection devices enhance real-time noise monitoring, but remain underutilised due to high costs and policy gaps. Moderately relevant studies further highlight implementation barriers, including reliance on paper-based systems, low digital literacy, and limited funding for technological innovation. Weak regulatory enforcement further limits technology adoption in HCPs.

Conclusion: While 4IR technologies present significant opportunities for ONIHL prevention, their implementation in Africa requires investment, regulatory reform, and multi-sectoral collaboration. Policy updates, financial incentives, and workforce training are crucial to integrating these innovations into occupational health strategies. The African experience offers lessons for other low- and middle-income countries, and future research should prioritise examining real-world industry adoption of these technologies.

INTRODUCTION

Occupational noise-induced hearing loss (ONIHL) remains one of the most prevalent, yet preventable, occupational diseases worldwide,[1] particularly in low- and middle-income countries (LMICs), where regulatory enforcement and occupational health infrastructure are often inadequate.[2] In Africa, industrialisation, mining, construction, and manufacturing industries expose workers to hazardous noise levels,[3] contributing significantly to the burden of ONIHL. While traditional hearing conservation programmes (HCPs) have been implemented in some sectors, their effectiveness is often limited by resource constraints, poor adherence, and a lack of integration with emerging digital health solutions.[4,5] With advancements in technology – particularly in artificial intelligence (AI), tele-audiology, internet of things (IoT), and digital health – there is an opportunity to revolutionise the management and prevention of ONIHL in Africa.

The burden of ONIHL in Africa is exacerbated by socio-economic and structural challenges.[6] High-risk sectors such as mining, manufacturing, and agriculture employ a large proportion of the workforce under suboptimal occupational health and safety (OHS) conditions.[7] Inadequate regulation and enforcement, coupled with limited access to preventive audiology services, contribute to delayed diagnosis and management of ONIHL.[8,9] Additionally, many African workers lack awareness of the risks associated with occupational noise exposure and often do not prioritise hearing protection, given more immediate occupational hazards such as respiratory diseases and physical injuries.[10]

In South Africa, the mining industry – a major contributor to the economy – has one of the highest rates of ONIHL, with studies indicating that, despite existing HCPs, many workers develop hearing loss due to inconsistent use of hearing protection devices (HPDs), limited audiometric surveillance, and poor noise monitoring practices.[11,12] Similar trends are observed in Nigeria's sawmill industry, where excessive noise exposure occurs with minimal protective measures.[13] This issue is not unique to southern or South Africa. Many LMICs struggle with ineffective enforcement of hearing conservation protocols, as seen in studies from Malaysia

and India.[14,15] These recurring patterns of poor enforcement of regulations, inadequate use of protective technologies, and limited surveillance highlight the systemic nature of ONIHL risks in resource-constrained settings, and underscore the urgent need for enhanced technological interventions to strengthen HCPs across African workplaces.

The fourth industrial revolution (4IR) ushered in an era of digital transformation that presents opportunities to enhance OHS measures.[16] Technological advancements can address limitations of conventional HCPs by improving early detection, facilitating continuous monitoring, and promoting individualised hearing conservation strategies.[17]

First, as far as AI and predictive analytics are concerned, AI-driven solutions can improve early diagnosis of ONIHL, by analysing large datasets from audiometric testing and occupational noise exposure levels, and individual risk factors, to predict ONIHL progression.[18] Artificial Intelligence algorithms have demonstrated the potential to automate hearing screenings, reducing dependence on specialist audiologists and improving accessibility in resource-limited settings.[17] Artificial intelligence can also support occupational noise management by identifying high-risk workers and recommending tailored interventions.[19]

Second, in terms of tele-audiology and mHealth solutions, the use of tele-audiology has been shown to expand access to hearing healthcare in LMICs by enabling remote hearing assessments and consultations.[20] Smartphone-based audiometry and digital hearing health platforms can facilitate large-scale hearing screenings, particularly in rural and underserved areas.[21] Telehealth solutions also enable ongoing worker education, reinforcing compliance with HCP protocols.[22]

Third, with regard to IoT and wearable hearing protection devices, IoT-integrated HPDs provide real-time monitoring of noise exposure, alerting workers and supervisors when sound levels exceed safe thresholds.[23] These smart HPDs can also record and analyse exposure data, contributing to improved occupational risk assessments and governance compliance.[24]

Last, when it comes to big data and noise management strategies, the application of big data analytics in occupational health enables the identification of noise exposure patterns across industries, facilitating data-driven policymaking.[25] Noise mapping tools and environmental sensors can improve workplace noise control strategies, ensuring that interventions are both proactive and effective.[26]

While technological innovations offer promising solutions, their successful implementation in Africa requires a contextually responsive approach. Challenges such as digital infrastructure gaps, workforce digital literacy, and financial constraints must be addressed to ensure equitable access to technology-driven ONIHL interventions.[27] Moreover, ethical considerations regarding data privacy, informed consent, and algorithmic bias in AI-driven solutions must be examined critically to align with occupational health best practices.[28,29]

Given Africa's diverse economic and industrial landscapes, a one-size-fits-all approach to ONIHL prevention may not be effective. Traditional HCPs often rely on outdated, resource-intensive methods that do not address the increasing burden of occupational noise exposure.[2,30] The integration of digital solutions offers the potential to overcome these challenges, yet adoption remains slow due to limited policy enforcement and industry hesitancy.[2] By understanding the barriers and opportunities in this transition, stakeholders can develop more sustainable, culturally appropriate, scalable, and effective interventions, which require collaboration – engaging governments, industries, healthcare providers, and worker unions.[31]

Advancements in technology-driven interventions present an opportunity to rethink and modernise occupational hearing conservation strategies in Africa. However, their feasibility and implementation remain uncertain, necessitating a critical review of existing literature to assess both the potential benefits and limitations of these innovations.

The aim of this narrative review was to explore and synthesise the available literature on technology-driven approaches to ONIHL prevention and HCPs in Africa and other LMICs. Specifically, it sought to:

- Examine the burden of ONIHL in Africa, highlighting industry-specific risks and challenges
- Identify and analyse technological advancements in ONIHL management, including AI, tele-audiology, IoT, and big data analytics
- Evaluate the feasibility, accessibility, and effectiveness of these technologies within the African occupational health context
- Identify potential barriers and facilitators to the adoption of technology-driven solutions for ONIHL management
- Provide recommendations for policymakers, industry stakeholders, and healthcare professionals on integrating 4IR technologies into sustainable and contextually relevant HCPs in Africa

By consolidating evidence from existing research, this review contributes to the discourse on digital transformation in occupational hearing conservation, offering insights into how Africa can leverage 4IR technologies to mitigate the impact of ONIHL. This review offers not only a synthesis of technological innovations in ONIHL prevention, but also a focused lens on their relevance and feasibility in African occupational settings – something that previous reviews have not fully explored. Earlier global reviews have generally emphasised broad technological trends without adequately addressing the contextual factors that influence their adoption in LMICs. By anchoring the discussion in Africa-specific challenges, such as regulatory inertia, infrastructure deficits, and industry-level implementation barriers, this review provides a critical framework for translating global advancements into actionable strategies within under-resourced occupational health systems. In this way, the review fills an important gap between global innovation discourse and regional implementation realities.

METHODS

A narrative review was chosen to synthesise diverse sources of literature, identify knowledge gaps, and provide a broad, contextualised understanding of how 4IR technologies – including AI, tele-audiology, IoT, mHealth, and big data analytics – can enhance ONIHL prevention and hearing conservation efforts. Findings from peer-reviewed journal articles, policy documents, government reports, and grey literature were integrated to provide a comprehensive examination of the technological advances in occupational audiology.

Literature search strategy

A systematic and transparent literature search was conducted following the guidelines of Levac et al. (2010)[32] to ensure rigour, feasibility, and reproducibility. The search was performed across multiple electronic databases to capture relevant studies, including PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, CINAHL, EBSCOHost, MEDLINE, ProQuest, and African Journals Online (AJOL). Institutional repositories and grey literature from the World Health Organization (WHO), International Labour Organization (ILO), African Union (AU), and the South African Mine Health and Safety Council (MHSC) were also searched. Searches of the World Health Organization (WHO), International Labour Organization (ILO), and African Union (AU) did not yield additional studies that met the inclusion criteria. However, these sources informed contextual understanding and reinforced the rationale for focusing on technology integration in occupational hearing conservation.

The search strategy incorporated medical subject headings (MeSH) and free-text terms, with Boolean operators, to maximise the identification of relevant literature. Key search terms were:

- 'occupational noise-induced hearing loss' OR 'ONIHL'
- 'hearing conservation programmes' AND 'occupational health'
- 'artificial intelligence in audiology' OR 'AI' AND 'occupational hearing loss'
- 'tele-audiology' AND 'occupational noise exposure'
- 'Internet of Things (IoT)' AND 'hearing protection'
- 'mHealth' AND 'hearing conservation programmes'
- 'big data analytics in occupational health' AND 'hearing loss prevention'
- 'noise exposure monitoring technology' AND 'hearing protection devices'

Supplementary search methods were adopted to source additional literature. This ensured a comprehensive review of the available literature, while maintaining transparency and reproducibility in the search strategy. To ensure relevance and methodological rigour, studies were selected based on predefined inclusion and exclusion criteria.

Inclusion criteria

- Studies published from 2000 to 2024 (to capture recent advancements in 4IR technologies) in English
- Empirical studies, systematic reviews, meta-analyses, and policy reports focusing on:
  - o occupational noise-induced hearing loss
  - o hearing conservation programmes
  - o technology-driven interventions in occupational audiology
  - o regulatory frameworks for hearing conservation
- Studies from LMICs, particularly in Africa, but also including comparative global insights

Exclusion criteria

- Studies not addressing occupational hearing loss or workplace noise exposure
- Research outside the African context (unless it provided comparative perspectives on technology adoption in LMICs)
- Studies focusing exclusively on non-occupational hearing loss or paediatric hearing impairment

Study selection and data extraction were conducted by two independent reviewers. Each reviewer screened the titles and abstracts of the identified records, assessed full texts for eligibility, and categorised the studies as highly relevant, moderately relevant, or not relevant. Discrepancies were resolved through discussion and consensus. Where disagreements could not be resolved, a third reviewer was consulted to reach a final decision.

Data extraction and analysis

A narrative synthesis approach, consistent with established guidance for narrative reviews, such as those by Ferrari (2015),[33] was used to extract and analyse findings thematically across included studies. From an initial 1 147 records identified, 55 studies were assessed for relevance. Of these, 22 were selected for in-depth review (Table 1). Relevance was assessed independently by two reviewers, based on the extent to which each study addressed the objectives, technological interventions, and African or LMIC contexts.

Tables were designed to capture:

1. Study characteristics (author, year, country, study design)
2. Industry sector and worker population studied (e.g. mining, construction, manufacturing, agriculture)
3. Prevalence and impact of ONIHL and effectiveness of HCPs
4. Technological interventions explored (e.g. AI, tele-audiology, IoT-based hearing protection, big data applications)
5. Identified gaps in HCPs and technology adoption barriers
6. Policy and regulatory frameworks discussed
7. Recommendations for integrating 4IR technologies into occupational hearing conservation strategies

Table 1. Summary of process used to select articles for final review

Step	Description	n
Identified through database searching	Peer-reviewed journal databases and indexed searches (PubMed, Scopus, Web of Science, etc.)	1 147
Screened for relevance	Based on title and abstract review	1 147
Full-text assessed for eligibility	Comprehensive reading	55
Excluded after full-text review	Deemed not relevant	33
Identified via supplementary searches (e.g. citation tracking)*	Added to ensure completeness	11
Included in final synthesis	Highly or moderately relevant	22
Highly relevant	Directly addressed study aim and African context	10
Moderately relevant	Provided contextual or comparative insights	12

Note: supplementary searches contributed to the 55 full-text articles assessed, but did not yield articles additional to the final 22
* included in the 55 full-text articles assessed for eligibility

A thematic analysis approach[34] was used to synthesise findings, categorise emerging themes, and identify patterns, challenges, and policy gaps related to ONIHL and technological interventions in African occupational health settings. Thematic saturation was reached when additional studies no longer introduced novel insights,[35] ensuring a comprehensive and balanced synthesis of the literature.

Quality assurance and interpretation

While narrative reviews offer flexibility, rigorous methodological safeguards were implemented to ensure reliability, transparency, and credibility.[36] These included 1) systematic documentation of the search strategy and study selection process; 2) continuous refinement of the research focus as new insights emerged; 3) critical evaluation of selected studies for methodological soundness, relevance, and applicability; and 4) reflexivity to account for potential researcher biases and contextual influences on interpretation. These measures strengthened the validity and reproducibility of the review's findings, while ensuring a balanced synthesis of perspectives on technology-driven ONIHL management and hearing conservation in Africa.

Although formal ethical approval was not required, ethical integrity was maintained through comprehensive citation of all sources to uphold academic integrity and avoid plagiarism; use of publicly available, peer-reviewed research to ensure credibility; objective selection and analysis of studies to minimise bias; and recognition of potential conflicts of interest and limitations in available data. Additionally, efforts were made to incorporate diverse perspectives, recognise gaps in existing research, and ensure transparency in reporting and interpretation of findings.[37,38]

RESULTS AND DISCUSSION

The results of this analysis are presented thematically to illustrate both the scope of technological innovation and the contextual challenges unique to the African occupational health environment.

The 22 studies analysed varied in study design, geographic focus, and industry sector. Ten were considered to be highly relevant (Table 2) and 12 to be moderately relevant (Table 3). The majority were literature reviews, observational studies, policy analyses, and experimental research, exploring ONIHL and HCPs within African and LMIC contexts. Most were conducted in Africa – primarily South Africa[2,17,17] and Nigeria;[13] several were from outside Africa, including western India[15] and Malaysia[14] (for comparative insights), while others did not specify a geographic focus but offered insights applicable to LMIC settings. For clarity, the tables indicate the country or region (where known). Most were qualitative reviews,[2,7] cross-sectional analyses of HCPs,[11,12] and technology-focused experimental studies on AI and IoT applications.[17,39]

Table 2. Comprehensive evidence synthesis of technology-driven approaches to ONIHL and HCPs in the African context (highly relevant sources)

Author (year), country	Industry sector, worker population	Prevalence/impact of ONIHL and effectiveness of HCPs	Technological interventions explored	Gaps in HCPs and technology adoption barriers	Recommendations for integrating 4IR technologies
Moroe and Khoza-Shangase (2022),[30] not specified – LMIC insights	Not specified, focus on general principles	Discusses HCPs and the industrial revolutions	Not specified	Not specified	Integrating 4IR technologies into HCPs
Madahana et al. (2022),[19] South Africa	Mining	Effects of changes in mining practices on ONIHL	Impact of AI and fully-automated systems	Manual vs automated systems	Implementing AI in ONIHL management
Sandström et al. (2016),[21] South Africa	Underserved primary healthcare contexts	Not specified	Smartphone threshold audiometry	Not specified	Using smartphone audiometry in hearing care
Khoza-Shangase and Moroe (2020),[29] South Africa	Not specified, focus on general principles	South African HCPs	Tele-audiology	Tele-audiology in hearing conservation	Using tele-audiology in HCPs
Danielson (2007),[40] not specified – comparative perspective	Not specified, focus on general principles	Not specified	Contemporary technology for hearing conservation audiometric monitoring	Not specified	Using contemporary technology in audiometric monitoring
Mahomed-Asmail and Swanepoel (2022),[20] sub-Saharan Africa	Not specified, focus on general principles	Not specified	mHealth solutions in hearing care	Not specified	Using mHealth solutions in hearing care
Tank et al. (2024),[15] Western India	Mining	Prevalence and predictors of high-frequency hearing loss	Not specified	Need for comprehensive HCP	Implementing comprehensive HCPs
AlSamhori et al. (2024),[18] not specified – LMIC insights	Not specified, focus on general principles	Not specified	AI for hearing loss prevention, diagnosis, and management	Not specified	Using AI for hearing loss management
Mahomed-Asmail et al. (2024),[39] South Africa	Not specified, focus on general principles	Not specified	Trends in digital hearing health and computational audiology	Not specified	Using digital hearing health and computational audiology
Madahana et al. (2024),[17] South Africa	Mining	Not specified	Development of an AI- based ONIHL early warning system	Not specified	Developing AI-based early warning systems

4IR: fourth industrial revolution, AI: artificial intelligence, HCP: hearing conservation programme, LMIC: low- and middle-income country, ONIHL: occupational noise-induced hearing loss
Note: policy and regulatory frameworks not consistently specified across included studies; column removed for clarity

Mining was the most studied industry, [7,12,17,19] reflecting the high risk of ONIHL due to chronic noise exposure. Other high-risk industries included iron and steel production,[11] and wood sawmills,[13] where workers are exposed to prolonged high-decibel noise. Several studies[4,20,29] examined general occupational hearing conservation strategies, applicable across multiple industries.

In the studies, a range of 4IR technologies aimed at improving ONIHL prevention were analysed, including: 1) AI for predictive audiology and threshold shift detection,[17,18] 2) tele-audiology for remote hearing screenings and monitoring,[21,29] 3) mHealth solutions for mobile HCPs,[20] and 4) IoT-based hearing protection and noise exposure monitoring.[23,40] Despite these advancements, many studies also identified key barriers to adoption, particularly in African contexts, where digital health infrastructure and policy enforcement remain underdeveloped.

Thematic analysis of the data highlighted advancements in technology-driven approaches to ONIHL prevention and HCPs, particularly through the integration of AI, tele-audiology, mHealth, IoT, and digital audiology solutions, as shown in Tables 2 and 3. While these technologies present a paradigm shift in occupational hearing healthcare, their adoption in Africa remains limited by structural, funding, and policy-related challenges. The highly relevant studies provided direct insights into technology use in African occupational hearing conservation, while the moderately relevant studies offered critical context – particularly around implementation barriers such as cost, infrastructure limitations, and regulatory delays. Findings from both groups were integrated thematically to provide a comprehensive synthesis.

Table 2 shows the synthesis of evidence from highly relevant sources, focusing on technology-driven approaches to ONIHL management and HCPs. The themes that emerged highlight the increasing recognition of AI, tele-audiology, digital health solutions, and contemporary technology in addressing ONIHL in Africa.

Theme 1: Increasing recognition of AI in ONIHL management

Several studies have emphasised the transformative role of AI in ONIHL prevention, particularly through early warning systems and predictive analytics in improving ONIHL detection and management.[17-19] Artificial intelligence has been shown to enhance audiometric surveillance in

Table 3. Comprehensive evidence synthesis of technology-driven approaches to ONIHL and HCPs in the African context (moderately relevant sources)

Author (year), country	Industry sector, worker population	Prevalence/impact of ONIHL and effectiveness of HCPs	Technological interventions explored	Gaps in HCPs and technology adoption barriers	Recommendations for integrating 4IR technologies
Ebekozien et al. (2023),[13] Nigeria	Wood sawmills	Hazards in wood sawmills	4IR technologies	Not specified	Role of 4IR technologies
Maswanganyi (2021),[16] South Africa	Mining (underground gold mine)	Not specified	4IR and industry 4.0 considerations	Not specified	Consider Industry 4.0
McBride (2004),[12] not specified – comparative perspective	Mining	Noise-induced hearing loss and hearing conservation	Not specified	Not specified	Effective implementation of hearing conservation
Mizan et al. (2014),[11] South Africa	Iron and steel industry	Noise-induced hearing loss and hearing conservation	Not specified	Not specified	Effective implementation of hearing conservation
Moroe and Khoza-Shangase (2020),[2] South Africa	Not specified, focus on general principles	Recent advances in HCPs	Not specified	Not specified	Advances in HCPs
Rogers et al. (2009),[44] not specified – comparative perspective	Not specified, focus on general principles	What makes a successful HCP?	Not specified	Not specified	Elements of successful HCPs
Moroe et al. (2018),[7] Africa	Mining	Management of ONIHL	Not specified	Not specified	Managing ONIHL in mining
Yuen (2014),[14] Malaysia	Not specified, focus on general principles	Environmental and occupational noise pollution	Not specified	Not specified	Addressing noise pollution
Patel et al. (2001),[10] not specified – comparative perspective	Not specified, focus on general principles	Barriers to preventive health actions for ONIHL	Not specified	Barriers to preventive actions	Overcoming barriers to prevention
Chis et al. (2025),[26] not specified – comparative perspective	Industrial environments	Integrated noise management strategies	Not specified	Not specified	Integrated noise management strategies
Waterworth et al. (2022),[27] not specified – focus on LMICs	Not specified, focus on general principles	Barriers to access to ear and hearing care services in LMICs	Not specified	Barriers to access	Improving access to ear and hearing care
Madahana et al. (2019),[41] not specified – LMIC insights	Mining	Mineworkers threshold shift estimation	Optimisation algorithms for deep recurrent neural networks	Not specified	Using optimisation algorithms for threshold shift estimation

4IR: fourth industrial revolution, HCP: hearing conservation programme, LMIC: low- and middle-income country, ONIHL: occupational noise-induced hearing loss
Note: policy and regulatory frameworks not consistently specified across included studies; column removed for clarity

threshold shift detection, automate audiometric screenings, and facilitate occupational risk assessment in South African mining industries, where manual hearing monitoring remains a challenge. Mahomed-Asmail et al. (2024) identified AI-driven computational audiology as a promising tool for personalised hearing healthcare.[39] Similar applications have been reported in Europe, where AI models improved occupational hearing screening efficiency.[22]

These findings, suggesting a growing acknowledgment of AI's role in addressing ONIHL proactively, align with global literature,[22] which supports AI's potential in occupational health monitoring, early detection of hearing loss, and data-driven decision-making. However, Africa lags in AI implementation, largely due to 1) lack of digitised patient data, limiting AI training models, 2) high costs of AI-based audiometry solutions, making them inaccessible in resource-limited settings, and 3) absence of policy frameworks to support AI integration in occupational health. While countries such as South Africa have begun to explore AI for ONIHL prevention in the mining industry, its full implementation remains fragmented and largely research-driven rather than practice-driven.[29] Without infrastructure investment and regulatory oversight, AI in ONIHL management will remain an underutilised potential in Africa.

