

# Occupational health

SOUTHERN AFRICA

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- Southern African Institute for Occupational Hygiene
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## From the Editor . . .



**Gill Nelson,  
Editor-in-Chief**

**W**elcome to the start of another new year, and our 25th volume of *Occupational Health Southern Africa*. In continually striving to improve the Journal, we introduce new improved aspects at the start of each year. In 2017, we stopped the practice of including sponsors' advertisements on the same pages as the scientific papers. In 2018,

you will have noticed that we introduced continuous page numbering, starting at page 1 in the Jan/Feb issue, and ending on page 203 in the Nov/Dec issue. This year, we require that all research papers include a list of contributions from the authors. All these changes are in line with international norms, and are in preparation for our application for international recognition of *Occupational Health Southern Africa*. As most of you know, the Journal is already accredited with the Department of Higher Education and Training. Accreditation, once achieved, is not for life; we need to adhere to a high standard to maintain our status, and reapply to the administering body every five years.

This issue is packed with news, reports and research. We also feature Karen Michell, the longest-serving Editorial Board member since the Journal started, and celebrate her personal and professional achievements.

SAIOH and SASOHN members feature strongly in this issue. Derk Brouwer and colleagues from the University of the Witwatersrand discuss the differences (and similarities) between occupational hygiene and exposure science. This is particularly relevant as Wits has introduced a new MSc in Exposure Science this year. Not to be outdone, research colleagues from North-West University present a technical review of six inhalable aerosol samplers. We hope that this will generate discussion amongst our SAIOH members (and other occupational hygienists). Only a step away from

inhalable exposures, Muthelo and her fellow researchers have taken a slightly different tack with regard to noise-induced hearing loss (NIHL), by asking mine workers and hearing conservation programme managers about their perceptions with regard to factors that cause the impairment. Disappointingly, the original NIHL-related milestones set by the Mine Health and Safety Council were not met, by a long shot. We hope that the targets set for 2024 are more realistically achievable.

SASOM, SASOHN and SAIOH continue to provide members and non-members alike with interesting news and reports of past events. It is encouraging to the occupational health community that the Societies are growing – in member numbers, the quality and quantity of scientific meetings, and international participation.

Finally, I would like to draw your early attention to an international conference that will be held in Durban in May 2020. The 7th International Conference on the History of Occupational and Environmental Health will be hosted by the University of KwaZulu-Natal (see our Events page for contact details). This gives you ample time to prepare abstracts for submission to what promises to be a fascinating event, especially if some of our country's more senior occupational health practitioners agree to come out of retirement for a brief period and share both their knowledge and memories. South Africa has led the world in many aspects of occupational health, stemming primarily from the long-standing interest of occupational health practitioners in mining-related diseases. There is also a growing occupational health community across Africa – we therefore look forward to strong participation from our continent.

On behalf of the *Occupational Health Southern Africa* team, I wish you a productive and exciting 2019.

# Upcoming events

## LOCAL EVENTS

DATE	PLACE	EVENT	MORE INFORMATION
9 May 2019	Emperors Palace Conference Centre, Kempton Park, Gauteng	SASOHN Academic Day	E-mail: <a href="mailto:office@sasohn.co.za">office@sasohn.co.za</a> Website: <a href="http://www.sasohn.co.za/home.php">www.sasohn.co.za/home.php</a>
29-31 May 2019	Emperors Palace Conference Centre, Kempton Park, Gauteng	Mine Ventilation Society of South Africa (MVSSA) Conference 2019	E-mail: <a href="mailto:secretary@mvssa.co.za">secretary@mvssa.co.za</a> Website: <a href="http://www.mvssa.co.za">www.mvssa.co.za</a>
24-26 Jul 2019	Durban Exhibition Centre, Durban, KwaZulu-Natal	KwaZulu-Natal Industrial Technology Exhibition (KITE)	E-mail: <a href="mailto:info@kznindustrial.co.za">info@kznindustrial.co.za</a> Website: <a href="http://www.kznindustrial.co.za">www.kznindustrial.co.za</a>
31 Jul-3 Aug 2019	Protea Hotel by Marriott, OR Tambo International Airport, Kempton Park, Gauteng	Joint SASOM-MEDICHEM Conference	E-mail: <a href="mailto:info@sasom.org">info@sasom.org</a> Website: <a href="http://www.sasom.org">www.sasom.org</a>
18-19 Sep 2019	Emperors Palace Conference Centre, Kempton Park, Gauteng	OSHAfrica 2019 Conference	E-mail: <a href="mailto:info@oshafrica2019.com">info@oshafrica2019.com</a> Website: <a href="http://www.oshafrica2019.com">www.oshafrica2019.com</a>
1 Nov 2019	CSIR, Pretoria, Gauteng	SASOHN Conference	E-mail: <a href="mailto:office@sasohn.co.za">office@sasohn.co.za</a> Website: <a href="http://www.sasohn.co.za/home.php">www.sasohn.co.za/home.php</a>
27-29 May 2020	University of KwaZulu-Natal, Durban, KwaZulu-Natal	7th International Conference on the History of Occupational and Environmental Health	E-mail: <a href="mailto:icohhistory2020@ukzn.ac.za">icohhistory2020@ukzn.ac.za</a> Website: <a href="http://icohhistory2020.ukzn.ac.za">http://icohhistory2020.ukzn.ac.za</a>

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3-7 Mar 2019	Antalya, Turkey	3rd International Occupational and Environmental Diseases Congress	E-mail: <a href="mailto:oedc2019@ftskongre.org">oedc2019@ftskongre.org</a> Website: <a href="http://www.oedc2019.org">www.oedc2019.org</a>
20-22 Mar 2019	Frankfurt, Germany	International Conference on Toxicology and Risk Assessment	E-mail: <a href="mailto:toxicology@madridge.com">toxicology@madridge.com</a> Website: <a href="https://toxicology.madridge.com/">https://toxicology.madridge.com/</a>
24-26 Apr 2019	Budapest, Hungary	7th Federation of Occupational Health Nurses within the European Union (FOHNEU) International Congress	E-mail: <a href="mailto:fohneupresident@gmail.com">fohneupresident@gmail.com</a> Website: <a href="http://www.fohneu.org/7th%20Congress">http://www.fohneu.org/7th%20Congress</a>
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22-24 May 2019	Paris Issy-les-Moulineaux, France	Fifth International Conference on Wellbeing at Work	E-mail: <a href="mailto:waw2019@inrs.fr">waw2019@inrs.fr</a> Website: <a href="http://www.inrs-waw2019.fr">www.inrs-waw2019.fr</a>
5-7 Jun 2019	Odense, Denmark	Work Disability Prevention and Integration Conference 2019	E-mail: <a href="mailto:m.jensen@nikkb.dk">m.jensen@nikkb.dk</a> Website: <a href="http://wdpi2019.dk">http://wdpi2019.dk</a>
17-18 Jun 2019	London, UK	7th World Congress on Nursing & Healthcare (WCNH-2019)	E-mail: <a href="mailto:wcnh-2019@scientificfederation.com">wcnh-2019@scientificfederation.com</a> Website: <a href="https://www.scientificfederation.com/wcnh-2019/">https://www.scientificfederation.com/wcnh-2019/</a>
28-30 Aug 2019	Leuven, Belgium	11th International Symposium on Biological Monitoring in Occupational and Environmental Health	Website: <a href="https://kuleuvencongres.be/isbm-11/">https://kuleuvencongres.be/isbm-11/</a>
2-5 Sep 2019	Bologna, Italy	PREMUS 2019 - 10th International Scientific Conference on the Prevention of Work-Related Musculoskeletal Disorders	E-mail: <a href="mailto:roberta.bonfiglioli@uniibo.it">roberta.bonfiglioli@uniibo.it</a>
8-11 Sep 2019	Helsinki, Finland	EUROTOX 2019	E-mail: <a href="mailto:kai.savolainen@ttl.fi">kai.savolainen@ttl.fi</a> Website: <a href="http://www.ttl.fi">http://www.ttl.fi</a>
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# Farewell to Karen Michell

**D**r Karen Michell, PhD, Fellow of the Academy of Nursing of South Africa, South African Society of Occupational Health Nursing Practitioners (SASOHN) Honorary Life Member, South African Institute of Occupational Safety and Health (Saiosh) member, and Occupational Health and Safety (OHS) Consultant at Concept Safety Systems, recently resigned from the Editorial Board (EB) of *Occupational Health Southern Africa*. Karen is the longest-serving member of the Board, having been nominated in 2001. When she began, she was, in her words, “a novice with limited understanding of the process required to take a scientific manuscript from submission to publication”. She counts herself as fortunate to have worked with two editors at this early time – Dr Fiona Robinson and Dr Linda Grainger – who served as mentors, and helped her to appreciate the hard work that goes into the publication of a peer-reviewed paper. This was at a time when the Journal had no academic accreditation and the Board wanted to change this. The change included the need to engage with a publisher who shared our vision of attaining academic accreditation. Karen was instrumental in engaging Kevin Beaumont from Technique who remains the Journal’s publishing partner (although he moved away from Technique and now has his own publishing company, MettaMedia).

As the Journal is the official mouthpiece of SASOHN and three other professional Societies, namely the Southern African Institute for Occupational Hygiene (SAIOH), the South African Society of Occupational Medicine (SASOM) and the Mine Medical Professionals Association (MMPA), Karen encouraged occupational health nurses to write and submit scientific papers, based on their research, to the Journal. A motivational initiative was the introduction of the SASOHN award to the occupational health



Dr Karen Michell

nursing practitioner (OHNP) judged as having the best published paper in the Journal during a prescribed 12-month period. There have been a number of recipients of this award, and Karen was herself honoured with the award on two occasions.

Another of Karen’s initiatives was the implementation of a writing skills workshop for OHNPs. The workshop objective was to encourage and promote writing within this professional group. A few papers did emerge as a result of this workshop but it has sadly not yielded the desired number of publications.

Representing SASOHN as a Board member has been a challenge in many respects. Karen’s biggest challenge was to fulfil her EB duties while completing her doctoral degree. We are very proud to announce that she graduated from the University of the Witwatersrand with a PhD in December 2018.

In her farewell message to the EB, Karen said, “I wish to thank all the Board members with whom I have served over the years, for their support and friendship on both a professional and personal level. It has been a period of significant change in the Journal, including the ongoing quality improvement and the professional recognition through academic accreditation. I am a true believer that it is only we, as professionals, who can improve the recognition of our professions, and the Journal is a very positive vehicle for this growth. I wish Gill Nelson, Editor-in-Chief, and the Board, success with all future endeavours in enhancing the Journal’s academic status.”

In return, the *Occupational Health Southern Africa* team wishes Karen a successful and happy future. She has been one of the most productive Board members that we have had, and her boundless knowledge, energy, and enthusiasm for occupational health will be greatly missed.

## 2018 Reviewers

We are most grateful to our reviewers for their evaluation and guidance on articles that are submitted to the Journal. As always, we acknowledge this contribution by listing those who assisted in 2018. Their names and countries are listed below, in alphabetical order.

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# Transformation of occupational hygiene into exposure science to meet practice demands in the 21st century

D Brouwer, D Masekamani, G Keretsetse

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## INTRODUCTION

Over our lifetimes we are exposed, daily, to agents that have the potential to affect our health – through the personal care products we use, our water intake, the food we eat, the soil and surfaces we touch, and the air we breathe. With this holistic view, described as the human ‘exposome’, exposure science addresses the intensity and duration of contact of humans or other organisms with those agents (defined as chemical, physical or biologic stressors) and their fate in living systems.<sup>1</sup> Recently, a number of reports have been published by the US National Academy of Sciences, which elaborate on exposure science and its role in risk assessment.<sup>2,3</sup> Exposure science is described by the National Research Council (NRC) as “the collection and analysis of quantitative and qualitative information needed to understand the nature of the contact between physical, chemical or biological stressors, and receptors”, e.g. residents, consumers, workers, etc.<sup>2</sup> Importantly, at the level of the receptor, this contact, defined as an ‘exposure event’<sup>4,5</sup> results in intake, uptake, dose and, possibly, an (adverse) health effect (Figure 1).

In order to harmonise exposure-related terms, the International Society for Exposure Analysis (now the International Society for Exposure Science) adopted an official glossary in 2005<sup>5</sup> (which was amended by Mattingly et al., 2012) to their Exposure Science Ontology framework.<sup>4</sup> In the amendment, the terms ‘agent’ and ‘target’ were replaced with ‘exposure stressor’ and ‘exposure receptor’, respectively (Table 1).

The concept of the exposome requires consideration of an individual’s exposure over the lifecourse rather than focusing on a specific exposure stressor in a specific domain, e.g. residential, consumer or occupational exposure, over a defined period.<sup>1,7-9</sup> The concept of an aggregate exposure pathway,<sup>10</sup> representing

multiple sources and transfer through single pathways to the target site exposure (TSE), single sources and transfer through multiple pathways to the TSE, or any combination thereof,<sup>11</sup> should raise awareness about the contribution of the exposure from various domains. Focusing on the contribution to the lifetime exposure of the working lifestage, a number of attributes of occupational exposure are relevant. First, exposure associated with, and emanating from, occupational sources will (most likely) occur during adulthood – the lifestage during which an individual is considered to be less susceptible than childhood, adolescence and late adulthood. Second, occupational exposure is temporally intermittent, i.e. periods of exposure are followed by periods of absence of exposure, e.g. before and after work, weekends, and vacation periods, which is pivotal to physiological recovery, i.e. clearance, metabolism, excretion, etc. Third, levels of occupational exposure can substantially exceed exposure levels in other domains.

Not surprisingly, there are some similarities between the descriptions of exposure science and occupational hygiene. The International Occupational Hygiene Association (IOHA) provides the following description: “Occupational hygiene is the discipline of anticipating, recognising, evaluating and controlling health hazards in the working environment with the objective of protecting worker health and well-being and safeguarding the community at large”.<sup>12</sup> Occupational hygiene has also been defined as the practice of identifying hazardous agents in the workplace (chemical, physical and biological) that could cause disease or discomfort, evaluating the extent of the risk due to exposure to these agents, and the control of the risks to prevent ill-health in the long or short term.<sup>12</sup>

Apart from including biomechanical and psychological stressors in occupational hygiene, another important difference with regard to the definition of exposure science by the NRC<sup>2</sup> is that, in the definition of occupational hygiene, the terms ‘control’ (of exposure and risk) and ‘prevention’ (from an adverse outcome) are explicitly used. This makes sense since, in contrast to other exposures, e.g. through ambient air, water or food, exposure in the work environment can be relatively easily controlled as the exposure source is, in most cases, in the worker’s (micro) environment, or even emanates from the activity of the worker himself or herself. It should be noted, however, that a number of scientists had already addressed the prevention issue in 2006, when they described exposure science as “the study of human contact with



**Figure 1. Pathways of the stressor from source to receptor, and the fate in the receptor, resulting in an (adverse) effect (figure inspired by US-EPA, 2016<sup>6</sup>)**

**Table 1. Definition of some terms used in exposure science**

Term	Definition	Reference
Absorption barrier	Any exposure surface that may retard the rate of penetration of an exposure stressor into an exposure receptor	Zarterian et al., 2005 <sup>5</sup> Mattingly et al., 2012 <sup>4</sup>
Dose	The amount of an exposure stressor that enters an exposure receptor after crossing an exposure surface. If the exposure surface is an absorption barrier, the dose is the absorbed/uptake dose; otherwise, it is an intake dose	Zarterian et al., 2005 <sup>5</sup> Mattingly et al., 2012 <sup>4</sup>
Exposure	Contact between a stressor and a receptor. Contact takes place at an exposure surface over an exposure period. A person's contact with the concentration of a material before and after it crosses a boundary (nose, skin or mouth) between the human and the environment, over an interval of time leading to a potential biological effective dose	Zarterian et al., 2005 <sup>5</sup> Mattingly et al., 2012 <sup>4</sup>  NRC, 2012 <sup>2</sup>
Exposure event	An interaction between an exposure stressor and exposure receptor	Mattingly et al., 2012 <sup>4</sup>
Exposure receptor	An entity that interacts with an exposure stressor during an exposure event	Mattingly et al., 2012 <sup>4</sup>
Exposure stressor	An agent, stimulus, activity or event that causes stress or tension on an organ and interacts with an exposure receptor during an exposure event	Mattingly et al., 2012 <sup>4</sup>
Exposure surface	A surface on an exposure receptor where an exposure stressor is present. Examples of outer exposure surfaces are the conceptual surface over the nose and open mouth, and the skin surface. Examples of inner exposure surfaces are the respiratory and gastro-intestinal tracts	Zarterian et al., 2005 <sup>5</sup> Mattingly et al., 2012 <sup>4</sup>
Intake	The process by which an exposure stressor crosses an outer exposure surface of an exposure receptor without passing an absorption barrier, e.g. through inhalation or ingestion. Inhalation intake = concentration (mg/m <sup>3</sup> ) x inhalation rate (l/min) x exposure duration (min)	Zarterian et al., 2005 <sup>5</sup> Mattingly et al., 2012 <sup>4</sup>
Uptake	The process by which an exposure stressor crosses an absorption barrier	Zarterian et al., 2005 <sup>5</sup> Mattingly et al., 2012 <sup>4</sup>

chemical, physical or biological agents in their environments, and advanced knowledge of the mechanisms and dynamics of events either causing or preventing adverse health outcomes".<sup>13</sup>

The application of exposure science in risk evaluations is expected to develop risk assessments of individuals rather than groups further, by improved exposure assessment of individuals through better characterisation of the various micro-environments, and detailed activity (residence) time patterns of individuals and the use of (relatively) low-cost sensors in combination with tracking systems.<sup>14</sup> In addition, computational exposure assessments (use of exposure models) and statistical techniques, e.g. Monte Carlo simulations and Bayesian statistics, in combination with appropriate high-throughput toxicological screening techniques, will enhance probabilistic risk assessments which take into account variances in the populations and stressor levels.<sup>3,15</sup> This will replace the often-used (in occupational hygiene) simplification of the risk assessment, i.e. the ratio between a time-weighted average (TWA8h) and an occupational exposure limit (OEL).

In this paper, we advocate transforming the discipline of occupational hygiene into a sub-specialism of exposure science.

## THE PRINCIPLES OF EXPOSURE SCIENCE

Exposure can be considered to be the result of a cascade of underlying processes which, in general terms, can be described by a source-receptor model with the key elements of release, emission, transmission and immission (Table 2). At the source, a chemical/biological agent or physical stressor is released by natural or anthropometric processes, e.g. volatilisation, evaporation, leaching, combustion, mechanical stress, etc. After release, the stressor is emitted to a compartment such as ambient or indoor/workplace air, surface water, soil, or the skin. The transmission process within the compartment is affected by numerous processes (ventilation, air currents, etc.) which, in the air compartment, govern agglomeration, deposition (of aerosols) and dilution; in some cases, resuspension of the deposited particles may occur. In other compartments, e.g. the skin, surface transmission is driven by diffusion at the molecular level (permeation). Immission is a generic term and alternative terms are used specifically for inhalation exposure: 1) the concentration and particle size distribution in the near field (referred to as a virtual cube 1 m around the nose and mouth of the receptor which may be the worker)<sup>16</sup> and, 2) the breathing zone concentration (usually within a 0.3 m (or 10 inch))

**Table 2. Key processes of a source-receptor model**

Term	Description
Release	The liberation of a stressor during a natural or technical process, which may be expressed without a specific metric, as a dispersion-specific fraction or percentage of the total release, or as a mass per unit of area or unit quantity of the matrix
Emission	The transfer process of a liberated stressor to a compartment, e.g. the workplace air; usually expressed as flow, e.g. quantity per unit time or unit of area
Transmission	The transfer of a liberated stressor to the receptor through the compartment, e.g. the workplace air. Efficacy is determined by interception or distraction (e.g. absorbent materials or baffles, in the case of noise), dilution by ventilation (in the case of chemical and biological stressors), and deposition and resuspension (in the case of particles)
Immission	The introduction of the stressor into the near field zone of the receptor; usually expressed as a concentration or an energy/ pressure level
Exposure (event)	The contact of the stressor at an exposure surface over an exposure period; usually expressed as concentration, or an energy/pressure level x exposure duration, or as a time weighted average (TWA) over the exposure period

radius of the nose and mouth).<sup>17</sup> The assumptions are that a contaminant in the near field zone is homogeneously distributed, and that its concentration is equivalent to the concentration inhaled by the receptor. It should be noted that in life cycle assessment (LCA) and residential and consumer exposure assessment, the term 'near field' is used for the indoor environment to distinguish from 'far field' pathways, such as ambient air, soil, drinking water and diet.<sup>18</sup>

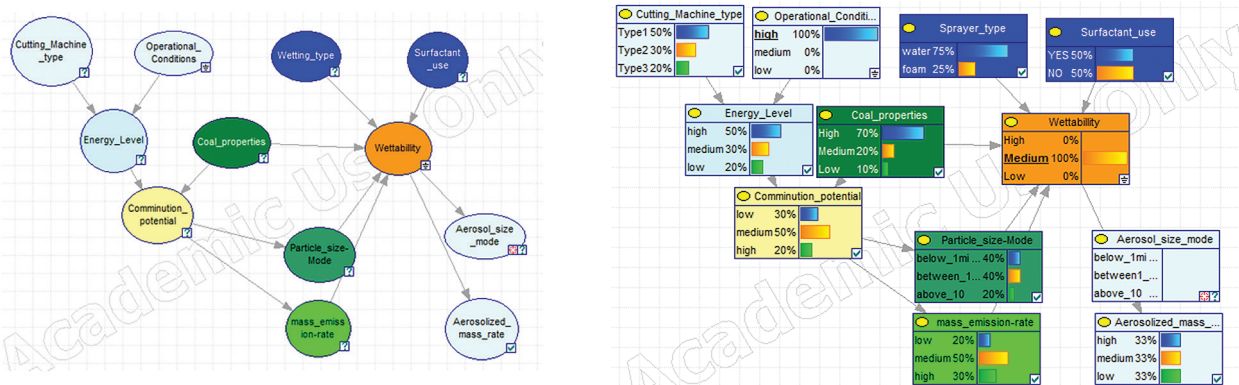
If no personal protective equipment (PPE) is used, e.g. respiratory, skin or ear protection, the near field concentration will be equal to the concentration at the exposure surface, i.e. the conceptual surface over the nose and mouth, skin, and ear, respectively (Table 1). If PPE is used, the exposure concentration will be the attenuated 'near field' concentration. Note that the transmission process can also be direct contact, e.g. direct contact of the skin with water while swimming, or with indoor surfaces.

**SCRUTINISING THE UNDERLYING PROCESSES**

The underlying processes that result in exposure might be complex as each process is governed by determinants and modifying factors. To illustrate the complexity, on one hand, and, on the other hand, to show how this complexity can be reduced by breaking it into sections, the following scenario is presented as an example:

extracting coal in an underground room and pillar type of mine, using a continuous miner (CM). In this scenario, the release of coal dust will be determined by 1) the CM-type and, 2) the conditions under which the CM is operating. In combination, these factors will determine the energy level of the fragmentation (the stress level) that will be employed. This stress level, in combination with the properties of the coal, e.g. type (rank – degree of metamorphism, and grade – range of impurities) will determine the ease of fragmenting. The level of comminution will determine which fraction of the released particles will emanate in debris (the actual product) and which fraction has the potential to become airborne (dust). The probability of becoming airborne, i.e. emitted into the stope air, will be modified by the wettability of the coal seam. The latter is the result of the use and the efficacy of surface wetting, e.g. the type of wetting system, the use of surfactants, and the surface physical properties of the coal. The resulting emission can be described by aerosolised mass-rate and size-distribution.