Theme 2: Tele-audiology and digital health solutions in HCPs

Researchers [20,21,29] have highlighted the viability of tele-audiology and mHealth solutions in improving access to hearing conservation services. Khoza-Shangase and Moroe (2020)[29] highlighted tele-audiology as a viable approach to improving hearing conservation efforts, particularly in remote and underserved regions. Sandström et al. (2016) explored smartphone-based audiometry, emphasising its cost-effectiveness and feasibility in low-resource settings.[21] Mahomed-Asmail and Swanepoel (2022) demonstrated the potential of mHealth applications to enhance patient engagement in hearing conservation efforts.[20] The benefits of these digital solutions include:

- Remote audiometric screening and monitoring
- Cost-effective hearing conservation interventions
- Better patient engagement through mobile applications

These approaches that aim to improve accessibility and efficiency of hearing care services, especially in resource-limited settings, are consistent with international evidence,[22] which highlights the role of tele-audiology in bridging service delivery gaps in occupational health. However, Africa's digital divide presents a barrier to the adoption of tele-audiology, as noted in some of the studies presented in Table 3.[10,27] Key challenges include limited broadband connectivity in rural areas, low digital literacy among workers in high-risk industries, and concerns about data security and patient confidentiality in tele-audiology platforms. These barriers mirror broader healthcare system challenges in LMICs, where digital health strategies remain underdeveloped due to financial constraints and policy misalignment. Moving forward, multi-stakeholder collaboration – including government, industry leaders, and technology developers – is essential to scale up the adoption of tele-audiology in African occupational settings. In addition, studies such as those published by Waterworth et al. (2022)[27] and Patel et al. (2001)[10] emphasise that, while tele-audiology offers improved access to care, implementation is constrained by low digital literacy among workers, limited institutional readiness, and a lack of sustained funding for scaling digital platforms in occupational health.

Theme 3: The internet of things and contemporary technology for hearing protection

The integration of contemporary technology into audiometric monitoring is noted. IoT-enabled hearing conservation has been explored in some studies,[23,40] emphasising the need for real-time noise exposure and audiometric monitoring and automated compliance tracking. Canetto and Voix (2008) explored wearable hearing protection devices with IoT capabilities, which allow for automated noise exposure tracking and user compliance monitoring.[23] In high-risk industries such as mining, construction, and manufacturing, these smart HPDs could revolutionise worker safety by providing continuous noise exposure data, sending real-time alerts when noise thresholds are exceeded, and tracking worker compliance with HPD usage. Despite these advantages, Africa has not yet adopted IoT-integrated HPDs at scale, as evidenced in some findings presented in Table 2.[12,16] A moderately relevant study (Maswanganyi, 2021)[16] showed that, despite growing discourse on Industry 4.0 (the next stage in the digital transformation of the manufacturing sector, propelled by disruptive developments such as increased data connectivity, advanced analytics, human-machine collaboration, and advancements in robotics), integration of IoT-enabled safety technologies in South African industrial settings remains rare due to prohibitive costs, low employer investment in advanced safety technologies, insufficient workforce preparedness, and lack of enforcement of workplace noise monitoring policies.[16] Moderately relevant studies, such as by Maswanganyi (2021)[16] and McBride (2004),[12] point to an overreliance on outdated, paper-based surveillance systems in industries like mining and steel manufacturing. These systems hinder real-time monitoring and slow the responsiveness of HCPs, reinforcing the need for digitisation.

These findings align with global reports,[13,26] which indicate that, while Industry 4.0 has the potential to improve OHS, adoption remains slow in developing economies. Without targeted policy incentives and employer engagement, IoT solutions for hearing conservation will remain a technological luxury rather than a standard workplace requirement in Africa.[41]

Theme 4: Regulatory and implementation gaps in African HCPs

Across studies summarised in Tables 2 and 3, a recurring theme was the absence of strong policy frameworks to drive technology adoption in ONIHL prevention. Studies by Moroe and Khoza-Shangase (2020),[2] Madahana et al. (2022),[19] and Tank et al. (2024)[15] highlight the lack of regulatory enforcement in ONIHL prevention as a major challenge to hearing conservation efforts. Moroe and Khoza-Shangase (2020)[2] argue for policy updates to integrate 4IR technologies into hearing conservation strategies, particularly in industries with high noise exposure.

Study findings suggest that, while Africa has occupational health regulations, these often lack technological integration mandates for ONIHL prevention; are poorly enforced, especially in informal and small-scale industries; and do not incentivise industries to invest in hearing conservation technologies – pointing to potential implementation gaps. These results are consistent with international evidence, which suggests that policy gaps in LMICs slow down occupational health technology implementation.[31,42,43] Without updated and enforceable regulations, technology-driven hearing conservation solutions will remain underutilised in African workplaces.

Overall, key findings from studies in Table 2 indicate that 1) AI-based ONIHL management tools are gaining traction but remain underutilised due to cost and infrastructure challenges, 2) tele-audiology and mHealth show promise for scalable hearing HCPs in Africa, 3) the lack of integration of IoT into hearing protection devices limits real-time noise exposure tracking, and 4) policies must evolve to accommodate technological advancements, ensuring compliance with HCPs.

Studies in Table 3 highlight industrial applications of 4IR, barriers to effective hearing conservation, integration of AI and data analytics into ONIHL management, and occupational health risks in various sectors in Africa. Several moderately relevant studies, including Chis et al. (2025)[26] and Yuen (2014),[14] highlight how fragmented occupational health regulations, limited cross-sector collaboration, and a general lack of policy enforcement contribute to technology underutilisation in hearing conservation. Outdated occupational safety policies in LMICs often lack the provisions necessary to support the adoption of innovative technologies, even when such technologies are available. This reinforces the need for stronger regulatory frameworks that are responsive to digital innovation and context-specific occupational health realities. Such findings underscore that regulatory alignment is as critical to progress as technological advancement itself. The studies reviewed highlight practical challenges and broader systemic issues related to ONIHL management, offering valuable perspectives that support the conclusions of this review.

First, with regard to industrial applications of 4IR in noise management, Ebekozien et al. (2023)[13] and Maswanganyi (2021)[16] explored the role of Industry 4.0 in occupational noise management, particularly in mining and wood sawmills. Findings suggested that, while digital transformation is occurring, the adoption of noise monitoring technology remains fragmented across industries. Second, concerning barriers to effective hearing conservation in Africa, Patel et al. (2001)[10] and Waterworth et al. (2022)[27] identified accessibility, awareness, and regulatory gaps as major barriers to effective ONIHL prevention in LMICs. Yuen (2014)[14] and Chis et al. (2025)[26] examined noise pollution mitigation efforts, emphasising the need for stricter enforcement of hearing conservation policies. Third, with regard to AI and data analytics in ONIHL management, Madahana et al. (2019)[41] explored deep learning algorithms for ONIHL detection, advocating for AI-powered threshold shift estimation models. Rogers et al. (2009)[44] and Moroe et al. (2018)[7] highlighted the importance of predictive analytics in hearing conservation, although practical implementation in Africa remains limited by cost and digital infrastructure. Last, regarding occupational health risks and gaps in hearing protection, McBride (2004)[12] and Mizan et al. (2014)[11] focused on hearing conservation efforts in high-risk industries, particularly mining and manufacturing. They reported that many HCPs in Africa remain paper-based, with minimal adoption of digital solutions for noise exposure monitoring.

Overall, key findings from studies summarised in Table 3 were that 1) industrial adoption of 4IR technologies remains slow, particularly in hearing conservation, 2) barriers to ONIHL prevention include lack of funding, awareness, and regulatory enforcement, 3) AI-driven threshold shift estimation and predictive analytics have potential for early detection of ONIHL, targeted intervention planning, and improving the efficiency of occupational HCPs, but are underutilised, and 4) current HCPs rely on outdated, paper-based systems, limiting real-time monitoring of worker noise exposure. Artificial intelligence-driven threshold shift estimation and predictive analytics hold significant potential for early detection of ONIHL, targeted intervention planning, and improving the efficiency of occupational HCPs.

Although African studies clearly highlight the promise and constraints of adopting 4IR technologies in occupational hearing conservation, comparisons with global literature reveal both shared and divergent challenges. For example, in high-income countries such as the United States of America and the United Kingdom, AI-driven audiometric tools and IoT-enabled noise surveillance systems are being integrated into workplace hearing conservation efforts with increasing institutional and regulatory support. However, even in these contexts, data privacy concerns, workforce resistance, and uneven implementation persist – albeit mitigated by better funding and infrastructure. In contrast, African workplaces face steeper obstacles due to systemic underinvestment in digital health infrastructure, fragmented occupational health systems, and a lack of political prioritisation for hearing loss. This global comparison highlights that, while technological solutions are not context-exclusive, the enablers for success, such as policy enforcement, digital literacy, and investment, are disproportionately lacking in LMICs, particularly in Africa. Therefore, any efforts to replicate global best practices in the African context must be adapted to local socio-economic and infrastructural realities.

Limitations

While this review provides a comprehensive synthesis of technology-driven approaches to ONIHL prevention in Africa, several limitations must be acknowledged. The first is the heterogeneity of the included studies, which varied in methodological quality, scope, and industry focus. While efforts were made to synthesise findings systematically, the lack of uniform study designs presents comparability challenges. Second, there is limited empirical data on AI and IoT applications in Africa. While AI and IoT are widely discussed in the hearing conservation literature, empirical studies on their implementation in Africa are scarce; most focus on theoretical potential rather than real-world applications. Third, articles published in languages other than English, particularly French-, Portuguese-, and Arabic-language studies from Africa, were excluded. These articles may have described relevant research. Fourth, while efforts were made to include policy reports and grey literature, many African occupational health reports are unpublished or inaccessible, limiting insights into regulatory frameworks and real-world industry practices. Last, this review relied exclusively on published articles and grey literature, and did not include data from companies or occupational health providers. It is acknowledged that some companies in South Africa and other African countries may already be adopting elements of AI, IoT, or digital hearing conservation solutions in line with available technologies, regulatory compliance needs, and digital record-keeping requirements. However, the investigation of industry-level implementation or adoption of these technologies was outside the scope of the present review.

Despite these limitations, this review provides critical insights into the current state of, challenges to, and opportunities for technology-driven ONIHL prevention in Africa. Research into technology-based ONIHL prevention strategies in Africa must expand beyond theoretical explorations. Future investigations, comprising both global and regional collaborations, should prioritise empirical studies that evaluate the real-world implementation, feasibility,

cost-effectiveness, and scalability of AI and IoT solutions across occupational settings – enabling the co-development of scalable and context-sensitive hearing conservation strategies that respond not only to technological opportunity, but also to systemic occupational health disparities. Comparative studies across LMICs could provide insight into regional variations and transferable practices. Future research should 1) prioritise empirical evaluations of AI, IoT, and digital audiology solutions in real-world occupational settings to drive evidence-based policy changes, and 2) include industry-specific investigations to map the use, outcomes, and challenges of integrating 4IR technologies into HCPs, particularly in sectors with high ONIHL burdens such as mining, manufacturing, and construction.

Recommendations include enhanced investment in AI and IoT for ONIHL management that could lead to automated, real-time hearing conservation solutions; capacity-building initiatives to train professionals on digital hearing conservation tools; and prioritisation of Africa-specific policy reforms to ensure contextually relevant integration of 4IR technologies in occupational health. Ethical considerations – including data privacy, informed consent, and potential biases in AI-driven tools – must be addressed systematically to avoid reinforcing inequities within occupational health systems.

CONCLUSION

This review provides a comprehensive synthesis of the role of emerging technologies in ONIHL prevention and HCPs within the African context. While advancements in AI, tele-audiology, mHealth, IoT, and digital audiology hold immense potential for revolutionising ONIHL management, their adoption remains limited due to persistent infrastructural gaps, limited funding, and outdated regulatory systems. In an era where digital transformation is shaping global healthcare systems, Africa finds itself at a crossroads – poised to integrate these technologies into occupational health frameworks, but hindered by barriers to implementation.

Rather than examining each technology in isolation, this review highlights a cross-cutting pattern of challenges that include the lack of digitised systems, limited workforce capacity, prohibitive costs, and regulatory inertia. These systemic issues continue to restrict the widespread implementation of even well-established innovations. While AI offers predictive capabilities and automated hearing assessments, and tele-audiology and mHealth can expand access to underserved regions, their effectiveness is constrained by inadequate infrastructure and limited interoperability between systems. Likewise, the integration of IoT into hearing protection offers promise for real-time noise monitoring, yet uptake remains slow due to cost constraints and the absence of incentives for industrial adoption.

Africa's regulatory frameworks for OHS are not keeping pace with technological advancements. Many policies governing hearing conservation remain outdated, lacking explicit mandates for integrating digital health solutions or supporting data-driven monitoring systems. Without strong regulatory enforcement, industry-driven HCPs remain fragmented and, in some cases, ineffective in addressing the long-term risks of ONIHL. Given the disproportionate burden of noise-induced hearing loss in high-risk sectors such as mining, manufacturing, and construction, urgent policy reform is required to align occupational health governance with the realities and demands of the 4IR.

To advance the integration of emerging technologies into ONIHL prevention, a coordinated, multi-sectoral approach is essential. Governments, industries, and healthcare professionals must co-develop standardised protocols that promote the responsible and sustainable use of AI, tele-audiology, and IoT in occupational health. Investment in digital infrastructure – particularly in rural and industrial regions – must be paired with targeted capacity-building initiatives to equip occupational health professionals with the digital competencies needed to deploy and manage these tools. Public-private partnerships and government-backed incentives can play a vital role in encouraging industries to adopt technology-driven hearing conservation strategies.

Ultimately, this review underscores the fact that, while Africa is well-positioned to benefit from 4IR technologies, the path to meaningful implementation will require sustained effort, strategic investment, agile policymaking, and evidence-based collaboration. By aligning occupational health priorities with global digital innovation trends, Africa can significantly reduce the burden of work-related hearing loss and secure the long-term auditory health of its workforce. The convergence of technology and occupational audiology presents an unprecedented opportunity to modernise HCPs, and this must be embraced with urgency and strategic foresight. Looking ahead, the African experience regarding ONIHL prevention offers valuable lessons for other LMICs grappling with similar resource and policy constraints.

DECLARATION

The author declares that this is her own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

Author's contributions

This is a sole-authored review, where the author conceptualised the study and conducted the research, analysed the data, and wrote the manuscript.

KEY MESSAGES

1. Emerging technologies – such as AI, tele-audiology, mHealth, and IoT – can transform the prevention and management of ONIHL in Africa.
2. Fourth industrial revolution technologies have the potential to support early detection, real-time noise exposure monitoring, and personalised hearing protection, particularly in high-risk industries.
3. Implementation barriers in LMICs include inadequate digital infrastructures, regulatory shortcomings, and limited industry incentives.
4. The findings provide practical guidance for policymakers, occupational health professionals, and industry leaders aiming to modernise HCPs.

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The interplay of occupational noise-induced hearing loss and middle ear disorders: towards comprehensive hearing conservation in Africa

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ABSTRACT

Background: Occupational noise-induced hearing loss (ONIHL) is preventable, particularly in low- and middle-income countries (LMICs). Middle ear disorders frequently co-occur with ONIHL, but remain neglected in hearing conservation programmes (HCPs). These conditions can complicate diagnosis, impair workers' ability to use hearing protection devices (HPDs), and exacerbate functional hearing deficits.

Objectives: The objectives of this review were to: 1) describe the prevalence and impact of middle ear disorders among noise-exposed workers, 2) examine the interplay between ONIHL and middle ear pathology in occupational settings, 3) explore the influence of systemic health factors, such as human immunodeficiency virus (HIV), on conductive hearing loss, and 4) identify gaps in current HCPs in African LMICs.

Methods: This narrative review included peer-reviewed articles, policy documents, and occupational health reports published from 2000 to 2024. PubMed, Scopus, Web of Science, Google Scholar, and African Journals Online (AJOL) databases were searched for relevant literature. Articles were included if they discussed HCPs, workplace safety regulations, and audiological health in Africa, or provided comparative insights from LMICs outside Africa. Thematic analysis was conducted to identify patterns, gaps, and policy implications.

Results: Eighteen of the 1 417 articles identified were included in the final synthesis. Most studies originated from LMICs, particularly in southern Africa, while several provided global comparative insights. The studies predominantly focused on workers in mining, manufacturing, and construction sectors. Thematic analysis revealed four core themes: 1) underdiagnosis of middle ear pathologies in occupational settings, 2) lack of enforcement of noise exposure regulations, 3) low compliance with HPDs, and 4) inadequate integration of audiological assessments in HCPs. Limited research addressing the dual burden of sensorineural and conductive hearing loss was noted, complicating intervention design in African LMICs.

Conclusion: The review demonstrated a clear disconnect between HCP implementation and the dual burden of sensorineural and conductive hearing loss. Addressing this gap requires an integrated approach that incorporates middle ear assessments, context-sensitive policy reforms, and feasible interventions such as mobile screening and task-shifting. Strengthening both the clinical and policy frameworks for occupational hearing health is essential for effective, inclusive, and sustainable prevention strategies in resource-constrained environments.

INTRODUCTION

Occupational noise-induced hearing loss (ONIHL) remains a public health concern, particularly in low- and middle-income countries (LMICs), where regulatory frameworks and workplace protections are often deficient.[1] Chronic exposure to hazardous noise levels leads to irreversible sensorineural hearing loss, due to damage to the hair cells in the cochlea.[2] Hearing loss impacts communication, social interaction, workplace productivity, and overall quality of life. Industries where ONIHL is most common include mining, construction, and manufacturing.[2]

Middle ear disorders such as chronic otitis media, tympanic membrane perforations, and eustachian tube dysfunction are often overlooked in occupational hearing conservation efforts, despite their potential to exacerbate hearing impairment and complicate diagnostic and management strategies.[3,4] While global reviews, such as that by Chen et al. (2020),[2] have shown declines in ONIHL in high-income countries (HICs) due to strict regulations and effective hearing conservation programmes (HCPs), these trends are not mirrored in LMICs.[1,5]

Middle ear conditions can result in conductive hearing loss (CHL), which compounds the effects of noise-induced sensorineural damage, making it difficult to identify the primary aetiology of hearing impairment.[5] In South Africa, the burden of human immunodeficiency virus (HIV) is high, and HIV-infected workers are at high risk of CHL due to opportunistic infections such as chronic otitis media, which are aggravated by occupational noise exposure.[5] However, most HCPs do not incorporate routine screening for HIV-related middle ear disorders, resulting in underdiagnosis and untreated hearing loss.

The economic burden of occupational hearing loss and middle ear disorders is often overlooked, despite evidence that hearing impairments significantly impact productivity, workplace safety, and quality of life.[6] Workers with hearing loss are at higher risk of workplace accidents and job instability.[7,8] Additionally, middle ear pathologies can affect workers' ability to use hearing protection effectively, as earplugs and other devices may worsen symptoms or become uncomfortable due to underlying ear conditions.[9,10] Studies have shown that workers exposed to noise exhibit altered middle

ear function, with changes in resonance and sound absorbance.[11] Thus, the co-occurrence of ONIHL and middle ear disorders poses unique challenges in hearing conservation.

In Africa, workers in mining, manufacturing, construction, and agriculture are frequently exposed to excessive noise without adequate protective measures.[12] These sectors contribute significantly to economic development, but they also expose workers to noise levels that exceed recommended safety thresholds set by the World Health Organization (WHO), the International Labour Organization (ILO), and others. A systematic review of middle ear pathologies among miners in South Africa found a high prevalence of chronic otitis media and tympanic membrane perforations, suggesting that these conditions may exacerbate the effects of ONIHL.[3] The high prevalence of middle ear conditions in African populations is due to factors such as recurrent untreated infections, poor healthcare access, and environmental conditions.[13] Research has also indicated that inadequate screening for middle ear pathologies in noise-exposed workers may lead to misdiagnosis, resulting in incorrect or delayed interventions.[14] These middle ear pathologies can interact with ONIHL in ways that complicate audiological assessment, amplify functional hearing deficits, and hinder rehabilitation efforts. Furthermore, hearing protection devices may be less effective or uncomfortable for workers with middle ear disorders, making compliance with safety measures challenging.[15] Another affected group is informal sector workers, who often have limited access to medical interventions and lack employer-sponsored hearing conservation measures. Without adequate screening and customised interventions, they are at risk of both progressive hearing loss and occupational exclusion.[4,16] Lack of comprehensive occupational HCPs that consider both ONIHL and middle ear disorders results in suboptimal prevention, diagnosis, and intervention strategies.