The relationship between the discrete influencing variables and their outcome can be captured in a graphical presentation, e.g. a Bayesian belief network (BBN) which shows Bayesian variables or nodes, subdividing 'parent' variables with their direct links (arrows) to their 'child' variable(s).<sup>19,20</sup> In Figure 2 (left panel) the example of dust formation during coal excavation, as described



**Figure 2. Graphical structure of the Bayesian belief network (BBN) model for emission of dust in an underground coal mine (left panel); right panel shows the associated conditional probability tables**

above, is illustrated in a BBN. However, the quantitative relationship between the variables is often unknown. The advantage of a BBN is that limited knowledge can be used to build so-called conditional probability tables (CPTs). Each network variable contains a limited number of sets to which their realised value can belong. This can also be considered as a probability distribution. Looking more closely at the CPTs of the example in Figure 2 (right panel), the distributions of the probability of the two parent variables are shown: first, the probability that a specific type of CM (type 1,2 or 3) is used and, second, the probability of the operational conditions (high, medium or low load). The probability of the value of the resulting 'child' variable, i.e. the energy level of the fractioning, is a function of the probability distribution of both 'parent' variables. Numerous software tools are currently available to support the development of BBNs.<sup>20</sup>

The model can be further extended by adding similar BBNs for the determinants affecting the transmission, e.g. dust suppression, dilution, air velocity, etc., to develop, in combination with an activity-time profile, a rudimentary scenario-specific exposure model.

If quantitative data are not available, the development of a BBN and, more specifically, the CPTs, relies heavily on the experience, expertise and intuition of experts. Structured inputs by experts can be achieved by expert elicitation protocols as demonstrated by Shandilya et al. (2018) in their development of a nanomaterial release model for waste shredding.<sup>21</sup>

## RELATIONSHIP BETWEEN OCCUPATIONAL HYGIENE AND EXPOSURE SCIENCE

### Anticipation and recognition

Both anticipation and recognition of potential risk due to exposure to harmful stressors require knowledge of the processes leading to release/emission, i.e. thorough knowledge of the materials and products to be used or produced, the associated processes, operations and tasks, and the operational conditions. Cross-reading of (similar) technical processes and exposure models are tools that can be used to understand whether a process or operation may pose a risk. Computational exposure assessment, or the use of exposure models, plays a pivotal role in anticipating potential for exposure, especially in the case of a future or envisioned scenario, e.g. the introduction of a new chemical agent or a different physical form of an existing agent in an existing process, change of operational conditions of an existing process, a totally new process, etc. Currently, a number of mechanistic, deterministic and empirical models (and combinations of these) exist and are accessible as web-based- or down-loadable standalone tools. With respect to inhalation exposure to chemical stressors, various mechanistic or deterministic models are captured in IH-Mod 2.0, e.g. well-mixed box room and various two-box models.<sup>22</sup> IH-Mod 2.0 is a mathematical modelling MS Excel spreadsheet used for estimating occupational exposures. Most of the models are described in a series of articles published in the *Journal of Environmental and Occupational Hygiene*.<sup>23-26</sup> Examples of exposure predictive tools that are a mixture of mechanistic and empirical models are Stoffenmanager®<sup>27</sup> and the Advanced Reach Tool (ART).<sup>28</sup>

The mechanistic part of Stoffenmanager® is a source-receptor model that is captured in an algorithm, whereas the empirical part calibrates the outcome scores of the algorithm, using exposure data.<sup>29-31</sup> ART is based on Stoffenmanager® and incorporates a mechanistic model of inhalation exposure and a statistical facility to update the estimates, with measurements selected from an in-built exposure database or from the user's own data.<sup>32-34</sup> In addition, a number of scenario-specific predictive models have been developed, e.g. for spray painting, pesticide application, etc. Generic models that predict dermal exposure are limited;<sup>35</sup> however, some empirical models have been published.<sup>36,37</sup> Recently, research has been conducted to develop a model for inadvertent ingestion exposure by hand-mouth contact.<sup>38</sup>

For biological stressors, the models for airborne transmission of pathogens are more complicated as they also consider the (conditions of) viability of the pathogens during transmission. Therefore, the transmission model component is often incorporated into a risk model.<sup>39-41</sup>

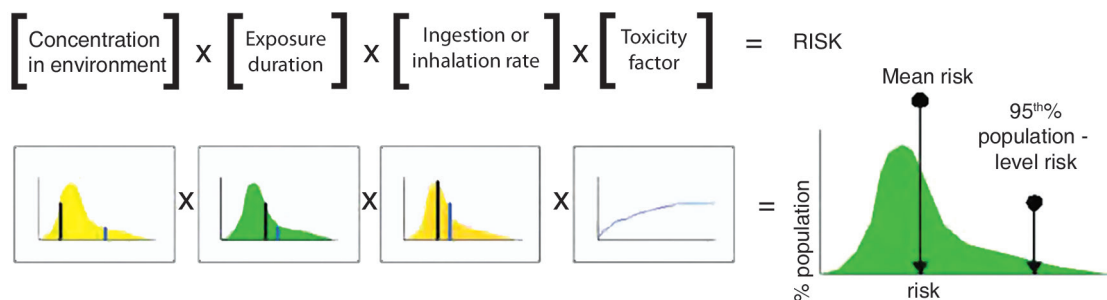
For physical stressors, the transmission from source to receptor is generally governed by the inverse-square law, which states that a specified physical quantity or intensity is inversely proportional to the square of the distance from the source of that physical quantity. The propagation of the energy can be affected, however, in case the free field is disturbed by (un)intentional obstacles, such as shields or baffles.

Anticipation can also be considered as an approach that encompasses the selection of safer materials, processes or technologies. The most stringent method of anticipation is 'designing the risk out'. This so-called prevention through design (PtD) has been promoted over the last decade, especially in the context of emerging technologies.<sup>42</sup> However, comparative risk assessment, addressing both hazard and exposure of potential alternatives, and 'life cycle thinking' should be taken into consideration to avoid similar risks, risk shifts, or risk trade-offs.<sup>43</sup>

### Evaluation and control

Biological monitoring is a key component in the exposome and exposure to exogenous and endogenous chemicals at the level of the receptor and the individual's characteristics, with regard to his or her specific toxicokinetics (absorption, distribution, metabolism and excretion). Such a top-down approach will provide very relevant information for risk assessment, and employs the collection and analysis of biological samples, which is feasible with rapidly-developing analytical techniques.<sup>3</sup> A drawback, however, is that the exposure cannot be directly linked to the sources and their pathways; thus, interventions to reduce exposure cannot be targeted. Therefore, a bottom-up approach, i.e. sampling of sources of exposure, will remain important from the perspectives of risk assessment, exposure analysis and control.

Unfortunately, the current practice of occupational hygiene measurements in South Africa focuses on demonstrating compliance with OELs set by regulatory bodies, such as the Departments of Mineral Resources and Labour. Measurements are important since workplaces need to comply with the relevant Acts and



**Figure 3. Illustration of a probabilistic risk assessment of exposure to a hazardous chemical agent in air (source: US-EPA<sup>47</sup>)**

Regulations and, since the results may have legal implications, quality assurance and control of the measurements are essential. However, compliance measurements are not a substitute for a risk assessment, nor do they automatically support the risk assessment itself. First, the regulatory OELs are not necessarily health-based values. For example, the descriptions of the OELs in both the current and proposed revisions of the Hazardous Chemical Substance/Agents<sup>†</sup> Regulations explicitly address OEL-recommended/restricted limits feasibility issues related to implementation and enforcement, in practice, and additional socio-economic impact issues related to OEL-control/maximum limits. Second, the format of the measurements is a time-weighted average (TWA) over a defined period (15 min (STEL) or 8 hr), which is not necessarily an accurate reflection of the duration of exposure. Third, OELs are generally defined as an (airborne) concentration of a hazardous (chemical) substance/agent and not necessarily as personal exposure. Fourth, if the OEL did represent a health-based value, the ratio of the OEL-value/ TWA8h-value could only be an indicator of the risk potential. This is because a full risk assessment takes into account the intake (see Table 1) as a proxy for the dose, rather than the external exposure (concentration, energy). In the widely-accepted method for risk assessment of residential and environmental exposure to a chemical agent,<sup>44</sup> the risk of non-carcinogenic effects is expressed by the hazard quotient (HQ) which is the (aggregated) daily intake divided by the reference concentration (or dose) of the agent (RfC and RfD, respectively). The RfC or RfD is the estimate of the chemical concentration or dose, respectively, that will not cause non-carcinogenic effects during a specified exposure period.<sup>45</sup> For carcinogenic effects, the cancer risk is expressed as the (aggregated) daily intake multiplied by the cancer slope factor (CSF), where the CSF is the slope of the curve representing the relationship between dose and cancer risk.<sup>46</sup> Note that, with substantial increases in computational power and advances in analytical and integrative methods, the current trend is to move from deterministic analyses towards probabilistic risk assessment (Figure 3). The probabilistic approach incorporates information regarding uncertainty and/or variability into analyses to provide insight regarding the degree of certainty of a risk estimate, and how the risk estimate varies among different members of an exposed population, including sensitive populations and lifestages.<sup>47</sup> This contrasts with the outcome of the deterministic analyses which report risks as point

estimates, e.g. 'central tendency' (mean, median), or 90<sup>th</sup> percentile.

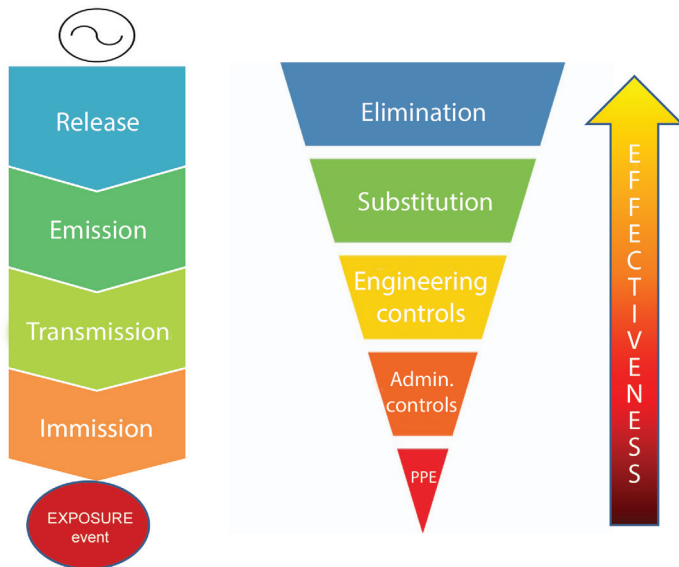
In addition to supporting risk assessment, occupational measurements can also support the analysis of the underlying processes of exposure. As outlined in Table 2, the starting point of any exposure is the release from a source followed by emission. Specific measurements will provide an estimate of the release or emission of materials and products during a process, task or handling, e.g. release of asbestos fibres from asbestos cement products by weathering,<sup>48</sup> or release of nanoparticles by mechanical treatments.<sup>21</sup> The use of direct reading instruments, e.g. those integrated in a task-based exposure assessment strategy, can already provide a first impression of the source strength.<sup>49,50</sup> Since release indicates the potential for exposure, release libraries can be helpful in mapping the exposure processes.<sup>51,52</sup>

As stated, a well-founded knowledge of the underlying processes resulting in exposure plays a pivotal role in developing an effective exposure control strategy. It provides information about which intervention option would achieve the highest efficacy. Therefore, exposure control should be more than a reference to the generic hierarchy of control, but should provide tailor-made intervention options. However, a successful intervention depends not only on the expected efficacy but also on the selection of the optimum control option that takes into account the (cost-related) efficiency, the acceptance of control options by the stakeholders, e.g. the workers, and other implementation issues.

Since exposure emanates from release at a source and consecutive emission in a compartment, followed by its transmission and, consequently, results in immission at a receptor, interventions can focus on the various stages of this exposure process. The types of interventions are captured in the so-called hierarchy of control,<sup>53</sup> which is strongly linked to the source receptor-based exposure process and therefore also represents the decline of effectiveness towards the lower levels of the hierarchy (Figure 4).

As already mentioned, especially with regard to the elimination by PtD, for the substitution option, it is key to select alternatives that do not pose similar risks, risk shifting or risk trade-offs. Formal frameworks, e.g. alternative assessment, have been developed to assist industry and academics to select chemical alternatives.<sup>54,55</sup> However, their extensive use by industrial experts is hampered by methodological challenges.<sup>43</sup>

<sup>†</sup>HCA2018: Draft Revision of Regulations for Hazardous Chemical Substances



**Figure 4. The relationship between the cascade of processes resulting in exposure (left section) and the hierarchy of control, demonstrating the increase of effectiveness of an intervention closer to the source**

Critical but often under-valued aspects of exposure control relate to the decision-making<sup>56</sup> or selection where, in addition to efficacy and costs, the above-mentioned aspects should be considered.<sup>57</sup> Moreover, the implementation stage and, more explicitly, the barriers and enablers perceived by the various stakeholders, should receive sufficient attention to enhance a successful implementation of a proposed exposure control.

## DISCUSSION AND RECOMMENDATIONS

To date, the relationship between exposure science and occupational hygiene has not been extensively described and both fields appear to exist in separate silos. Even within the International Society for Exposure Science, there is a strong focus on target groups such as consumers, residents, the general public, and environmental and indoor exposures, rather than workplace exposures, which does not correspond with the concept of the exposome. Integration of these fields from this holistic perspective should be encouraged since the two fields have much to offer each other. As illustrated, workplace exposures have the unique feature (compared with many other exposures) of frequently having the exposure source within the same domain or manageability area, i.e. the workplace. However, a pre-condition is that the exposure pathways from source to receptor should be identified and well understood. Occupational hygiene can keep pace with developments in other fields that are consolidated in the field of exposure science. In our view, higher education institutions that offer curricula in the field of environmental and occupational health and hygiene should evolve their programmes to train students to develop a broader view about environmental, residential and occupational exposures. In addition to the current occupational hygiene and environmental health curricula, students should be challenged with the fundamentals of comparative risk assessment, computational exposure assessment, implementation science, and decision-making and analysis, in order to understand and apply these concepts.

We acknowledge that it is impossible to cover all aspects of

exposure science extensively thus, inevitably, sub-specialisms will be needed for every individual exposure domain, target group, or exposure pathway, e.g. through food, drinking water, etc. Occupational hygiene should be one of these sub-specialisms. The process of transformation is imminent.

## REFERENCES

- Rappaport SM. Implications of the exposome for exposure science. *J Exposure Sci Environ Epidemiol* 2011; 21(1):5-9.
- National Research Council. *Exposure science in the 21st century: a vision and a strategy*. Washington, D.C.: NRC; 2012.
- National Academies of Science, Engineering and Medicine. *Using 21st century science to improve risk-related evaluations*. Washington, D.C.: National Academies Press; 2017.
- Mattingly CJ, McKone TE, Callahan MA, Blake JA, Hubal EA. Providing the missing link: the exposure science ontology ExO. *Environ Sci Technol*. 2012; 46(6): 3046-53.
- Zartarian V, Bahadori T, McKone T. Adoption of an official ISEA glossary. *J Exposure Anal Environ Epidemiol*. 2005; 15(1):1-5.
- United States. Environmental Protection Agency. *Guidelines for Human Exposure Assessment*. Washington, D.C.: EPA; 2016.
- Wild CP. The exposome: from concept to utility. *Int J Epidemiol*. 2012; 41(1):24-32.
- Lioy PJ, Rappaport SM. Exposure science and the exposome: an opportunity for coherence in the environmental health sciences. *Environ Health Perspect*. 2011; 119(11):A466-A467.
- Lioy PJ, Smith KR. A discussion of exposure science in the 21st century: a vision and a strategy. *Environ Health Perspect*. 2013; 121(4):405-509.
- Teeguarden JG, Tan YM, Edwards SW, Leonard JA, Anderson KA, Corley RA, et al. Completing the link between exposure science and toxicology for improved environmental health decision making: the aggregate exposure pathway framework. *Environ Sci Technol*. 2016; 50(9):4579-4586.
- Teeguarden JG, Tan YM, Edwards SW, Leonard JA, Anderson KA, Corley RA, et al. Expanding on successful concepts, models, and organization. *Environ Sci Technol*. 2016; 50(17):8921-8922.
- International Occupational Hygiene Association. *What is Occupational Hygiene?* Available from: <https://ioha.net/faq/> (accessed 5 Nov 2018).
- Barr DB. Human exposure science: a field of growing importance. *J Exposure Sci Environ Epidemiol*. 2006; 16:473.
- Guidotti TL. Exposure science comes of age. *Arch Environ Occup Health*. 2014; 69(3):127-128.
- Egheghy PP, Sheldon LS, Isaacs KK, Özkaynak H, Goldsmith MR., Wambaugh JF, et al. Computational exposure science: an emerging discipline to support 21st-century risk assessment. *Environ Health Perspect*. 2016; 124(6):697-702.
- Cherrie JW, Maccalman L, Fransman W, Tieleman E, Tischer M, Van Tongeren M. Revisiting the effect of room size and general ventilation on the relationship between near- and far-field air concentrations. *Ann Occup Hyg*. 2011; 55(9): 1006-1015.
- United States. Occupational Safety and Health Administration. *Standard Interpretations. Correct placement of air sampling cassettes on employees performing welding operations; 1999*. Available from: <https://www.osha.gov/laws-regs/standardinterpretations/1999-02-03> (accessed 4 Dec 2018).
- Fantke P, Aylward L, Bare J, Chiu WA, Dodson R, Dwyer R. Advancements in life cycle human exposure and toxicity characterization. *Environ Health Perspect*. 2018; 126(12):125001.

19. Uusitalo L. Advantages and challenges of Bayesian networks in environmental modelling. *Ecol Model.* 2007; 203(3):312-318.
20. Landuyt D, Broeck S, D'Hondt R, Engelen G, Aertsens J, Goethals PLM. A review of Bayesian belief networks in ecosystem service modelling. *Environ Model Softw.* 2013; 46: 1-11.
21. Shandilya N, Ligthart T, Van Voorde I, Stahlmecke B, Clavaguera S, Philippot C, et al. A nano material release model for waste shredding using a Bayesian belief network. *J Nanopart Res.* 2018; 20(2):33.
22. United States. American Industrial Hygiene Association-Exposure Assessment Strategy Committee. IH-Mod\_2\_0. AIHA-EASC; 2018. Available from: <https://www.aiha.org/get-involved/VolunteerGroups/Pages/Exposure-Assessment-Strategies-Committee.aspx> (accessed 4 Dec 2018).
23. Hewett P, Ganser GH. Models for nearly every occasion: Part I - One box models. *J Occup Environ Hyg.* 2017; 14(1):49-57.
24. Ganser GH, Hewett P. Models for nearly every occasion: Part II - Two box models. *J Occup Environ Hyg.* 2017; 14(1): 58-71.
25. Hewett P, Ganser GH. Models for nearly every occasion: Part III-One box decreasing emission models. *J Occup Environ Hyg.* 2017; 14(11):907-918.
26. Ganser GH, Hewett P. Models for nearly every occasion: Part IV-Two-box decreasing emission models. *J Occup Environ Hyg.* 2017; 14(11): 919-930.
27. Stoffenmanager®. Available from: <https://stoffenmanager.com/> (accessed 12 Dec 2018).
28. Advanced Reach Tool. Available from: <https://www.advancedreach-tool.com/> (accessed 12 Dec 2018).
29. Marquart H, Heussen H, Le Feber M, Noy D, Tielemans E, Schinkel J, et al. 'Stoffenmanager'®, a web-based control banding tool using an exposure process model. *Ann Occup Hyg.* 2008; 52(6):429-441.
30. Tielemans E, Noy D, Schinkel J, Heussen H, Van der Schaaf D, West J, et al. Stoffenmanager® exposure model: development of a quantitative algorithm. *Ann Occup Hyg.* 2008; 52(6):443-454.
31. Schinkel J, Fransman W, Heussen H, Kromhout H, Marquart H, Tielemans E. Cross-validation and refinement of the Stoffenmanager as a first tier exposure assessment tool for REACH. *Occup Environ Med.* 2010; 67(2):125-132.
32. Fransman W, Van Tongeren M, Cherrie JW, Tischer M, Schneider T, Schinkel J, et al. Advanced reach tool (ART): development of the mechanistic model. *Ann Occup Hyg.* 2011; 55(9): 957-979.
33. Schinkel J, Warren N, Fransman W, Van Tongeren M, McDonnell P, Voogd E, et al. Advanced REACH Tool (ART): calibration of the mechanistic model. *J Environ Monit.* 2011; 13(5): 1374-1382.
34. Schinkel J, Ritchie P, Goede H, Fransman W, Van Tongeren M, Cherrie JW, et al. The advanced REACH tool (ART): incorporation of an exposure measurement database. *Ann Occup Hyg.* 2013; 57(6):717-727.
35. Fabian CL, Binder CR. Dermal exposure assessment to pesticides in farming systems in developing countries: Comparison of models. *Int J Environ Res Pub Health.* 2015; 12(5):4670-4696.
36. Oppl R, Kalberlah F, Evans PG, van Hemmen JJ. A toolkit for dermal risk assessment and management: an overview. *Ann Occup Hyg.* 2003; 47(8):629-640.
37. Warren ND, Marquart H, Christopher Y, Laitinen J, Van Hemmen JJ. Task-based dermal exposure models for regulatory risk assessment. *Ann Occup Hyg.* 2006; 50(5): 491-503.
38. Gorman Ng M, Davis A, Van Tongeren M, Cowie H, Semple S. Inadvertent ingestion exposure: hand-and object-to-mouth behavior among workers. *J Exposure Sci Environ Epidemiol.* 2016; 26(1):9-16.
39. Liao CM, Chang CF, Liang HM. A probabilistic transmission dynamic model to assess indoor airborne infection risks. *Risk Anal.* 2005; 25(5):1097-1107.
40. Issarow CM, Mulder N, Wood R. Modelling the risk of airborne infectious disease using exhaled air. *J Theor Biol.* 2015; 372:100-106.
41. Noakes CJ, Sleigh PA. Mathematical models for assessing the role of airflow on the risk of airborne infection in hospital wards. *J R Soc Interface.* 2009; 6(Suppl 6):S791-S800.
42. Schulte PA, Rinehart R, Okun A, Geraci CL, Heidel DS. National prevention through design (PtD) initiative. *J Safety Res.* 2008; 39(2):115-121.
43. Tickner J, Jacobs M, Malloy T, Buck T, Stone A, Blake A, et al. Advancing alternatives assessment for safer chemical substitution: a research and practice agenda. *Integr Environ Assess Manag.* 2019. Available from: <https://doi.org/10.1002/ieam.4094> (accessed 29 Nov 2018).
44. United States. American Industrial Hygiene Association. Demonstrating the business value of industrial hygiene. Methods and findings from the value of the industrial hygiene profession study. Fairfax: AIHA; 2008. Available from: [https://www.aiha.org/votp\\_new/pdf/votp\\_report.pdf](https://www.aiha.org/votp_new/pdf/votp_report.pdf) (accessed 3 Jan 2019).
45. United States. Environmental Protection Agency. A review of the reference dose and reference concentration processes. Washington, D.C.: EPA; 2002.
46. United States. Environmental Protection Agency. Guidelines for carcinogen risk assessment: Washington, D.C.: EPA; 2005.
47. United States. Environmental Protection Agency. Probabilistic risk assessment methods and case studies. Washington, D.C.: EPA; 2014.
48. Obersta AF, Poye L, Compton SP. Releasability of asbestos fibers from weathered roof cement. *J Occup Environ Hyg.* 2018; 15(6):466-473.
49. Eastlake AC, Beaucham C, Martinez KF, Dahm MM, Sparks C, Hodson LL, et al. Refinement of the nanoparticle emission assessment technique into the nanomaterial exposure assessment technique (NEAT 2.0). *J Occup Environ Hyg.* 2016; 13(9):708-717.
50. Brouwer D, Van Duuren-Stuurman B, Berges M, Jankowska E, Bard D, Mark D. From workplace air measurement results toward estimates of exposure? Development of a strategy to assess exposure to manufactured nano-objects. *J Nanopart Res.* 2009; 11(8):1867-1881.
51. Koivisto AJ, Jensen ACØ, Kling KI, Nørsgaard A, Brinch A, Christensen F, et al. Quantitative material releases from products and articles containing manufactured nanomaterials: towards a release library. *NanoImpact.* 2017; 5:119-132.
52. Levin M, Rojas E, Vanhala E, Vippola M, Liguori B, Kling KI, et al. Influence of relative humidity and physical load during storage on dustiness of inorganic nanomaterials: implications for testing and risk assessment. *J Nanopart Res.* 2015; 17:337.
53. Peterson J. Principles for controlling the occupational environment. The industrial environment – its evaluation and control. Washington, D.C.: NIOSH; 1973. pp 511-517.
54. United States. National Research Council. A framework to guide selection of chemical alternatives. Washington, D.C.: NRC; 2014. Available from: <https://www.nap.edu/catalog/18872/a-framework-to-guide-selection-of-chemical-alternatives> (accessed 10 Dec 2018).
55. Organization for Economic Cooperation and Development. OECD substitution and alternatives assessment toolbox; 2017. Available from: <http://www.oecd-saatoolbox.org/> (accessed 10 Dec 2018).
56. Malloy T, Zaunbrecher V, Beryt E, Judson R, Tice R, Allard P, et al. Advancing alternatives analysis: The role of predictive toxicology in selecting safer chemical products and processes. *Integr Environl Assess Manag.* 2017; 13(5):915-925.
57. Linkov I, Bates ME, Trump BD, Seager TP, Chappell MA, Keisler JM. For nanotechnology decisions, use decision analysis. *Nano Today.* 2013; 8(1):5-10.