Research and policy initiatives in LMICs tend to focus on ONIHL in occupational settings, often ignoring middle ear conditions. In Africa, HCPs have been criticised for their narrow focus on noise exposure, without sufficient attention to other factors that contribute to hearing loss, including middle ear pathologies and chemical exposures.[4] This limits the effectiveness of HCPs, as workers with pre-existing or concurrent middle ear disorders may experience aggravated hearing loss due to workplace noise exposure. A longitudinal study, published in 2017, demonstrated that timely intervention and effective management of HCPs can reduce the incidence of noise-induced hearing loss, emphasising the importance of early screening for all auditory disorders, including middle ear conditions.[17] Additionally, many South African occupational health regulations fail to address the unique audiological needs of workers who present with both ONIHL and middle ear pathologies, leading to gaps in prevention, screening, and rehabilitation services.[5]

In this narrative review, we critically examined the intersection of ONIHL and middle ear disorders within occupational settings, with Africa as a focus, highlighting the implications for workplace HCPs,[1] and giving specific attention to the documented challenges of HCP implementation in South African mines.[19] The objectives of this review were to: 1) describe the prevalence and impact of middle ear disorders among noise-exposed workers, 2) examine the interplay between ONIHL and middle ear pathology in occupational settings, 3) explore the influence of systemic health factors, such as HIV, on conductive hearing loss, and 4) identify gaps in current HCPs in African LMICs.

METHODS

A narrative review[20] was chosen to synthesise diverse sources of literature, identify knowledge gaps, and provide a broad, contextualised understanding of how middle ear pathologies impact hearing conservation efforts in noise-exposed workers.

Literature search strategy

A systematic and transparent literature search was conducted, following the guidelines of Levac et al. (2010)[21] to ensure rigour, feasibility, and reproducibility. The search was performed across multiple electronic databases, including PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, CINAHL, EBSCOHost, MEDLINE, ProQuest, and African Journals Online (AJOL), as well as institutional repositories and relevant grey literature from the WHO, the ILO, and the African Union (AU).

The search strategy incorporated Medical Subject Headings (MeSH) and free-text terms, with Boolean operators. Key search terms were:
- 'occupational noise-induced hearing loss' OR 'ONIHL'
- 'middle ear disorders' AND 'occupational hearing loss'
- 'hearing conservation programmes' AND 'occupational health'
- 'occupational noise exposure in Africa'
- 'hearing conservation policies in LMICs'
- 'workplace hearing loss and middle ear pathologies'

Additional literature was identified through forward and backward citation tracking (i.e. examining studies that either cited or were cited by key sources) and manual searches of reference lists in key publications.

To ensure relevance and methodological rigour, the following inclusion and exclusion criteria were applied.

Inclusion criteria

- Studies published from 2000 to 2024 in English
- Empirical studies, systematic reviews, meta-analyses, and policy reports focusing on ONIHL and/or middle ear disorders in occupational settings
- Articles discussing HCPs, workplace safety regulations, and audiological health in Africa
- Studies from LMICs outside Africa that provided comparative insights

Exclusion criteria

- Studies not addressing occupational hearing loss or workplace noise exposure

Data extraction and analysis

A narrative synthesis methodology was applied systematically to extract, organise, and interpret findings from the selected literature. This approach followed established principles for conducting narrative reviews.[20] The initial search yielded 1 417 records, of which 32 full-text articles were evaluated for eligibility. Following detailed appraisal, 18 studies were included in the final synthesis (see Table 1). Two reviewers independently assessed study relevance and methodological appropriateness to enhance rigour and reduce selection bias.

Tables were developed to capture:
- Study characteristics (author, year, country, and study design – where specified)
- Industry sector and worker population studied

- Prevalence and impact of ONIHL and middle ear disorders
- Identified gaps in HCPs
- Policy and regulatory frameworks discussed
- Recommendations for occupational hearing health

A thematic analysis approach[22] was used to synthesise findings, categorise emerging themes, and identify patterns, challenges, and policy gaps related to ONIHL and middle ear disorders in African occupational health settings. The review included a critical appraisal of each study's design quality, relevance to African LMICs, and the applicability of findings to real-world occupational settings. Specifically, studies were examined for methodological robustness (e.g. clear sampling methods, reliable outcome measures), relevance to key industry sectors (such as mining or construction), and the inclusion of vulnerable worker populations. These criteria were not only used to determine study inclusion but also to guide thematic interpretation. For example, studies with stronger design rigour and direct focus on occupational noise and middle ear disorders in African settings were weighted more heavily in identifying key themes.

Thematic analysis, following a structured framework based on Braun and Clarke's[22] 2006 six- phase approach to thematic analysis, was conducted to synthesise and interpret findings across the included studies. An iterative approach allowed themes to emerge both inductively from the literature and deductively in alignment with the study objectives. Key themes were derived through close reading, comparative coding, and clustering of findings according to recurrent patterns related to ONIHL, middle ear pathology, and hearing conservation challenges. Particular attention was given to how these themes varied across geographical regions, industry sectors, and study designs. The themes highlighted both common and divergent experiences across African LMICs, with reference to global literature for comparative insight.

Thematic saturation was reached when the review of additional studies no longer yielded novel insights into the core themes, challenges, or policy gaps related to ONIHL and middle ear disorders, thereby confirming analytical completeness.[23]

Quality assurance and interpretation

While narrative reviews offer flexibility, rigorous methodological safeguards were implemented to ensure reliability and transparency,[24] viz. 1) systematic documentation of the search strategy and study selection process; 2) continuous refinement of the research focus as new insights emerged; 3) critical evaluation of selected studies for methodological soundness, relevance, and applicability; and 4) reflexivity to account for potential researcher biases and contextual influences on interpretation. These measures strengthened the credibility, validity, and reproducibility of the review's findings, while ensuring a balanced synthesis of perspectives on ONIHL and middle ear disorders in occupational hearing conservation.

Although formal ethical approval was not required, ethical integrity was maintained through comprehensive citation of all sources to uphold academic integrity and avoid plagiarism; use of publicly available, peer-reviewed research to ensure credibility; objective selection and analysis of studies to minimise bias; and acknowledgement of potential conflicts of interest. Additionally, efforts were made to incorporate diverse perspectives, recognise limitations in available data, and ensure transparency in reporting and interpretation of findings.[25]

RESULTS

Descriptive profile of the studies

The findings of this review are presented thematically to highlight the dual burden of ONIHL and middle ear disorders in African LMICs, and to illustrate how these conditions are addressed (or overlooked) within existing hearing conservation frameworks. Eighteen of the 1 417 studies initially identified were included in the final synthesis, of which 10 were deemed highly relevant as they directly addressed the intersection of ONIHL, middle ear pathology, and occupational hearing conservation within African contexts (Table 2). Eight were classified as moderately relevant; while not central to the study aim, they provided comparative or conceptual insights into occupational hearing health challenges in LMICs (Table 3).

The studies represented a diverse range of study designs and analytical approaches. Six were systematic or narrative literature reviews, which provided broad overviews of ONIHL prevalence, biological mechanisms, risk factors, and existing hearing conservation strategies.[2,3,8,15,18] These contributed background and highlighted global and regional trends. Four were cross-sectional studies that estimated the prevalence and characteristics of ONIHL and/or middle ear disorders among workers in specific industries.[11,26-28] Three were longitudinal cohort studies that provided insights into the progression of ONIHL over time and the long-term effects of workplace noise exposure.[17,29,30] Three occupational health policy reports and regulatory analyses examined the state of national and industry-level frameworks for hearing conservation, including enforcement gaps and structural weaknesses.[4,14,16] Two experimental or risk assessment studies assessed the auditory effects of noise exposure below regulatory limits and examined early markers of auditory dysfunction.[31,32]

Table 1. Summary of process used to select articles for final review

Step	Description	n
Identified through database searching	Peer-reviewed journal databases and indexed searches (PubMed, Scopus, Web of Science, AJOL, etc.)	1 417
Screened for relevance	Based on title and abstract review	1 417
Full-text assessed for eligibility	Comprehensive reading	32
Excluded after full-text review	Deemed not relevant	14
Identified via supplementary searches	Added to ensure completeness	0
Included in final synthesis	Highly or moderately relevant	18
Highly relevant	Directly addressed ONIHL, middle ear disorders, and African HCPs	10
Moderately relevant	Provided contextual or comparative insights	8

AJOL: African Journals Online, HCP: hearing conservation programme

Table 2. Comprehensive evidence synthesis of interplay of ONIHL and middle ear disorders in HCPs in the African context (highly relevant sources)

Study	Industry sector, worker population	Prevalence and impact of ONIHL and middle ear disorders	Gaps in HCPs	Policy and regulatory frameworks	Recommendations
Sebothoma (2020)[3] South Africa, cross-sectional study	Mining industry; mineworkers (South Africa)	Limited studies on middle ear pathologies in miners; suggests high prevalence due to trauma and infections; evidence suggests the presence of conditions like chronic otitis media	ONIHL research dominates; middle ear disorders are neglected; little integration of middle ear disorder assessments	MHSC regulations – South Africa	More research on middle ear pathologies, incorporation into HCPs
Chen et al. (2020)[2] global, literature review	Various industries, including mining, manufacturing, construction	ONIHL is one of the most prevalent occupational diseases; risk varies with genetics, environment, and exposure	Noise control measures exist, but implementation is inconsistent; lack of worker compliance	Global occupational health guidelines (NIOSH, WHO)	Stronger enforcement of noise regulations, better worker education, use of antioxidants for prevention
Hong et al. (2013)[15] global, review article	General occupational noise exposure	Individual susceptibility to NIHL varies, influenced by genetic and environmental factors	Poor implementation of noise exposure control; lack of personalised prevention strategies	NIOSH standards for noise exposure	Need for individualised risk assessments, better integration of middle ear screening in hearing conservation
Frederiksen et al. (2017)[17] Denmark, longitudinal cohort study	High-noise industries, including manufacturing (Denmark)	10-year study showed declining noise levels, but persistent hearing loss risk in early-exposed workers	Older workers with prolonged exposure face higher risk; late intervention limits effectiveness	Danish hearing conservation regulations; HPD policies in place, but compliance varies	Stricter regulations for older workers; longitudinal monitoring and early intervention needed
Habig and De Koker (2004)[14] South Africa, cross-sectional study	South African mines; gold mineworkers	High prevalence of middle ear disorders; 27.1% had middle ear pathologies detected via tympanometry; 49.7% via otoscopy	Mineworkers unaware of risks; occupational health personnel lack training in middle ear pathology; lack of screening for middle ear disorders in medical surveillance programmes	MHSC, South Africa	Tympanometry should be included in routine screening
Khoza-Shangase et al. (2020)[4] South Africa, mixed-methods study	African mining sector	73.2% of miners exposed to excessive noise (> 85 dB); ONIHL rates remain high despite HCPs	HCPs not effectively implemented, despite policies	MHSC, South Africa	Comprehensive, multi-component HCP implementation required; locally relevant policies needed
Le et al. (2017)[18] global, review article	Various industries with noise (global)	12% of the world population at risk for ONIHL; noise also impacts vestibular function and causes tinnitus	Hearing loss under-reported due to inadequate testing methods; lack of focus on vestibular impacts of ONIHL	WHO occupational noise guidelines	Need for improved diagnostic tools for early detection; exploration of pharmaceutical interventions like antioxidants and steroids
Yilmaz et al. (2022)[11] Turkey, cross-sectional study	Metal industry; industrial workers (Turkey)	Chronic noise exposure affects middle ear resonance and absorbance	Standard audiometry misses middle ear damage; tympanometry not widely used; no routine screening for subtle middle ear dysfunctions	No specific mention of policies	Wideband tympanometry should be included in occupational screening for early detection of middle ear changes
Setyawan (2021)[8] Indonesia, survey-based study	Various industries (Indonesia)	NIHL prevalent in industrial settings; linked to concentration loss, fatigue, and economic burden; leading to job loss and social effects	Hearing conservation is inconsistent; lack of worker education on risks	Indonesian occupational noise regulations	Education and awareness campaigns needed for workers; comprehensive HCP strategies
Park et al. (2016)[29] South Korea, analytical cross-sectional study	Shipyard workers (South Korea)	CHL may reduce ONIHL risk; mixed results on protective effect	Lack of research on CHL's role in ONIHL prevention	Korean Occupational Safety and Health Agency (KOSHA)	More research needed on interactions between CHL and ONIHL – CHL as a potential protective factor

CHL: conductive hearing loss, HCP: hearing conservation programme, HPD: hearing protection device, MHSC: Mine Health and Safety Council, NIOSH: National Institute for Occupational Safety and Health, NIHL: noise-induced hearing loss, ONIHL: occupational noise-induced hearing loss, WHO: World Health Organization

These studies[31,32] expanded the scope of the review by interrogating the adequacy of existing occupational noise exposure thresholds.

Eleven of the studies were conducted in the USA, UK, Sweden, Canada, Denmark, South Korea, and Turkey, where occupational noise regulations are strictly enforced.[28,30,31] Seven were conducted in LMICs – South Africa and Indonesia – highlighting unique challenges in policy enforcement, access to healthcare, and worker compliance with hearing protection measures.[3,8,14,27] Some studies provided comparative analyses of ONIHL prevalence and policy effectiveness worldwide, including in African LMICs.[7,16,18]

The studies focused on a range of industries with high occupational noise exposure risks, viz. mining (six studies), particularly in South Africa where mineworkers have high rates of both ONIHL and middle ear disorders, due to chronic exposure to underground noise and poor access to healthcare;[3,14] construction and manufacturing (five studies), due to high noise exposure, poor compliance with hearing protection devices (HPDs), and gaps in HCP implementation;[11,17,26] the general workforce (three studies assessed hearing health risks across education, agriculture, and urban workplaces);[7,16,28] shipyard and metal industry workers (two studies) that assessed how CHL and vibration affect ONIHL susceptibility;[29,32] and one study that explored hearing loss outside traditional industrial noise exposure settings (musicians and teachers).[31] Although mineworkers in South Africa may have better access to occupational healthcare than the general population, gaps in comprehensive audiological and otological services, especially for middle ear pathologies, remain a challenge.

Theme 1: Prevalence and occupational impact of ONIHL and middle ear disorders

Occupational noise-induced hearing loss remains the most prevalent occupational disease across multiple industries, primarily mining, construction, and manufacturing, with a high economic burden.[2,3,4] Studies highlight that middle ear pathologies, such as chronic otitis media, tympanic membrane perforations, and eustachian tube dysfunction, are common in occupational settings, particularly among mineworkers.[3,14] Noise exposure can affect

Table 3. Comprehensive evidence synthesis of interplay of ONIHL and middle ear disorders in HCPs in the African context (moderately relevant sources)

Study	Industry sector, worker population	Prevalence and impact of ONIHL and middle ear disorders	Gaps in HCPs	Policy and regulatory frameworks	Recommendations
Weier (2020)[32] USA, systematic review	Various industries using vibrating tools (construction, manufacturing)	Occupational exposure to hand-arm vibration may be associated with hearing loss, independent of noise exposure	Limited research on vibration-induced hearing loss; lack of standardised measurement protocols	No specific policies addressing vibration-induced hearing loss	More research on vibration's role in hearing loss, integration of vibration monitoring into HCPs
Palmer et al. (2015)[28] UK, case-control study	General workforce across multiple industries	Hearing impairments and balance disorders increase the risk of workplace injury	Occupational health programmes fail to screen for auditory-vestibular dysfunctions	No specific regulations addressing balance disorders and work safety	Integration of vestibular and auditory screening into occupational health assessments
Landen et al. (2004)[26] USA, cross-sectional study	Sand and gravel mining industry	37% of workers had hearing impairment; poor hearing protection compliance	Many workers not enrolled in HCPs, despite high-risk exposure	MSHA noise exposure regulations mentioned, but inconsistently enforced	Stronger enforcement of noise control measures, improved education on hearing protection
Kim (2010)[27] Korea, review article	Various industries in Korea	NIHL is the most common occupational disease after musculoskeletal disorders	Workplace noise remains a major occupational hazard, despite regulatory improvements	Korean Occupational Safety and Health Act covers NIHL, but compliance varies	Systematic implementation of HCPs across industries
Shan et al. (2020)[7] USA, systematic review	General workforce, multiple sectors	Hearing loss linked to unemployment and job instability	Occupational hearing loss interventions often neglect employment impacts	WHO global disability statistics referenced	Workplace accommodations for workers with hearing loss, employer incentives for inclusion
Nelson et al. (2005)[16] global, risk assessment study	Various global industries	16% of disabling hearing loss worldwide is occupational	High burden in developing regions, weak noise control regulations	WHO occupational noise exposure guidelines referenced	Engineering controls to reduce noise exposure, global standardisation of HCPs
Lindblad et al. (2014)[31] Sweden, prospective study	Teachers, musicians, industrial workers	Even noise below regulatory limits may cause inner ear dysfunction	Standard audiograms fail to detect early auditory damage	No specific policies on subtle hearing dysfunctions	Expansion of hearing screening beyond pure-tone audiometry
Masterson et al. (2015)[30] USA, longitudinal study	Various industries, 30-year hearing loss trends	Decline in overall ONIHL, but persistent high prevalence in mining and construction	Hearing loss risk remains high in certain industries, despite regulations	NIOSH and OSHA standards referenced	More targeted interventions in high-risk sectors, continuous monitoring

HCP: hearing conservation programme, HPD: hearing protection device, MHSC: Mine Health and Safety Council, MSHA: Mine Safety and Health Administration, NIOSH: National Institute for Occupational Safety and Health, NIHL: noise-induced hearing loss, ONIHL: occupational noise-induced hearing loss, OSHA: Occupational Safety and Health Administration, WHO: World Health Organization

middle ear resonance and absorbance.[11] Workers with middle ear disorders may be at an increased risk of developing ONIHL, as CHL can affect sound transmission, potentially leading to misdiagnosis and inappropriate interventions.[11,29] Evidence suggests that noise exposure below regulatory limits may cause inner ear dysfunction, affecting cochlear processing and leading to tinnitus and other auditory problems.[31] A more nuanced understanding of hearing conservation is needed; current noise regulations focus primarily on high-decibel exposure, without considering subtle damage occurring at lower noise levels.[29] Hearing impairments and balance disorders increase the risk of workplace injury.[8]

Theme 2: Gaps in HCPs

Hearing conservation programmes often focus on the outer ear and neglect middle ear conditions.[2,3] Many HCPs focus primarily on ONIHL and neglect middle ear disorders, leading to gaps in prevention, early detection, and treatment.[2,17] Routine screening for middle ear dysfunction is rarely incorporated into workplace audiological assessments, leading to underdiagnosis of conditions that may influence susceptibility to ONIHL.[11,14] Hearing protection device compliance remains a challenge, particularly among workers with middle ear pathologies who may find HPDs uncomfortable or ineffective.[15] Some industries lack comprehensive and standardised HCPs, particularly in LMICs where enforcement of occupational health regulations is inconsistent.[8,16] The implementation of comprehensive HCPs that include middle ear screening may be challenged by shortages of trained audiologists, high equipment costs, and limited workplace health infrastructure. In such contexts, task-sharing with primary healthcare providers, deployment of mobile screening units, and inclusion of basic otoscopy in worker examinations could serve as interim strategies to improve feasibility of hearing health interventions.

Theme 3: Policy and regulatory frameworks

Several studies mention the existence of occupational health guidelines and regulations, e.g. the National Institute for Occupational Safety and Health (NIOSH), WHO, and Mine Health and Safety Council (MHSC); however, there is often inconsistent enforcement and compliance with these regulations. Occupational noise regulations, such as those set by NIOSH, the Occupational Safety and Health Administration (OSHA), and the WHO, focus primarily on noise exposure limits and HPD use, without sufficient consideration of middle ear health.[4,30] Variability in HCP implementation and enforcement across industries and countries leads to inconsistent protection for workers. For example, the mining and construction industries have persistently high prevalences of ONIHL, despite regulations.[26,30] There is limited integration of balance and vestibular assessments into occupational health programmes, despite evidence that auditory-vestibular dysfunction contributes to workplace injuries,[28] especially in high-risk industries like mining and construction. Therefore, incorporating vestibular assessments into workplace screenings may improve occupational safety and reduce worker compensation claims.[27] Economic factors influence policy effectiveness, with workers in LMICs often lacking access to screening and intervention measures, including those for middle ear disorders,[14] due to resource constraints.[7,16]

Theme 4: Recommendations for occupational hearing health

Several recommendations emerged from this theme. First, integration of routine middle ear screening into HCPs is key. Studies recommend expanding audiological assessments to screening for middle ear disorders, ensuring that both conductive and sensorineural hearing impairments are assessed.[3,14] Comprehensive multicomponent HCPs that include noise control measures, regular hearing tests that incorporate tympanometry, and hearing protection should be implemented.[15,32] Second, the use of diagnostic tools such as wideband tympanometry are recommended .for the early detection of hearing damage.[3,11] Third, engineering noise control solutions should be prioritised over reliance on HPDs to provide long-term ONIHL prevention.[8,17] Fourth, personalised risk assessments based on individual susceptibility, including pre-existing middle ear conditions, should be integrated into workplace health programmes.[15,18] Fifth, stronger enforcement of workplace noise regulations is needed, particularly in high-risk industries such as mining and construction.[30] Sixth, longitudinal monitoring and early intervention programmes should be implemented.[18] Seventh, workplace accommodations for workers with hearing loss should be improved, including employer incentives for disability-inclusive workplace policies that ensure accessibility, provide reasonable accommodations, and reduce stigma – alongside the provision of assistive listening devices.[7] Education and awareness campaigns about the risks of noise exposure should be provided for workers.[29] Last, further research should be conducted on the interplay between ONIHL and middle ear disorders, the role of vibration in hearing loss, and the effectiveness of various intervention strategies.[3,4,26,29]

DISCUSSION

Knowledge gaps in middle ear disorders and ONIHL

Gaps in research on middle ear disorders in occupational settings were a key finding in this review, particularly in LMICs. While ONIHL has been extensively studied, only a few studies specifically addressed middle ear pathologies in noise-exposed workers.[3,11] This underlines the diagnostic limitations of current hearing conservation practices, which often rely solely on pure tone audiometry without consideration for middle ear screening. As a result, middle ear disorders may go undetected, leading to misdiagnosis or underestimation of hearing loss severity in workers with both ONIHL and conductive hearing impairment.