# Perceptions about factors contributing to noise-induced hearing loss amongst mine workers at a platinum mine in Limpopo province, South Africa

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## ABSTRACT

**Background:** Excessive noise exposure can lead to permanent hearing loss. Noise-induced hearing loss (NIHL) has been reported to be one of the three most prevalent occupational diseases within the platinum mines in South Africa.

**Objectives:** The objective of this study was to describe the perceptions of mine workers at a platinum mine in the Limpopo province, regarding factors contributing to NIHL.

**Methods:** A qualitative study, applying a phenomenological design, was conducted. Data were collected from six hearing conservation programme managers and seven mine workers by conducting face-to-face interviews, using a semi-structured interview tool. Data were analysed using the open coding qualitative data analysis method.

**Results:** Three themes emerged: experiences and factors leading to NIHL, hearing-protection device (HPD) factors, and management and leadership factors.

**Conclusion:** Hearing loss was perceived by mine workers with NIHL to be caused by partial application of guidelines, policies and procedures from the Department of Minerals and Energy, as well as the employer taking too long to repair damaged hearing-protection devices, poor adherence to the use of protection devices, and the late introduction of custom-made protection devices.

**Keywords:** occupational safety, hearing-protection devices, mine workers, hearing conservation

## INTRODUCTION

Noise is defined as a sound that is unpleasant, distracting, unwarranted or, in some other way, undesirable.<sup>1</sup> Noise is dangerous to man because of its adverse physical, psychological, physiological and social effects.<sup>2</sup> Globally, the United States of America (USA), the European Union (EU), Asia, the South American countries, and other developing countries such as South Africa, list noise-induced hearing loss (NIHL) as one of the most common occupational diseases.<sup>3,4,5</sup>

Noise exposure is a widespread problem in mining due to the confined working environment, the use of heavy equipment, and the processes of drilling, breaking, transferring, sorting and milling of rocks.<sup>6</sup> The National Institute for Occupational Safety and Health (NIOSH) reports that 80% of USA miners work in an environment in which noise levels exceed the legislated permissible exposure limit (PEL) of 85 dB(A).<sup>7</sup> Hearing loss may affect one or both ears, although not always to the same extent, and is progressive.<sup>8</sup> Excessive noise in the workplace can also limit a worker's ability to communicate and hear signals, which can impact on safety and productivity.<sup>9</sup>

In its 2011/2012 annual report, the Chamber of Mines of South Africa (now the Minerals Council South Africa) reported that NIHL was one of the top three occupational diseases in South African mines, where noise levels ranged from 63.9 to 113.5 dB(A).<sup>10</sup> Approximately 73.2% of miners are exposed to noise levels above the legislated limit of 85 dB(A).<sup>7</sup> In 2003, the South African Mine Health and Safety Council (MHSC) committed to achieving two important milestones; namely, that there should be no deterioration in hearing greater than 10% amongst occupationally exposed individuals after December 2008, and that the total noise emitted by any equipment must not exceed 110 dB(A) at any location in the workplace by December 2013.<sup>11</sup> By 2014, the South African mining industry had not achieved these milestones, and the MHSC revised them as follows: "by December 2024, the total operational or process noise emitted by any equipment must not exceed a milestone sound pressure level of 107 dB(A), and by December 2016, no employee's standard threshold shift (STS) should exceed 25 dB(A) from the baseline when averaged at 2000, 3000 and 4000 Hz in one or both ears".<sup>12</sup>

Despite the commitment by the MHSC, in 2017, the Department

**Table 1. Demographic details of study participants**

Characteristic	n	%
<b>HCP manager occupation</b>		
Occupational hygienist	2	33.3
Health and safety officer	2	33.3
Shift supervisor	2	33.3
<b>Mine workers occupation</b>		
Change house attendant	2	28.6
Winch operator	3	42.8
Rock drill operator	2	28.6
<b>Experience of mine workers (years)</b>		
26-35	2	28.5
36-45	5	71.4
<b>Experience of HCP managers (years)</b>		
3-5	2	33.3
6-15	2	33.3
16-25	1	16.7
26-35	1	16.7
<b>Hearing loss at time of employment (%)</b>		
0-5	1	14.2
6-10	4	57.1
11-15	1	14.2
15-20	1	14.2
<b>Hearing loss at time of study (%)</b>		
10-20	2	28.5
21-30	5	71.4

of Mineral Resources stated, in its July occupational health and safety report, that the number of NIHL cases had increased by 36%.<sup>13</sup> This prompted an investigation into factors perceived to be contributing to the NIHL, by mine workers and hearing conservation programme (HCP) managers within the mining industry.

## METHODS

A phenomenological research design was used to explore the lived experiences of mine workers and HCP managers with regard to factors perceived to contribute to NIHL. The circumstances under which mine workers were exposed to noise, and the effects of noise on mine workers' hearing, were investigated.

The Betty Neuman health care systems model<sup>14</sup> was adopted to identify factors that were perceived to contribute to NIHL amongst mine workers. The model reflects how stress and the reaction to stress affect the maintenance of health.<sup>14</sup> The environmental stressor was defined as excessive noise to which mine workers are exposed.

The mine, which has been operational for more than 50 years, is located in the Limpopo province of South Africa. Approximately 6 300 mine workers work in four underground shafts and one open cast area. The study population consisted of 37 mine workers diagnosed with NIHL in 2014, and 14 HCP managers who worked in the four mine shafts. The mine HCP managers team comprised three members from each shaft and two members from the central mine

health and safety office, including occupational hygiene officers, health and safety officers, and the shift supervisors. Four mine workers and three HCP managers were purposively selected from each of the four shafts. A total of 16 mine workers and 12 HCP managers participated in the study.

A pilot study to test the ambiguity of the questions was conducted amongst six mine workers and two HCP managers, who were excluded from the main study.

Semi-structured one-on-one interviews were conducted over a three-month period. The researchers started by collecting demographic data to put mine workers at ease and to create rapport. All the mine workers with NIHL and the HCP managers were asked one overarching question at the beginning of the interview: "Can you describe the factors that might have contributed to NIHL in your workplace?" Probing questions were then asked that enabled the HCP managers to describe their experiences in their work environment, and how the mine workers made sense of what happened to them in terms of factors perceived to have contributed to NIHL at their workplace. All the interviews were audio-recorded. Data were collected until saturation was reached.

The open coding qualitative data analysis method<sup>15</sup> was used to analyse the data. Responses during the interviews were transcribed verbatim from the audiotapes, after which the transcripts were read carefully. A list of all the topics was made and similar topics were clustered together.<sup>16</sup> The most descriptive wording from each topic was used to identify themes and sub-themes.

Ethical clearance was obtained from the Medunsa Research Ethics Committee (MREC/HS/292/2014:PG), and permission to conduct the study was granted by the platinum mine management.

## RESULTS

The ages of the seven mine workers and the six HCP managers ranged from 41 to 60 years, and from 27 to 50 years, respectively. Two of the seven mine workers were change house attendants, three were winch operators and two were rock drill operators; all had been employed for more than 26 years. The HCP managers comprised two occupational hygienists, two health and safety officers and two shift supervisors. The HCP managers' work experience ranged from 3 to 35 years (Table 1).

Data saturation was reached at the seventh mine worker and at the sixth HCP manager. Three themes and nine sub-themes emerged from the data (Table 2).

### Theme 1: Experiences and factors leading to NIHL

The views of the participants on the factors that contribute to NIHL emerged in the following sub-themes: the presence of noise hazards, maintenance and repair of faulty equipment, hearing loss acquired in the line of duty, sources of noise and prevention of NIHL, and mine workers' perceptions about noise.

#### The presence of noise hazards

The participants shared similar views on the presence of excessive noise in their work environments, which was perceived to be the cause of their hearing problems.

**Table 2. Themes and sub-themes reflecting the factors perceived to have contributed to NIHL**

Theme	Sub-theme
Experiences and factors leading to NIHL	Presence of noise hazards
	Maintenance and repair of faulty equipment
	Hearing loss acquired in the line of duty
	Sources of noise and prevention of NIHL
	Mine workers' perceptions about noise
Hearing-protection device factors	Availability and quality of hearing-protection devices
	Educational health programme for noise control
Management and leadership factors	Availability and implementation of policies, guidelines and regulations to minimise noise hazards

Mine worker no.1 said:

*"I'm working as a driller and there is a lot of noise coming from the machine that we use to drill and also from the fans. This noise is there every day and I've been working in this noisy area since 1996 till today. Even now I cannot hear well because of this noise."*

HCP manager no. 2 participant added:

*"In the mining environment underground there is a lot of noise because we are using like different machines which emit a lot of noise. The other things especially in the mining can be the difference in sound pressure levels, like when you are in the cages. When we go down underground with the cage (lift) the pressure increases the level of noise and when you get out you have temporary hearing loss."*

### **Maintenance and repair of faulty equipment**

Engineering control is one of the essential components of noise management programmes. The HCP managers indicated that there were policies with regard to maintenance and repair of machines.

HCP manager no. 1 said:

*"The machines are serviced by the manufacturing companies quarterly. If there is breakdown we call them, they come and fix them. We also have a policy in place on the service and maintenance of machines where they also check if the noise silencers in the machines are still effective – this is done quarterly. The mine workers also have a responsibility to check the machines before the beginning of the shift should there be a problem they must report immediately."*

However, mine workers indicated that there were work areas where there was no noise or the noise level was minimal, but this was usually where equipment had malfunctioned.

Mine worker no. 5 said:

*"I'm now working in change house where there is no noise. Only if the washing machine is not in good condition that's when there is noise. This happens most of the time and they give us ear plugs so we can use when the machine start to make noise."*

Mine worker no. 2 added:

*"The cage also makes a lot of noise if the pipes inside are*

*not in good condition. A cage is something like an elevator which transports us to underground and inside there are pipes for smoke. The pipes sometimes are broken and they make a lot of noise like Waa."*

### **Hearing loss acquired in the line of duty**

The mine workers shared similar experiences on how they acquired hearing loss at work due to noise in their work environments.

This was supported by mine worker no. 3:

*"Hee!! (changing facial expression and moving forward) I think my ears were damaged by the work that I was doing. I used to work as a winch operator which makes a lot of noise for many years before they removed me from underground because my ears were damaged."*

Mine worker no. 4 added:

*"I think the reason why I cannot hear well is because of the noise from the machines. I've been working underground for a long time. I think is also because years ago in the early 80s when we started to work the mines did not have hearing-protection devices."*

### **Sources of noise and prevention of NIHL**

Mine workers were knowledgeable about the sources of noise in their different work areas.

Mine worker no. 1 said:

*"The noise which came from the blasting of rocks was too loud, but currently they only blast after we have knocked off. The other thing is that you as a mine worker must take responsibility of using the ear plugs and know that if you are not using them you are killing yourself."*

### **Mine workers' perceptions about noise**

Mine workers viewed noise as normal and part of their daily working lives:

Mine worker no. 5 said:

*"Here in the mine there is a lot of noise from the machines that we are using, so it is not possible that you can prevent this noise, this noise has been there for a long time since I started to work in the mine it is still there even now."*

## Theme 2: Hearing-protection device factors

The following sub-themes emerged about hearing-protection devices: availability and quality of hearing-protection devices (HPDs), and knowledge about and adherence to the use of personal protective equipment (PPE).

### Availability and quality of hearing-protection devices

The mine workers used different HPDs, such as custom-made devices, disposable ear plugs and ear muffs. However, they raised the concern that the custom-made HPDs were introduced late, when their hearing ability was already compromised.

Mine worker no. 2 said:

*"Now they provide us with different hearing-protective devices. I'm using the custom-made ones which are measured and fitted to our ears before they give them to us and they are better in protecting noise. The problem is that they gave them to us late when our ears were already damaged. We have started using the custom-made ones in 2005."*

Mine worker no. 6 added:

*"All along we have been using the plastic ones which were not effective because you could still hear lot of noise even when you wear them. But now they gave us the ones like bones, if you wear them properly you cannot hear noise. We only started to use them not long."*

The custom-made ones were perceived to be effective as HPDs but their quality was questionable, according to the mine workers.

Mine worker no. 7 said:

*"The personalised hearing protective devices are like bones, they sometimes fall and break. Unlike the plastic ear plugs which are like rubber – they do not break easily. The other thing with the personalised hearing protective devices is that if they break it takes more than a month to be fixed."*

Mine workers also revealed that the process of replacement of broken HPDs was a challenge as they took a long time to be repaired.

Mine worker no. 4 said:

*"If you report that the custom-made hearing protective devices is broken, they take them for repair in the clinic. The problem is that after they take them they just let us back to work without protection. Preferably they should give us plastic earplugs so we can use them, for now they just let us go without saying anything. But we the old ones we go to our supervisors who send us to the store room to collect the plastic ones. The new people just go and work for a month without protecting their ears and that may damage their ears."*

Mine worker no. 5 added:

*"Eee, if the custom-made hearing protective devices are broken they must provide us with temporary ear plugs. Because they take more than a month to fix the broken ones."*

## Knowledge about, and adherence to, the use of PPE

The mine workers knew about the importance of using HPDs in their workplaces:

Mine worker no. 6 said:

*"(Nodding) Jaa!!! They give us different ear plugs like noise bans and ear plugs, you cannot operate a machine without hearing protection. Should the supervisors or safety officers find you working without protecting your ears they will stop you and take you to the office, they are very strict."*

However, HCP managers argued that, even though the mine workers were knowledgeable about the use of HPDs, compliance and adherence were still a challenge.

HCP manager no. 3 said:

*"What I have realised is that the mine workers remove the ear plugs when they are busy working, when they see safety officers or someone from the management they wear them and remove them when they leave. I think it is because they are used to the excessive noise as they have been working in the noisy environment for a long period."*

## Theme 3: Management and leadership factors

The following sub-themes emerged under management and leadership factors: availability and implementation of policies, guidelines and regulations to minimise noise hazards, and educational health programmes for noise control.

### Availability and implementation of policies, guidelines and regulations to minimise noise hazards

The HCP managers stated that precautionary measures fell under the HCP, which is the main umbrella under which activities of noise control and prevention are implemented.

HCP manager no. 2 said:

*"We have NIHL investigation procedures and the Code of Practice, which is like a Constitution to guide the mines on how to deal with noise. We also have legislation, guidelines, policies and operating procedures available for different departments."*

HCP manager no. 5 said:

*"The contents of the HCP include: risk assessment and occupational hygiene monitoring, noise control engineering, education and training, medical surveillance, which includes audiometric test, investigation of hearing loss, hearing-protection devices, availability and implementation of policies and guidelines in relation to noise prevention to the process of compensation and record keeping."*

### Educational health programmes for noise control

The implementation of education and training programmes, and hearing investigations, is an important aspect in protecting mine workers. However, HCP managers highlighted that, even though training was available and implemented, there was a need for

additional training on how hearing loss occurs because it develops gradually and is not visible.

HCP manager no. 6 said:

*“Awareness must be an ongoing thing, what I have realised is that most of the people have limited knowledge about the effect of noise. They must be trained on what noise is and that hearing loss occurs after some years. It is not like other diseases that you will start to experience them immediately.”*

HCP manager no. 5 added:

*“We do training in different places like training centre by the accredited facility and in the clinic when they do medicals initial and periodic. Even when we are doing hearing investigations if we found that the mine worker does not know how to use the HPDs, we retrain them.”*

## DISCUSSION

All the participants in this study were male. Historically, mining has been a male-dominated sector.<sup>17</sup> Although progress has been made regarding the increase in the number of women employed in mining, local mining companies are struggling to achieve the South African Mining Charter's 10% employment quota for women.<sup>17</sup>

The mine workers are exposed to excessive noise in the work environment. This was evidenced by participants indicating that exposure to noise from different machines, such as drills, winch machines and fans, in their daily working environments might have contributed to their current hearing problems. These findings are in agreement with those from a study done by Amponsah-Talwan, et al. (2013)<sup>18</sup> on the impact of physical and psychosocial risks on employees' wellbeing and quality of life in the mining industry in Ghana. Their study indicated that the 'outrageous' noise created by the machines used in the mines, combined with the enclosed workspace that characterises underground mines, increased the likelihood of hearing loss amongst mine workers.

A study by Ware (2014) on the epidemiology, mechanisms, and interventions of human hearing loss, revealed that the main impact of hearing loss is on the individual's ability to communicate with others, which affects them in all aspects of their lives (socially, emotionally and economically).<sup>19</sup> Additionally, Edwards' and Kritzinger's study on NIHL milestones reported that excessive noise exposure can lead to permanent hearing loss and poor verbal communication, which leads to social isolation and disruption of lives.<sup>9</sup>

Mine workers viewed noise as a normal and natural part of their working lives in the mines. This view is supported by a study in India on the effects, monitoring and control of noise pollution, which reported that employees believed that noise control was difficult to maintain and that employees did not comply with the use of HPDs.<sup>20</sup> The participants in our study acknowledged that the mine provided them with custom-made HPDs, and that they were more effective in protecting their hearing than the earplugs provided in the past. However, the mine workers were concerned that the custom-made devices were introduced too late, when their hearing had already been affected. They believed that, if

they had been introduced earlier, their hearing status would have been better. Compliance with the use of HPDs by mine workers is poor. This is not unique to the South African mining industry, however. In a study done by Musiba (2015) on the prevalence of NIHL amongst Tanzanian miners,<sup>21</sup> it was reported that, although the employees were provided with different HPDs, compliance was poor. In addition, Musiba also indicated that it was an ongoing struggle for many employers to ensure that workers wore hearing protection at all times while working.

Although there were policies, guidelines and regulations in place, there were shortcomings in the application of some elements, e.g. the maintenance and repair of faulty or worn equipment. In India, a study reviewing the effects, monitoring and control of noise pollution identified the need for proper implementation of rules and regulations as an important strategy to overcome the burden of NIHL.<sup>20</sup>

Training on the use and maintenance of HPDs, as well as other health and safety issues, was facilitated by the accredited training facility and the relevant medical personnel in the clinic – upon commencement of employment, periodically, and during the hearing investigations. HCP managers indicated that one of the methods used to train mine workers during hearing loss investigations by the HCP Committee was to retrain affected mine workers about the importance and use of HPDs. However, the HCP managers suggested that the content of training should be extended to the hearing loss process, with more emphasis on the fact that hearing loss gradually occurs over some years. It was further suggested that it would be more effective if this process started at top management and fed down to mine workers in the lower levels. In agreement with these findings, a study conducted in Australia by Timmins and Granger (2010) underlined that training must be intense and stimulate an understanding that hearing is precious, and that loss of hearing can affect different aspects of life.<sup>8</sup>

## LIMITATIONS

Only mine workers with NIHL were included in this study. These mine workers might have been more aware of noise than those who had not been diagnosed with NIHL or did not experience loss of hearing. The study was limited to only one mine and two groups of mine workers; the HCP managers and those workers who were diagnosed with NIHL. Consequently, the sample size was small. The results can therefore not be generalised beyond the study participants.

## RECOMMENDATIONS

Hearing conservation programme managers should constantly monitor and review the effectiveness of the HCP and the application of all the elements, and identify gaps in the programme. The following four methods to control noise should be applied: 1) implementing engineering control measures in full to control noise directly from the source, such as maintenance and quick repair of machines, e.g. the cage; 2) designing and/or identifying new technology for noise reduction and control to produce quieter heavy machinery; 3) applying administrative controls, such as limiting the time for noise exposure, specifically for those in high-risk occupations, which were identified as rock drillers; 4) promptly

repairing protection devices. Comprehensive training programmes, including education about the hearing-loss process, might assist mine workers to understand and comply with preventive measures better. There is a variance between the high level of knowledge of the importance of HPDs displayed by mine workers, and their low level of compliance with the use of HPDs. This indicates the need for further research on the reasons for non-compliance.

## CONCLUSION

Factors perceived to contribute to NIHL amongst mine workers at the platinum mine were noise from heavy machinery, the late introduction of HPDs, the protracted time taken to repair HPDs, and poor adherence with regard to the use of HPDs. The mine workers are accustomed to the noise which has become part of their daily lives at the workplace. Although the mine has an HCP that co-ordinates activities concerning the control and prevention of NIHL, as governed by the Department of Minerals and Energy guidelines, there are gaps in the application of the programme, such as poor maintenance and repair of faulty machines. It is necessary for the mine to standardise and apply effective and efficient programmes to prevent and control NIHL.

## LESSONS LEARNED

- Mine workers with NIHL are aware of the dangers of excessive noise.
- Mine workers and HCP managers' perceptions about factors causing NIHL are correct.
- Mine workers do not use their hearing-protection devices as required.
- The mine needs to improve aspects of its HCP.

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## 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.