Regulatory and policy disparities between HICs and LMICs

The geographical distribution of studies highlights that regulatory approaches vary substantially between HICs and LMICs. While HICs have well-established occupational noise exposure regulations, such as OSHA and NIOSH standards in the USA, and EU noise directives in Europe, African LMICs often lack comprehensive occupational noise policies or struggle with enforcement and compliance.[4,16] For example, HICs enforce mandatory baseline testing, employer accountability, and advanced technologies such as electronic dosimetry, while African LMICs face significant enforcement and resource challenges. Additionally, studies in Africa show that policies primarily address ONIHL, without adequate screening for middle ear disorders.[3,14]

Industry-specific risks and understudied sectors

There is a need for industry-specific interventions. While mining and manufacturing remain high-risk sectors, the review identified other industries where ONIHL and conductive hearing loss overlap. Shipyard workers and metal industry employees were reported to experience complex interactions between CHL and ONIHL, requiring different intervention strategies than those used in other industries.[29,32] While ONIHL risks from chronic exposure to lower-level

noise have been studied, e.g. in teachers and musicians, similar studies are lacking in LMICs.[31] Vibration exposure was identified as an independent risk factor for hearing loss, yet it is rarely assessed in standard HCPs.[32]

Under-representation of African research and local contexts

Despite a disproportionate burden of ONIHL and middle ear disorders, Africa remains under-represented in primary occupational health research. Most region-specific contributions are limited to reviews and policy documents, rather than large-scale empirical, population-based research. There is also limited longitudinal research on the progression of ONIHL in African workers, making it difficult to assess the long-term effectiveness of HCPs. The influence of environmental factors, healthcare infrastructure, and economic constraints on occupational hearing health in Africa remains underexplored.

Overlooked role of middle ear pathologies in HCPs

An important finding from this review is that middle ear pathologies, such as chronic otitis media and tympanic membrane perforations, are prevalent among noise-exposed workers, yet these pathologies are rarely integrated into occupational health frameworks.[3,11] Research from Turkey and South Korea suggests that chronic noise exposure affects middle ear resonance and absorbance, potentially compounding hearing loss severity.[11,29] In Africa, middle ear infections remain widespread due to poor healthcare access, untreated infections, and environmental conditions, exacerbating hearing impairment in occupational settings.[14,33] Unlike in HICs, where early detection and treatment of middle ear disorders are integrated into occupational health screening, many African workers do not have access to routine otological assessments, leading to delayed diagnosis and worsening outcomes.[16,33] Additionally, HIV-positive workers may experience higher rates of middle ear infections and eustachian tube dysfunction, leading to an increased risk of CHL. These combined factors may contribute to greater occupational functional limitations, affecting job performance and safety; however, occupational health screenings rarely address these multiple risk factors simultaneously.[19] In LMICs, the lack of coordinated occupational health services results in workers seeking care only when hearing loss is advanced, thereby limiting the effectiveness of interventions. This reinforces a reactive rather than proactive approach to hearing healthcare in occupational settings.[7,8,34]

In HICs such as the USA and UK, HCPs are highly regulated, requiring routine audiometric testing, noise exposure monitoring, and worker education.[28,30] For example, in the USA, the OSHA and NIOSH enforce noise monitoring, baseline audiograms, and employer accountability.[4,30] Similarly, the European Union enforces directives on physical agents (including noise), which include mandatory employer responsibilities for risk assessment and engineering controls. In contrast, many African LMICs lack mandatory baseline testing, formal follow-up procedures, and/or penalties for non-compliance. Furthermore, HICs have begun to integrate technological advances, such as electronic dosimetry and individualised hearing risk tracking, which are not available in resource-limited settings. In Africa, HCPs are often poorly enforced or non-existent in informal industries, leaving workers vulnerable to hearing loss.[4] Where HCPs are implemented, they rarely incorporate middle ear assessments such as tympanometry, wideband absorbance testing, or vestibular evaluations, which could enhance early detection of middle ear disorders and appropriate intervention.[3,11,31]

Barriers to HPD use and compliance

Compliance with the use of HCPs remains a challenge in both HICs and LMICs. Studies suggest that, in LMICs, workers often reject HPDs due to discomfort, lack of awareness, and perceptions that they interfere with communication and job performance.[15,26] This is compounded in workers with pre-existing middle ear disorders, as standard HPDs may exacerbate ear pain or worsen symptoms of eustachian tube dysfunction.[29] In contrast, HICs are increasingly using personalised hearing protection solutions, such as custom-moulded earplugs and electronic noise-cancelling devices, to improve comfort and compliance.[18] African LMICs would benefit from similar innovations, but cost and accessibility remain significant barriers.[19]

There are significant disparities in policy enforcement between HICs and LMICs, regarding ONIHL prevention and management. In countries such as the USA, UK, and South Korea, strict occupational noise regulations mandate noise exposure monitoring, employer responsibility for protective measures, and regular audiometric surveillance.[27,30] In contrast, many African LMICs either lack robust occupational health regulations or fail to enforce existing policies.[4,8] A key policy gap in LMICs is the lack of integration between occupational health and general healthcare systems, which limits worker access to audiological and otological assessments.[3,14] There is limited coordination between government agencies, industries, and healthcare providers, resulting in fragmented implementation of hearing conservation efforts.[16,19] Economic constraints also influence policy effectiveness, particularly in LMICs where employers may resist costly interventions, and workers may prioritise job security over personal health.[7,35] This is in stark contrast to HICs, where government-funded initiatives and worker compensation schemes provide incentives for compliance.[16,26] For example, in countries such as Denmark and Canada, national health systems cover routine hearing screenings and middle ear assessments as part of occupational medical surveillance.[28,30,31] These comparative examples reveal a gap, not only in regulatory enforcement, but also in resource availability and policy commitment to hearing health.

Recommendations for integrating ONIHL and middle ear management

Recommendations for a comprehensive approach to occupational hearing health to enhance ONIHL prevention and middle ear disorder management, in Africa and similar LMICs, are proposed. First, audiological assessments in occupational settings should include middle ear evaluations (e.g. tympanometry, wideband absorbance, and vestibular screening) in addition to standard audiometry.[3,11] Second, occupational noise regulations should be strongly enforced.[16,30] Third, worker education and training on hearing loss prevention, focusing on HPD use, early symptoms of hearing impairment, and the importance of medical check-ups should be mandatory.[15,17] Fourth, cost-effective noise control solutions should be developed, prioritising engineering interventions over reliance on HPDs.[8,18] Finally, occupational health policies must evolve towards a more integrated preventive model, linking hearing conservation efforts with broader health system interventions – including the management of middle ear disorders and chronic infections such as HIV.[4,28]

Critical observations of the included studies

There was substantial variability in the study designs and quality of the articles reviewed. While systematic reviews and longitudinal studies provided strong evidence of noise exposure trends and HCP

impact, several of the cross-sectional studies had small sample sizes or limited generalisability to African workplaces. Few studies considered middle ear disorders as a primary outcome, and those that did were often based on highly specific populations (e.g. mineworkers from a single company or geographical region). Most studies from HICs emphasised sensorineural outcomes and did not account for co-morbid factors such as HIV. These limitations highlight the need for contextualised, multi-factorial research in the region.

Figure 1 illustrates the interaction of occupational noise exposure, middle ear pathology, and systemic health risks in African LMICs. Barriers to effective hearing conservation and practical intervention across clinical, policy, and infrastructural domains are indicated.

CONCLUSION

This review synthesised the interaction between sensorineural and conductive hearing loss in African workplaces, highlighting the under-recognised role of middle ear disorders in undermining the effectiveness of HCPs. While global literature has extensively documented ONIHL, this review is among the first to systematically interrogate how middle ear pathologies – especially common in immunocompromised and under-resourced populations – complicate diagnosis, intervention, and prevention efforts in occupational health contexts.

The findings highlight the need for a paradigm shift in hearing conservation in LMICs, particularly in Africa. In high-risk industries such as mining, construction, and manufacturing, workers are routinely exposed to excessive noise without adequate protection or access to comprehensive audiological and otological care. Most HCPs focus exclusively on ONIHL, failing to screen for, or manage, middle ear pathologies, resulting in missed opportunities for early intervention and rehabilitation.

To strengthen occupational hearing health systems, we propose the following: 1) integrating middle ear assessments into routine occupational health screenings, 2) reinforcing regulatory frameworks and enforcement mechanisms to align with international noise exposure standards, 3) expanding worker education to promote early detection and HPD compliance, 4) investing in engineering noise control solutions at source, and 5) designing contextually appropriate, cost-effective hearing conservation strategies. These must also account for high HIV prevalence in regions like South Africa, where immunosuppression exacerbates middle ear disorders. Addressing the intersection of noise exposure, infectious disease, and structural gaps in occupational health systems is key to a more effective and inclusive hearing conservation model.

Limitations

Despite its comprehensive scope, this narrative review has several limitations. First, it relied on the published literature, which may have introduced publication bias, as studies with significant or positive findings are more likely to be published than those with null or inconclusive results. Additionally, data availability on middle ear disorders in occupational settings remains limited, particularly in Africa, where research on hearing conservation often focuses solely on ONIHL. While the number of studies reviewed was relatively small, this was offset by a detailed, thematic and critical analysis that prioritised contextual relevance over volume. Future research should prioritise empirical work that simultaneously addresses noise exposure and middle ear disorders in African workplaces. Another limitation was the absence of large-scale longitudinal studies in Africa on the interplay between ONIHL and middle ear disorders, which limits the ability to draw conclusions about causality and long-term occupational hearing health trends. Furthermore, differences in regulatory frameworks across regions make direct comparisons between HICs and LMICs challenging. Many of the policy

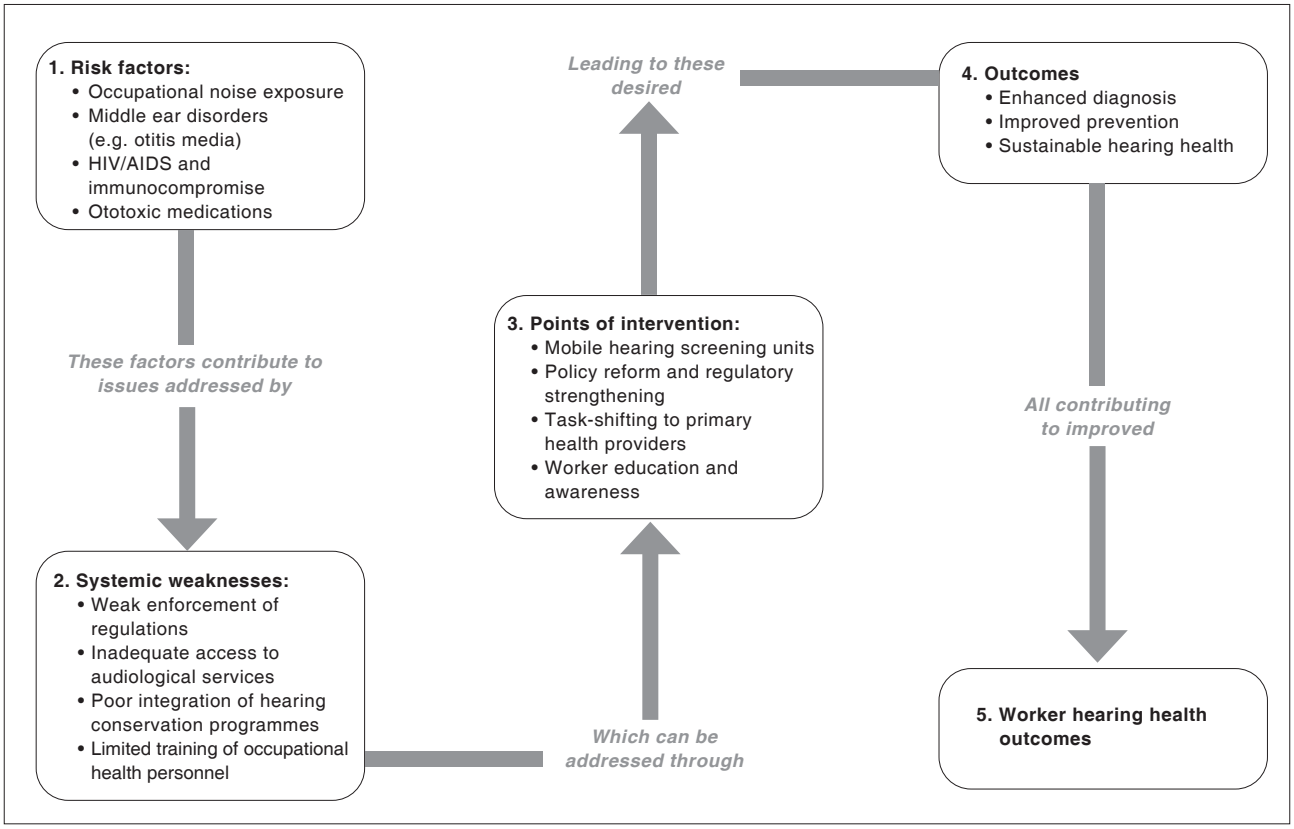


Figure 1. Conceptual framework for integrated occupational hearing conservation in African LMICs

recommendations and interventions that are effective in HICs may not be directly transferable to African LMICs without considering economic, infrastructural, and healthcare system constraints. For example, in HICs, hearing loss compensation programmes and regular workplace audiological screenings are mandated, whereas in many African LMICs, employers and workers alike may lack the resources or awareness to prioritise hearing health. Creating policy frameworks that incentivise noise control at the industry level, while providing low-cost hearing interventions for workers, is crucial. Finally, this review did not include primary data collection or meta-analysis, which limits its ability to assess quantitatively the magnitude of ONIHL and middle ear disorders in occupational settings. Future research should focus on longitudinal, population-based studies in LMICs, examining the combined effects of occupational noise exposure and middle ear pathologies, as well as the effectiveness of integrated hearing conservation interventions.

KEY MESSAGES

1. Middle ear disorders – often undetected due to the absence of otological screening – undermine the diagnostic accuracy and functional outcomes of HCPs. There is a need for an expanded audiological assessment and a multidisciplinary approach to hearing conservation, which include middle ear assessments.
2. Systemic challenges in LMICs, including weak regulatory enforcement, high HIV prevalence, and limited access to audiological services, exacerbate the risk and impact of occupational hearing loss.
3. A multidisciplinary, context-responsive approach is essential, combining expanded audiological assessment, policy reform, worker education, and cost-effective noise control interventions.

DECLARATIONS

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

Authors' contributions

Both authors conceptualised the study, conducted the research and analysis, and wrote the manuscript.

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Noise-induced hearing loss: what does the implementation of the standard threshold shift look like?

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INTRODUCTION

Occupational noise-induced hearing loss (ONIHL) is prevalent in settings where workers are exposed to noise levels that exceed the regulated levels. Regulated noise exposure levels vary from country to country; South African industries use a level of ≥ 85 dBA (8-hour rating level).[1] Nonetheless, arguments have been made that the regulated level (85 dBA) is not protective against ONIHL, suggesting that 55–60 dBA is the ideal level to prevent noise-induced hearing loss (NIHL).[2] Another factor to consider is how occupational noise is measured using sound level meters, some of which do not accurately measure damage caused by noise at the level of the ear.[3]

The South African mining industry (SAMI) has been struggling to reduce noise exposure levels across all its working areas, thereby increasing workers' risk for ONIHL.[4] This requires a paradigm shift in surveillance programmes for noise and ONIHL prevention.[5]

The 2022 Guideline for a Mandatory Code of Practice for an Occupational Health Programme for Noise – mandated by the South African Department of Mineral Resources and Energy – includes the design of hearing conservation programmes (HCPs), which include audiometry assessments and calculations such as the standard threshold shifts (STSs) and percentage loss of hearing (PLH).[6]

Noise-induced hearing loss in the South African mines

Hearing screening assessments have been used to track and monitor hearing deterioration of workers, as part of audiometry surveillance in HCPs. In addition to hearing loss, early identification of tinnitus and hyperacusis, which are common symptoms of excessive noise exposure, are documented as part of audiometry surveillance to determine risk for ONIHL. Research has shown that the South African mineworkers who present with tinnitus (as a secondary effect of excessive noise levels), have an increased risk of ONIHL.[7] Additionally, research findings have profiled the risk of ONIHL for South African mineworkers as: younger than 40 years, less than 10 years of working experience, HIV/AIDS-related conditions, exposure to recreational noise, etc., adding to the complexity of predicting ONIHL.[9-11] The combined risks associated with ONIHL are a constant challenge for the South African mines. The high prevalence of ONIHL reported by the industry warrants proactive medical audiometry surveillance for all the mineworkers at risk of developing ONIHL.[12] In addressing the high prevalence rates of ONIHL in the mines, the SAMI continuously reviews the NIHL Regulations and guidelines, as well as their implementation, in efforts to prevent ONIHL in the sector.

Elimination of noise-induced hearing loss: is the set standard effective and comprehensive?

In 2015, the Mine Health and Safety Council (MHSC) set a milestone for NIHL (Noise Induced Hearing Loss, Regulation 839), which stated that *"By December 2016, no employee's Standard Threshold Shift (STS) will exceed 25 dB from baseline, when averaged at 2 000, 3 000 and 4 000 Hz, in one or both ears".* [13]

- Baseline mandated from 2014 to December 2016
- No employee's STS should be ≥ 10 dBHL, averaged at 2 000, 3 000, and 4 000 Hz from baseline in one or both ears
- A shift in hearing threshold of ≥ 25 dBHL, averaged at 2 000, 3 000, and 4 000 Hz for one or both ears = reportable

The caveat for the STS milestone implementation is the Department of Mineral Resources and Energy's code of practice for occupational health programmes for noise, incorporating the SANS 10083[14] and Instruction 171.[1] In addition, the mines should record the new STS baseline at the start of each new mineworker's employment. However, there are evidence-based and practical challenges related to the implementation of the milestone:

- Audiometry surveillance data quality needs attention (cleaning up) to improve the quality of the records.
- The SANS 10083 and Instruction 171 refer to entry/initial audiogram (PLH calculation) when individual mineworkers, who already have a history of employment, move to a different company. Do currently used electronic health systems used by mining companies accurately allocate/record the correct baseline STS? This question relates similarly to the entry/initial audiogram. Both the PLH and STS calculations are drawn from the audiogram's hearing thresholds that are recorded. Accurate and consistent scores of the PLH and STS should be recorded.
- There is a basic understanding that the PLH calculations (Instruction 171) are for compensation and STS (NIHL milestones) hearing monitoring to prevent NIHL. However, the different *baseline* definitions are used interchangeably and incorrectly.

Table 1. Comparison of OSHA, NIOSH, and SAMI approaches to STS

OSHA	NIOSH	SAMI
• Occupational noise exposure standard at 29 CFR 1910.95(g)(10)(i) • Ave ≥ 10 dB at 2 000, 3 000, and 4 000 Hz in either ear • Age corrections (not mandatory)	• Significant threshold shift (STS) • ≥ 15dB at 500, 1 000, 2 000, 3 000, 4 000, or 6 000Hz • Annual testing • 30-day retest • 12-hour no exposure • TTS vs PTS • Interventions: HPD; education; training and motivation; administrative controls	• NIHL Regulation 839 1. Baseline mandated from 2014 to December 2016 • No employee's STS should be ≥ 10 dBHL averaged at 2 000, 3 000, and 4 000 Hz from baseline in one or both ears 2. A shift in hearing threshold of ≥ 25 dBHL averaged at 2 000, 3 000, and 4 000 Hz for one or both ears = reportable

HPD: hearing protection device, NIHL: noise-induced hearing loss, NIOSH: National Institute for Occupational Safety and Health, USA, OSHA: Occupational Safety and Health Administration, USA, SAMI: South African mining industry, STS: standard threshold shift

- There is a lack of clarity when it comes to the custodians of the medical surveillance data (audiometry data included). Whoever owns the data should be able to design codes for the electronic health systems, and review and revise the code to match the desired outcomes. Therefore, defined roles, regarding medical surveillance data, are necessary for good-quality data to be generated and collected for analysis.

With the above in mind, we have missed opportunities to identify changes in hearing threshold relative to the baseline audiogram (STS). Missing the early signs of hearing loss for these mineworkers renders the set NIHL milestone ineffective. These challenges highlight gaps in understanding the set milestone, which, in turn, undermine the comprehensiveness of NIHL prevention by the mining companies.

Outward look at STS

A limited overview (with caution, because a body of evidence-based work has been conducted, and continues, so it is limited to the region) could be based on the review of the American approaches to STS and audiometry surveillance, against the 2016 SAMI STS milestone guidance note (see Table 1).

Parting points to consider

- The current SAMI STS milestone guidance note definition requires rewording to clarify the requirements for implementation.
- The current South African mineworkers' profile of those at risk of developing ONIHL requires a mindset shift, to consider the term '*significant* threshold shift' instead of the currently used '*standard* threshold shift'.
- Inconsistent and inaccurate STS data lead to poor reporting rates. Good-quality audiometry surveillance data should be prioritised to improve accuracy of STS reporting (STS in this case).
- The STS milestone guidance note, which incorporates SANS 10083 and Instruction 171, has audiometry medical surveillance aspects that require step-by-step instructions. This should be considered in order to improve the efficiency of the set NIHL milestone.
- Finally, clarity is needed to guide companies on what to report and when to report.

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A rational approach to workplace drug and alcohol testing: scientific validity, legal defensibility, and ethical practice

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ABSTRACT

The accuracy, ethics, and legal defensibility of workplace drug and alcohol testing have become increasingly significant in contemporary occupational settings. As drug use legislation evolves and the principle of procedural fairness gains prominence, testing protocols must be scientifically justified and contextually appropriate. This paper explores the rationale behind testing, the relevance of pharmacokinetics and biological matrices, the importance of measurement uncertainty, and lessons from recent South African case law. It advocates for a rational, evidence-based framework that aligns scientific validity with legal and ethical workplace requirements.

INTRODUCTION

Workplace drug and alcohol testing is a widely implemented occupational health practice and risk management system across industries in South Africa. Its primary objective is to promote safety, productivity, and legal compliance, particularly in safety- and risk-sensitive environments. However, the methods, thresholds, and interpretations of such tests can raise legal and ethical concerns, especially in contexts where the presence of a substance does not necessarily imply impairment or workplace risk.[1]

In South Africa, evolving case law and changes in substance legislation – such as the decriminalisation of cannabis – have brought increased scrutiny to workplace testing protocols.[2] This shift has created significant challenges for employers, who must navigate their duty of care obligations under the Occupational Health and Safety Act while respecting employees' constitutional rights to privacy and dignity. The historical 'zero-tolerance' approach that characterised workplace drug and alcohol testing programmes has become increasingly difficult to justify, particularly for substances like cannabis that can be detected long after their impairing effects have dissipated.[3]

The inconsistency between scientific understanding and workplace policies has led to numerous legal challenges. Courts are increasingly demanding that employers demonstrate a rational nexus between testing outcomes and legitimate workplace safety concerns. This article explores a *rational* approach to testing that aligns with occupational health principles and evolving legal standards.

FRAMING THE QUESTION: THE PURPOSE OF TESTING

Clarity about the purpose of a drug test is the starting point for any scientifically defensible workplace testing regime. Different testing contexts – pre-employment screening, random testing, post-incident testing, or monitoring compliance – call for different approaches. The nature of the question being asked directly informs the appropriate matrix, test type, and interpretation framework.

For example, pre-employment testing may aim to assess lifestyle choices that could impact long-term suitability. At the same time, post-incident testing must focus on recent use and potential impairment. Random testing serves as a deterrent and monitoring mechanism, but requires particular attention to procedural fairness. Return-to-duty testing following rehabilitation may require a different approach entirely, with lower thresholds and more frequent monitoring.

The selection of an appropriate testing protocol should reflect these different objectives. For example, in safety-critical roles where current impairment is the primary concern, oral fluid or breath testing might be preferable to urine testing, as these matrices better reflect recent use and potential current impairment.[4] Without this contextual alignment, testing risks becoming arbitrary or legally indefensible, as illustrated in cases like *Enever v Barloworld Equipment South Africa*, where the Labour Appeal Court criticised an employer's failure to consider the nature of the employee's work when applying a zero-tolerance cannabis policy.[5]

Pharmacokinetics and matrix selection

Pharmacokinetics, the study of how substances are absorbed, distributed, metabolised, and excreted in the body (ADME), is central to interpreting drug test results.[6] A key consideration is that the detection window for a substance varies, depending on the matrix (e.g. blood, urine, hair, oral fluid, breath) and the drug's pharmacological properties.

Blood and oral fluid typically reflect recent use and are most relevant for assessing impairment.[7] Cannabis presents a particular challenge as delta-9-tetrahydrocannabinol (THC), the primary psychoactive compound, is highly lipophilic and distributes rapidly into adipose tissue. Blood THC levels peak quickly after inhalation and then decline rapidly, while psychoactive effects may persist for several hours. This creates a complex relationship between measured THC levels and actual impairment, further complicated by the development of tolerance in regular users.[8]

Urine testing, while common in South African workplace settings, detects inactive metabolites (primarily THC-COOH for cannabis) that can persist for days or weeks after use, making it unsuitable for determining current influence but appropriate for monitoring abstinence programmes.[9] Hair analysis extends the detection window further, potentially to months, but cannot provide information about the current status.[10]

Oral fluid testing has gained prominence in workplace settings due to its non-invasive collection, reduced risk of adulteration, and better correlation with recent use. Studies suggest that THC in oral fluid primarily reflects recent cannabis use, with detection typically limited to 12–24 hours after smoking, although longer in heavy users.[11] This makes oral fluid particularly suitable for assessing potential workplace impairment rather than historical use.

Breath testing remains the most practical method for workplace screening for alcohol, although the relationship between breath alcohol concentration (BrAC) and blood alcohol concentration (BAC) can vary between individuals. Most international jurisdictions and workplace policies establish a blood alcohol equivalent of 0.02% (20 mg/dL) as the threshold for workplace violations.[12]

A rational approach to matrix selection acknowledges these differences. It selects the specimen type that best answers the question at hand – whether assessing recent use, monitoring compliance with abstinence programmes, or investigating historical patterns of substance use.

Cut-off concentrations and quantitative measurement uncertainty

All testing instruments and procedures are subject to some degree of variability, which introduces measurement uncertainty (MU).[13] Regulatory and internal workplace thresholds must, therefore, be set and interpreted using statistically sound principles. A key concept is the lower confidence limit (LCL) – the lowest plausible value for a test result, taking uncertainty into account.

A test result should only be deemed definitively 'positive' when the LCL exceeds the prescribed cut-off. This 'guard band' approach is critical in workplace testing, where false positives can have significant consequences for individuals' livelihoods. For example, if a workplace policy sets an alcohol breath threshold at 0.02%, and the measured result is 0.021% with an uncertainty of ± 0.005%, then the LCL would be 0.016%, which falls below the cut-off, making the result inconclusive.

It is also vital to remember that '0.000%' – often misinterpreted as indicating 'zero tolerance' rather than a scientifically rational approach – represents another form of cut-off concentration. This, too, necessitates applying a guard band to account for measurement uncertainty and the LCL.

Sources of quantitative measurement uncertainty in drug testing include random variations in the measurement process, electronic noise in the testing equipment, variations in sampling techniques, temperature and environmental factors, biological variation between specimens, calibration errors, and instrument drift. It is important to bear in mind that these random variations influence the analytical and diagnostic sensitivity and specificity of the test.

In quality-conscious testing programmes, these uncertainties are quantified and incorporated into decision rules for interpreting results. The International Organization for Standardization (ISO) guidelines and forensic science best practices recommend that laboratories and testing facilities document their measurement uncertainties and apply appropriate decision rules when reporting results.[14]

The National Union of Metalworkers of South Africa (NUMSA) obo Naidoo v the Commission for Conciliation, Mediation and Arbitration (CCMA) case illustrates the practical importance of this approach. The company revised its alcohol testing policy to implement a 0.002% (rather than 0.000%) threshold after acknowledging that complete abstinence might not be realistic, due to residual alcohol levels from social drinking that don't lead to impairment and the potential for false positives, due to biological variations or dietary effects.[15]

For cannabis testing, the establishment of appropriate cut-off concentrations is even more complex, as THC levels vary significantly between matrices and have an imperfect relationship with impairment. In oral fluid, initial screening cut-offs typically range from 4–10 ng/mL, with confirmation cut-offs of 2–5 ng/mL.[16]

Failing to account for measurement uncertainty can lead to decisions based on ambiguous results, possibly violating employee rights and leaving employers vulnerable to legal disputes. Accordingly, decision rules must be incorporated into policy to account for the statistical range within which a result may fall. This approach aligns with international laboratory best practices and enhances the legal defensibility of testing outcomes.

Case law and legal trends in South Africa

Recent South African labour law decisions illustrate the consequences of irrational or inadequately substantiated drug and alcohol testing practices. Several key trends have emerged that are shaping the legal landscape.

Scientific justification for thresholds: courts have emphasised the importance of evidence-based cut-offs. In *Marasi v Petroleum Oil and Gas Corporation of South Africa*, the Labour Court established specific cut-off levels for workplace cannabis testing, stating, *"The maximum permissible cut-off level in relation to cannabis is 50 ng/ml (nanograms per ml)"* for urine testing.[17] For alcohol, the court referenced urine testing limits *"commensurate with a blood alcohol concentration of above 0.02% (20 milligrams/100 ml blood)."* The judgment confirmed that employers can establish appropriate threshold levels as long as they are scientifically rational and consistently applied.[18]

Impairment versus presence: positive test results without supporting evidence of impairment have been deemed insufficient grounds for dismissal, particularly in non-safety-critical roles.[19] In *NUMSA obo Nyawuza v PFG Building Glass*, the Commissioner found that dismissal was substantively unfair because the minimal level of cannabis detected in urine (below 15 ng/ml) did not cause impairment, and the employee continued working safely for six days after testing positive.[18] This shift highlights the need to distinguish between drug presence and actual risk to workplace safety.

Confirmatory testing: the *Engels v McCain SA* case established the importance of confirmatory testing when initial results are disputed. A senior employee was dismissed after testing positive for alcohol in

a routine test, but a subsequent blood test returned negative results. The Commissioner ruled: *"The applicant's version is relevant and credible. It simply means the applicant did not test positive for alcohol. The respondent has failed to prove that the applicant's dismissal was for a fair reason"*.[20] This case underscores those disciplinary outcomes based solely on preliminary screening (e.g. breathalysers or point-of-care tests) are vulnerable to challenge when confirmatory laboratory testing is not conducted.

Policy alignment with the law: the landmark *Enever v Barloworld Equipment South Africa* case addressed the effect of cannabis decriminalisation on workplace policies. The Labour Appeal Court ruled that Barloworld's zero-tolerance approach, which treated cannabis use identically to alcohol use, failed to account for the different pharmacokinetic properties of these substances. The court stated that *"despite pursuing the legitimate reason of workplace safety, the respondent's insistence that testing positive for cannabis after a urine or blood test was the same as testing positive for alcohol after a breathalyser and that sobriety at the time of the test was always of no relevance regardless of the nature of the employee's job, failed to adequately consider the position cannabis users have been placed in"*.[5]

Procedural fairness: the SGB Cape Octorex case reinforced that, while employers have the right to establish rules to maintain workplace safety, these rules must be applied consistently and with due process.[21] Employees must be informed about the testing protocols, their rights, and any consequences of positive results. Failure to follow due process has led to reinstatement and compensation awards in numerous cases.

Nature of work: the Taxi-Trucks Parcel Express case demonstrated that the nature of the employee's work is a crucial consideration. The court ruled in favour of an employee who was a general worker, loading tyres, finding that the presence of alcohol in his blood did not necessarily justify dismissal, given his non-safety-critical role.[22] This establishes that the employee's specific job duties and safety risks should be considered when determining appropriate sanctions.

These rulings collectively signal a judicial expectation that employers adopt fair, rational, and scientifically credible testing practices that balance legitimate safety concerns with respect for employee rights.[23]

Policy design and implementation

An effective workplace testing policy must integrate both scientific rigour and procedural safeguards. Core components include:

Purpose-specific protocols: policies should clearly delineate the conditions under which testing is conducted, the substances tested for, and the matrices used in each context.[1] Drug testing for cannabis requires particular attention, given its unique pharmacokinetics and the potential for false positive test results from passive exposure or CBD product use.[24]

Risk-based categorisation: not all workplace roles carry the same safety risks. A tiered approach that categorises positions according to safety and risk sensitivity allows for proportionate testing regimens that balance safety concerns with privacy considerations. This might include:

- *High-risk roles* (e.g. heavy machinery operators, drivers): comprehensive testing with stringent thresholds
- *Medium-risk roles:* testing focused on reasonable suspicion and post-incident scenarios
- *Low-risk roles:* limited testing with higher thresholds and emphasis on visible impairment

Evidence-based thresholds: cut-off concentrations must be supported by pharmacological data and must account for both MU and substance-specific detection windows. For cannabis, this may involve matrix-specific thresholds: 2–5 ng/mL for THC in oral fluid, 50 ng/mL for THC-COOH in urine for screening purposes, and blood THC concentrations of 2–5 ng/mL.

Confirmatory testing requirements: screening results should be followed by confirmatory testing using validated laboratory methods before any disciplinary measures are enacted. For cannabis, this typically involves gas chromatography-mass spectrometry (GC-MS) or liquid chromatography-tandem mass spectrometry (LC-MS/MS) to identify THC or its metabolites, specifically.

Consistency and equity: policies must be applied consistently across employee groups, with mechanisms to accommodate medical conditions, prescribed medication use, or substance dependence rehabilitation.[25] The policy should recognise the distinction between dependency (potentially a disability requiring accommodation) and misconduct, with different intervention pathways for each.[26]

Medical review officer (MRO) involvement: qualified healthcare professionals should be involved in reviewing positive test results, particularly to identify legitimate medical explanations. For cannabis, this may include distinguishing between THC from recreational use and that from using CBD products, which can contain traces of THC.[27]

Employee education: clear communication of policy expectations, testing procedures, and consequences is essential for procedural fairness. This includes information about detection windows for different substances and testing methods.[28]

Legal compliance and review: policies should be regularly reviewed to align with changing legislation (e.g. cannabis law reform) and case law developments.[29] What constituted a reasonable policy five years ago, may no longer withstand legal scrutiny in today's evolving landscape.

These features ensure that drug and alcohol testing serves its intended function – protecting workplace safety – without compromising legal or ethical standards. The goal is to create a policy that is rational, proportionate, and defensible before labour tribunals and courts, while effectively managing genuine workplace safety risks.

CONCLUSION

Workplace drug and alcohol testing must balance the goals of safety and productivity with the privacy rights and dignity of employees. Scientific precision, legal compliance, and ethical fairness must underpin every aspect of policy and practice. A rational, evidence-based approach – grounded in pharmacokinetics, measurement science, and legal precedent – provides the most robust framework for achieving this balance.

The evolution of case law in South Africa, particularly regarding cannabis, signals a clear shift away from zero-tolerance approaches toward more nuanced policies that consider the nature of work,

the relationship between test results and actual impairment, and the privacy rights of employees. Employers who fail to adapt their testing regimens to this changing landscape face significant legal and reputational risks.

KEY MESSAGES

1. Workplace drug testing must balance safety and risk management goals with employee rights, requiring scientific precision, legal compliance, and ethical fairness in all policies and practices.
2. Pharmacokinetics is essential for accurate test results interpretation, as detection windows vary significantly between biological matrices (blood, urine, hair, oral fluid) and do not always indicate current impairment.
3. Positive test results alone are insufficient grounds for dismissal, without evidence of workplace impairment in terms of the Occupational Health and Safety Act; in addition, employers should specify scientifically justified cut-off levels in employment contracts to allow a 'per se' approach, where exceeding these predefined thresholds constitutes a policy violation regardless of observable impairment.
4. Effective workplace testing policies must include purpose-specific protocols, evidence-based thresholds that account for measurement uncertainty, confirmatory testing requirements, and regular reviews to align with changing legislation.

DECLARATION

The author declares that this is his own work; all sources used in this paper have been duly acknowledged, and there are no conflicts of interest.

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Smart technology preventing workplace hearing loss

Noise is one of the most common – and most underestimated – hazards in the workplace. In industries like manufacturing, construction, mining, and transport, workers are often exposed to sound levels that can cause permanent damage.

Noise-induced hearing loss (NIHL) is irreversible. But it is completely preventable with the right approach.

At Sedulitas, we've teamed up with global leaders in hearing protection to bring smarter, more proactive safety solutions to South African industries. Two standout technologies – Minuendo's Smart Alert earplugs and Larson Davis's Spartan Noise Dosimeter, now integrated with the RiskSight platform – are changing the way companies manage noise risks.

Together, these tools cover both sides of hearing safety: personal awareness and data-driven oversight.

Minuendo Smart Alert earplugs: making noise risk visible

The Smart Alert earplug is not just hearing protection – it is smart personal protective equipment (PPE). These earplugs actively monitor the noise workers are actually exposed to, not just the ambient noise in the room. Using haptic and sound-based alerts, they notify the wearer in real time when sound levels become dangerous, even after attenuation.

In simpler terms, Smart Alert tells you what your ears are really experiencing. It helps confirm if the earplugs are being worn correctly and consistently throughout the day – something traditional earplugs cannot track.

This kind of instant feedback encourages better habits on the floor and allows safety officers to step in before damage is done. It is a proactive, real-time tool that moves hearing protection from passive compliance to active prevention.

Larson Davis Spartan Noise Dosimeter: reliable, real-world exposure data

While live alerts are critical, long-term safety depends on solid data. The Spartan Model 730 dosimeter is a small, durable device worn by workers throughout their shift. It tracks and records detailed noise exposure data, such as:

- A-, C-, and Z-weighted sound pressure levels
- Time-weighted averages (TWAs)
- Peak and maximum levels
- Movement and bump events
- Optional octave band frequency and audio recordings

The device is wireless and Bluetooth-enabled, meaning safety teams can monitor exposure in real time without interrupting workers. The device is also available in intrinsically safe models (730IS), suitable for hazardous environments like mines or chemical plants.

Larson Davis is trusted worldwide and meets international standards (OSHA, ISO 9612, ACGIH, EU Directive 2003/10/EC). Whether you are doing a baseline survey, exposure profiling, or preparing compliance reports, the Spartan Dosimeter gives you reliable data to work from.



Smart hearing protection technology
Photograph: courtesy of Sedulitas

RiskSight: smarter noise data management

Collected exposure data needs to be managed effectively across teams and sites. To achieve this, the Spartan Dosimeter has been integrated with RiskSight, a modern platform developed by Larson Davis, Sedulitas, and Apeiros.

RiskSight simplifies noise management, using these features:

- Automated uploads: data sync wirelessly at the end of each shift – no more need for manual downloads
- Live monitoring: exposure levels can be seen in real time, across workers and locations
- AI-powered reporting: risk insights and reports are generated instantly
- Multi-site dashboards: exposure data across roles, teams, or sites can be compared in one view
- Custom access levels: everyone – from hygiene teams to site leads – gets the data needed, when needed

RiskSight does not only store data – it also helps safety teams understand it, act on it, and predict future risks with trend tracking and 'what-if' scenarios.

Smarter tools, safer ears

NIHL develops gradually and has no medical cure. Sedulitas integrates technology and equipment to help prevent NIHL, providing:

- **Smart Alert:** immediate feedback and behavioural nudges
- **Spartan Dosimeter:** accurate, certifiable exposure data
- **RiskSight:** insightful, scalable, and strategic noise management

Whether you need one dosimeter or a full solution across multiple sites, Sedulitas helps you to design the right setup, and offers training and ongoing support tailored to your operation.

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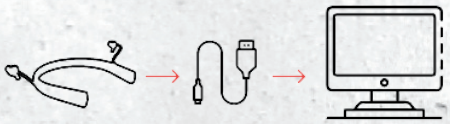
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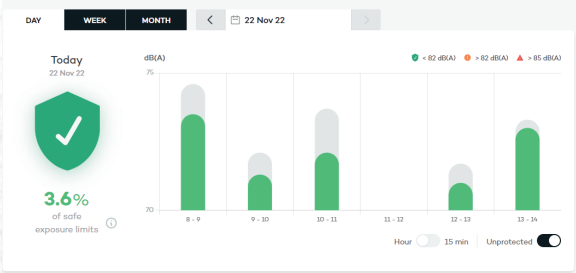
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- Monitors in-ear noise after attenuation
- Verifies if earplugs are worn correctly
- Real-time protection + behavioural insight

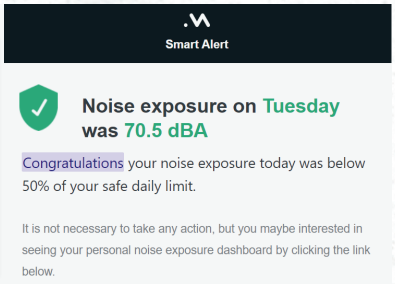


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Noise Exposure Regulations, 2024 and Physical Agents Regulations, 2024 promulgated under the Occupational Health and Safety Act No. 85 of 1993, as amended

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On 6 March 2025, the Minister of Employment and Labour promulgated two new regulations: the Physical Agents Regulations (PAR) and Noise Exposure Regulations (NER). The PAR were published in the Government Gazette No. 52226, under Government Notice R. 5952, and the NER were published in the same Government Gazette, but under Government Notice No. 5953.[1,2] In the publishing of these new regulations, explanatory notes were included for both. These explanatory notes should not be read in isolation, but are meant to be read in conjunction with the regulations. Also accompanying the NER was the new Code of Practice (CoP) for Audiometry, which must also be read together with the NER. As these new regulations and the CoP were promulgated under Section 43 of the Occupational Health and Safety Act, No. 85 of 1993 (OHS Act), as amended, they are applicable to all workplaces that fall under the OHS Act.[3]

The NER replace the Noise-Induced Hearing Loss Regulations, 2003, and the PAR replace the Environmental Regulations for Workplaces. The Department of Employment and Labour (the Department) undertook to replace the old regulations as they were misaligned with developments in the field of occupational hygiene. Both new regulations seek to affirm the International Labour Organization's (ILO's) recognition of occupational health and safety (OHS) as a fundamental right.[4] These new regulations also address gender sensitivity and vulnerable employees (defined in the regulations), and include requirements for employers to consider vulnerable employees when assessing risks and implementing control measures.

To extend coverage to exposed employees, the regulations needed to be specifically updated regarding the control of exposure to noise in the workplace; the 'old' regulations were reactive in nature, which often led to affected employees falling through the cracks. This relates to the impact of concomitant exposure to noise and other occupational stressors, such as ototoxic chemical agents and whole-body vibration, which may exacerbate hearing loss.[5,6] A more proactive approach in addressing noise exposure was required to reduce the high incidence of hearing loss in workplaces, which negatively affects employees' quality of life.