## Contributions of authors

Conception and design of the study: All authors

Data acquisition: RNM

Data analysis: ML, RNM

Interpretation of data: ML, RNM

Drafting of paper: ML, RNM

Critical revision of paper: All authors

All authors approved the final version of the paper; and agree to be accountable for all aspects of the work, by ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## REFERENCES

1. Humes LE, Joellenbeck LM, Durch JS. Noise and military service: implementation for hearing loss and tinnitus. Washington, D.C.: National Academies Press; 2005.
2. Akinkuade ST, Fasae KP. A survey of noise pollution in Ado-Ekiti metropolis using mobile phones. *Nat Sci*. 2015; 7:475-482.
3. Masterson EA. Hearing impairment among noise-exposed workers. United States, 2003-2012. *MMWR*. 2016; 65 (15):389-394.
4. Strauss S, Swanepoel DW, Becker P, Eloff FZ, Hall JW. Prevalence and degree of noise-induced hearing loss in South African gold miners. *Occup Health Southern Afr*. 2012; 18(6):20-25.
5. Moroe NF, Khoza-Shangase K. Research into occupational noise induced hearing loss in South African large-scale mines: access denied? *AAS Open Res*. 2018; 1:4.
6. Edwards AL, Dekker JJ, Franz RM, Van Dyk T, Banyini A. Profiles of noise exposure levels in South African mining. *Journal of The Southern African Institute of Mining and Metallurgy*. 2011; 112(5):315-322.
7. United States. The National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational noise exposure. Revised criteria 1998; 1998. Cincinnati: NIOSH. Available from: <http://www.cdc.gov/niosh/docs/98-126/pdfs/98-126.pdf> (accessed 3 Jan 2018).
8. Timmins P, Granger O. Occupational noise-induced hearing loss in Australia: overcoming barriers to effective noise control and hearing loss prevention. *Safe Work Australia*; 2010. Available from: [https://www.safeworkaustralia.gov.au/system/files/documents/1702/occupational\\_noiseinduced\\_hearing\\_loss\\_australia\\_2010.pdf](https://www.safeworkaustralia.gov.au/system/files/documents/1702/occupational_noiseinduced_hearing_loss_australia_2010.pdf) (accessed 8 Jan 2019).
9. Edwards AL, Kritzing D. Noise induced hearing loss milestones: past and future. *Journal of The Southern African Institute of Mining and Metallurgy*. 2012; 112:865-869.
10. Chamber of Mines of South Africa. Annual report 2011/2012. Johannesburg: COM; 2012. Available from: <https://www.mineralscouncil.org.za/industry-news/publications/annual-reports> (accessed 9 Jan 2019).
11. Msiza D. The road to zero harm performance review against the 2003 Milestones: Mine Health and Safety Council; 2014. Available from: <http://www.mhsc.org.za/site/sites/default/files/public/publications/Mr%20Msiza%20Performance%20Review%20Against%20The%202003%20Milestone.pdf> (accessed 3 Jan 2019).
12. South Africa. Mine Health and Safety Council. Process document on occupational health milestones interpretation and reporting. Available from: <https://www.mhsc.org.za/sites/default/files/Occupational%20Health%20%20reporting%20template.pdf> (accessed 9 Jan 2019).
13. South Africa. Dept. of Mineral Resources. Occupational Health and Safety Report: July 2017. Available from: <http://www.dmr.gov.za/Portals/0/MHSI%20Library/Mine%20Accidents%20and%20Disasters/OHS%20Monthly%20Report%202017-07.pdf?ver=2018-03-15-105126-570> (accessed 9 Jan 2019).
14. Masters K. Nursing theories: a framework for professional practice. Sudbury: Jones & Barlett learning; 2012.
15. Tesch R. Qualitative research: analysis types and software tools. Philadelphia: RoutledgeFalmer; 1990.
16. Creswell JW. Research designs: qualitative, quantitative and mixed methods approaches. 3rd ed. Thousand Oaks: SAGE Publications; 2009.
17. Buthelezi N. Women making inroads into male-dominated mining sector despite challenges. *Engineering News*. 9 Aug 2013. Available from: <http://www.engineeringnews.co.za/print-version/exploring-the-leadership-role-of-women-in-the-mining-industry-2013-08-02> (accessed 9 Jan 2019).
18. Amponsah-Tawiah K, Leka S, Jain A, Hollis D, Cox T. The impact of physical and psychosocial risks on employee well-being and quality of life: the case of the mining industry in Ghana. *Saf Sci*. 2014; 65:28-35.
19. Ware SL. Human Hearing Loss. Epidemiology, Mechanisms, Interventions. University of Kentucky Colleges of Medicine and Public Health; 2014. Available from: <https://peerj.com/preprints/378v1.pdf> (accessed 3 Jan 2019).
20. Kulkarni SJ. A review on effects, monitoring and control of noise pollution. *International Journal of Research and Review*. 2015; 2(7):455-460.
21. Musiba Z. The prevalence of noise-hearing loss among Tanzanian miners. *Occupational Medicine (Lond)*. 2015; 65(5):386-390.

# Performance of selected inhalable aerosol samplers

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## ABSTRACT

**Background:** The collection of a sample that is representative of inhalation exposure relies on the selection of a sampler that is appropriate for the specific workplace conditions. The objective of this paper was to compare the performance of six inhalable aerosol samplers, using information from various field and laboratory (wind tunnel) evaluation studies, and manufacturers' descriptions.

**Methods:** Twenty-three aerosol sampler evaluation studies were reviewed. The sampler design characteristics and factors that might influence the performance of different inhalable aerosol samplers were compared. The Institute of Occupational Medicine (IOM) sampler, seven-hole (SH) sampler, Gesamtstaubprobenahme an der Person (GSP) sampler, Button sampler, personal air sampler (PAS-6), and closed-face cassette (CFC) sampler were assessed. Performance was defined as the efficiency with which a sampler collected particles as described in the sampling conventions.

**Findings:** The IOM sampler is ideal for sampling large particles since it is not affected by impaction. The GSP, SH, PAS-6, and CFC samplers under-sample large particles at higher wind speeds. The Button sampler's performance, described by the manufacturer as being independent of orientation to wind and wind speeds, showed higher sampling efficiency at higher wind speeds.

**Conclusion:** With the exception of the IOM sampler, all samplers are negatively affected by gravitational settling, whilst the efficiencies of the CFC and PAS-6 samplers are reduced in the presence of larger particles and higher wind speeds. Environmental conditions and types (and sizes) of particles likely to be present must be considered when selecting a suitable sampler.

**Keywords:** sampling, aspiration efficiency, sampling efficiency, wind speeds, inlet orientation angle

## INTRODUCTION

Aerosol measurements in workplaces are carried out because inhalation is considered to be the major route of employees' exposure to aerosols.<sup>1,2</sup> Measurements are taken either in the worker's breathing zone for personal sampling, or in the general environment for area or static sampling.<sup>3</sup> One must bear in mind that the airflow closer to the sampler inlet will differ between personal and area sampling.<sup>3</sup> Nevertheless, no significant differences have been found between area and personal sampling at wind speeds of < 0.1 m/s or 0.36 km/h.<sup>4</sup>

For measurements to be meaningful, the sample that is collected must be a true representation of the aerosol particle concentration and distribution in the air during the measuring period. However, the inherent physical properties of particles may prevent their entry into the sampling inlet, and the mere presence of the sampler in an environment may change the particle concentrations and disturb the airflow dynamics in the direct vicinity of the sampler.<sup>4</sup> Factors that need to be considered when selecting an

appropriate sampler include wind speed, inlet orientation in relation to wind direction, particle aerodynamic diameters, gravitational settling, electrostatic charge, and the way that cassettes are handled.

Sampler performance is defined, in this paper, as the efficiency with which a sampler collects inhalable aerosol particles, compared to known standards, such as the inhalable convention or a reference ambient concentration.<sup>5,6</sup>

## METHODS

Several electronic databases were searched for articles and documents that described the characteristics of different types of samplers available for the sampling of inhalable (0-100 µm) aerosols. The databases, EBSCOHOST, Google Scholar and Science Direct, were searched using the following keywords: inhalable aerosol sample performance, personal aerosol samplers, aerosol sampler efficiency, aerosol sampler aspiration, aerosol sampler characteristics, and individual sampler evaluation. Articles published in the period 1994 to 2017 were selected; sampling conventions,

manufacturers' descriptions of samplers, and laboratory and field-testing studies were included.

The following inhalable aerosol samplers were reviewed: Institute of Occupational Medicine (IOM) sampler, seven-hole (SH) sampler, Gesamtstaubprobenahme an der Person (GSP) sampler, Button sampler, personal air sampler (PAS-6), and closed-face cassette (CFC) sampler. The IOM, SH and GSP samplers are recommended for sampling and gravimetric analysis of inhalable dust.<sup>7</sup> The additional three samplers were included to ensure a comprehensive comparison.

## FINDINGS

Findings from a total of three books and 43 articles, which included two sampling conventions-related documents and 23 sampler evaluation studies, were analysed in this paper.

## INHALABLE AEROSOL SAMPLER DESIGN

The characteristics and factors influencing the efficiency of each of the selected samplers are provided in Table 1. In the following descriptions, the names of manufactures/distributors are indicated in brackets after the name of the sampler.

### Institute of Occupational Medicine (IOM) sampler (SKC Inc.)

The IOM sampler has a cylindrical body made from conductive plastic and stainless steel in which an internal cassette is incorporated.<sup>3</sup> The sampler body is 37 mm in diameter and 27 mm in length. A 25 mm filter is placed at the bottom of the thin-walled ( $\approx 0.5$  mm) cassette, which weighs approximately 0.8 g and protrudes 1-2 mm from the base of the cylindrical body when mounted. The cassette cap and a transport clip that fit over the cassette prevent filter contamination.<sup>9</sup> The sampler operates at a flow rate of 2.0 l/min.<sup>3</sup> The cassette and filter are weighed as one unit, taking all particles deposited on the internal surfaces into account.<sup>8,9</sup> Variability may exist amongst the cassettes from different batches, thus cassettes used for a sampling exercise should be from the same batch, since these will have similar relative weight variations that occur during sampling and acclimatisation stages.<sup>9</sup>

### Seven-hole (SH) sampler (SKC Inc.)

The SH sampler is made from non-conductive plastic and has seven 4 mm-diameter outward-facing openings in the faceplate. It provides uniform distribution of particulate matter onto a 25 mm filter at a flow rate of 2.0 l/min. The faceplate faces forward during sampling<sup>2,3</sup> and therefore offers only one direction of sampling.

### Gesamtstaubprobenahme an der Person (GSP) sampler (BGI Inc., Waltman, MA)

The GSP sampler is a German version of the European conical inhalable sampler. The sampler aspirates the aerosol through an 8 mm conically-shaped inlet at a flow rate of 3.5 l/min. The cassette, in which a 37 mm filter is housed,

is made from a metal grid fused onto a plastic ring.<sup>3,10</sup> The manufacturer leaves the option of weighing the filter separately, or with the cassette, to the discretion of the user, based on the degree of sample loading.<sup>11</sup> The sampler's conical profile provides an efficient internal environment that decreases deposition of particles on sampler walls once particles have been sampled.<sup>2</sup> Some particle losses are still possible when the filter is weighed separately,<sup>12,13</sup> even though this practice overcomes mass gain due to moisture absorption by the plastic ring that holds the filter.<sup>14</sup>

### Button sampler (SKC Inc.)

The Button sampler is made from conductive stainless steel. It has a curved surface with numerous 381  $\mu$ m-diameter pores. The pores are evenly spaced to occupy 21% of the surface, allowing for an even distribution of particles on the filter, which enhances avoidance of oversampling and multi-directional sampling. The sampler has an O-ring that holds the 25 mm filter tightly. After sampling, the O-ring is lifted carefully to avoid any sample losses.<sup>13</sup> The small distance between the filter and the inlets reduces losses in transmission. The design of the Button sampler eliminates electrostatic effects and sensitivity to wind direction and speed. The sampler operates at a flow rate of 4.0 l/min.<sup>2,15-17</sup>

### Personal air (PAS-6) sampler (University of Wageningen, Netherlands)







The PAS-6 sampler is an all-metal Dutch version of the conical inhalable sampler, with a 6 mm inlet. It collects the aerosol sample at a flow rate of 2.0 l/min onto a 25 mm filter. The PAS-6 sampler orifice faces downwards during sampling, at a 45° angle.<sup>3</sup>

### Closed-face cassette (CFC) sampler (SKC Inc.)

The CFC sampler comprises a three-part cassette system moulded from clear non-conductive plastic (polystyrene) material. The filter sits on top of a backing pad during cassette assembly. The assembled cassette is sealed with a shrink band. If not properly compressed, the cassette suffers from air leakage of 50% to 75%<sup>18,19</sup> despite the sealing shrink band. Air and particle velocity in a cassette that is properly sealed is approximately 0.13 m/s and is likely to increase to 5.0 m/s or higher as particles get closer to the leak in a leaking cassette. The high radial velocity at which particles impact the filter is characterised by high kinetic energy and an acute angle to the surface of the filter, leading to particles bouncing off the filter into the leak.<sup>20</sup> The larger the leak, the greater the number of particles that will be driven towards the leak by the high radial velocity. Finally, the total particle loss is determined by the nature and size of particles being sampled, which is also dependent on the height of the leak and the particle aerodynamic diameters.<sup>20</sup>

The CFC sampler functions at a flow rate of 2.0 l/min with the orifice facing downwards at a 45° angle. Only the

**Table 1. Summary of inhalable aerosol sampler characteristics and factors influencing their performance**

		Inhalable aerosol sampler					
		IOM	SH	GSP	Button	PAS-6	CFC
Sampler characteristics							
		Cover cap and transport clip		Showing cassette			
	Type of material <sup>2,3</sup>	Conductive black plastic and stainless steel	Non-conductive black plastic	Conductive black plastic	Conductive steel	Steel; conductivity not specified	Non-conductive clear plastic (polystyrene)
	Inlet orientation <sup>2,3</sup>	Forward: one-directional	Forward: one-directional	Forward: one-directional	Forward: multi-directional	Downward: 45°; one-directional	Downward: 45°; one-directional
	Flow rate <sup>3</sup>	2.0 l/min	2.0 l/min	3.5 l/min	4.0 l/min	2.0 l/min	2.0 l/min
Factors influencing sampler performance	Wind speed <sup>3,13</sup>	Over-samples large particles at higher wind speeds, since they enter as projectiles	Efficiency lower than IOM at higher wind speeds		Precision higher at higher wind speeds; over-samples at lower wind speeds		More suitable for lower wind speeds
	Angle of inlet orientation to wind direction <sup>37</sup>	Particles > 20 µm over-sampled at 0° and under-sampled at 90° and 180°		Under-samples particles of 30-50 µm for all angles; inside wall losses increase at 90° and 180°	Particles > 20 µm oversampled at 0° and under-sampled at 90° and 180°	At 0° angle and speeds of 0.5-4.0 m/s, inside losses increase with increasing particle size	Under-samples particles 30-50 µm for all angles; inside wall losses increase at 90° and 180°
	Gravity (on captured particles)	Small effect: all particles on cassette weighed <sup>13</sup>	Large effect: impaction of large particles to walls <sup>13</sup>	Impaction of large particles to walls is lower than SH and CFC, higher than that of IOM <sup>13</sup>	Small effect due to small distance between filter and multi-orifice <sup>2</sup>	Particle losses to walls for large particles; lower than CFC <sup>2</sup>	Very high particle losses to walls, and air leakage of cassette <sup>2,3</sup>
	Sampling efficiency in relation to particle sizes	Higher when particles are large <sup>12</sup>	Lower when particles are large <sup>3</sup>	Lower when particles are large <sup>37</sup>	Lower when particles are large and feathery <sup>16</sup>	Lower when particles are large <sup>12</sup>	Lower when particles are large <sup>37</sup>

substances collected on the filter are analysed to determine the sampling efficiency.<sup>2</sup> The suggested improvement of its efficiency by wiping the internal walls and adding the deposits to the analysis of the filter, as practised by the Occupational Safety and Health Administration (OSHA),<sup>21</sup> was found to increase the aerosol particle concentration by only 5%.<sup>22</sup> The inclusion of an internal capsule bonded together with a filter into the cassette, and placed on top of a support pad, is a practice recommended to improve this sampler's efficiency.<sup>23</sup> One such capsule, made from polyvinyl chloride (PVC), called Accu-Cap (SKC), is sufficient only for gravimetric analysis, since it is not easily digestible for elemental analysis. The second type, a cellulose-based capsule, is easily digested by the strong acid in which the mixed cellulose ester (MCE) filters are usually dissolved for elemental analysis.<sup>24</sup>

**FACTORS INFLUENCING SAMPLER EFFICIENCY**

**Aspiration and sampling efficiency**

The performance of a sampler is determined primarily by its aspiration or sampling efficiencies. The aspiration efficiency (A) is the efficiency with which it can extract aerosol particles

from the source or external environment and draw them into the sampler. Aspiration efficiency is a suitable performance measurement for samplers such as the IOM since the entire cassette, including wall deposits, are analysed together.<sup>2</sup>

The formula for aspiration efficiency (A) is:<sup>2,13</sup>

$$A = C_s / C_0$$

Where A = aspiration efficiency

C<sub>s</sub> = aerosol concentration that passes through the plane of the inlet, and

C<sub>0</sub> = concentration in unobstructed external environment

For the remaining samplers (SH, GSP, PAS-6, Button and CFC), only the mass of aerosol collected on the filter is considered, and only sampling efficiency (E) is applicable.<sup>2</sup>

The formula for sampling efficiency (E) is:<sup>2</sup>

$$E = C_f / C_0$$

Where E = sampling efficiency

C<sub>f</sub> = concentration collected on the filter

C<sub>0</sub> = concentration in unobstructed external environment

The  $C_f$  may be different from the concentration that enters the sampler inlet due to particles being lost to the internal walls, resulting in sampling efficiency being lower than aspiration efficiency.<sup>25-27</sup> One should expect particle losses at the inlet entrance due to the combination of the actual capture of particles, the difference between airflow outside and inside the inlet, and the manner in which particles drop onto the sampling medium or filter.<sup>28,29</sup>

### Overall sampler design and flow rate

According to Bartley,<sup>14</sup> the inhalable aerosol samplers' overall designs and flow rates ensure their compliance with the inhalable sampling convention. The convention relates to the fraction of particulates that are breathed into the nose or mouth and deposited anywhere in the respiratory tract.<sup>30</sup> The samplers therefore function to match the human respiratory system. The samplers with higher flow rates seemingly produce lower sampling errors when the dust concentrations are low.<sup>11</sup> However, the higher flow rate precludes the usage of filters such as polyvinyl chloride filters (PVC) with the GSP sampler. This is caused by the hydrophilic tendency of the PVC, resulting in clogging of the filter, which can be avoided by using hydrophobic Teflon filters.<sup>31</sup>

### Sampler inlet type and angle of orientation during sampling (refer to Table 1)

Sampler characteristics, such as inlet shape, size and orientation, together with airflow near the inlet of the sampler, will have a direct effect on the direction of flow, especially for large particles which include inhalable particles.<sup>21</sup> Samplers with outward-facing inlets, e.g. GSP and IOM, tend to passively collect particles  $>100 \mu\text{m}$  as projectiles driven by inertia in the presence of higher airflow velocity.<sup>13,32-34</sup> In contrast to previous reports about the GSP, the inlet geometry of the GSP and Button samplers was found to preclude the entrance of particles driven into the inlet by flowing air when particles were large ( $\approx 65 \mu\text{m}$ ).<sup>35</sup>

The smaller 6 mm inlet of the PAS-6 sampler, as well as the  $45^\circ$  angle at which it functions, reduce its sampling efficiency, especially when there are large particles. The same was noted for the CFC sampler.<sup>27</sup> For this sampler, changing the angle of inlet orientation from the usual angle of  $45^\circ$  to  $0^\circ$  produced no significant differences in the concentrations of collected particles.<sup>23</sup>

### Particle aerodynamic diameter, wind speeds and angle of sampler orientation to wind

The testing of sampler performance is carried out at either low wind speeds which occur in most indoor workplaces, or at higher wind speeds to show the effects of ventilation.<sup>3,36</sup> Moderate to strong positive correlations were shown between the IOM, CFC and GSP samplers in field studies at a wind speed of 0 m/s.<sup>37</sup> However, for the CFC, this

only holds true when particle diameters are small.<sup>12</sup> More specifically, the only time the sampling efficiency of the CFC sampler is in agreement with the inhalable convention is when the particle aerodynamic diameter is  $< 10 \mu\text{m}$  and the wind speed is  $\leq 0.1 \text{ m/s}$  (0.4 km/h).<sup>13</sup> The Button sampler over-sampled inhalable particles at a wind speed of 0.1 m/s (0.4 km/h),<sup>38</sup> whilst best precision was achieved at 0.24 m/s (0.9 km/h) and 0.42 m/s (1.5 km/h).<sup>3</sup> Agricultural dust with larger, more fluffy particles, led to the blockage of inlets to an extent where the Button sampler was more comparable to the 37 mm CFC sampler than to the IOM.<sup>38</sup>

At wind speeds of 0.55 m/s and 1.0 m/s (2.0 km/h and 3.6 km/h, respectively), the sampling efficiencies of the SH, CFC, GSP and Button sampler were lower than that of the IOM, with the CFC showing significant reduction due to the increase in internal losses.<sup>34,39</sup> The sampling efficiencies of the GSP and Button samplers were similar for large particles ( $\approx 65 \mu\text{m}$ ) but were lower than that of the IOM.<sup>34</sup> Similar efficiencies were also shown for the SH and GSP samplers at a wind speed of 0.5 m/s (1.8 km/h).<sup>12</sup> Variable results were obtained when the SH sampler was used to test for inhalable particles in different wood-products facility workplaces.<sup>35</sup> This variability could be related to the loss of particles which remain attached to the sampler walls, and are therefore not included in gravimetric analysis.<sup>40</sup> Hence, the use of a cassette similar to the one used in the IOM sampler has been recommended. Comparably, other laboratory and field studies showed higher efficiency results for the IOM, with the term 'oversampling' being used.<sup>27,16,40-42</sup> Specifically, sampling efficiency of the IOM was found to increase as particle sizes and wind speeds increased.<sup>34</sup> Generally, the aspiration and sampling efficiency of inhalable aerosol samplers exhibit U-shaped curves at highest wind speeds of  $\geq 4.0 \text{ m/s}$  (14.4 km/h). This translated to decreasing sampler efficiencies when particle aerodynamic diameters were  $\approx 20 \mu\text{m}$  and increases when particle sizes were  $> 60 \mu\text{m}$ .<sup>3,13</sup>

When a sampler is positioned on a worker's lapel during personal sampling, the angle at which the inlet faces the direction of wind changes with the worker's movements.<sup>43</sup> The IOM, SH and Button samplers have been shown to over-sample particles  $> 20 \mu\text{m}$  at  $0^\circ$  (angle of inlet orientation to the direction of wind) and under-sampled at angles of  $90^\circ$  and  $180^\circ$ .<sup>13,27,39</sup> This is in spite of the Button sampler being reported to be independent of the angle of inlet orientation to the wind.<sup>38</sup>

Under-sampling for the CFC and GSP samplers applied to particles of  $> 30 \mu\text{m}$  and  $50 \mu\text{m}$ , respectively, for all angles of orientation with respect to the direction of wind, with inside wall losses increasing at  $90^\circ$  and  $180^\circ$ .<sup>13</sup> At a  $0^\circ$  angle of inlet orientation to the wind<sup>41</sup> and wind speeds of 0.5-4.0 m/s (1.8-14.4 km/h), the PAS-6 sampler produced inside losses that increased with increasing particle aerodynamic diameter.<sup>3</sup>

## Sampler precision

Precision, also known as the residual standard deviation from the same measurement cycle within a controlled environment, such as a wind tunnel, is defined as the sampler's production of the lowest residual variance and is another measure of performance.<sup>3,44,45</sup> The Button sampler had the highest or second-highest precision (after the IOM) compared to the GSP, IOM and CFC samplers for the collection of particles with aerodynamic diameters of 6.9 µm to 76 µm.<sup>3,16</sup> Kenny et al.<sup>3</sup> showed that the GSP sampler had higher precision than the PAS, IOM and CFC, and that the SH sampler had the lowest precision of all samplers at lower wind speeds (0.5 and 1.0 m/s, or 1.8 and 3.6 km/h, respectively). Interestingly, the precision of the IOM sampler was independent of wind speeds.