The scope of application for the NER has been expanded to include employees exposed to the noise action level of 82 dBA for continuous noise or 135 dBC for impulse noise, together with concomitant exposures. The new regulations have also tightened existing criteria for exposure risk assessment, exposure monitoring, control measures, and hearing protection devices. The inclusion of peak noise exposure, an action level of 135 dBC, and an exposure limit of 137 dBC, is one of the highlights of the regulations. There is also a major change in the requirements for medical screening and medical surveillance, and the process for undertaking such has been expanded and is outlined in the CoP for Audiometry. In relation to medical surveillance, the 'old' Noise-Induced Hearing Loss Regulations referred to the requirements in SANS 10083 to be followed when conducting audiometric tests on employees exposed to noise. The Department developed the CoP for Audiometry, which has been incorporated into the NER. This CoP must be followed for all audiometric tests conducted in terms of the OHS Act and NER.

The Department updated the Environmental Regulations for Workplaces, which were promulgated in 1987, as they did not take into account changes in weather conditions due to climate change. Due to these changes, employees are exposed to higher temperatures than in the past whilst working, which negatively impacts their health and safety.[7] In 2024, the ILO published a report on the effect of climate change on the world of work; two workplace stressors that were highlighted were excessive heat and ultraviolet radiation.[7] The Environmental Regulations for Workplaces did not provide employers and employees with sufficient guidance to assess exposures to heat, cold, illumination, ventilation, and vibration appropriately and correctly; these are comprehensively addressed in the new regulations. Considering the impact of high temperatures on both indoor and outdoor employees, and the working conditions of outdoor employees, it was important to address the requirements for indoor air quality and non-ionising radiation to strengthen the protection of such employees through the new regulations.

The Department allowed a phase-in period of 18 months from the date of promulgation for workplaces to implement the new regulations and the CoP. Employers have until 5 September 2026 to finalise the implementation of the new regulations in their existing occupational health and safety management systems.

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Recent amendments to the Occupational Health and Safety Act – new Regulations

Kate Collier: Partner, Webber Wentzel
Kalene Watson: Senior Associate, Webber Wentzel

On 6 March 2025, the Minister of Employment and Labour promulgated the Physical Agents Regulations, 2024, the Noise Exposure Regulations, 2024, and a notice regarding amendments to the General Safety Regulations. These amendments primarily consolidate obligations previously contained in the Environmental Regulations, which will be repealed by the new Physical Agents Regulations. These Regulations fall under the Occupational Health and Safety Act (OHSA) No. 85 of 1993, as amended, and are intended to protect the health and safety of persons who may be exposed to cold or heat stress, vibration, radiation, illumination hazards, and harmful noise in the workplace.

The full text of the amended Regulations can be accessed here. We summarise some of the material changes that employers regulated by OHSA are required to consider and implement.

PHYSICAL AGENTS REGULATIONS, 2024

The Physical Agents Regulations, 2024 will repeal the Environmental Regulations for Workplaces, 1987, 18 months from their promulgation date, i.e. on 6 September 2026. It is not clear whether both sets of Regulations apply concurrently until that date, or whether the new Physical Agents Regulations only take effect in September 2026. In either case, employers are encouraged to begin implementation, so far as is reasonably practicable, to ensure full compliance by the effective date.

The Physical Agents Regulations apply to any employer or self-employed person who performs work at a workplace that may expose any person to a physical agent, and designers, manufacturers, importers, or suppliers of plant and machinery for workplace use.

The Physical Agents Regulations provide several measures to minimise and/or control health risks associated with exposure in the workplace. A 'physical agent' is defined as a *"source of energy which may result in injury or disease after exposure and includes, but is not limited to, cold stress, heat stress, vibration, non-ionising radiation, and illumination"*. The Physical Agents Regulations introduce the concept of 'vulnerable employees', defined as *"an employee who is at a higher risk of injury, disease or complications caused by exposure to a Physical Agent"*.

The Physical Agents Regulations require that a competent person conduct a documented risk assessment at least every two years. Thereafter, informed by the findings of the risk assessment, employers must implement a physical agent exposure monitoring programme, if the assessment indicates that employees may be exposed to a physical agent: i) at or *above* the occupational exposure limits set out in Tables 1 and 2; ii) at or above the guideline values in Table 3; or iii) *outside* the range for the guideline values in Table 3. This exposure monitoring programme must be conducted by a competent person.

Employees must be placed under a documented medical screening programme, where such a need is identified in the risk assessment or where the employee is a vulnerable employee. The appointed occupational medicine practitioner (OMP) must determine the need for medical screening and specify the screening requirements. Medical screening must be carried out by an OMP: *immediately before an employee commences employment*; and subsequently at intervals recommended by the OMP, but *not exceeding two years*. The OMP must inform the employer in writing of the outcome of an employee's health evaluation, where the outcome is normal. Exit medical screening must be carried out upon termination of an employee's employment, unless medical screening was conducted within six months prior to the termination date.

The employer must establish, implement, and maintain a documented system of medical surveillance, overseen by an OMP. Employees must provide written informed consent for their participation in the medical screening and medical surveillance programme.

The employer must ensure that exposure to a physical agent is eliminated, as far as is reasonably practicable. Where elimination is not reasonably practicable, the employer must reduce exposure to below the occupational exposure limits (OELs) set out in Tables 1 and 2, by implementing the hierarchy of control measures outlined in Regulation 15(2). These include engineering controls to eliminate or reduce exposure at the source; maintaining plant and machinery that generate a physical agent in good working order; administrative control measures to limit the number of persons exposed and the duration of exposure; and provision of suitable personal protective equipment (PPE) capable of reducing exposure. The employer must ensure that all control measures are properly and consistently used; maintained in an efficient state and in good working order, good repair, and clean condition; and reviewed for effectiveness through inspections and testing by a competent person at intervals not exceeding two years.

Employers must consult with health and safety representatives and/or the health and safety committee to inform them of the intention to conduct the required assessments, monitoring and surveillance, and must share the documented outcomes.

Instruction and training must be provided to employees, mandataries, and any other persons exposed to physical agents. Training must include both practical and theoretical knowledge of potential sources of exposure to physical agents; the associated risks to health and safety; existing control measures; precautionary measures employees must take to protect themselves from exposure; procedures for reporting and accessing risk assessments, monitoring results, and personal medical records. Refresher training must be conducted *annually*.

Records relating to training, risk assessments, action plans, monitoring, measurements, medical screening and surveillance, and the maintenance of control measures must be retained for 40 years. These records must be made available to the health and safety representative, health and safety committee, or an inspector.

Regarding specific physical agents

Cold stress/heat stress

Employers must eliminate cold or heat stress at the source, where reasonably practicable. If not reasonably practicable, and where exposure is at or below the OEL set out in Table 1, employers must implement minimum measures in Regulations 9(2), 10(2), and 10(3).

Illumination

Employers must ensure that workplace illumination accounts for illuminance values, glare, uniformity, flicker, and stroboscopic effects. Specialised illumination must be provided for hazardous or precision tasks. Requirements under Regulation 11 include:

- *maintaining illuminance* values in accordance with Tables 4 and 5 (interior workplaces) and Tables 6 and 7 (exterior workplaces)
- *eliminating* or *reducing* glare, flicker, and stroboscopic effects to preserve visual performance; and
- *providing* emergency illumination evacuation, in accordance with Regulations 11(5) and 11(6).

Employers must conduct an illumination measurement and monitoring programme at the workplace, where a risk assessment indicates that any employees may be exposed to substandard illumination, specifically: illumination below the minimum maintained average illuminance values set out in Tables 4, 5, 6, and 7; flicker; stroboscopic effect; or a need for specialised illumination for hazardous or precision tasks. The monitoring programme must be conducted by a competent person at a frequency determined by the physical agent exposure risk assessment, or at intervals not exceeding *two years*. Employers must consider the recommendations set out in the illumination measurement and monitoring report, and must develop a *documented action plan* for implementation.

Indoor air quality

Employers must ensure that the risk of exposure to hazardous biological, chemical, or physical agents affecting indoor air quality is eliminated at source, where reasonably practicable. If elimination is not reasonably practicable, employers must control indoor air quality to the guidance levels contemplated in Table 3. Artificial ventilation systems must be routinely tested by a competent person and maintained in accordance with OEM specifications. Monitoring must include air temperature, velocity, and relative humidity.

Vibration

Hand-arm or whole-body vibration must be eliminated at source. If this is not reasonably practicable, control measures must be reviewed to reduce exposure below the prescribed action levels. Employers must investigate alternative working methods, ensure that plant and machinery are designed to generate minimal vibration, and maintain them in proper working condition. The magnitude and duration of exposure must be limited. Detailed monitoring, and medical screening and surveillance, are required. Exposure monitoring must comply with SANS 2631 and be representative of actual employee exposure.

Occupational non-ionising radiation

Non-ionising radiation must be eliminated at source. Where this is not reasonably practicable, alternative working methods must be investigated, and plant or machinery that produces the least possible radiation must be used. The magnitude and duration of exposure must be limited. Suitable PPE must be issued and used. Required signage must be displayed, and monitoring must take into account the sources and type of occupational non-ionising radiation.

NOISE EXPOSURE REGULATIONS, 2024

The Noise Exposure Regulations, 2024 (new Noise Regulations) will repeal the Noise-Induced Hearing Loss Regulations, 2003, with effect from 6 September 2026. The new Noise Regulations apply to any employer at a workplace, where persons are exposed to continuous or impulse noise at, or above, either the noise-rating limit or the noise action level, where there is concurrent exposure to ototoxic chemical agents and/or whole-body vibration, and any designer, manufacturer, importer, or supplier of plant or machinery for use at a workplace.

Once in force, the new Noise Regulations will require employers to ensure that a competent person conducts a documented risk assessment every two years. If the risk assessment indicates that employees may be exposed to noise at, or above, the noise-rating limit or noise action level, the employer must implement a noise exposure monitoring programme. This programme must be carried out by an approved noise inspection authority at least every two years. Employers must ensure that exposure to noise is eliminated, as far as reasonably practicable. Where this is not reasonably practicable, exposure must be reduced to below the limits specified in Regulation 2, by implementing the hierarchy of control measures set out in Regulation 10(2). These include engineering control measures to eliminate or reduce exposure at source; keeping plant and machinery in good working order; and administrative controls to limit the number of persons exposed and the duration of exposure. The employer must also ensure that any control measure is fully and properly used; maintained in an efficient state and in good working order, good repair, and clean condition.

Where indicated by the risk assessment, or where an employee is a vulnerable employee, the employee must be placed under a documented medical screening programme. The appointed OMP must determine the necessity for, and requirements of, this screening. Medical screening must be carried out: immediately before the employee commences employment; at intervals determined by the OMP, not exceeding two years. The OMP must inform the employer in writing of the outcome of the employee's health evaluation, where the outcome is normal. Exit medical screening must be conducted at the termination of employment, unless the employee underwent screening within the previous six months. In addition, employers must implement audiometry for any employee who may be exposed to noise, or who is a vulnerable employee. Audiometric testing must be conducted by a competent person: audiometric testing, in accordance with the Code of Practice for Audiometry.

Noise zones must be identified and clearly demarcated. No person may enter or remain in these areas unless they are wearing effective hearing protective devices (HPDs) correctly. All employees must be issued with suitable HPDs.

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Employers must consult with health and safety representatives and/or the health and safety committee to inform them of their intention to conduct the required assessments, training, monitoring, and surveillance, and to share documented outcomes.

Instruction and training must be provided to employees, mandataries, and any other persons exposed to noise. Training must include *practical and theoretical knowledge* on: potential sources of exposure to noise; associated health and safety risks; applicable control measures; personal precautions to reduce adverse effects of exposure; and procedures for reporting and accessing risk assessments, monitoring results, and personal medical records. Training must be conducted by a competent person, with refresher training provided annually.

All records relating to training, risk assessments and action plans, monitoring, medical screening and surveillance, and maintenance of control measures must be kept for 40 years, and be readily available to the health and safety representative, health and safety committee, or an inspector.

UPCOMING EVENTS

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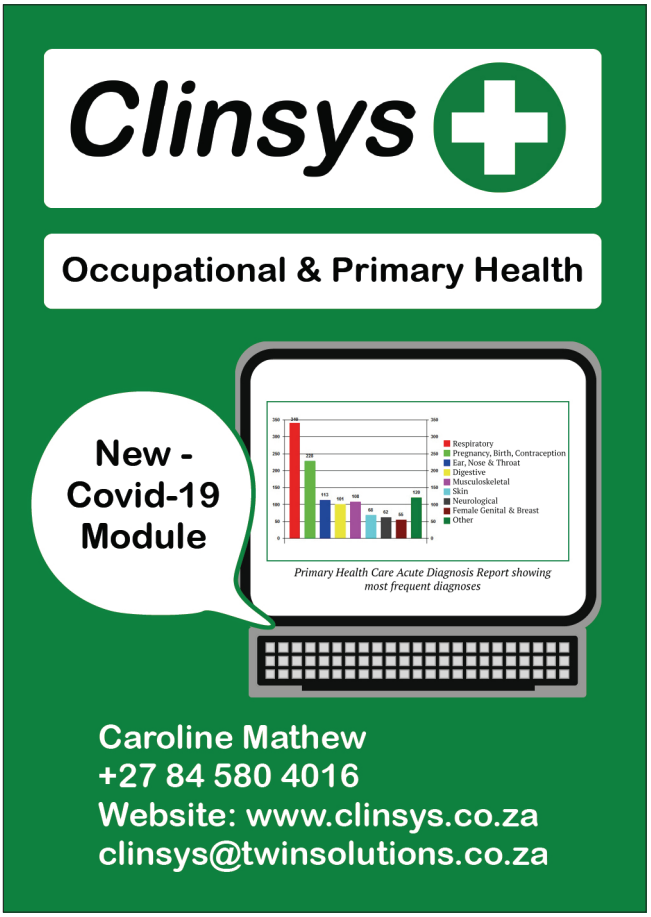
SAIOH Annual Scientific Conference
Radisson Blu Hotel, Umhlanga, South Africa
20-23 October 2025
Website: https://www.saioh.co.za/page/SAIOHConference2025
e-mail: info@saioh.co.za

INTERNATIONAL

10th Occupational Environmental Exposure of Skin to Chemicals Conference (OEESC)
Park Inn by Radison, Manchester, UK
14-16 September 2026
Website: https://www.bohs.org/events-networking/

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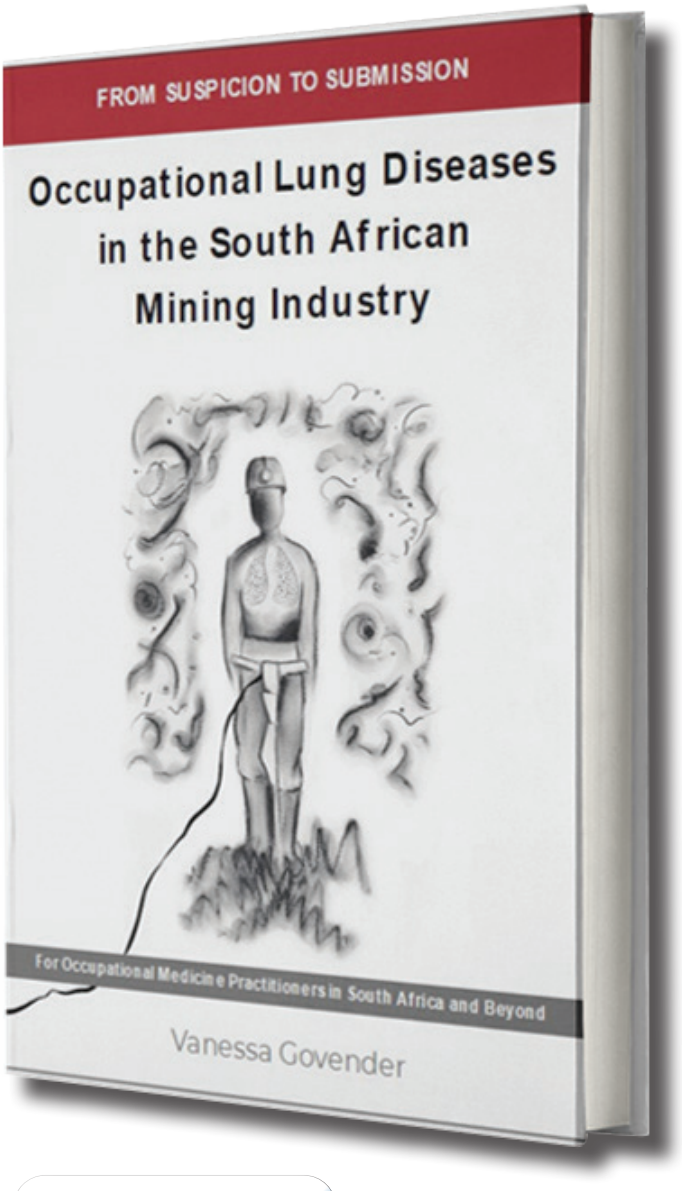
HANDBOOK

Endorsed by the ILO and aligns to the ILO's milestone to elevate occupational safety and health to a fundamental principle and right at work.

Simphiwe Mabhele – ILO Technical Advisor

This is an invaluable contribution to the understanding of occupational lung diseases, and to the care of workers who are at risk. The breadth of information contained within this easily carried handbook, and the user-friendly manner in which the information is set out, is a truly remarkable achievement. This is a goldmine of information that no occupational health practitioner, not only those directly involved in the care of workers at risk of occupational respiratory diseases (whether within mining or any other at-risk industry), can afford to be without.

Don Emby – Emeritus Chief Consultant Radiologist to the Minerals Council South Africa, Honorary Emeritus Member of the American Roentgen Ray Society, Honorary Life Member of the College of Radiologists of South Africa



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With the rich history of internationally recognised scientific excellence in occupational lung disease that resides in South Africa, it is not surprising that an elegant handbook such as this one should have been written by a South African occupational medicine specialist. The benefit of this handbook will be realised not only in South Africa, but indeed beyond the country's borders. It is clearly a labour of love and the product of a desire to share knowledge, driven by the noble cause of prevention of occupational respiratory diseases.

Jack Parker, MD – Professor Emeritus of Medicine, Radiology, Public Health, Occupational & Environmental Health Sciences, West Virginia University, USA

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SASOM news

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DoEL HOSTS A COIDA SCHEDULE 3 REVIEW WORKSHOP

The Department of Employment and Labour (DoEL), through the Compensation Fund (CF), hosted a Compensation for Occupational Injuries and Diseases Act (COIDA) Schedule 3 Review Workshop at the Birchwood Hotel and OR Tambo Conference Centre, on 7 and 8 February 2025. Medical practitioners, academics, employer groups, and representatives from organised labour, government agencies, and medical associations were invited to attend. Claudina Nogueira, ExCo member of the South African Society of Occupational Medicine (SASOM), attended the workshop, representing SASOM and the Southern African Institute for Occupational Hygiene (SAIOH).

Dr Nandipa Kahla was programme director, and Julian Soupen, Chief Director: COID, delivered the welcome note. The objectives of the workshop were presented by Dr Lebo Motsepe, Director: Medical Benefits. The workshop was held to finalise work that started in 2023, when a committee of medical officers and legal representatives was formed to review the Schedule 3 list of occupational diseases (and/or associated exposures), with the objective of aligning it with the International Labour Organization (ILO) listing. The amended list was approved and gazetted by the Minister of Employment and Labour. This workshop brought together sector representatives to discuss the updated list and to obtain insight from academia before implementation, which must be aligned with South African legislation, viz. the Constitution and the COIDA.

Dr Lucas Mosidi, Head of Medical Management at Rand Mutual Assurance (RMA) and member of the Schedule 3 Review Committee, provided the background and historical context of the ILO list, particularly the ILO Conventions. South Africa was an ILO member state from inception of the ILO (1919) to 1966, and has again been a member since 1994. The main ILO objective is to advance economic and social justice by establishing international labour standards. Since inception, it has concerned itself with workplace diseases, starting with lead poisoning and anthrax exposure in 1919. Over the years, the ILO has added more conditions and agents to the list, e.g. radium, silicosis, arsenic, benzene, and others. The tools developed by the ILO are the 'conventions' (which are binding and, once ratified, become law in the respective member states) and the 'recommendations' (which are guidelines and therefore not binding). As a direct result of industrial development and advances in medical and occupational health services, the ILO has continuously revised its list of occupational diseases to reflect current knowledge. The objective of the list is to prevent and compensate occupational disease; the most recent revision was undertaken in 2020. This includes a process of revision, a tripartite consensus mechanism, and adoption and implementation through a 'convention' (requiring a parliamentary process) or 'recommendation' in the respective ILO member states. The list is maintained by continuous reviews by the ILO and its member states, which make proposals for inclusion of 'new' diseases or agents, based on their workforce demographics; not all proposed diseases/agents are added to the list. A two-thirds majority is required for any occupational disease to be included. Member states that ratify the list are obliged to implement it within one year of ratification. Member states have the right to expand their lists based on proven scientific criteria developed by the ILO Secretariat. When the list is developed through an autonomous recommendation and not a convention, member states can apply the list in a discretionary way.

Prof. Mohamed Jeebhay, Head of Occupational Medicine at the University of Cape Town (UCT) and member of the Schedule 3 Review Committee, spoke about the relationship between Schedule 3 and the ILO list of occupational diseases, as well as 'new' and 'other' conditions. He gave examples of exposures omitted from both the ILO and COIDA lists, and discussed whether non-listed diseases could be categorised as 'other'. Diseases caused by exposures to chemical agents should be aligned with the agents included in the Hazardous Chemical Agents (HCA) Regulations, e.g. formaldehyde and silica; diseases caused by exposures to biological agents, infections, or parasites should be aligned with the agents in the Hazardous Biological Agents (HBA) Regulations, e.g. malaria, and fungal infections of nails (in wet work). Occupational cancers form too large a category, so listing of all carcinogenic agents in workplaces is not possible. Instead, a proposal should be considered to adopt the International Agency for Research on Cancer (IARC) Class 1 Carcinogens, itself a dynamic list. Overall, there must be alignment between the ILO/COID Schedule 3 list of occupational diseases and the tenth and eleventh revisions of the International Classification of Disease (ICD) codes of the World Health Organization (WHO): ICD 10 and ICD 11, respectively. Linking disease and exposure codes will facilitate the collection of more comprehensive information for monitoring trends in occupational disease.

Prof. Rajen Naidoo, Head of Occupational and Environmental Health at the University of KwaZulu-Natal (UKZN), provided guidance on the new guidelines in respect of the amended ILO list of occupational diseases and challenges that can be anticipated. Current COIDA prescripts are clear, with good definitions of occupational disease and inclusion of a presumptive clause. The latter, specifically Section 66 of the COIDA, establishes a presumption that an

occupational disease arose out of, and in the course of, employment if an employee contracted a disease listed in Schedule 3, and was employed in work related to that disease. This presumption can shift the burden of proof to the employer to demonstrate that the disease did not arise from the employment. However, there is a fundamental change, viz. specific disease with a specific exposure. Hence, Section 66 becomes very 'open' with a presumptive clause that ensures one does not have to go through a legal process to prove that a disease is work-related and, therefore, compensable. However, there is a burden to stakeholders when it comes to deciding on disease causation, as it remains unclear who makes the call – the CF panel, the worker, or the employer? A structured approach is required to decide about causation; the definition of disease is clearly outlined in Annex A of COIDA. A stepwise approach should be used when diagnosing occupational disease. Factors that must be considered include identification and dose of workplace exposure, a proven link between exposure and disease, and any mitigating factors and/or differential diagnoses. The 'ILO Guidance Note (2022) – Diagnosis and exposure criteria for occupational disease' serves as a guideline for stakeholders by outlining the criteria for diagnosing and identifying occupational diseases, and includes: 1) characteristics of the causal agent, 2) associated occupational exposures, 3) toxicological profile of the agent, 4) short description of the disease, and 5) diagnostic criteria. Prof. Naidoo made some recommendations, including: 1) revising the definition of 'work' because, in South Africa, the non-traditional work environment is not considered when it comes to compensable disease lists; 2) anticipating new hazards, risks, and emerging occupational diseases must be considered along the full value chains of new industries, e.g. the solar energy sector; 3) including the entertainment and sports sectors in the work compensation realm, e.g. musculoskeletal disorders and vocal cord damage of musicians, and injuries of professional sportsmen.

Milly Ruiters, Chief Inspector of the DoEL, presented 'The Occupational Health and Safety (OHS) Act and occupational disease', highlighting the many challenges experienced in terms of compensation. The Department makes use of ILO statistics, which focus on the most hazardous work sectors, such as agriculture. Non-compliance of OHS regulations in South Africa leads to injuries, diseases, morbidity, and mortality. Per quarter, the Inspectorate conducts almost 30 000 inspections and risk-based assessments. A significant number of employers are not registered with COID and do not pay any financial levies. This leads to considerable under-reporting, as employers who are not compliant will not report injuries or diseases. For every rand spent on direct costs of workers' injury and illness, much more is spent to cover the indirect and hidden health costs.

The DoEL launched its OHS Strategy and Objectives (2024–2029) in October 2024, and public comments were considered before finalising the document. The Hazardous Physical Agents (HPA) Regulations were signed off by the Minister of Employment and Labour in February 2025, with a strong focus on the impacts of climate change on workers' health, e.g. cold and heat stresses. Non-ionising radiation and exposure to noise are also included in the regulations, guided by the principle of prevention and with a strong focus on hearing conservation programmes. There is a minor amendment to the general safety regulations, which speaks to risk assessment, and imparts more power to the Inspectorate. The OHS Strategy and Objectives can be summarised as follows:

- Coherent and effective legislation and policy, proactive measures, awareness, and enforcement of OHS standards,
- Promotion of a culture of safety in the workplace by fostering active participation of employers, employees, and other OHS stakeholders,
- Strengthened legal frameworks and compliance,
- Enhanced capacity and skills of OHS stakeholders, and
- Strategic information obtained from proactive research and data collection.

The most frequent occupational diseases notified to the DoEL, although very under-reported, are related to hearing loss, ergonomics, and lung disease.

The afternoon session was dedicated to breakaway discussions and reports from each group. Take-home messages were derived from the group discussions led by Prof. Mohamed Jeebhay, Dr Mpume Ndaba from the National Institute for Occupational Health, and Dr Manthoba Lekalakala from the DoEL. Several are listed below:

- Mental and behavioural disorders should be included under 'other diseases' in the Schedule.
- A new section needs to be added to include disorders of the reproductive system, specifically those associated with occupational exposures (which need to be specified). Examples are infertility, miscarriages, and congenital abnormalities. Treatment modalities for these conditions need to be specifically described, and treatment costs need to be capped by the CF.
- Tuberculosis (TB) is covered under two sections, viz. infections (pulmonary and extra-pulmonary TB), and in the circular instructions that cover exposures in healthcare workers and silica-exposed workers.
- Silica needs to be added as an exposure. Silicosis is a lung disease resulting from the inhalation of respirable crystalline silica dust. However, silica exposure can also affect other organ systems to cause renal diseases like nephrotic syndrome, and autoimmune disorders like systemic sclerosis (scleroderma), rheumatoid arthritis, and lupus.
- Malaria must be included under biological/infectious agent-borne diseases, but requires a specific guideline to establish occupational exposure. Hazardous biological agents, like *Plasmodium* parasites that cause malaria and the SARS-CoV-2 virus that causes COVID-19, need to be aligned with the HBA Regulations.
- Occupational cancers should be covered by a 'catch-all' phrase such as, *"as described by the IARC as Group 1 Carcinogens"*. Forty-seven carcinogens from the IARC list should be included, but some may need to be added – on a case-by-case basis – following in-depth research, analysis, and toxicological information.
- The definition of chronic obstructive pulmonary disease (COPD) needs to be expanded, and chronic bronchitis should be included as a respiratory disorder.
- Some emerging and re-emerging conditions are linked to occupational exposures. There needs to be a high level of suspicion for a certain exposure believed to cause disease to be added to the list.
- Chemical agents such as silica and formaldehyde need to be aligned with the HCA Regulations.
- Physical agents like heat, cold, and non-ionising radiation need to be aligned with the HPA Regulations. Climate change brings its own complex set of health impacts.
- Diagnostic criteria need to be defined comprehensively, as do company data like duration of exposure. In addition, delayed symptoms (latent effects) can make it challenging to link the

illness to the specific occupational exposure, complicating diagnosis and compensation processes.
- It is important to consider the available human expertise and other resources within the country, which should be shared across different medical expert panels.
- Legally, timeframes are important. It has taken more than 20 years to update Schedule 3 to its current format; review processes will be required more frequently and at regular intervals.
- Both voluntary and statutory methods of reporting occupational disease are not optimal as evidenced by under-reporting – less than one percent of occupational disease is reported. There needs to be a way to triangulate the data collected by various facilities and entities, and analyse them as 'big data'.
- Voluntary reporting systems may work better where there is an existing culture of reporting, and the trust between employers and employees.
- Statutory reporting tends to be more effective in countries where there is a high risk of under-reporting, or where repercussions are feared if diseases are reported.
- There is a reporting culture in the automotive industry, which is worth investigating to develop a model for reporting occupational disease across all industries.
- There should be a dedicated e-mail address for communication with the Office of the Chief Inspector; submitting an occupational disease incident form (W.As.2 – registration of an employer with the CF) may not be an efficient reporting mechanism.
- Increasing the reporting of occupational disease requires a combination of awareness, incentives, and efficient systems (e.g. ease of reporting, streamlining of the compensation processes), to encourage both employers and medical doctors to report occupational disease incidents.
- Employers should be informed about their legal obligations and be responsible for inculcating a reporting culture in their health and safety programmes.
- Workers must be educated about the importance of reporting occupational disease and the benefits of timely reporting, such as access to healthcare and compensation.
- In terms of monitoring and enforcement, data transparency is crucial; occupational disease data should be made publicly available, to promote awareness and track trends.

Key messages for formulating guidelines for the COID are:
- The workshop participants made good progress in terms of the list of diseases, with some consensus on which diseases should be added.
- The list must be a dynamic and living document, and must remain current.
- There is good guidance from the ILO on how to diagnose disease and adjudicate cases for compensation. The ILO list must include both exposure and disease codes; there must be alignment between the ILO and the COID lists.

The outcomes from the first day of the workshop will assist the CF with the processes of adjudication and compensation. The Chief Director of COID is expecting to receive an increased number of claims, with the associated financial impacts. A major consideration is the impending National Health Insurance (NHI) Act, which will impact what funds will be made available to the CF.

The second day was dedicated to inputs from members of academia and medical associations, and discussions around draft guidelines for mental and behavioural health, and respiratory, skin, and musculoskeletal diseases.

NEWS FROM THE GLOBAL OCCUPATIONAL HEALTH ARENA

WHWB presence at the AIHA Connect 2025 in Kansas City, USA, 16–22 May 2025

Workplace Health Without Borders (WHWB)-International hosted a meeting at the American Industrial Hygiene Association (AIHA) Connect 2025 in Kansas City, Missouri, USA, on 19 May to raise awareness of its activities and those of its branches in Australia, the UK, and the USA. WHWB and its branches are non-profit organisations, dedicated to promoting occupational health around the world. Several WHWB members participated as session organisers, moderators, or speakers at the event.



Come one, come all – WHWB meeting at AIHA Connect 2025
L to R standing: Sa Liu (USA), Mark Wilson (USA), Nicole Greeson (USA, President of AIHA), and Bert Schiller (USA)
L to R seated: Rebecca Seevers (USA, Coordinator of WHWB-International Online Training), Sashikala Chandrasekar (India), Jennifer Galvin (USA, Past President of WHWB-International and Chair of the WHWB Training Committee), Jason Green (Australia, President of WHWB-Australia), and Sheila Bubka (USA, Sound Environmental Associates NY)
Absent: Steven Verpaele (Belgium, Past WHWB Board member)
Photograph: Cheryl Schiller (WHWB-US)

News from ICOH

The next international congress of the International Commission on Occupational Health (ICOH), the 35th International Congress on Occupational Health (ICOH2027), will be held in Mumbai, India, from 14 to 19 February 2027, with the theme, *Occupational Health, Safety, and Environment – Growth and Sustainability in Changing Times*. The first announcement of the ICOH2027 Congress has been published: https://www.icohweb.org/site/multimedia/events/pdf/ICOH%202027%20FIRST%20ANNOUNCEMENT_hyperlinked.pdf.

Update on the ICOH webinar series

Following the successful launch of this new initiative in October 2024, webinars have been offered free of charge to ICOH members, who can register on the ICOH website to participate. The recordings of the webinars become available within a couple of months in the restricted area (member zone) of the ICOH website, for access on demand. The webinars that have been offered through to the end of June 2025 are as follows:

- Webinar 1 (21 October 2024) – Connection from occupational practice to research and global evidence: an ICOH webinar for practitioners
- Webinar 2 (14 January 2025) – Emergencies in occupational medicine
- Webinar 3 (17 April 2025) – Human biomonitoring: applications in occupational exposure assessment
- Webinar 4 (14 May 2025) – Wildfires and occupational health of firefighters
- Webinar 5 (26 June 2025) – *Le monde de la santé au travail francophone* (French) [The French-speaking world of occupational health]

Support for NIOSH, USA

ICOH, the International Ergonomics Association (IEA), and the Collegium Ramazzini, representing their individual and collective members from more than 100 countries, joined forces to express grave concern about the perturbing news of massive layoffs of staff from the National Institute of Occupational Safety and Health (NIOSH, USA) – employees, research scientists, and leadership – and the closure of NIOSH offices, infrastructure, and programmes. The joint statement on the crucial role of NIOSH for workers' health, globally, over many decades, is accessible at: https://www.icohweb.org/site/multimedia/news/pdf/Joint%20ICOH%20IEA%20CR%20statement%20for%20NIOSH.pdf

NEWS FROM THE SASOM NATIONAL OFFICE

ICOH survey on occupational biohazards post-COVID-19

The SASOM National Office and the ICOH National Secretary (NS) for South Africa, Claudina Nogueira, contributed to a survey on occupational biohazards post-COVID-19. The ICOH President, Dr Seong Kyu-Kang, endorsed the survey being undertaken by the ICOH Scientific Committee on Biohazards and Occupational Health (SC BOH), and the ICOH Vice President for NSs, Dr Shyam Pingle, supports the initiative. The aim of the SC BOH survey is to identify the current surveillance, reporting mechanisms, and management of occupational biohazards, and any additional information, on the priority occupational biohazards and groups of exposed workers in ICOH member countries. SC BOH has requested assistance from the ICOH NSs to obtain relevant information on both occupational infectious and non-infectious diseases caused by biological agents from ICOH member countries, which are estimated to represent a sizeable portion of the global workforce.

SASOM – monthly CPD meetings and proposed topics for Q3 and Q4 of 2025

Date	Topics	Responsibility
July	Mid-year holidays	-
12 August	Designing a medical surveillance programme (from HIRA to OREPs) (TBC)	Haidee Williams SASOM Western Cape Chapter
29 August 14:00–18:00	**SASOM national Webinar 2** Theme: *Occupational health of informal and migrant workers* 1. Save the date – First International Conference of the Global Coalition on Informal Workers' Health and Wellbeing (GCIW) 2. Panel – Perspectives on informal and migrant work from founding member organisations of GCIW – ICOH, IEA, IOHA	SASOM National Office + GCIW + ICOH + IEA + IOHA
2 September	**SASOM ExCo meeting**	
9 September	Occupational health issues in diving/ionising radiation	Jack Meintjes SASOM Western Cape Chapter
14 October	1. Workplace respiratory protection programme – 'An occupational hygiene perspective' 2. Respirator fit testing (NIOH – TBC)	Paul Neal SASOM Western Cape Chapter
11 November	Integrating OHS and Employee Wellness activities (TBC)	Charlotte Kasiringua, Tapiwa Muhamba, Yumna Williams-Mohamed SASOM Western Cape Chapter
14 November	**SASOM ExCo meeting**	
14–15 November (full day) Venue: Pretoria (TBC)	**SASOM AGM and Conference/Academic Day** – hybrid Themes: 1. *Occupational health of informal and migrant workers – identifying and addressing gaps with the assistance of Artificial Intelligence* 2. *Countdown and update – First International Conference of the Global Coalition on Informal Workers' Health and Wellbeing (GCIW)*	SASOM National Office in collaboration with GCIW, IEA, ESSA, University of Pretoria, University of Stellenbosch
December	Year-end holidays	-

CPD: continuing professional development, ESSA: Ergonomics Society of South Africa, GCIW: Global Coalition on Informal Workers' Health and Wellbeing, HIRA: hazard identification and risk assessment, ICOH: International Commission on Occupational Health, IEA: International Ergonomics Association, IOHA: International Occupational Hygiene Association, NIOH: National Institute for Occupational Health (South Africa), OREP: occupational risk exposure profile, SASOM: South African Society of Occupational Medicine, TBC: to be confirmed

A previous survey by the (then) ICOH Working Group on Occupational Infectious Agents (WG OIA, the precursor to SC BOH), covering occupational infectious diseases in 2017, elicited responses from 74% of the ICOH NSs. The SC BOH hopes to get a high response rate to assess any changes after the COVID-19 pandemic, which raised the global profile of occupational biohazards and led to the formation of SC BOH.

Update on recent technical issues and service enhancements

SASOM extends its sincere appreciation to members for their continued patience and support as the Society resolves technical and operational challenges that affected service delivery and response times from December 2024 through the first half of 2025. During this period, some members experienced difficulties accessing the digital platform to renew their annual memberships, and prospective members were unable to submit online applications. Several corrective actions have been implemented to improve communication channels and overall service efficiency. In recognition of the inconvenience caused and as a gesture of goodwill to rebuild trust, SASOM is offering a once-off 50% discount on the 2025 membership fee to new members applying for the first time. Members who join under this offer will be required to pay the full membership fee for 2026. SASOM remains committed to improving its systems and services and is grateful for the continued trust and understanding of its members. For more information, please visit www.sasom.org and note the updated contact e-mail address for the SASOM National Office: office@sasom.org

SAIOH news

The Southern African Institute for Occupational Hygiene (SAIOH) remains steadfast in its dedication to its members and the ongoing advancement of the occupational hygiene profession. In pursuit of this commitment, we regularly provide updates and share key developments with our community. SAIOH flourishes through the active participation and ethical contributions of its members, whose engagement continues to shape the field. To further strengthen our collective efforts, we welcome and encourage feedback on the topics covered in this edition of the Journal.

SAIOH PRESIDENT'S ADDRESS

Karen du Preez: SAIOH President
e-mail: president@saioh.co.za



Karen du Preez
Photograph: courtesy of SAIOH

With winter fast approaching and temperatures dropping, the risk of cold stress will be assessed at many workplaces.

Consider all risks when assessing cold stress this winter

The Occupational Health and Safety Act and the Mine Health and Safety Act require that employers identify all hazards that can affect the health and safety of employees at the workplace, assess the risk(s) associated with each hazard, and implement suitable control measures to protect the health and safety of employees.[1,2]

Workers who are required to work in cold environments for extended periods may be at risk of experiencing cold stress. Core body temperature is maintained at approximately 37 °C through thermoregulation, which is achieved through a combination of physiological responses, e.g. vasoconstriction and shivering, and change in behaviour.[3,4] When workers are exposed to cold environments without sufficient clothing or measures to prevent or limit heat loss, the core body temperature can decrease. This can trigger physiological responses and behavioural change, which can include dressing warmer, seeking shelter, or making fires in cold ambient conditions. Where work is performed outdoors, the equivalent chill temperature (ECT), which takes both dry-bulb temperature and air velocity into account, should be assessed, as this will significantly influence the perceived temperature.[5]

Carbon monoxide (CO) is a by-product of incomplete combustion of any carbon-containing materials such as wood or fossil fuels, which are often used to make fires. Combustion in areas that are poorly ventilated, such as indoor or enclosed environments, may cause accumulation of CO, which is an asphyxiant. It displaces oxygen in the blood and inhalation of high concentrations can lead to loss of consciousness and can be fatal.[6-8] Symptoms of CO poisoning include weakness, headache, dizziness, and confusion. People who fall asleep in enclosed or semi-enclosed areas, where carbon-containing materials are burned to provide heat, can perish without experiencing symptoms. [6,7]

When assessing the risk of cold stress, CO poisoning should also be considered. Where employees are required to work in cold environments, the requirements of the Environmental Regulations for Workplaces (ERW) should be followed, which include provision of shelter and clothing with adequate insulation.[9] The ERW will soon be replaced by the recently promulgated Physical Agents Regulations (PAR), which will come into effect on 6 September 2026.[10] Employees should be suitably trained and instructed to ensure they are well informed about the risks associated with exposure to cold environments and the control measures that should be implemented to prevent this. The risk of CO poisoning extends to the community, and employees should be encouraged to share information regarding this risk at home and in their communities to help prevent avoidable fatalities.

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NATIONAL COUNCIL FEEDBACK

Karen du Preez: SAIOH President
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Karen du Preez, SAIOH's newly appointed President, and Prof. Cas Badenhorst, the new Vice-president, have seamlessly transitioned into their roles, with Cas also assuming the responsibilities of SAIOH Treasurer.

During the first five months of 2025, SAIOH management actively engaged in several key meetings. The SAIOH Strategic Session and the first Council meeting were held in a hybrid format on 26 and 27 February 2025 at the SAIOH Offices in Broadacres; 12 Council members participated. On 16 April 2025, the second Management Board meeting was conducted online.

Recent engagements and key updates

- SAIOH management has actively participated in various important meetings and discussions over the past months.
- Impromptu Zoom and MS Teams sessions were held with the conference organising and planning committee to ensure smooth coordination for the SAIOH 2025 Annual Scientific Conference.
- In March 2025, the Department of Employment and Labour promulgated the new Noise Exposure and Physical Agents Regulations, which were officially launched on 11 April 2025.
- On 19 March 2025, SAIOH, the Department of Employment and Labour, and the Occupational Hygiene Approved Inspection Authorities (OH AIA) Association convened a meeting at the SAIOH offices.
- Several members of the SAIOH management team participated in the OH AIA Association meeting on 21 February 2025, where SAIOH information about activities was shared. Another OH AIA Association meeting was held on 23 May 2025.
- On 16 May 2025, SAIOH management attended the South African National Accreditation System's Occupational Hygiene Specialist Technical Committee (OH STC) meeting. Plans for a special meeting to review the new Department of Employment and Labour OH AIA report formats were discussed. Currently, 57 OH AIAs are accredited, with six new applicants.
- The SAIOH administration team held a hybrid meeting on 19 March 2025 at the SAIOH offices. Staff meetings are held on a six-week cycle, with another meeting held on 28 May 2025.

SAIOH strategic plan

The SAIOH five-year strategic plan is led by Jaco Pieterse, who is guiding its implementation. Matters arising, key targets, and progress evaluations are reviewed regularly during the monthly SAIOH Management Board meetings and the quarterly Council sessions.