## Humidity

The general methods for sampling and gravimetric analysis of all aerosol fractions recommends an average of 12 hours (overnight) for cassette and filter acclimatisation in the weighing room. The methods state that certain sampling media may require more time to stabilise but offer no further clarity.<sup>7</sup> A study determined that weighing imprecision can be reduced to 0.05 mg when the acclimatisation in the weighing room is extended to a week before and after sampling. This practice considers the differences in humidity between the weighing room and the workplace where the sampling occurs, as well as the absorption of moisture that is applicable to carbon black used in IOM and GSP samplers. Comparatively, the percentage weight increase for the GSP sampler cassette was 30% lower than that of the IOM sampler.<sup>9</sup> A combination of these factors, therefore, strengthens the importance of the use of reference laboratory cassettes to compensate for weight changes.

## Handling of reusable cassettes

The handling of the IOM cassette with bare hands contributes to a weight increase of 0.02 mg. This might be higher and not easily quantifiable when the hands are dirty, which happens easily in the work areas where sampling is done.<sup>9</sup> It is also crucial that contamination is avoided during the removal of dust that collects on the outer surface of the protruding cassette before the clip is placed back on, or at least before weighing. It is also possible for dust to move from the cassette to the clip during transportation, adding to the sampling errors when the IOM is used.<sup>9,13</sup> The GSP sampler cassette can be taken apart for cleaning in warm water and mild soap, after which it needs to be air dried. To avoid cassette contamination, good hygiene practices must be implemented.<sup>31</sup>

## Gravitational settling and inertia

In the absence of ventilation systems, wind speeds of < 0.3 m/s (< 1.1 km/h) are observed in indoor workplaces.<sup>37</sup>

The movement of particles towards the sampler inlet is therefore under the influence of gravitational force and not inertia.<sup>32</sup> Inertial force is defined as the ability of particles to continue to travel in the direction of their original motion when the sampler is facing moving air.<sup>2,46</sup> In environments with low airflow, gravitational settling and inertial force are both dependent on the particle aerodynamic diameter and sampling flow rate. An increase in sampling flow rate could overcome the two opposing forces and help improve the sampling efficiency.<sup>32,39</sup> The recommendation, however, might not necessarily work for the CFC sampler since the rate at which it aspirates the particles through the small (4 mm) opening is already high, as observed from the uneven spread of the sample on the filter.<sup>17</sup>

In many instances, the body of the sampler might obstruct falling particles, inhibiting them from entering the inlet. This could be applicable to both downward-facing inlets of the CFC and PAS-6 and forward-facing inlets of the IOM, SH and GSP samplers. In theory, the conical profile of the PAS-6 and GSP samplers gives these samplers an advantage over the other samplers.<sup>2</sup> In practice, however, the GSP sampler's efficiency is similar to that of the IOM at lower particle sizes and decreases in the presence of larger particles.<sup>12</sup> The multi-directional sampling of the Button sampler, on the other hand, gives it better precision in spite of gravitational force.<sup>2</sup> Additional particle losses occur due to their impaction onto the walls of the sampler body once inside the sampler.<sup>12</sup> However, the practice of weighing the filter and cassette as one unit for the IOM,<sup>2,3</sup> as well as inclusion of wall deposits when a CFC cassette is used with a capsule,<sup>24</sup> reduces the particle losses for those two samplers.

## Electrical charge

An electrical field is created around and extends from the sampler body since both the sampler and particles are charged. Consequently, the degree to which particles stick to the sampler walls (the electrostatic effect) has greater influence on the performance of samplers made from non-conductive materials, such as the CFC and SH, than those made from conductive materials (IOM, GSP and Button samplers).<sup>22,39</sup>

## CONCLUSION

Knowledge of sampler material, inlet size and cassette handling (where applicable), particle sizes, angle of orientation to the wind, and wind speeds, enable personnel performing sampling to anticipate sampling errors associated with the sampler in use. The Button sampler's design is suited to all wind speeds and orientations, although it functions better at higher wind speeds. The efficiencies of GSP, CFC and SH samplers are lower than those of the IOM at higher wind speeds (0.55 m/s or 2 km/h). The CFC and PAS-6 samplers

experience considerable losses when large particles are collected, and changing the CFC inlet orientation from 45° to 0° does not produce significant improvement. Gravitational settling affects the capture of particles more specifically for the CFC and PAS-6 as well the GSP and SH samplers. Despite the shortcomings of the CFC, it is still widely used.

## RECOMMENDATIONS

The GSP, CFC and PAS-6 samplers should be used for sampling of smaller particles (< 30 µm) at lower wind speeds. Similarly, the SH sampler is not suitable for collection of large aerosol particles since it suffers from wall losses. The Button sampler can be used as a replacement for the IOM except when larger (> 65 µm), fluffy and feathery particles are sampled. The aspects of higher efficiency and over-sampling of larger particles should always be borne in mind when the IOM sampler is used.

## LESSONS LEARNED

- The CFC, GSP and PAS-6 samplers are most suitable for sampling smaller particles (< 30 µm) at lower wind speeds.
- Contamination of samplers with cassettes should be avoided as additional errors might be introduced.
- The IOM and Button samplers have higher efficiency at higher wind speeds, although the IOM tends to over-sample larger particles.
- The adherence of particles to the walls of the GSP and SH samplers lowers their efficiency when compared to IOM and Button samplers.

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## 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.

## Contributions of authors

Conception and design of the study: MCR, JLDP, PJJ, FCE

Data acquisition: MCR

Interpretation of data: MCR, AF, JLDP, SJLL, PJJ, CvdM

Drafting of paper: MCR

Critical revision of paper: All authors

All authors approved the final version of the paper; and agree to be accountable for all aspects of the work by ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## REFERENCES

1. Drolet D, Beauchamp G. Chemical and Biological Hazards Prevention. Studies and Research Projects. Technical Guide t-15. Sampling guide for air contaminants in the workplace. Technical Guide. 8th ed. Version 8.1 updated. Montreal: Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail; 2013. p. 17-25. Available from: [www.irsst.qc.ca/files/documents/pubirsst/t-15.pdf](http://www.irsst.qc.ca/files/documents/pubirsst/t-15.pdf) (accessed 9 Jan 2019).
2. Vincent JH. Aerosol sampling: science and practice. Chichester, UK: John Wiley; 2007. p. 9-40.
3. Kenny LC, Aitken R, Chalmers C, Fabriés JF, Gonzales-Fernandez E, Kromhout H, et al. A collaborative European study of personal inhalable aerosol sampler performance. *Ann Occup Hyg.* 1997; 41(2):135-153.
4. Brockmann JE. Sampling and transport of aerosols. In: Willeke K, Baron PA, editors. *Aerosol Measurement – Principles, Techniques and Applications*. New York: Van Nostrand Reinhold; 1993. p. 77-111.
5. European Committee for Standardization. CEN - EN 481. Workplace atmospheres - size fraction definitions for measurement of airborne particles. Bruxelles: Comité Européen de Normalisation; 1993. Available from: <https://standards.globalspec.com/std/969024/en-481> (accessed 9 Jan 2019).
6. International Organization for Standardization. ISO 7708:1995. Air quality - particle size fraction definitions for health-related sampling. Geneva: ISO; 1995.
7. United Kingdom. Health and Safety Executive. General methods for sampling and gravimetric analysis of respirable and inhalable dust. MDHS 14/4. Buxton: HSE; 2014. Available from: [www.hse.gov.uk/pubns/mdhs/pdfs/mdhs14-4.pdf](http://www.hse.gov.uk/pubns/mdhs/pdfs/mdhs14-4.pdf) (accessed 9 Jan 2019).
8. Smith JP, Bartley DL, Kennedy ER. Laboratory investigation of mass stability of sampling cassettes from inhalable aerosol samplers. *Am Ind Hyg Assoc J.* 1998; 59(8):582-585. Available from: <http://dx.doi.org/10.1080/15428119891010767> (accessed 9 Jan 2019).
9. Lidén G, Bergman G. Weighing imprecision and handleability of the sampling cassettes of the IOM sampler for inhalable dust. *Ann Occup Hyg.* 2001; 45(3):241-252.
10. Jiménez AS, Van Tongeren M, Cherrie JW. A review of monitoring methods for inhalable hardwood dust. Research Report P937/1A. Edinburgh: Institute of Occupational Medicine; 2011. p. 4-11. Available from: <https://ec.europa.eu/social/BlobServlet?docId=10153&langId=en> (accessed 9 Jan 2019).
11. Kerr SM, Muranko HJ, Vincent JH. Personal sampling for inhalable aerosol exposures of carbon black manufacturing industry workers. *Appl Occup Environ Hyg.* 2002; 17(10):681-692.
12. Kenny LC, Aitken R, Baldwin PEJ, Beaumont GC, Maynard AD. The sampling efficiency of personal inhalable aerosol samplers in low air movement environments. *J Aerosol Sci.* 1999; 30(5):627-638.
13. Sleeth DH, Vincent JH. Performance study of personal inhalable aerosol samplers at ultra-low wind speeds. *Ann Occup Hyg.* 2012; 56(2):207-220.

14. Bartley DL. Instrument performance criteria: inhalable aerosol samplers. *Appl Occup Environ Hyg.* 1998; 13(5):274-277.
15. Kalatoor S, Grinshpun SA, Willeke K, Baron P. New aerosol sampler with low wind sensitivity and good filter collection uniformity. *Atmos Environ.* 1995; 29(10):1105-1112.
16. Aizenberg V, Grinshpun SA, Willeke K, Smith J, Baron PA. Performance characteristics of the Button personal inhalable aerosol sampler. *Am Ind Hyg Assoc J.* 2000; 61:398-404.
17. Witschger O. Sampling for particulate airborne contaminants. Review and analysis of techniques. 2002. Rapport IRSN/Département de prévention et d'étude des accidents – SERAC; 2002. p. 28 - 47. Available from: <https://www.eu-alara.net/images/stories/Pdfdivers/SMOPIE/smopie-annex%203-appendix%201.pdf> (accessed 9 Jan 2019).
18. Lee T, Harper M, Slaven JE, Lee K, Rando RJ, Maples EH. Wood dust sampling: field evaluation of personal samplers when large particles are present. *Ann Occup Hyg.* 2011; 55(2):180-191.
19. Baron PA, Khanina A, Martinez AB, Grinshpun SA. Investigation of filter bypass leakage and test for aerosol sampling cassettes. *Aerosol Sci Technol.* 2002; 36:857-865.
20. Baron PA, Bennet JS. Calculation of leakage and particle loss in filter cassettes. *Aerosol Sci Technol.* 2002; 36:632-641.
21. Hendricks W, Stones F, Lillquist D. On wiping the interior walls of 37-mm closed face cassette: An OSHA perspective. *J Occup Environ Hyg.* 2009; 6:732-734.
22. Ashley K, Harper M. Closed-face filter cassette (CFC) sampling - guidance on procedures for inclusion of material adhering to internal sampler surfaces. *J Occup Environ Hyg.* 2013; 10(3):D29–D33.
23. Harper M, Ashley K. Acid-soluble internal capsules for closed-face cassette elemental sampling and analysis of workplace air. *J Occup Environ Med.* 2013; 10:297-306.
24. Cook DM, Sleeth DK, Thiese MS, Larson RR. A comparison of the closed-face cassette at different orientations while measuring total particles. *J Occup Environ Hyg.* 2015; 12:199-204.
25. Su WC, Vincent JH. New experimental studies to directly measure aspiration efficiencies of aerosol samplers in calm air. *J Aerosol Sci.* 2002; 33:102-118.
26. Vincent JH. Testing personal inhalable aerosol samplers: a suggested improved protocol based on new scientific knowledge. *J Environ Monit.* 2006; 8:53-62.
27. Gorner P, Simon X, Wrobel R, Kauffer E, Witschger O. Laboratory Study of Selected Personal Inhalable Aerosol Samplers. *Ann Occup Hyg.* 2010; 54(2):165-187.
28. Okazaki K, Willeke K. Transmission and deposition behavior of aerosols in sampling inlets. *Aerosol Sci Tech.* 1987; 7:275-283.
29. Sreenath AS, Ramachandran G, Vincent JH. Aspiration characteristics of idealized blunt aerosol sampler at large angles to the wind. *J Aerosol Sci.* 2002; 33:871-881.
30. World Health Organization. Hazard Prevention and control in the work environment: airborne dust. WHO/SDE/OEH/99.14. Geneva: WHO; 1999. Available from: [http://www.who.int/occupational\\_health/publications/en/oehairbornedust3.pdf](http://www.who.int/occupational_health/publications/en/oehairbornedust3.pdf) (accessed 17 Jun 2018).
31. Davies HW, Teschke K, Demers PA. A field comparison of inhalable and thoracic size selective sampling technique. *Ann Occup Hyg.* 1999; 43(6):381-392.
32. Su WC, Vincent JH. Experimental measurement of aspiration efficiency for idealized spherical aerosol samplers in calm air. *J Aerosol Sci.* 2003; 35:1151-1165.
33. Baron PA. Personal aerosol sampler design: a review. *Appl Occup Environ Hyg.* 1998; 13(5):313-319.
34. Aizenberg V, Grinshpun SA, Willeke K, Smith J, Baron PA. Measurement of the sampling efficiency of personal inhalable aerosol samplers using a simplified protocol. *J Aerosol Sci.* 2000; 31(2):169-179.
35. Tatum VL, Ray AE, Rovell-Rix DC. The performance of inhalable dust samplers in wood products industry facilities. *App Occup Environ Hyg.* 2001; 16(7):763-769.
36. Aizenberg V, Choe K, Grinshpun SA, Willeke K, Baron PA. Evaluation of aerosol samplers challenged with large particles. *J Aerosol Sci.* 2001; 32:779-793.
37. Baldwin PEJ, Maynard AD. A survey of wind speeds in indoor workplaces. *Ann Occup Hyg.* 1998; 42(5):303-313.
38. Li SN, Lundgren DA, Rovell-Rix D. Evaluation of six inhalable aerosol samplers. *Am Ind Hyg Assoc J.* 2000; 61:506-516.
39. Reynolds SJ, Nakatsu J, Tillery M, Keefe T, Mehaffy J, Thorne PS, et al. Field and wind tunnel comparison of four aerosol samplers using agricultural dusts. *Ann Occup Hyg.* 2009; 53(6):585-594.
40. Aitken RJ, Donaldson R. Large particle and wall deposition effects in inhalable samplers. HSE Contract Research Report No.117/1996. Edinburgh: Institute of Occupational Medicine; 1196. p. 5-16. Available from: [www.hse.gov.uk/research/crr\\_pdf/1996/crr96117.pdf](http://www.hse.gov.uk/research/crr_pdf/1996/crr96117.pdf) (accessed 2 May 2018).
41. Tsai PJ, Vincent JH, Wahl GA, Maldonado G. Worker exposures to inhalable and total aerosol during nickel alloy production. *Ann Occup Hyg.* 1996; 40(6):651-659.
42. Skaugest NP, Ellingsen DG, Notø H, Jordbekken, Thomassen Y. Intersampler field comparison of Respicon (R), IOM, and closed-face 25-mm personal aerosol samplers during primary production of aluminium. *Ann Occup Hyg.* 2013; 57(8):1054-1064.
43. Dunnet SJ. An analytical investigation into the nature of air-flow near a spherical bluff body with suction. *J Aerosol Sci.* 1999; 30(2):163-171.
44. Witschger O, Grinshpun SA, Fauvel S, Basso G. Performance of personal inhalable aerosol samplers in very slowly moving air when facing the aerosol source. *Ann Occup Hyg.* 2004; 48(4):351-368.
45. English Oxford Living Dictionaries. Oxford: Oxford University Press; 2009. Available from: <http://www.oxforddictionaries.com/definition/english/precision> (accessed 18 Aug 2018).
46. Vincent JH. Aerosol science for industrial hygienists. Oxford: Elsevier Science; 1995. p. 90.

# National Institute for Occupational Health Research Day 2018



NATIONAL INSTITUTE FOR  
OCCUPATIONAL HEALTH

Division of the National Health Laboratory Service

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The National Institute for Occupational Health (NIOH) hosted a Research Day on 30 October 2018. This provided an opportunity for NIOH staff and students to showcase their work, encouraging discussion around, and support for, preventive interventions in the workplace. The creation, and optimal utilisation, of new knowledge through research can support and provide opportunities to make a positive impact on occupational health and safety, in South Africa and internationally.

The event was opened by the Head of the NIOH Occupational Hygiene Section, Mrs Jeanneth Manganyi, with a message from the Executive Director, Dr Sophie Kisting. She highlighted that occupational health is an integral part of public health, and that collaborations in the sector have enriched our lives. She expressed hope for future collaborations with others in Africa. Two distinguished keynote speakers led the talks of the day: Prof. Nelson Torto, Executive Director of the African Academy of Sciences (AAS), and Prof. Koleka Mlisana, Executive Manager of Academic Affairs, Research and Quality Assurance (AARQA) at the National Health Laboratory Service (NHLS). Prof. Torto began by motivating upcoming scientists, saying “The only limits are the limits in your mind”. Upcoming researchers need to see the possibilities in the future. It is not difficult to be a researcher in Africa, he went on to say, but stepping up to the role is still a challenge. Researchers need to aim for the Africa they want to see and seek to transform lives through the impact of their research. The Academy’s vision is indeed to transform lives in Africa through science, as its mandate is to recognise excellence, provide advisory think tanks, and implement key science, technology and innovation (STI) programmes. Prof. Mlisana highlighted the NHLS research support and capacity development provided by AARQA. The NHLS conducts research that is patient-centred or related to quality control in the laboratory. It is currently training 230 registrars and 232 medical scientist interns. Dr Muzimkulu Zungu was the first NIOH presenter and spoke about *Ubuntu* (African spirituality) in occupational health. He highlighted the poor access to occupational health services in South Africa, which affects more than 80% of workers. Occupational disease remains a hidden epidemic. While industry may be moving away from harmful manual-labour jobs to service jobs, this will not remove all risks for occupational disease. It merely changes the type of risk and the associated disease. Dr Zungu motivated that there should not be a choice between profit and the preservation of a person’s life; occupational health depends on political will. He ended with a poignant question: “The realisation of occupational health takes the efforts of the tripartite alliance plus stakeholders. We have great policies, but no implementation – is that *Ubuntu*?”

## PRESENTATION ABSTRACTS

### Testing for allergy to chemical preservatives in occupational settings

A Fourie (presenter), T Singh

**Introduction:** Methylchloroisothiazolinone/Methylisothiazolinone (MCI/MI) and methylisothiazolinone (MI) are chemical preservatives found in cosmetics, industrial and household products. There is a reported epidemic of allergic reactions to these substances in several countries (e.g. increases of 4.1% per annum over 16 years in England). Workers who come into contact with the agents may develop occupational contact dermatitis. Therefore, detecting these allergens is important to manage workers’ skin conditions and exposures better. The aim of this study was to determine the prevalence of contact dermatitis to MCI/MI and MI before and after changes in allergen testing were introduced.

**Methods:** A retrospective assessment of workers referred to the NIOH Dermatology Clinic from 2006 to 2017 was conducted. Workers with work-related dermatitis were patch tested for sensitisation to MCI/MI and/or MI, using the European baseline series (Chemotechnique). Frequencies of sensitisation to the allergens (MCI/MI and MI) were calculated using Microsoft Excel.

**Results:** A total of 608 occupational referrals were seen and 434 were patch tested, using the European standard series of patches, to determine a possible allergic aetiology for the dermatitis. About a tenth (31/274; 11%) were positive to these allergens (MCI/MI and MI) in the period January 2006 to January 2018. The testing concentration of the MCI/MI was doubled in September 2015 and MI was introduced in 2014. More cases were identified (6/86; 7%) after changes were introduced post-2014 compared to previous allergen concentrations (10/327; 3.1%). The workers identified with sensitisation to the chemicals included beauticians, cleaners, a millwright, a waitress and several workers that mixed the chemicals.

**Conclusion:** MCI/MI and MI are important occupational allergens and the correct testing concentrations must be used to avoid misdiagnosing cases. The importance of keeping abreast with developments in the field was highlighted by the implemented changes which improved the detection of these allergens.



**Dr Babatyi Malope-Kgokong, Prof. Nelson Torto, Dr Boitumelo Kgarebe, and Prof. Koleka Mlisana (left to right) at NIOH Research Day**

*Photograph: Guy Hall*



**Delegates and staff were able to network and discuss their research at the poster viewing**

*Photograph: Guy Hall.*

## Methanol exposure – should we worry?

B Southon (presenter), P Matatiele, B Kgarebe

**Introduction:** Methanol is widely used in household products such as paints and the manufacturing of other chemicals such as ethylene glycol. It is also popular as a substitute for motor fuel. It is recommended that methanol in urine levels should be less than 15 mg/L at the end of an eight-hour work shift. Biological monitoring for methanol exposure is not regularly conducted due to the small volumes of tests requested; hence, very limited studies exist in South Africa regarding the exposure to methanol in the workplace. This therefore begs the question, should we be worried?

**Methods:** A retrospective review of the requests for methanol testing was conducted on methanol samples received at the Analytical Services Laboratory, within NIOH, from January 2012 to September 2018. Samples for methanol exposure were analysed using an Agilent HP-Innowax® column, and connected to a G1888 Headspace Auto sampler (Agilent Technologies®) coupled to a 6890N Agilent® gas chromatography instrument utilising a flame ionisation detector. This method uses the addition of an internal

standard (2-Propanol) to ensure accuracy and to eliminate any matrix effects. The method has a linear range of 0.73 to 17.82 mg/L and a limit of quantification (LOQ) of 0.73 mg/L.

**Results:** A total of 567 samples were requested for methanol analysis over the period of 2012 to 2018. The general trend was an increase of samples received in 2012 (n = 111 samples) and 2013 (n = 431 samples) and then a sudden decrease of no samples received in 2014 and 2015. In 2016 to 2018 samples were received, with a decline seen again from 2016 to 2018. Methanol was the only compound tested in these specimens.

**Conclusion:** The retrospective review shows that very few samples are requested for methanol detection. More emphasis should be placed on methanol exposure in the workplace and not only on the common exposures, such as benzene. It is recommended that the laboratory develop a method to detect the methanol metabolite (formate); ambient air should also be analysed in conjunction with biological monitoring.

## Coal dust exposure assessment in the South African coal mining industry: constitution of homogenous exposure groups

F Made (presenter), D Brouwer

**Introduction:** Current practice in the South African mining industry (SAMI) to constitute homogenous exposure groups (HEGs) is based on activity areas. Constitution of HEGs is a key factor in the exposure monitoring of workers, since HEGs are considered as an exposure entity. Unfortunately, this broad categorisation of grouping introduces variances of coal dust exposure, which may result in misclassification and masking of high-risk jobs. Exposure to coal dust causes incurable lung diseases among coal miners. The objective of this study was to investigate the feasibility of using job titles as an additional parameter for grouping of workers according to exposure levels.

**Methods:** A dataset of 856 eight-hour time-weighted coal dust data was analysed using Statistica V13. The measurements comprised

of 49 HEGs and 39 job titles across mines. Box plots and ANOVA were used to evaluate the homogeneity of different groupings.

**Results:** Comparison of mean variation between job titles showed statistically highly non-significant differences ( $P > 0.05$ ).

**Conclusion:** This analysis revealed that the introduction of job titles improved homogeneity of the HEGs, thus enabling improved identification according to the level of exposure. Integration of the improved method to constitute HEGs has potential to improve exposure estimates. Follow-up research has been initiated to identify job titles exposure levels to coal dust and compare these with occupational exposure limits. Advanced statistics, including principle components analysis (PCA) and a Bayesian hierarchical framework, will be used for the assessment.

## Managing occupational exposures to hazardous chemical substances in a laboratory environment using occupational hygiene statistics

G Mizan (presenter)

**Introduction:** Diagnostic pathology laboratory work involves potential exposure to a wide range of hazardous chemical substances (HCS), notably volatile organic compounds (VOCs), including xylene, which is mainly used for tissue staining processes, and formaldehyde, used for preservation and fixing of tissue. This study was conducted in 14 laboratories, including histopathology, cytology, clinical pathology and tuberculosis (TB), all forming part of approximately 300 laboratories operating under the largest diagnostic laboratory service provider in South Africa.

**Methods:** Concentrations of VOCs and formaldehyde were measured in the 14 laboratories, using standard air sampling pumps connected to substance-specific sampling media, following the NIOSH methods 1501 and 2541, respectively. Each laboratory was sampled for two separate shifts. A statistical package (IH DataAnalyst) was used to verify that the data sets conform to the lognormal distribution hypothesis and to calculate various statistical parameters related to the results. The software, which includes a Bayesian statistics component, was also used to calculate the probability of exceeding the occupational exposure limit

(OEL) and to classify the data sets from each laboratory into one out of five management and exposure control categories.

**Results:** The data showed that although measured concentrations of VOCs and formaldehyde were below the respective OELs, different laboratories fell under different exposure categories, corresponding to different control strategies, from “No action required” (0, or green category) to “Implement hierarchy of controls and monitor to validate respirator protection factor selection” (5, or red category).

**Conclusion:** It is recommended that histopathology and cytology laboratories implement a medical surveillance programme, including a screening questionnaire, for formaldehyde and biological monitoring for xylene. In addition, routine checking of the ventilation systems and air monitoring should be implemented in these laboratories. This study demonstrates that compliance or non-compliance with an OEL is insufficient to classify and manage exposure in an occupational hygiene setting. Further statistical interpretation of the sampling data is needed in order to make informed decisions about the level of control required for exposure to HCS.

## Time to compensation, ODMWA compensation system for living miners and ex-miners

N Ndaba (presenter), S Kgalamono, D Rees

**Introduction:** The Occupational Diseases in Mines and Works (Act No. 78 of 1973, as amended in 2002) (ODMWA) provides for compensation of living and deceased miners and ex-miners for occupational lung diseases. Certification and compensation data constitute a valuable source of information on occupational diseases in the mining industry, and efficiency of the compensation service.

**Objectives:** To determine time from the certification to compensation payment, using a proportion of cases certified in the 2009, 2010 and 2011 financial years.

**Methods:** The Department of Health’s Medical Bureau for Occupational Diseases (MBOD) database was used to select diseases with considerable numbers from the 2009, 2010 and 2011 financial years. A ten percent sample of each disease group was selected through random sampling using stata 12, and this sample was used to determine time to compensation, joined with the Commission for

Compensation of Occupational Diseases (CCOD) compensation database. Stata version 12 was used to clean and analyse data.

**Results:** From the sample of 389 certified cases for the 2009–2011 financial years, 26.5% (n = 103) were compensated at the end of the 2012 financial year. The mean time to compensation was 38 months, 36 months and 19.4 months for the 2009, 2010 and 2011 financial years, respectively.

**Conclusion:** Low proportions of certified diseases had been compensated for each year in this study, and the time to compensation was unacceptably long, particularly in those with serious diseases. A mean time of approximately three years for first-degree diseases is bothersome. However, the same period for second-degree diseases is even more concerning, as second-degree is equivalent to more than 40% impairment. This implies that a miner certified with mesothelioma has almost no chance of benefiting personally from the ODMWA.

## Biobanking: a game changer for scientific research

M Maseme (presenter), B Duma

**Introduction:** Biobanking has evolved in response to advances in specimen preservation and data infrastructure and technologies. This in turn has enabled usage of biobanking as a game-changing resource for supporting scientific research and development through readily available biomaterials and the associated data. The NHLS Biobank is a human biobank with a vision and mandate to secure and manage collections and storage of biomaterials,

and the associated data, for the purpose of ongoing and future research activities. The aim of this presentation was to describe the operational and regulatory landscape pertaining to biobanking as a resource for supporting scientific research.

**Methods:** The requirements for ensuring conformity to long-term specimen stability and viability, as well as the associated data integrity in line with international best practices in biobanking

and maintenance of a quality management system (QMS), are described.

**Results:** The NHLS Biobank process flow entails specimen and data collection, receiving of the collected specimens as well as storage and retrieval of specimens and data. Key ethical and regulatory considerations include legally binding agreements between the NHLS Biobank and interested parties, addressing specimen and data ownership, as well as benefit sharing. Practical application of the ethical principles of donor autonomy to grant informed consent and research for the benefit of society, as well as doing no harm to donors, is ensured through adherence to legislation and guidelines as implemented through our ethics procedure.

Consistency of operational procedures is maintained through the ISO9001 certification framework. There is no clear national governance and regulatory structure for biobanks in South Africa. Therefore, regulatory compliance at the Biobank is maintained through compliance with the relevant national and international biobank best practices, and continued collaborations with various stakeholders, which involves information sharing.

**Conclusion:** The challenges associated with the global burden of disease are huge. However, they are not insurmountable when biobanking is recognised as a combative resource for enhancing healthcare research and collaboration.

## Phenol vs. t,t-muconic acid as biomarkers for benzene exposure biomonitoring

G Riley (presenter), P Matatiele, B Kgarebe

**Introduction:** Benzene is a major component of petroleum products and is used in the manufacture of plastics, rubbers, detergents and pesticides. Due to the volatile nature of benzene, inhalation is the primary route of exposure. Prolonged exposure to benzene can be the cause of blood diseases such as leukaemia. Urinary benzene biomarkers, t,t-muconic acid and phenol, are used to assess occupational benzene exposure. However, literature suggests the use of t,t-muconic acid over phenol for benzene biomonitoring. The objective of this study was, therefore, to compare the phenol and t,t-muconic acid concentrations of a cohort of urine samples in which benzene biomonitoring was requested.

**Methods:** Both analytes were assessed in 24 urine samples of occupationally-exposed individuals. Phenol was analysed using a SANAS-accredited method that utilises gas chromatography coupled with mass spectrometry. t,t-Muconic acid was analysed using a validated method using high-performance liquid chromatography

coupled with a diode-array detector.

**Results:** The correlation coefficient between phenol and t,t-muconic acid for the samples was  $r = 0.55$ . There was only one sample in which the phenol concentration (87.73 mg/g creatinine) was higher than the BEI for South African standards of 50 mg/g creatinine. There were 22 samples in which the t,t-muconic acid concentration was higher than the BEI for international standards (0.05 mg/g creatinine). The monitoring of phenol for low occupational benzene exposures is limited due to the specificity of the metabolite. Phenol is used as a solvent in several different industries, including the chemical and plastic industry, and subsequent exposure can cause false positives.

**Conclusion:** Benzene metabolism is the only means by which t,t-muconic acid is formed within the body. In conclusion, t,t-muconic acid is a more specific biomarker for benzene biomonitoring.

## Efficacy assessment of ultraviolet germicidal irradiation (UVGI) devices for inactivating airborne *Mycobacterium tuberculosis*

T Singh, Z Ngcobo (presenter), O Kgasha, W Leuschner, O Matuka, T van Reenen, P de Jager

**Introduction:** Tuberculosis (TB) remains one of the top ten causes of death globally, with approximately two million people dying from this infectious disease. There have been attempts to minimise the spreading of the airborne *Mycobacterium tuberculosis* (MTB). However, the lack of evidence-based efficacy assessments on the UVGI devices is of concern. This study aimed to determine the efficiency of the MTB DNA extraction method from filters, the efficacy of UVGI fixtures in inactivating *M. tuberculosis*, and the UVC output of these devices.

**Methods:** DNA extraction efficiency from *M. tuberculosis* from filters was determined using the Quant-iT PicoGreen assay. The efficacy of 13 UVGI fixtures was tested and determined using the constant aerosolisation of *M. tuberculosis* in a walk-in test

chamber and qPCR was used to quantify the 16S rRNA gene of MTB from filters. Descriptive and inferential statistics were used for data analysis.

**Results:** The DNA extraction efficiency of *M. tuberculosis* from filters ranged from 80.2-115.6%. *M. tuberculosis* survival percentage ranged from 0-56.3% when the efficacy of the fixtures was tested, with 46% of these being 100% effective.

**Discussion:** The high efficiency of the DNA extraction process and quantification of the microbial survival rate indicates reliability of the qPCR method to quantify *M. tuberculosis* from filters. The efficacy of South African devices is highly variable with minimum UVC output. Many of the readily installed fixtures in healthcare facilities are not efficient and thus need to be addressed.

## Dissolution of functionalised nanoparticles in simulated biological and environmental fluids

O Mbanga (presenter), E Cukrowska, M Gulumian

**Introduction:** The study aims to determine the dissolution kinetics, which include dissolution rates, rate constants, order of reaction, and half-lives, of functionalised nanomaterials when exposed to simulated biological and synthetic environmental fluids. The functional groups of interest were polyethylene glycol, carboxyl and amine functional groups. The dissolution behaviour of nanomaterials was investigated through in vitro acellular tests using the static dissolution method. The nanomaterials of interest were gold and titanium dioxide nanoparticles.

**Methods:** Nanoparticles were dialysed against the simulated fluid and samples analysed to determine the concentration of ions dissolved in simulated fluids under physiological conditions (37° C) using inductively coupled mass spectroscopy. The simulated biological fluids included gastric fluid (pH 2), phagolysosomal

fluid (pH 4.5), intestinal fluid (pH 6.8), blood plasma (pH 7.2), and gamble's fluid at pH 7.4. Environmental fluids were synthetic river and sea water at pH 6.8 and 8.0, respectively.

**Results:** Low dissolution rates were observed for titanium dioxide nanoparticles functionalised with polyethylene glycol under basic conditions, due to steric hindrance. Gold nanoparticles functionalised with the amine group at pH 7.2 also showed low dissolution. The factors observed to influence the dissolution of nanomaterials were pH, steric hindrance of the functional groups and ionic strength of the fluids of interest.

**Conclusion:** Gold and titanium dioxide nanoparticles with low dissolution rates are biodegradable, hence may cause both short- and long-term health effects and show high environmental persistence.

## Mercury – a potential South African problem?

L Mochaki (presenter), B Kgarebe, P Poongavanum

**Introduction:** Mercury (Hg) has been recognised as a chemical of global concern owing to its long-range atmospheric transportation, its persistence in the environment, ability to bioaccumulate in ecosystems and its negative effects on human health and the environment. Mercury continues to be released into waterways, soil, the atmosphere and food. Biological and environmental monitoring of mercury can be used to assess exposure. The determination of mercury in blood is used to assess short-term exposure, and in urine long-term exposure. The objectives of this study were to report on an overview of test requests for mercury in blood, urine and water submitted to the Analytical Services Laboratory from the years 2005 to 2018; and to identify any trends that could point to an existing problem of mercury exposure, be it environmental, occupational, or non-occupational.

**Methods:** This is a retrospective and descriptive assessment of Hg results obtained from samples received in the Analytical

Services Laboratory for the years 2005 to 2018. The assessment uses historical data from the Analytical Services archives. At the time of laboratory analysis, the samples were digested with nitric acid and then analysed by cold vapour atomic absorption spectrometry (CV-AAS), on a flow injection mercury system (FIMS), and mass spectrometry, on an inductively coupled plasma mass spectrometer (ICP-MS). Microsoft Excel was used for data analysis.

**Results:** The Analytical Services Laboratory received a total of 9 533 mercury requests in the period under review. Of the requests, 7 438 were biological samples and 2 095 were environmental samples, where blood and urine samples were 5 511 and 1 927, respectively. Water samples were 2 085 and traditional medicine requests were six during the period 2005 to 2018.

**Conclusion:** From the number of requests received, biological and environmental monitoring in both an occupational and non-occupational setting is a need.

## The performance of particle-size selective samplers in wet conditions

K Renton (presenter)

**Introduction:** The primary health concern of respirable crystalline silica (RCS) particles is the fibrogenic capacity that can lead to the development of silicosis through the accumulation of dust in the lungs and the tissue reactions to its presence. A study of South African miners estimated that there was a 77% risk of developing silicosis after working for 37 years in gold mines, at an average exposure concentration of 0.4 mg/m<sup>3</sup> respirable crystalline silica. Assuming a linear dose response, the risk of contracting silicosis would still be about 20% for a working lifetime exposure at the Department of Minerals and Energy (DME) occupational exposure limit of 0.1 mg/m<sup>3</sup>. In order to control RCS, accurate measurements need to be made to ensure that when

“safe” levels are identified, they really are safe. It is suggested that the measurements using a cyclone may be biased negatively as the cyclone itself acts to remove heavy particles of water which have coalesced with RCS. It is conjectured that a proportion of the silica dust particles are taken down by a combination of gravity and centrifugal force to the pot at the bottom of a cyclone. This would mean that not all dust sampled by a cyclone in wet, misty conditions would be collected on the filter, and the low RCS level will give workers a false sense of security.

**Methods:** To test this hypothesis, the results measured using two types of cyclone, Higgins Dewel and GK 2.69 cyclone, will be compared to a horizontal elutriator in controlled dust atmospheres

in the Polley dust duct. The horizontal elutriator should not be as biased with respect to the effect of water mist droplets, which are not subject to centrifugal force but only to the weaker force of gravity alone. Based on the comparisons between all four

size-selective samplers, including the inhalable sampler which is included as a control, a determination will be made as to which type of sampler is the least biased for sampling quartz in the respirable range in wet underground conditions.

## POSTER PRESENTATION ABSTRACTS

### Possible non-cancer and cancer risk of communities surrounding gold mine tailings storage facilities in Gauteng and North West provinces due to silica dust inhalation

C Andraos (presenter), W Utembe, K Dekker, M Gulumian

**Introduction:** Despite the known association between occupational exposure to crystalline silica and adverse health effects, the risk associated from exposure to crystalline silica from environmental sources is largely unknown. Gold mine tailings storage facilities (TSFs) are known to be a major environmental dust-generating source in South Africa, particularly in Gauteng and North West provinces.

**Objectives:** The objectives of this study were to assess the potential exposure of surrounding communities to tailings dust, assess the presence of crystalline silica in tailings dust samples and, lastly, determine the risk associated with developing respiratory diseases.

**Methods:** Environmental PM10 filters and personal PM4 filters were collected in communities surrounding the TSFs. The crystalline silica polymorph content (quartz, tridymite and cristobalite) on the filters was determined using direct-on-filter X-ray diffraction (XRD). Particle-size distribution analysis was conducted using

a scanning mobility particle sizer and aerodynamic particle sizer. The risks for both cancer-related and non-cancer-related endpoints were calculated based on the crystalline silica levels measured on the personal PM4 filters.

**Results:** PM10 and PM4 sampling showed that surrounding areas experienced silica levels as high as 90  $\mu\text{g}/\text{m}^3$  and 51  $\mu\text{g}/\text{m}^3$ , respectively. All samples consisted mostly of quartz (73-87%) with only trace amounts of tridymite and cristobalite. A large percentage of incidental nanoparticles were identified (67-71%) indicating the potential of the dust to lodge deep within the lungs. Risk calculations showed hazard quotients between 5.5 and 16.2 for potential non-cancer risks and three to nine individuals out of 10 000 potentially developing cancer over a 70-year lifetime period.

**Conclusion:** These results indicate a high lifetime risk to surrounding communities from exposure to crystalline silica emanating from these TSFs.

### Assessment of exposure to benzene, toluene and xylene in a group of South African petroleum refinery workers

B Dabula (presenter), P Matatiele, B Kgarebe

**Introduction:** During petroleum distillation, creosote and fuel oils are produced with fuel oils obtained as a distillate and creosote as a by-product of the high-temperature distillation process. Petroleum contains hundreds of different hydrocarbons like phenols, cresols, and toluene. Petroleum refineries and petrochemical plants are therefore classified as major sources of volatile and toxic hydrocarbons in the environment. Petroleum refineries have a complex system of multiple operations, where specific operations used depend on the desired products. The characteristic of the crude oil inhalation and dermal contact are the two major routes of exposure for industrial workers where fuel oils are produced or used.

**Methods:** Full-shift urine samples of 29 workers were received from 2010 to 2013 and analysed for phenol, o-cresol and methylhippuric acid, the biomarkers of exposure for benzene, toluene and xylene, respectively. The biomarkers were determined using high-performance liquid chromatography with diode array detection and liquid-liquid extraction followed by gas

chromatography-mass spectrometry (GC-MS).

**Results:** Benzene and xylene results were well within the recommended exposure levels of 50 mg/g phenol and 1 500 mg/g methylhippuric acid; with results ranging from 0.2-31 mg/g for phenol, with an exception of one worker in 2013 who exhibited 70.6 mg/g, and 2.18-246.9 mg/g for methylhippuric acid. Few workers were randomly found to be overexposed to toluene, with a range of 0.02-3.58 mg/g. Workers in the moderate exposure category were more exposed to xylene in 2012 compared to those in other categories ( $p = 0.01$ ). No difference was observed for BTX exposure with regard to race, age and gender ( $p > 0.05$ ), except in 2012 where women showed more exposure to benzene than men ( $p = 0.003$ ).

**Conclusion:** The random individual overexposure to benzene and toluene could be attributed to single chemical incidents, lifestyles and diets. Biomonitoring of petroleum workers and proper assessment of the health risks along with planning for adequate health protection, are recommended.

## Women in South African mines

N Kgekong (presenter), T Vorster, A Benya, S Kisting, N Vorajee, JI Phillips

**Introduction:** The findings of the statutory autopsy service conducted on deceased mine workers at the NIOH have been maintained on a database called PATHAUT since 1975. Previously in studies and analyses of the database women have been grouped with men due to their small numbers. Historically, women were employed unofficially and officially in South African asbestos mines, and since 2005 the Chamber of Mines has set a target to employ a workforce consisting of at least 10% women.

**Methods:** Data were extracted from the PATHAUT database between the years 2005-2016 and women were identified using ID numbers. SAS Enterprise Guide 7.1 was used to retrieve and analyse records from the PATHAUT database. The analysis described demographics such as age, where they came from,

commodity mined, clinical cause of death, occupational lung disease, duration of service and their job category.

**Results:** In total there were 414 women and of these 86% had a history of mining; the remaining 57 women (14%) were submitted as environmental cases by the Asbestos Relief Trust (ART). Half of the total number of women that had been employed were in asbestos and the majority of the remainder were employed in gold (20.1%). The overall mean age of women was 57.2 years ( $\pm 17.4$  SD).

**Conclusion:** The breakdown by commodity shows that women die younger in other commodities, particularly platinum and gold where the mean age at death was 37.8 years and 39.1 years, respectively. The women in these commodities also had a high incidence of unnatural deaths.

## Method development for the analysis of mercury in water by inductively-coupled plasma mass spectrometry (ICP-MS)

N Khoalinyane (presenter), F Sethosa, P Poongavanum, B Kgarebe

**Introduction:** Cold vapour atomic absorption spectrometry (CVAAS) used to be the common method for the determination of mercury (Hg) in environmental samples. However, a disadvantage of this method was that it required large sample volumes which are not always possible to obtain. The interest in the use of ICP-MS for the laboratory analysis of heavy metals has grown tremendously, because of its very small sample volume requirements, excellent sensitivity and selectivity, and its capacity to handle multi-element analysis. Our aim is to develop a method for the routine determination of mercury in water samples using ICP-MS.

**Methods:** The analysis was carried out using an Agilent ICP-MS 7700 Series. The instrument is equipped with a collision/reaction cell (octopole reaction system), and was operated in 'No gas' mode. The method included the online addition of germanium

( $^{72}\text{Ge}$ ) and indium ( $^{115}\text{In}$ ) as internal standards. Aqueous calibration standards and in-house quality controls (IQC) were acidified with nitric acid and hydrochloric acid and then analysed.

**Results:** The Hg showed good linearity with R values ranging from 0.9954 to 0.9997, and good repeatability with %RSD of 12% for 10  $\mu\text{g/L}$  IQC and 6% for 100  $\mu\text{g/L}$  IQC. Background equivalent correction (BEC) generated by the instrument will be used as the limit of detection (average BEC of 1.4887). Data generated using this method were used to calculate figures of merit confirming its suitability for the routine analysis of Hg in water samples.

**Conclusion:** Based on the acceptable R values, BEC, excellent precision and recovery (average of 95%), this method is deemed suitable for the routine analysis of Hg in water.

## Respirable dust exposure amongst waste reclaimers at a landfill site in Tshwane in Gauteng province

T Maeteletja (presenter), J Manganyi, J Wichmann

**Introduction:** Waste reclaimers have become a common sight in most cities and municipal landfill sites. This form of income generation has been found to be effective in reducing the amount of waste disposed at landfills in developing countries, thus prolonging the use of landfill sites. Hazardous exposures in this population have not been well understood due to limited studies conducted.

**Methods:** Personal exposure assessment and soil sampling were conducted at a landfill site in Tshwane for nine days. The landfill had on average 200 waste reclaimers working onsite daily. There were 74 personal respirable dust exposure samples that were taken according to the NIOSH 0600 method. Participants completed an interview-administered questionnaire to collect

background information. Soil samples were collected to characterise mineral composites.

**Results:** Personal exposure levels had a geometric mean of 0.44  $\text{mg/m}^3$  and variance of 0.17  $\text{mg/m}^3$ . These were below the South African exposure limit (5  $\text{mg/m}^3$ ) for respirable dust. Seasonal variation was not controlled due to only one season being sampled. All soil samples collected contained silica levels that comprised more than 1% of the soil mineral composites.

**Conclusion:** Further studies are needed to investigate personal exposure to respirable dust, with consideration of quartz levels and health outcomes of waste reclaimers. This will aid in better understanding the health challenges unique to waste reclaimers.

## The interference of gold nanoparticles (AuNPs) with the in vitro comet assay

M Magogoty (presenter), M Gulumian

**Introduction:** Very little is known about the health effects of gold nanoparticles (AuNPs) on workers and conflicting results have been observed between numerous genotoxicity studies of AuNPs. Interference of AuNPs with genotoxicity assays may be the reason for the observed inconsistent results. In this study, the potential interference of the in vitro comet assay with AuNPs was assessed.

**Methods:** To assess genotoxicity of AuNPs, bronchial epithelial cells (BEAS-2B) were exposed to 0.75 nM and 3 nM AuNPs at 37° C and 5% carbon dioxide for 24 hours prior to the comet assay. To investigate the ability of residual AuNPs to cause false positives during the assay, untreated cells were exposed to AuNPs just prior to the cell lysis step of the assay. The attachment of residual AuNPs to exposed DNA was assessed using the CytoViva hyperspectral imaging system. To determine possible optical interference, changes in fluorescence of ethidium bromide (EtBr) in the presence of AuNPs were measured using the fluorescent microplate

reader. The modified comet assay was also used to investigate the enzymatic activity of formamidopyrimidine glycosylase (FPG) in the presence of AuNPs.