Ethics

The legal review of the SAIOH Ethics Policy and Procedures has been successfully completed by NGO Law. A draft of the document has been distributed to SAIOH management for review, with a meeting scheduled for June to finalise this critical framework. The implementation of the ethics policy remains a priority initiative to facilitate the commencement of the Ethics Committee's work, as the ethics plan is an integral SAIOH strategic objective (#3).

The requirement for all SAIOH-certified members to complete an appropriate occupational hygiene ethics training course remains mandatory.

SAIOH has partnered with North-West University (NWU) to develop a dedicated ethics course, tailored to ethics in occupational hygiene. Several online meetings have been conducted to finalise a Memorandum of Understanding between SAIOH and NWU, and it is awaiting review and approval by the Management Board.

SAIOH branch activities and engagements

SAIOH continues to engage actively across its branches, with a series of successful meetings and workshops held in recent months.

- On 26 February 2025, following the Strategic Session, SAIOH Council Coordinator, Yvette Greeff, organised a productive hybrid branch workshop, attended by 12 participants.
- The Gauteng Branch convened its first meeting on 7 March 2025, drawing an exceptional attendance of more than 165 participants online, which exceeded the capacity of SAIOH's Zoom platform and caused technical difficulties. Presentations included Jeff Moredock's insightful discussion on ISO 23875 (Indoor air quality in enclosed environments), alongside a Professional Certification Committee (PCC) certification system and continuing professional development (CPD) overview, presented by Lee Doolan and Deon Jansen van Vuuren.
- The Gauteng Branch hosted its second meeting and workshop on 9 May 2025 – an in-person event at Dräger's offices in Midrand. Dräger contributed to the event's success by sponsoring gifts, raffle prizes, name tags, venue costs, and a well-curated lunch. The programme featured three impactful presentations, and three specialised 15-minute workshops focused on respiratory protection, effects of gas inhalation, filter efficiency assessments, breathing resistance evaluations, and workplace gas measurement systems. Despite the many registrations, attendance fell short, with only 31 of the 76 registered members participating.
- The KwaZulu-Natal (KZN) Branch conducted an engaging online meeting on 12 March 2025, attended by 128 participants. Presentations included:
  - Strategies for occupational health practitioners (OHPs) in assessing workplace health hazards
  - Implementation of hazardous chemical agent (HCA) programmes
  - Medical surveillance protocols for HCAs

The event featured a diverse panel of speakers, including SAIOH members and international experts such as Harold Gaze, Paul Muchemi, Dr Ivan Niranjan, Olinda Iannido, and Dr Okullo R Obako.

- The Western Cape Branch hosted a successful in-person meeting on 14 March 2025 at the Tygerberg Nature Reserve. Lesiba Joy Kekana of the U-Mask training division gave a presentation on personal protective equipment. The third Western Cape Branch meeting took place on 23 May 2025.
- Unfortunately, Central (Free State), Northern Cape, and Mpumalanga Branches, and the Zululand Discussion Group remain inactive.

SAIOH remains committed to professional development within the occupational hygiene community, through these branch-level initiatives.

SAIOH 2025 Annual Scientific Conference

The first planning meeting for the SAIOH Annual Conference took place in November 2024, during which the venue and theme were finalised, a dedicated webpage was created, and initial notifications, including the call for abstracts, were sent to all members and stakeholders. The Conference Organising and Technical Committee has held multiple meetings since November 2024.

As in previous years, the conference will be hosted in a hybrid format, allowing both in-person attendance and online participation via live streaming.

The development of the conference programme is underway, thanks to Prof. Cas Badenhorst, and the conference will commence on Monday, 20 October 2025, with two consecutive four-hour Professional Development Courses (PDCs). On Tuesday, 21 October, four additional PDCs will take place – bringing the total to six specialised PDCs. The SAIOH Council meeting is scheduled for the afternoon of 21 October. The conference will officially begin on 22 October 2025; keynote speakers have already been invited. The call for abstracts has been circulated multiple times to ensure broad participation.

On the afternoon of 22 October, the Annual General Meeting (AGM) will take place, followed by the highly anticipated Gala Dinner. The second official day of the conference will be 23 October 2025. As always, SAIOH remains committed to delivering an engaging and insightful 2025 conference experience.



New additions

- A full-day Advanced Cab Theory Workshop (ACTW) on indoor air quality (IAQ) in enclosed environments, using the simulator cab is in development for Friday, 24 October 2025, the day following the conference. This workshop will be organised by Jeff Moredock of Sy-Klone.
- Discussions are underway for the 2026 SAIOH Annual Conference.

International Occupational Hygiene Association Board, the National Accreditation Recognition Committee, and Occupational Hygiene Training Association feedback

The Occupational Hygiene Training Association (OHTA) and the International Occupational Hygiene Association (IOHA) continue to publish their newsletters, with links e-mailed to all SAIOH members and posted on the SAIOH website: www.saioh.co.za. Members can also access OHTA resources via www.ohtatraining.org.

SAIOH's newly appointed representative on the IOHA Board, Corlia Peens, has actively participated in IOHA Board and National Accreditation Recognition Committee (NARC) meetings this year, ensuring strong engagement and representation for SAIOH. The latest IOHA Board meeting took place on 24 May 2025 in New Zealand as a hybrid event.

An Occupational Hygiene Training Association (OHTA) feedback session was held on 18 February 2025 for approved training providers in southern Africa. SAIOH's OHTA representative, Peter-John Jacobs, provided valuable feedback.

Key updates

- The American Industrial Hygiene Association (AIHA) has introduced a mentorship programme at a cost of 25 USD per participant, with a special rate of 10 USD for students.
- Effective January 2025, OHTA exam fees will be 100 GBP or 125 USD per exam.
- A new pathway to the Board of Global Credentialing's (BGC's) Certified Industrial Hygienist (CIH) credential has been introduced for individuals holding the OHTA-Intermediate Certification (OHTA-ICert) qualification. Candidates must have a four-year bachelor's degree, have completed occupational hygiene courses (OHTA-ICert), and have a minimum of five years of full-time occupational hygiene experience to qualify for the CIH exam. For experience requirements, see https://gobgc.org/updated-applicant-cih-handbook/.

Excellent news

OHTA has awarded the OHTA-ICert qualification to several members, including Delvin Govender (South Africa), Sinah Seake (Botswana), and Palesa Makepe (Lesotho). This is a significant achievement for southern Africa and these SAIOH members!

SAIOH Technical Committee feedback

The SAIOH Technical Committee's research on welding fumes – specifically the measurement and analysis thereof – has been spearheaded by Dr Ivan Niranjan, SAIOH's Technical Portfolio Coordinator. A resolute sub-committee, comprising members from SAIOH and the OH AIA Association, has already convened to develop a comprehensive technical and position paper on this critical topic. The final position paper is expected to be completed later this year.

A second technical committee has been actively working on the development of technical procedures and a SAIOH position paper on heat stress management. Key partnerships are underway with the Council for Scientific and Industrial Research (CSIR) and Dr Johan Kielblock to ensure that the necessary research is conducted. The completion deadline is this year. This initiative has two objectives: to develop a technical paper, and to enable SAIOH to provide well-founded proposals to enhance the promulgated Physical Agents Regulations, which will replace the Environmental Regulations for Workplaces.

Wessel van Wyk, the former SAIOH Technical Coordinator, continues to contribute to a position paper on real-time monitoring. Once approved by the SAIOH PCC ExCo and the Technical Committee, this paper will be shared with all SAIOH members and stakeholders.

Under the leadership of Naadiya Mundy, SAIOH has launched a technical sub-committee focused on developing procedures and guidelines to assist occupational hygiene practitioners with ergonomic risk assessments. The first meeting of this sub-committee was held on 17 April 2025.

New SAIOH website

The SAIOH administration team, led by Naadiya Mundy and Kate Smart, is actively working on populating the new SAIOH website, ensuring that it is a comprehensive resource for members. We look forward to launching the new website soon and delivering an improved and streamlined platform for the SAIOH community. The Quality Management System (QMS), including the PCC Assessment procedures, is already accessible on the SAIOH website, providing essential guidance and documentation.

SAIOH publications and engagements

SAIOH continues to keep its members informed through its newsletter and President's Page, published in two electronic media:

- *Occupational Health Southern Africa* (OHSA) journal
- *African Occupational Safety and Health* (A-OS&H) magazine

The journal is published quarterly, while the magazine is released every two months. Links to both publications are shared with all members via Mailchimp and are also accessible on the SAIOH website (www.saioh.co.za).

In addition, the OHTA *Global Link* (March 2025) and *IOHA Global Exposure Manager* (GEM) (April 2025) newsletters have been posted on the SAIOH website and circulated to members via Mailchimp. Notably, Naadiya Mundy's OH Comix was featured in the January–March 2025 issue of GEM.

SAIOH representation and engagements

SAIOH actively participates in key industry meetings and discussions:

- The *Occupational Health Southern Africa* Editorial Board meeting took place on 13 March 2025; Deon Jansen van Vuuren and Prof. Johan du Plessis attended in-person and online, respectively.
- On 21 February 2025, Naadiya Mundy and Deon Jansen van Vuuren attended the first OH AIA Association meeting of 2025; 31 participants attended online.
- Jakes Jacobs represented SAIOH at the Department of Employment and Labour's Iron and Steel Workshop, held in Klerksdorp on 26–28 February 2025.

Communication and industry updates

SAIOH maintains ongoing communication with its stakeholders through various channels, including:

- e-mails and notifications via Mailchimp
- Phone calls and virtual meetings
- Dissemination of industry news, technical updates, legislative changes, new standards, job opportunities, and professional development courses

Webinars and conferences

Several occupational hygiene and health webinars have been promoted through SAIOH communications in 2025, including events hosted by:

- The International Occupational Hygiene Association (IOHA)
- The American Industrial Hygiene Association (AIHA)
- Workplace Health Without Borders (WHWB)
- The South African Society of Occupational Medicine (SASOM)
- The Ergonomics Society of South Africa (ESSA)
- The South African Society of Occupational Health Nursing Practitioners (SASOHN)
- Safety-First: PPE Conference (cancelled)

Recent online events and webinars hosted by stakeholders include:

- IOHA EXIMIOUS-EPHOR Occupational Hygiene Exposure joint symposium (20–26 March 2025)
- AIHA Connect Conference (17–21 May 2025)

Several of these events were attended by SAIOH management, members and staff, including the AIHA online seminar, 'Ensuring workplace health and safety with physiological monitoring to manage heat stress' on 20 February 2025, and the Workplace Health Without Borders' (WHWB's) Ergonomics webinar.

SAIOH remains committed to ensuring that members have access to the latest industry developments, training opportunities, and thought leadership in occupational hygiene.

PROFESSIONAL CERTIFICATION COMMITTEE

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The PCC ExCo held its first online meeting on 28 February 2025, followed by the PCC meeting on 28 March 2025.

Key updates from the PCC

- The sub-committee that is developing the Occupational Hygiene Skill Set for the self-assessment tool has made significant progress. The first draft was completed earlier this year and is being refined and reviewed before submission for PCC approval. The seven-member team continues to meet bi-weekly. Work is also underway to develop oral question scenarios and review the PCC oral assessment guideline.
- The sub-committee held online training sessions for PCC assessors: 14 February and 30 May 2025.
- A hybrid PCC PDC will be offered on the Skill Set and oral assessments at the 2025 SAIOH Annual Conference, accessible to all SAIOH members.
- Efforts continue to develop an electronic written assessment system on the MS Excel platform to replace the current LMS electronic assessment. Alternatives are being explored, including leveraging MySAIOH's functionality, to resolve technical challenges and improve administration of the assessments by the PCC administration team. Transitioning all certification assessments to a multiple-choice format has proven to be more complex than anticipated, and work on this initiative is ongoing.

Table 1. SAIOH PCC certification assessment results as of May 2025

Certification category	Written assessments				Oral assessments			
	Assessed	Passed	Failed	Pass rate	Assessed	Passed	Failed	Pass rate
	n	n	n	%	n	n	n	%
OH assistant	40	40	0	100	0	-	-	-
OH technologist	17	16	1	94.1	20	14	6	70.0
Occupational hygienist	18	11	7	61.1	14	9	5	64.3
Total	**75**	**67**	**8**	**89.3**	**34**	**23**	**11**	**67.7**

Table 2. SAIOH PCC written and oral assessment dates and deadlines, 2025

Assessment type	Deadline for applications	Deadline for assessment evaluations and payment	Assessment date
Written	12 January	14 February	14 March
Oral	-	-	Week of 11 April
Written	25 April	30 May	27 June
Oral	-	-	Week of 25 July
Written	1 August	5 September	3 October
Oral	-	-	Week of 14 November

- Due to system development challenges, written assessments in 2025 will continue in hard copy format until the new electronic system is implemented.
- The first quarter's written assessments were conducted on 28 February 2025, with oral assessments held between 28 March and 2 May 2025.

Certification assessments

A summary of results for the assessments that took place from February to May 2025 is provided in Table 1.

Additional PCC updates

- The updated Assessment Procedure/Guideline and Self-Assessment Tool will be launched at the SAIOH Annual Conference as part of a PDC.
- From 1 February 2025, no SAIOH certificates will be released to members who do not meet all registration criteria, e.g. meeting the required annual CPD claims, ethics certificate, and payment of annual membership and other outstanding fees.
- As of January 2025, the PCC ExCo is composed of:
  - Dr Ivan Niranjan – PCC Chair
  - Andre van Rooyen – PCC Vice Chair
  - Dr Goitsemang Keretetse – PCC Chief Examiner
  - Deon Jansen van Vuuren – SAIOH General Manager
  - Lee Doolan – PCC Administrator
  - Corlia Peens – SAIOH representative at IOHA and the NAR Committees
  - Jaco van Rensburg and Andrew Dickson – PCC Examination Committee and Continuous Professional Development (CPD) Review Panel

The PCC assessment dates for 2025 are in Table 2.

Occupational Hygiene Skills Forum

The Occupational Hygiene Skills Forum (OHSF) continues to engage actively in the OHTA Approved Training Provider forum meetings. The first two OHSF meetings for 2025 took place on 6 March and 22 May 2025. A key function of the OHSF is the evaluation of occupational hygiene-related qualifications from tertiary institutions. The Cape Peninsula University of Technology (CPUT) occupational health qualification has received approval from the PCC ExCo. Discussions with institutions in Botswana and Uganda are scheduled for later in 2025, while engagements with the Durban University of Technology, University of Pretoria, University of Johannesburg, and the University of Limpopo are ongoing.

Tertiary institutions offering occupational hygiene qualifications are encouraged to contact the PCC Administrator (lee@saioh.co.za) for recognition application details. Information on approved training providers and qualifications is available on the SAIOH website (www.saioh.co.za), helping students and certification candidates to identify suitable programmes aligned with SAIOH and international certification standards.

The OHSF was established to coordinate the recognition of occupational hygiene training materials, including asbestos courses, training providers, and institutions, while also overseeing assessment and examination systems, where appropriate.

To strengthen industry knowledge, the OHSF is looking at developing an in-house occupational hygiene legislation course for non-AIA members.

Dr Hennie van der Westhuizen has contributed to an initiative incorporating CPD questions based on *Occupational Health Southern Africa* articles, enhancing member engagement with the publication. SAIOH is ready to launch this initiative – thank you, Hennie!

Mine Medical Professionals Association Annual General Meeting 2025

Dr Mzwandile Dlamini: Senior Occupational Medical Practitioner, Platmed Amandelbult; MMPA President
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INTRODUCTION

The Mine Medical Professionals Association (MMPA) held its Annual General Meeting (AGM) on 12 April 2025 at Alchemy Health in Bryanston. The event culminated in the election of new leadership, comprising the MMPA President and Vice President, and new Council members, who will be driving the growth of the Association. Occupational medical practitioners (OMPs) from various mining houses, compensation institutions such as Rand Mutual Assurance, the Medical Inspector, and Mines Professional Associations' Secretariat (MPAS) support staff were in attendance. Members were welcomed by Dr Tumi Legobye, outgoing MMPA President, who chaired the meeting, which commenced with two case presentations prior to the AGM.

FIRST SESSION

Dr Philani Ntombela, an orthopaedic surgeon practising at Lenmed Randfontein hospital, with an interest in tumour and sepsis, presented a case of osteosarcoma from a gold mine. Dr Mzwakhe Khumalo, an orthopaedic specialist with an interest in spine orthopaedics, was also involved in the management of the patient and co-presented the case with Dr Ntombela.

Osteosarcoma case

A 39-year-old miner presented with a three-year history of right knee pain and a popliteal mass. Further enquiry elicited no contributing medical or surgical history. Clinical examination revealed a 5 x 5 cm mass above the joint line. The limb was neurovascular intact and the systemic exam was normal. Following numerous primary healthcare visits, the patient was referred to the orthopaedic surgeon, who conducted several investigations and diagnosed the patient with osteosarcoma.

Learning points

- A detailed history and examination are essential to make an accurate diagnosis and avert unnecessary investigations
- Consider referral if a patient repeatedly comes to the medical centre with the same symptoms despite receiving treatment
- X-rays offer a substantial amount of information
- Osteosarcoma is the most common bone cancer in adolescents and young adults
- Disease-free survival rate has improved over the years, but remains relatively low
- Surgery and chemotherapy are treatment options for osteosarcoma

SECOND SESSION

Dr Dipalesa Mokoboto, the Medical Inspector from the Department of Mineral and Petroleum Resources (DMPR) and Past President of the MMPA, provided an interactive session titled 'Sensory disputes'. The presentation comprised two interesting, complex cases referred to her via Section 20 of the Mine Health and Safety Act (MHSA) No. 29 of 1996. Dr Mokoboto kickstarted the session by reviewing important concepts in occupational medicine, which were imperative in the discussion of the two cases. She reminded the audience that the definition of an occupational disease is a disease/disorder that is primarily caused by exposure(s) directly



Dr Mzwandile Dlamini (L) presenting Dr Tumi Legobye (R) with a certificate of appreciation
Photograph: Courtesy of MMPA



Dr Dipalesa Mokoboto, Medical Inspector, presenting 'Sensory disputes'
Photograph: Courtesy of MMPA



Dr Mzwakhe Khumalo (L) receiving a token of appreciation from Dr Tumi Legobye (R)
Photograph: Courtesy of MMPA



Dr Philani Ntombela (L) receiving a token of appreciation from Dr Tumi Legobye (R)
Photograph: Courtesy of MMPA

arising from work activities. She also shared the requirements of Section 20 medical appeals under the MHSA, indicating that an appeal may be lodged for two reasons:

- When an employee disputes the unfitness status as determined by the OMP
- When an employee appeals any findings of the OMP as contained in the exit medical certificate prepared under Section 17 of the MHSA

Case 1

A 43-year-old miner had 20 years' work experience in noisy areas underground, where workplace noise levels were as high as 99 dBA. He had no comorbidities and no known ear pathology. A diagnostic audiogram confirmed a dead right ear. The percentage loss of hearing was 7.3% and he had an average bilateral hearing loss of 63.5%. The employee was declared unfit to work in noisy areas and his exit certificate stated non-occupational-related hearing loss. The employee disputed the fact that his hearing loss was non-occupational and that he was not eligible for compensation.

Learning points

- The Medical Inspector reminded OMPs of the two reasons for lodging a Section 20 medical appeal
- Noise-induced hearing loss can present as unilateral hearing loss
- Thorough Section 11.5 investigations of the MHSA are paramount in finding root causes and will assist the South African mining industry (SAMI) to reach its noise-related milestones
- This case highlighted the financial and social burdens associated with medical incapacity, where an employee expects to be compensated but does not meet the requirements for compensation. This necessitates comprehensive counselling and support of employees prior to medical boarding, to clarify the expectation and disappointment of not being compensated.

Case 2

A 53-year-old employee of a mining house had experience in various occupations at the mine since 2000. He had worked as an onsetter and a banksman, and had recently relieved a co-worker as a winding engine driver. The employee was known to have a congenital right eye pathology and, as a result, had diminished visual acuity in the right eye. Fourteen years later, the employee was subjected to a medical incapacity process due to his reduced visual acuity, thus failing to meet the minimal standards of fitness to work at a mine.

Learning points

- Each medical incapacity case should be considered according to its own merits
- An employee born with monocular vision adjusts and adapts to his/her condition; the other eye compensates for the deficiency
- When employees change roles at work, a transfer medical is imperative to record the employee's medical status with regard to the job requirements, as stated on the occupational risk exposure profile
- It takes two-to-three years for the eye to accommodate and develop vision depth perception after an eye injury
- It is essential to seek the expertise of an ophthalmologist when deemed necessary

ANNUAL GENERAL MEETING

Members of the MMPA were welcomed by Dr Tumi Legobye, the immediate Past President. Dr Legobye provided an overview of the MMPA's operational and financial performances during the past financial year. She highlighted the importance of paying yearly membership fees timeously for the sustainability of the MMPA, and thanked those who have paid. She then nominated Dr Mwandile Dlamini, outgoing Vice President, for the position of incoming President. Dr Dlamini presented Dr Tumi Legobye with a certificate of appreciation for her strategic leadership. Dr Angel Ndhlovu was elected as the incoming Vice President.

The following individuals were nominated as members of the new MMPA Council:

Dr Vusumuzi Ndlovu – OMP, Kumba Iron Ore, Anglo American
Dr Sifiso Ngcobo – Medical Advisor, Rand Mutual Assurance
Dr Fezile Gabela – OMP, Seriti Resources
Khanani Ramoshaba – Noise Adoption Team Manager, Minerals Council South Africa
Dr Richard Schmidt – OMP, De Beers, Venetia
Dr Miranda Moloto – Head of Rehabilitation, Rand Mutual Assurance

The full MMPA Council, including co-opted members, will be listed in the next issue of *Occupational Health Southern Africa*.