**Results:** A concentration-dependent and statistically significant increase in comet tail length was observed, thus suggesting genotoxicity. However, the results suggested that the DNA damage was induced by residual AuNPs. Incubation of AuNPs with EtBr showed that AuNPs decreased EtBr fluorescence, hence possibly interfering with the visualisation of DNA comets. The FPG enzyme was able to recognise the oxidised DNA base pairs and converted them to DNA strand breaks without any interference from the AuNPs.

**Conclusion:** The observed data revealed interference of AuNPs with the assay procedure, therefore the comet assay may not be suitable for genotoxicity assessment of AuNPs. The effects of AuNPs on in vitro assays need to be taken into consideration prior to their application.

## Kidney function changes in sugarcane workers in the south coast region of KwaZulu-Natal province

M Magombo (presenter), D Rees, S Kgalamono, L Barregard, E Dorkin, J George, S Naicker, R Naidoo, T Snyman, C Wesseling

**Introduction:** Chronic kidney disease of unknown origin (CKDu) has been discovered in some parts of the world amongst agricultural workers. The main speculated risk factor is undertaking strenuous work in hot conditions, with repeated episodes of dehydration. This study investigated evidence of acute kidney injury among sugarcane workers in KwaZulu-Natal province, South Africa, over the first few weeks of the harvest season.

**Methods:** The study design was replicated and has previously been described in a study done in Nicaragua. This study employed a longitudinal cohort study. A group of male sugarcane cutters in Sezela sugarcane estate (N = 37, aged > 18 years) was examined for kidney function biomarkers before and after shift, on the first day of the cutting season, on day ten, and nine weeks later. A control group, mainly workers not doing strenuous work in hot environments (N = 35, aged > 18 years) were examined at the start, and then after nine weeks into the harvest season.

**Results:** Over the harvest the average maximum temperature was 26.1° C. Across a working day there were significant changes in the biomarkers of kidney function, particularly creatinine, urea, uric acid, neutrophil gelatinase-associated lipocalin (NGAL), sodium and potassium, indicating dehydration. The cane cutters also developed cross-shift changes in these biomarkers. However, across the cutting season, the estimated glomerular filtration rate (eGFR) increased (12.1%) in the cane cutters, whilst the creatinine decreased (9%). Most of the workers in both groups had eGFR values within normal limits.

**Conclusion:** The increase in the biomarkers of renal function across shift provide evidence of acute kidney injury on each day of the cutting season. However, the increase in the eGFR across-harvest season provided absence of CKDu disease. These changes were related to the provision of water and low temperatures during the harvest season.

## Occupational tuberculosis in South Africa: are healthcare workers adequately protected?

M Malotle (presenter), J Spiegel, A Yassi, D Ngubeni, L O'Hara, P Adu, E Bryce, N Mlangeni, G Gemell, M Zungu

**Introduction:** Effective tuberculosis (TB) infection prevention and control (IPC) measures, including education and training, are crucial in limiting the spread of TB in healthcare settings. The objective of this study was to explore factors associated with the development of TB among healthcare workers (HCWs) in a provincial tertiary hospital; factors associated with protocol adherence in the use of respirators; the nature and extent of training related to TB IPC; and association of training and practices within different occupational groups.

**Methods:** A cross-sectional study was conducted. An interviewer-driven structured survey was conducted among HCWs in a provincial tertiary hospital in Gauteng province, South Africa. Data were analysed using SPSS version 24. Pearson's chi-squared test or Fisher's exact test checked differences between categorical variables; logistic regression assessed associations between covariates; backward stepwise regression was applied to select variables.

**Results:** Of the 285 HCWs, 50.7% were nurses, 5% doctors and 29% non-clinical HCWs. A total of 37.2% of HCWs were aware of a

protocol for managing TB patients; 45% reported ever using respirators when managing presumptive or confirmed TB patients; 9.8% of non-clinical HCWs reported ever using respirators. A total of 62.2% reported that N95 respirators were always or sometimes available, while 14.6% of non-clinical HCWs reported that respirators were available. Of nurses, 29.8% were trained in the proper use of N95 respirators; 5% of non-clinical workers were trained in mode of transmission. Non-clinical workers were more likely to report using respirators if trained in their proper

use (OR 36.23, 95%). Clinical workers were more likely to report using respirators if readily available (95% CI).

**Conclusion:** Major gaps were identified in availability of respirators and training of HCWs in TB transmission. Both factors are highly associated with lack of adherence to TB IPC measures. Hospital management should ensure respirators are readily available and all job categories are effectively trained, with particular attention to non-clinical staff being the minority group trained in this study.

## The ergonomic design and effects of Hewlett Packard (HP) 'all-in-one' computers at the National Institute for Occupational Health (NIOH)

B Nkosi (presenter), B Nyantumbu-Mkhize

**Introduction:** Work-related musculoskeletal disorders (MSDs) are associated with poor office ergonomics. The installation of the computers at the NIOH raised concerns when the ergonomics unit started to receive complaints from workers using the newly installed 'all-in-one' computers. An ergonomic assessment was done on all workers using the computers for more than four hours a day.

**Objectives:** The study aimed to assess the ergonomic design and effects of the Hewlett Packard (HP) 'all-in-one' computers on NIOH workers, and give recommendations where needed.

**Methods:** A list of workers was obtained from the NIOH IT department. A total of 45 workers were on the list. The assessment was conducted on 33 workers and 12 workers did not meet the inclusion requirements. The observation method was used to observe working height, viewing height, horizontal work area,

and the viewing distance of the workers as they performed their tasks. The measurement method used was to measure the deficit height of the computers.

**Results:** The horizontal work area and the viewing distance were suitable. The working height and viewing height were unsuitable because the height of the computers was low. This resulted in awkward upper-limbs posture. The deficit height ranged between 5.5-13.5 cm.

**Conclusion:** The low height of the HP 'all-in-one' computer deviated from the principles of the office ergonomics by promoting awkward postures of the upper limbs. Awkward postures are associated with upper-limb musculoskeletal disorders (MSDs). The measurement showed the need for the HP 'all-in-one' computers to be elevated, using adjustable computer stands which ranged from 5.5-13.5 cm.

## Occupational exposure assessment of engineered gold nanoparticles – a pilot study

L Ntlailane (presenter), X Masoka, M Gulumian

**Introduction:** Interest in the application of nanotechnology in South Africa has expanded. This document reports on efforts by the National Institute for Occupational Health (NIOH) to contribute to the responsible development of nanotechnology in the country. The efforts are in line with the Nanotechnology Health, Safety and Environment Research Platform of the National Department of Science and Technology. The aim of this study was to perform an exposure assessment during the synthesis of 80 L of 14 nm gold nanoparticles using the citrate reduction of chloroauric acid in water. This was done by collecting a sample of particles in the workplace air during the nanoparticles handling, and then characterising and evaluating the levels of nanoparticles based on available guidelines.

**Methods:** The assessment was carried out following a tiered method developed by Methner et al., which included reviewing the synthesis process, determining the kind of control measures in use, identifying which tasks will require a comprehensive exposure assessment, and conducting the assessment using a combination of direct-reading particle meters and filter-based sampling.

**Results:** The facility was fitted with a general ventilation system,

which was not used on the day of the assessment. Particle-number concentration measured during synthesis and harvesting of the nanoparticles did not show a significant increase compared to background, at a p-value of 0.324 and 0.795, respectively. The 2 714 particles/cm<sup>3</sup>, eight-hour time-weighted average at an exposure duration of 142 minutes and 1 413 particles/cm<sup>3</sup> for 50 minutes of both tasks was below the recommended nano reference value of 20 000 particles/cm<sup>3</sup> by Van Broekhuizen et al. Size distribution of the peak concentration as measured by a size-selective monitor consisted of nanoparticles in the size range 7.5-35 nm. The elemental mass concentration ranged from 0.01-0.16 µg/m<sup>3</sup> of Au, with a task of adding citrate having the highest personal exposure at 0.14 µg/m<sup>3</sup>, exposed for 44 minutes. The smallest particle size observed by electron microscopy (EM) was approximately 20 nm. Elemental composition analysis identified Au, confirming the presence of the aerosols in the air.

**Conclusion:** Synthesis of AuNPs resulted in emission and exposure, as confirmed by particle size distribution, mass concentration and EM. The particle number concentrations were, however, lower than the recommended exposure reference values.

## Health and working conditions of landfill waste pickers in Johannesburg, Gauteng province

V Ntlebi (presenter), K Wilson, T Kootbodien, F Made, N Tlotleng, N Naicker

**Background:** Landfills pose potential risks to health and safety. Risks related to recycling are biological, physical, chemical, ergonomic and psychosocial, and are intensified by the lack of access to personal protection equipment (PPE) and occupational healthcare. The aim of the study was to assess working conditions and the health of waste recyclers.

**Methods:** A cross-sectional analytical study was conducted at two landfill sites in Johannesburg. A total of 370 waste recyclers were conveniently and proportionately selected from the sites. An interview-driven structured questionnaire was used. Information on their working conditions and a health-screening assessment, consisting of anthropometric measurements, blood pressure monitoring, temperature monitoring, and fingerprick tests for blood glucose, haemoglobin and cholesterol were conducted. Data were analysed for frequencies

using Epi-info software.

**Results:** A total of 363 waste recyclers participated. The majority of participants were males (73%). Age ranged from 18 to 81 years with a mean of 41 years. About 93% had normal cholesterol levels while 5% were borderline and 2% were high. The glucose levels were found to be normal in 71% of them and in 15% were low, while in 14% were found to be high. Haemoglobin levels were found to be normal in about 60% of the participants and low in 39% of the participants. A large number were injured during work, with 83% reporting cuts, although almost all (98%) reported to have some form of PPE.

**Conclusion:** Although waste recyclers experience a number of physical and health risks in their daily work, the majority were shown to have normal levels of the different blood tests that were conducted. Education on proper use of their PPE is needed.

## Evaluation of noise levels to which forklift operators are exposed at a fresh produce market in South Africa

D Rangongo (presenter), N Claassen

**Background:** The fresh produce market is a retail whereby farmers sell fresh food directly to retailers and consumers. Activities that take place in the market involve delivering and loading of goods, usually on pallets, using forklifts. The forklifts used are the main source of noise and put the operators at risk of developing noise-induced hearing loss (NIHL).

**Methods:** Fifteen personal noise measurements were taken from forklift operators, according to the SANS 10083:2013 method using noise dosimeters. The dosimeters used were calibrated prior to, and validated after, taking measurements. An ethics approval certificate (reference number 448/201) to conduct the study was obtained from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

**Results:** Results revealed that 53% of the eight-hour equivalent (Leq,8hr) noise dosimetry measurements exceeded the noise rating limit of 85 dB(A). The minimum and maximum noise-dose exposure

levels measured were 82.6 dB(A) and 90.9 dB(A), respectively. The maximum peak recorded was 143.5 dB(A), whereas the minimum peak was 125.4 dB(A). From the interviews conducted, the forklift operators were aware of NIHL but they were not provided with any hearing-protection devices.

**Conclusion:** Forklift operators at the fresh produce market might be exposed to noise levels exceeding the exposure limit of Leq,8hr time-weighted average (TWA) 85 dB(A), thus are at risk of developing NIHL. According to the NIHL Regulations, a hearing-conservation programme must be implemented if the employees are exposed to noise levels equal to, or higher than, an Leq,8hr of 85 dB(A). The programme should include: noise zoning, training and awareness, noise control, medical surveillance and a hearing-protective devices programme. This programme should be effective to attenuate noise levels to below the noise-rating limit, and also to reduce the risk of NIHL among forklift operators.

## Interference of gold nanoparticles (AuNPs) in molecular biology assay systems

N Sanabria (presenter), M Gulumian

**Introduction:** Toxicology assesses the adverse effects related to different doses, type or composition of substances, in order to find the 'acceptably safe' level for living organisms, e.g. people in the workplace. Unfortunately, it has now been established that intracellular nanomaterials interfere with these different toxicity and genotoxicity assay systems. For example, there is a lack of validation when conducting routine tests for nucleic acid isolation, quantification, integrity and purity analyses, as well as in the verification of qPCR-related gene expression analyses.

**Methods:** Investigations were conducted to assess the interference

of gold nanoparticles (AuNPs) in various assay systems.

**Results:** The introduction of AuNPs to BEAS-2B cells produced absorbance peak shifts, which indicated changes in the quality of the isolated ribonucleic acid (RNA). Although the RNA isolated from the 24 h AuNP-treated samples was considered to be suitable for RNA-based techniques when using the traditional methods, additional screening identified changes that are associated with structural alterations of functional groups. The wavelength shift observed was most probably due to these AuNPs interacting with the amines found in nitrogenous bases of the nucleic acid. Results

have also indicated that AuNPs have the potential to interfere with the amplification and detection within the RT-qPCR assay mechanism, which relies heavily on the quantification of stably expressed reference genes.

**Conclusion:** Caution is advised when only assessing DNA/RNA quantity, since structurally altered or damaged nucleic acids could

be falsely interpreted as simply a low yield and, subsequently, produces false genetic expression data. Moreover, AuNPs have the potential to interfere with the assay mechanism of RT-qPCR, thus assay verification is required for AuNP-related gene expression studies used to evaluate toxicity, i.e. exposure studies of AuNPs in the workplace.

## Asbestos exposure in patients with malignant mesothelioma: a case series

N Tlotleng (presenter), K Wilson, N Naicker, T Voster, S Kgalamono, N Vorajee, C Koegelenberg, D Rees, JI Phillips.

**Background:** The adverse health effects of inhaling asbestos fibres have been known for many years. One disease caused by exposure to asbestos-containing materials is malignant mesothelioma, an aggressive, fatal tumour that affects the lining of the lungs. This case series describes sources of self-reported asbestos exposure in patients with malignant mesothelioma.

**Methods:** Seven cases were reported in Tygerberg and Chris Hani hospitals in July 2017–December 2017. The histology reports of the consenting patients were reviewed by a pathologist to confirm the diagnosis. Patients were contacted for a telephone interview to assess their exposure history to asbestos.

**Results:** Four cases had non-occupational exposure, even though two of the cases reported having being exposed to asbestos in their occupation: Case 1, a 70-year-old female worked in a place where asbestos was used, lived in a house

with an asbestos-cement roof in an asbestos mining area, and reported living with a spouse with asbestosis; Case 2, a 69-year-old female who lived near a power station for a period of 21 years; Case 3, a 58-year-old female living in an asbestos mining area; Case 4, a 74-year-old male who worked as a motor mechanic and had lived in an asbestos mining area. Two cases reported exposures exclusively to occupation. Cases 5 and 6 were males, 65- and 69-years-old, respectively, who worked in a construction and a cement industry, respectively.

**Conclusion:** Non-occupational exposure occurs predominantly in women. This case series highlights how ubiquitous asbestos is in the environment and how diverse the exposures may be. Through such exposures we can expect to continue to see cases of malignant mesothelioma of the pleura in South Africans, despite the banning of asbestos ten years ago.

## Demonstration of the uptake of gold nanoparticles using CytoViva technology and transmission electron microscopy

M Vetten (presenter), M Gulumian

**Introduction:** Gold nanoparticles (AuNPs) have a wide range of commercial applications and, therefore, the potential exposure of workers to these nanoparticles during production necessitates the need for toxicity studies and the establishment of occupational exposure limits (OELs). The uptake and intracellular fate of nanoparticles will influence their ability to cause toxicity and, therefore, needs to be determined.

**Methods:** We compared two techniques to assess uptake of 14 nm AuNPs, namely through the CytoViva HSI system and transmission electron microscopy (TEM). Cytotoxicity was measured in triplicate in two independent experiments using the xCELLigence RTCA system, which measures the electrical impedance across the base of the wells, which is influenced by the presence of adherent cells and can be used to monitor cell viability in real time.

**Results:** 14 nm AuNPs in the concentration range 1-5 nM were found to be non-toxic to the human bronchial epithelial cell line BEAS-2B for up to 24-hours incubation. The uptake of these particles at 1 nM was then assessed. The CytoViva HSI system

allowed for the acquisition of dark field microscopy images and the confirmation of the presence of AuNPs. In addition, CytoViva's 3D imaging confirmed the uptake and identified nanoparticles within the cells. This technology can locate non-labelled nanoparticles within 3D space relative to their surroundings; however, additional staining with fluorescent markers would allow for the identification of the intracellular localisation of nanoparticles relative to subcellular organelles. AuNPs are known to interfere with some fluorescent dyes, thus the use of dyes must be validated prior to use in studies. TEM imaging was used to confirm the uptake and the presence of AuNPs in vesicles/vacuoles and in the cytoplasm.

**Conclusion:** Both of these techniques require the availability of specialised equipment, however the sample preparation for TEM can be somewhat tedious and involves the use of hazardous reagents. On the other hand, the sample preparation for CytoViva is quick and easy, and this technique has been shown to be preferable in providing convenient qualitative information on uptake.

This event provided an opportunity to introduce and advertise the NIOH Twitter handle, with prizes for the best tweets posted during the day. The Twitter handle is @NIOH\_SA; please follow us and see what delegates said about the event.

# The 11th IOHA International Scientific Conference



**Prof. Gurumurthy Ramachandran was the Chair of the International Scientific Committee of the 11th IOHA International Scientific Conference**

The International Occupational Hygiene Association (IOHA) organises a scientific conference every three years. The 11th IOHA International Scientific Conference took place from 24 to 26 September, 2018 in Washington, D.C., in the USA. The Conference is a truly special occurrence and is held at venues across the globe, drawing an international audience of multidisciplinary professionals with a focus on worker health protection and exposure control. The theme for the 2018 Conference was 'Bringing Better Health to Workers Worldwide'. The Conference attracted more than 500 participants from 36 countries, with close to 200 speakers from 25 countries.

An International Scientific Committee (ISC), chaired by Prof. Gurumurthy Ramachandran (Johns Hopkins Bloomberg School of Public Health, Maryland, USA), was established to assist with reviewing proposals and had a tough task selecting submissions from the more than 100 that were received, for what turned out to be a tightly-packed schedule of high-value offerings. Main features were:

- 11 professional development courses (PDCs) that attracted over 250 participants;
- 57 educational sessions – all with an international focus, and highly ranked by participants post-conference; and
- the 8th Control Banding Workshop.

The Conference was officially opened by the outgoing IOHA President (2017-2018), Ms Andrea Hiddinga, followed by plenary speaker, Ms Nancy Leppink, the Chief of the Labour Administration, Labour Inspection and Occupational Safety and Health branch of the International Labour Organization (ILO). Ms Leppink's keynote address summarised the ILO's history, affirmed the organisation's continued relevance, and argued that the prosperity associated with globalisation has done little to protect the world's most vulnerable workers. Ms Leppink further stated that the ILO is also attempting to address changes wrought by modern technology, giving rise to the 'gig economy' and creating a class



**IOHA Collaboration Award recipients, L to R: Mr Peter-John 'Jakes' Jacobs (IOHA President and WHWB member), Dr Seshananda Sanjel (Kathmandu University School of Medical Science), Mr Homraj Acharya (Global Fairness Initiative), and Dr Steven Thygersen (Brigham Young University and WHWB member)**

of workers largely beyond the reach of occupational health and safety protection and services.

Other sessions highlighted the latest developments in occupational hygiene, and included sessions on real-time sampling to aid decision-making and provide actionable data, exposure modelling, the use of robots for exposure characterisation, new sampling techniques, hazard characterisation, and sophisticated epidemiological studies. Other presenters told of managing projects in a country with an Ebola outbreak and providing relief and assistance after a hurricane disaster in Puerto Rico, highlighting the crucial role played by the occupational hygiene discipline in first responses. There was also a panel discussion on global health challenges.

The volunteer non-profit international organisation – Workplace Health Without Borders (WHWB) – presented a session on 24 September, where WHWB Board member Ms Lydia Renton and fellow WHWB members mentioned that more than two billion workers lack basic access to the expertise and services of occupational safety, health and hygiene professionals. They highlighted strategies and opportunities for volunteers to engage in projects that will help support occupational hygiene efforts around the world, especially in economically developing countries, and in vulnerable worker populations.

The Conference provided the perfect platform to present the IOHA Collaboration and Lifetime Achievement Awards. The Collaboration Award honours collaboration between an occupational/industrial hygiene organisation and other countries or organisations, to share ideas and technologies to improve the calibre of occupational/industrial hygiene worldwide. Nominated by the American Industrial Hygiene Association (AIHA), the Brick Kiln Committee of WHWB and 'Global Fairness Initiative' (GFI)

were voted the winners for achieving outstanding results through collaboration, leading to better global understanding of brick kiln hazards. They worked together to establish a dedicated centre at Kathmandu University in Nepal to collect data on sampling, analysis, medical information, extent of child labour, and hazardous exposures in brick kilns. Through this international database, researchers around the world will be able to coordinate information on health and safety issues in brick kilns better. The Centre will provide valuable insights into working conditions and child labour in brick kilns, effective exposure measurement techniques, and solutions for controlling exposure and protecting worker health.

The Lifetime Achievement Award honours individuals who have made significant contributions to the promotion and development of occupational hygiene practices that improve the health and welfare of workforces around the globe. To be eligible, award candidates must have been working in the field of occupational hygiene for at least 15 years, and must still be active in the field. The award criteria include a substantial contribution to basic science, the establishment of occupational hygiene programmes, the promotion of the quality of occupational hygiene services, and/or a contribution to the harmonisation of occupational hygiene practice. Furthermore, the awardee's accomplishments are required

to exemplify IOHA's objectives. The recipient of this award was Mr Roger Alesbury (MSc, Dip OH, CFFOH) of the Occupational Hygiene Training Association (OHTA), who shared his hard-earned wisdom, and stressed that the key to creating lasting, positive change is persistence in the face of obstacles. Another key message from his presentation was '...the need to engage and communicate with employers about the need for quality health protection and the role of occupational hygiene training. By listening to employer concerns, training and development programmes can be tailor-made to suit local needs'.

If there is only one international conference dedicated to the occupational hygiene discipline that you can or would like to attend, the IOHA International Scientific Conference needs to be 'the one'. With early planning, you can turn this into a reality. The 12th IOHA International Scientific Conference will be held in Daegu, South Korea, from 16 to 22 October 2020. See you there!

*Report by:*

*Peter-John 'Jakes' Jacobs  
IOHA President (2018-2019)*

*SAIOH Council Member 2019: International Liaison Portfolio  
e-mail: [pjjacobs@sedulitas.co.za](mailto:pjjacobs@sedulitas.co.za)*



**IOHA Lifetime Achievement Award recipient, Mr Roger Alesbury**



**The panel discussion on global health challenges was a well-attended session**



**The theme of the 12th IOHA International Scientific Conference, to be held in South Korea in 2020, will be 'Bridging Gaps in Occupational Hygiene Development, Opening New Horizons'**

*All photographs courtesy of IOHA*

*Visit [www.occhealth.co.za](http://www.occhealth.co.za) to see more photographs from this event.*



# Report from SAIOH President and Council Members

## MESSAGE FROM THE SAIOH PRESIDENT

2018 was a pivotal year for the Southern African Institute for Occupational Hygiene (SAIOH), with Council delivering strongly on SAIOH's strategic objectives. Integral to these was the launch of the SAIOH Mining Forum at the Annual Conference in October. The main objective of the Mining Forum is for SAIOH representatives to work closely with our mining-related partner organisations to support and develop occupational hygiene practitioners in the mining industry.

The SAIOH branches and discussion groups have grown, with 12 active groups meeting on a regular basis. One of SAIOH's main success stories is the Botswana branch which has grown substantially since its launch a year ago. It aims to become a stand-alone association in the next few years.

Having served on the SAIOH Council for several years, I realise that many of our members are not aware of how we operate. Council Members meet quarterly to develop strategies, review operational requirements, oversee finances and spending, and ensure that SAIOH members are supported. To enable the Council to cope with the substantial workload, each Member is responsible for a specific portfolio. These include policy and planning, ethics, technical, liaison (national and international) with global entities, and sister associations and stakeholders in occupational health, such as the South African Department of Labour (DoL); branches (for the support and development of branches across southern Africa); communication and marketing; and the general management of the office and staff.

A lot of effort goes into managing the SAIOH certification system. In order for our members to be registered in the three professional categories, viz. registered occupational hygiene assistant (ROHA), registered occupational hygiene technologist (ROHT), and registered occupational hygienist (ROH), SAIOH has a Professional Certification Committee (PCC) that certifies the competence of members through written and oral assessments. The PCC meets three times a year to set examination papers, coordinate and run oral assessments, and mark the written papers. All Council and PCC Members are volunteers.

We look forward to 2019 and thank all the Council Members who contribute so much time and effort to the implementation of SAIOH strategies and objectives. A big 'thank you' to Julie Hills for presiding over Council so effectively in 2018. You have left big shoes to fill. We do, however, recognise that you will continue to play an important role in Council as Immediate Past President, and we appreciate your continued support and guidance.

*Celia Keet*  
SAIOH President 2019

## REVIEW OF THE DRAFT REGULATIONS FOR HAZARDOUS CHEMICAL AGENTS

SAIOH representatives, Julie Hills, Garth Hunter and Alan Hanley, met with Neels Nortje (CEO of the South African Institute of Occupational Safety and Health, Saioh) and Neil Enslin (Master Builders Association) to prepare a consolidated response to the DoL's call for comment on Phase 1 of the proposed Regulations for Hazardous Chemical Agents (RHCA).

SAIOH would like to thank members who submitted comments and suggestions to be included in the consolidated response.

## SAIOH ANNUAL CONFERENCE 2018

The SAIOH Annual Conference, held from 23 to 26 October at the Champagne Sports Resort in the central Drakensberg, was hosted by the SAIOH KwaZulu-Natal branch. The conference theme was 'Raising the bar in occupational hygiene – informed control reduces worker exposures', and the presenters did not disappoint. The quality and content of the presentations throughout the programme were of a very high standard. The programme was multi-layered with a selection of professional development courses (PDCs), the launch of the SAIOH Mining Forum, a breakfast meeting for SAIOH Branch Chairs, the SAIOH Annual General Meeting (AGM), and a scientific conference taking place during the four days. SAIOH members and guests showed their support and endorsement of the proceedings, with conference attendance being much higher than in recent years.

## PRE-CONFERENCE PDCS

SAIOH was fortunate to have secured the availability of three international experts who each presented a two-day pre-conference PDC.

The first PDC, 'Testing the performance of local exhaust ventilation (LEV) systems to achieve adequate control of employee exposures', was facilitated by Mr Adrian Sims, Managing Director of Vent-Tech Ltd, Bristol (UK). The PDC was outstanding in terms of its practical application, and it was delivered by an expert with a visible passion for ventilation. What set it apart from the other PDCs is that Mr Sims focused on his own professional experience during the presentation. Having designed numerous LEV systems over the years, he understands the opportunities and challenges of designing these systems. Although the PDC focused on the assessment of LEV systems, it wasn't all about 'getting a flow rate'. On the contrary, Mr Sims encouraged the art and science of looking for clues as to how well the systems work, such as dust or mist deposition, the use of a Tyndall lamp, and how to generate



**Peter-John (Jakes) Jacobs (SAIOH Council member and Past President) presented a gift on behalf of SAIOH, to Mr Aymen Jemni from Barcelona, Spain (left), after his PDC delivery, as a token of appreciation for his willingness to participate in the SAIOH Annual Conference. Mr Jemni, a technical expert on EMFs, also presented a keynote address in the scientific conference programme**

*Photographs (published in print and online for this report):  
Norman Khoza – SAIOH Council member 2019: Branches Portfolio  
Julie Hills – SAIOH Immediate Past President 2019  
Deon Jansen van Vuuren – SAIOH Council member 2019 and  
PCC Chief Examiner  
Rebecca Dick – SAIOH PCC Administrator*

different amounts of smoke, as required for the testing. If SAIOH members are presented with the opportunity of attending a future course in ventilation presented by Mr Adrian Sims, they would be advised to waste no time in booking a place.

The second PDC, 'Noise control engineering – proven and effective solutions', was presented by Mr Dennis P Driscoll, President and Principal Consultant, Associates in Acoustics, Inc. Denver, Colorado (USA). The reason that this PDC is consistently rated very highly at conferences of the American Industrial Hygiene Association (AIHA) is that noise control is a passion for Mr Driscoll. He lives with his wife's significant hearing loss from an accident, and suffers from a degree of hearing loss himself. His understanding of the impact of hearing loss and his desire to make a difference to the audience's awareness of noise was evident in the delivery of his PDC, where Mr Driscoll freely shared his knowledge and personal experiences, as well as access to a treasure trove of noise control tools. The PDC was informative and of a very high standard, with Mr Driscoll encouraging participants to ask questions related to noise issues in workplaces.

The third PDC, 'Electromagnetic fields (EMFs): measurement and control of human exposure to non-ionising radiation', was facilitated by Mr Aymen Jemni, Application Engineer from Wavecontrol S.L., in Barcelona (Spain). The PDC was run twice (on 23 and 24 October), and was well attended by



**Academic Presence – SAIOH members Daniel Masekameni (left) and Goitsewang Keretsetse, who both lecture at the School of Public Health, University of the Witwatersrand, attended and presented at the conference**

more than 30 SAIOH members over the two days. The PDC included an introduction to non-ionising radiation and EMFs and their health effects on the human body, the best control for exposure to EMFs, information on applicable standards, high-risk work environments, the types of instrumentation and their use in quantifying exposure to EMFs, and a practical EMF sampling demonstration.

Given the high level of interaction from participants, it was clear that occupational hygienists are interested in developing a better understanding of the health risks associated with EMF exposure and how to quantify this risk.

### **SAIOH MINING FORUM LAUNCH**

As part of the SAIOH five-year strategic plan, a decision was taken to form a special Mining Forum within SAIOH during 2018, to focus on and better understand the practice of occupational hygiene in the mining sector. It is envisaged that the Mining Forum will enable SAIOH Council and PCC members to understand better how SAIOH can support members and assess candidates from this sector.

The SAIOH Mining Forum champions from Council, Cas Badenhorst and Brian Mongoma, opened the launch by outlining the aims and objectives of this important forum. The keynote address was given by Dr Brian Davies AM (University of Wollongong, Australia) who spoke on diesel particulate matter (DPM) control strategies in the mining industry. Dr Davies has many years' experience in the mining sector in Australia and his core message was that emissions need to be controlled at source by implementing regular servicing and maintenance of diesel-powered vehicles and machinery.

Invited guest speakers from various mine-related departments and NGOs covered important topics, including dust and DPM exposure statistics, status of health reporting, methods of controlling dust and noise, future education opportunities in occupational hygiene, the use of real time and predictive





monitoring tools, occupational hygiene-based research in the mining industry, and the practice of occupational hygiene in the Botswana mining industry. The presentations were excellent and confirmed that the Forum will be a two-way relationship, as SAIOH's mining partners can certainly add value and teach important lessons to SAIOH members from different industries and sectors. The launch was followed by a social function, including a braai on the terrace, generously sponsored by Dale Kennedy of Ergomax, one of the exhibitor companies at the Conference.

### SCIENTIFIC CONFERENCE SESSIONS

The scientific conference started on Thursday 25 October with a keynote address by Dr Sally Spankie of the Institute of Occupational Medicine (IOM) in Scotland, titled 'Working with REACH – over a decade of helping companies to meet their regulatory obligations'. She described how the control of chemical exposures is being driven in the European Union (EU) by the implementation of Registration, Evaluation, Authorisation of Chemicals (REACH), where research and partnerships have aided the development of safety reports for over 20 000 chemicals. These reports help all types of manufacturers and chemical users to work safely with chemicals and to implement best practice control measures.

The first plenary session comprised five presentations related to the control and reduction of worker exposures to chemicals in the work environment. The presenters were able to communicate how control interventions in various situations, from formal work environments to informal workers and transporting of employees, can be achieved. The real understanding for most of the audience was the extent and scope of work and environments where we practise as occupational hygienists, and the reality of typical South African workplaces, where occupational hygiene skills are most required. The chemical session was wrapped up by an excellent keynote address by Mr Adrian Sims, titled 'Testing of LEV systems: status and practice in the UK'. He highlighted the need for common sense and emphasised that we should not rely solely on measurement data to understand the effectiveness of LEV systems.

The second plenary session covered control scenarios related to various physical stressors, including noise, the effectiveness of hearing conservation programmes, and behavioural safety as a control measure. Mr Dennis P Driscoll gave an impressive keynote address titled 'Hearing loss prevention: what are the barriers and what does it take to succeed?' As in his PDC session, Mr Driscoll was able to demonstrate practical and common sense approaches to achieving control of noise.

The last session of the day included presentations by representatives of SAIOH sister organisations in occupational health. Prof Daan J Kocks, Chair of The South African Society of Occupational Medicine (SASOM), presented the new requirements and proposed accreditation system for occupational health service providers in South Africa, and Ms Susanne Martinuzzi, representing the South African Society

of Occupational Health Nursing Practitioners (SASOHN), provided a practical example of how good controls aided in the decrease of biological lead levels at a lead nitrate plant in South Africa. The SAIOH AGM followed the final session.

The SAIOH gala dinner and awards evening was the social highlight of the conference, complemented by a superb performance by the world-renowned Drakensberg Boys Choir, a truly once-in-a-lifetime opportunity for conference participants.

The second day of the conference, Friday 26 October, kicked off with the third plenary session and a keynote address by Dr Brian Davies AM, on learnings from the development, implementation and maintenance of a control strategy for DPM. As in his presentation during the Mining Forum Launch, Dr Davies highlighted the need for common sense approaches and an informed understanding of emission sources in effectively reducing worker exposures to DPM.

The DoL's occupational hygiene specialists discussed the Hazardous Biological Agents Regulations and how the central theme of control drives the protection of workers in this sector. They also addressed the practical control and prohibition of compressed air lines.

A further session identified the difficulty in collecting reproducible and valid welding fume measurements, concluding that, whilst the occupational hygienist can spend much time and resources trying to perfect the science, the time would be best spent controlling the obvious emissions and reducing worker exposures.

The final keynote address, 'Human body exposure to EMFs', was delivered by Mr Aymen Jemni, and was followed by three brief presentations on the role of the occupational hygienist in emergency planning, the measurement and control of exposure to solar radiation, and using statistical measurement data to set the required level of control in a pathology laboratory.

The conference drew to a close with a SAIOH special session dedicated to PCC issues. This turned into a fun and interactive session with various groups of experts and members across all three categories (ROHA, ROHT and ROH) developing assessment scenarios across the full spectrum of skills sets required for a practising occupational hygienist. Those who stayed for this final session did not regret their decision, and the level of participation from the stalwart attendees was exceptional. This was the first time that SAIOH members were chased out of the conference venue to enjoy lunch and depart on their journeys home.

A full set of abstracts with author information is available for download from the SAIOH website, [www.saioh.co.za](http://www.saioh.co.za).

The SAIOH Council and PCC members would like to thank all the members who participated in this venture, and contributed to the success of the Annual Conference. The amount of learning material generated during the four days was phenomenal and will save the PCC many hours in the formulation of, and addition to, their assessment database.



## SAIOH AWARDS FOR 2017

As is normal practice, SAIOH honoured its Annual Award winners at the Gala Dinner. SAIOH

congratulates all of the nominees and winners in each category.

Name and Affiliation	Award Winner for 2017
Ms Kirsten Hamilton, Safetech	Top Achiever: Occupational Hygiene Assistant Assessment
Mr Albie Louw, The Safety Network – Africa	Top Achiever: Occupational Hygiene Assistant Assessment
Mr Anton Breedt, ASOH Consulting and Laboratories	Top Achiever: Occupational Hygiene Technologist Assessment
Ms Christia Steynberg, Industricon	Top Achiever: Occupational Hygienist Assessment
Mr Kevin Renton, National Institute for Occupational Health	Occupational Hygienist of the Year
Ms Matshidido Mbenge, Debswana Mines	Student of the Year – Vocational Educational and Training
Mr Stefan Linde, North-West University	Article of the Year: Linde SJL, Franken A, Du Plessis, JL. Occupational respiratory exposure to platinum group metals: a review and recommendations. Chem Res Toxicol. 2017; 30:1778-1790.
Ms Robyn Hyslop, North-West University	Student of the Year: Tertiary Institution



**A Touch of Class – The world-renowned, award-winning Drakensberg Boys Choir provided spectacular entertainment at the SAIOH Gala Dinner and Awards Evening**

### BRANCH CHAIRS BREAKFAST MEETING

The SAIOH Council took advantage of the presence of most of its Branch Chairs and representatives to hold a special planning meeting on Friday morning, before the start of the conference proceedings of the second day. The meeting afforded the opportunity to discuss branch needs and support mechanisms, content ideas and the future development and roll-out of SAIOH branches across the Southern African Development Community (SADC), in line with SAIOH strategic objectives. Projects and responsibilities were allocated to representatives who attended the meeting, and SAIOH hopes to see visible improvements and good alignments for its branches going forward.

### CONFERENCE EXHIBITORS AND SPONSORS

SAIOH Council and members would like to acknowledge the support of the conference exhibitors and sponsors. Without their patronage, the Annual Conference and associated events would not have been possible. We thank AMS Haden, Apex, Aquaticoh, Envirocon, Fellowes Beswick, H.A.S.S., Noise Clipper, Safety and

Allied Products, Schauenburg Systems, SKC, Ultimate Optical, Wavecontrol, Anglo American, BarNel Designs, Biograde, Ergomax, Occupational Hygiene Monitoring Services, Specialist Asbestos Training Services and Vine Promotions.

### ACKNOWLEDGEMENTS

SAIOH Council would like to thank Naadiya Nadasen, the KwaZulu-Natal branch committee, the SAIOH administration staff, and supporting Council members for organising and contributing to this successful conference. Very positive feedback was received from members, invited guests and exhibitors on the content and quality of the programme, venue and organisation.

### SAIOH 2019 ANNUAL CONFERENCE

The SAIOH Annual Conference 2019 will be organised and hosted by the SAIOH North West (Rustenburg) branch in conjunction with the Mining Forum team. The dates and venue will be communicated as soon as these are confirmed; the proposed venue is in the vicinity of the Rustenburg and Hartebeestpoort areas.

Visit [www.occhealth.co.za](http://www.occhealth.co.za) to see more photographs from this event.

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# SASOHN's 38th AGM and Conference

## Harvesting Knowledge

### OVERVIEW

The South African Society of Occupational Health Nursing Practitioners' (SASOHN's) 38th Annual Conference took place from 31 October to 2 November 2018 in the beautiful town of Stellenbosch, surrounded by vineyards, tranquil gardens and historic farm buildings. The Western Cape region hosted the Conference and aligned presentations to meet the SASOHN goals as far as possible, as listed below:

- The promotion of the highest possible standards in occupational health practice by encouraging accreditation and upgrading professional qualifications;
- The provision of a supportive network for occupational health nursing practitioners (OHNPs) working in a business environment, and a forum for sharing problems and experiences;
- The development of professional capacity and excellence through the presentation of workshops, conferences and training projects, including specific efforts to keep members abreast of changes in technology and legislation;
- The encouragement of the cost-effective delivery of quality occupational health services in the country; and
- The promotion of adherence by organisations to the legal requirements set in terms of current South African and International legislation.

The Western Cape regional executive committee wanted delegates to share a very different conference experience at the historic Spier Wine Estate, established outside Stellenbosch in 1692, and embodying the vision of sustainability, recycling and 'going green'.

The themes of the Conference were based on the concept of planting and harvesting seeds of knowledge, as well as the fermenting and bottling of seeds of ethics, research, management, leadership and technology, encouraging nurses to embrace and utilise new ideas and advances in their clinical practice. The selection of workshops and conference topics were intended to familiarise OHNPs with the soon-to-be-adopted continuous professional development (CPD) programme.

The Conference started with three simultaneous workshops presented by experts in the occupational health field. Dr Regis Rugira Marie Modeste of Cape Peninsula University of Technology (CPUT) presented the first workshop on publishing our own researchable activities, by providing attendees with the tools for the development of their own research. This interactive workshop provided an opportunity for participants to think about their own practice, identify research problems and apply the research process in developing their own studies that will be relevant and appropriate to their practice. Dr Modeste provided guidelines on how the workshop attendees should work towards developing a research problem, research purpose and objectives, based on relevant issues identified in their own workplaces. The various research methodologies were discussed to

highlight the steps that need to be taken in conducting research to solve the identified problem. The very interactive workshop in developing a research proposal was well received by members, and will hopefully ensure that the methodology is appropriately chosen within an acceptable ethical framework.

Dr Annemarie Lombard, founder and CEO of Sensory Intelligence Consulting, invited us to grow self-knowledge and to use sensory intelligence to create healthy and happy office environments. Dr Lombard presented on health and wellbeing in the modern workplace, and discussed how it has gained momentum as mental illness in the workplace steadily rises. The implications of the high costs of absenteeism and illness were outlined, together with the ongoing efforts that are needed to encourage and empower employers to tackle this problem effectively.

Mr Terence Hermanus, a senior lecturer at CPUT, presented the third workshop about personal branding of the practitioner. He defined the concept and importance of personal branding to optimally promote our own true value, regardless of age, position or type of business. We were reminded to take lessons from the big brands to know what it takes to stand out and prosper in the new world of work.

The day concluded with a 'Hallowine' night market and cocktail dinner – an evening of fun under a fresh night sky, with delegates and exhibitors sampling delectable food from market stalls, while enjoying cocktails and some superb Spier wine.

Day Two started with an opening address by the SASOHN President, Ms Denise Minnie, that encouraged members to change the focus of SASOHN so as to align themselves and the Society with business values. By giving relevant feedback from meetings, workshops and conferences, the OHNP promotes the profession and adds value to the business.

The Conference session themes continued to refer to the concepts of harvesting, fermenting and bottling. The first session, 'HARVESTING', was galvanised by Sharen Russell communicating passionately about the importance of body language, words and voice tone when interacting with people. Sharen is the owner of the Dale Carnegie franchise in the Cape and has every confidence in her abilities as a trainer, believing that her record speaks for itself. Her hands-on business background, and proven success in business management in high-pressure environments, give her the added advantage in being able to relate closely to the real-world challenges and pressures faced by all in her training.

Prof. Penelope Engel Hills, an Associate Professor and Acting Dean in the Faculty of Health and Wellness at CPUT, spoke about ethical decision-making for the OHNP and how to apply care ethics in our practices by being conscientious moral agents.

Dr Jack Meintjies, Head of the Unit for Infection Prevention

and Control, Department of Interdisciplinary Health Sciences, Division of Community Health, Stellenbosch University (SU) and Tygerberg Academic Hospital, concluded the first session. Case studies from the Tygerberg Occupational Health Unit reminded us to not forget the basic question when diagnosing: where does the person work? Valuable case studies were shared with the Conference delegates, as well as how easily we sometimes overlook the basics in diagnosing problems in clients.

The second session focused on 'FERMENTING', the process in which an agent causes an organic substance to break down into simpler substances. The session started with Mr Michael Bagraim, a practicing attorney, founder of Bagraims' Attorneys, and a Member of Parliament for the Democratic Alliance. He addressed the ever-popular subject of medical certificates. Delegates seemed to agree that there is discordance between the primary healthcare model of health delivery in South Africa and the Basic Conditions of Employment Act (Act No. 75 of 1997) that defines who may issue medical certificates. This was followed by Dr Younus Essack who presented two case studies to illustrate the pre-analytical variables that could impact a clinical result. Dr Essack is a consultant chemical pathologist and coordinator of point-of-care testing at Pathcare. The final speaker was Prof. Karien Jooste, Head of Nursing Science, CPUT, who discussed encouraging mastery through self-leadership.

The third session, 'BOTTLING', appealed to delegates to embrace technology and to understand how it has impacted on the millennial generation. Dr Waghid, a lecturer in Educational Technology at the Centre for Innovative Educational Technology (CIET) and the project manager of Analytics for Learning at CPUT, guided us towards blended-learning opportunities, using technology as a medium for teaching and learning. Debbie Jackson, leadership expert and business coach, helped the baby boomers and Y generation members of the audience to appreciate the 'magic of the millennial' and how to coach and mentor them. She pointed out millennials can do the same for the more mature colleague in the workplace – after all, they are ones who understand technology. Dr Jack van Zyl concluded the Conference with his presentation on occupational health

and employee benefits. A strong workplace commitment to health and safety; work modification for injured/ill workers; supervisor training in work disability and prevention; making early contact with injured/ill workers; and good communication between the employer and healthcare providers, are all good strategies that may help to reduce disability claims. Dr Van Zyl is Group Risk Manager of Sanlam Employee Benefits, overseeing all occupational health issues of the Sanlam group of companies and clients of the Sanlam group, including the mining industry, motor manufacturing, local authorities and parastatal organisations.

## AWARDS AND ACCOLADES

At the 'Uncork and Enjoy Gala Dinner', 2018 proved to be another exceptional vintage where we recognised the fruits of labour of our members:

Ian Webster Gold Award:	Karen Michell (PhD)
Ian Webster Silver Award:	Helene Mausling (Western Cape)
Janet Taylor Award:	Helen Mapeleba
Mentor of the Year:	Helen Horsman (Western Cape)
Region of the Year:	Pretoria region
Honorary Life Member:	Denise Minnie (West Rand)

The Conference had a poster display area at the entrance to the venue, which helped delegates gain new knowledge and skills from the awesome displays. Nine entries were received in three categories.

## Poster Competition Winners

Category 1: Formal Research – Agnes Huiskamp

Category 2: Informal Research – Susan Martinuzzi

Category 3: Health Promotion – Karen Koegelenberg

A poster quiz was held to encourage the delegates to visit the poster display. There was good participation and the winner of the quiz competition received a prize donated by Vaal PathCare.

The Annual General Meeting (AGM) commenced with a presentation by Justin Malherbe and Robin Vers on cannabis in



**Pretoria won the 'Region of the Year' award**

*Photograph: Sandra Muller*



**Amtronix sponsored the Gala Dinner**

*Photograph: Sandra Muller*



the workplace, and the implications of the recent Constitutional Court 'Prince' judgement. The Constitutional Court judgement was put into context and the findings were elaborated upon with the conclusion that an adult may lawfully use or consume cannabis (in its various forms), as long as it is done in private. Issues in the workplace include:

- *Can an employee carry or use cannabis whilst on the employer's premises?*

The workplace is not a private space, thus possession and use of cannabis at work is still unlawful. Disciplinary codes that prohibit the possession and use of cannabis are still valid.

- *Can an employer discipline an employee for being 'under the influence' of cannabis?*

Subject to the normal principles of fairness, an employer may dismiss an employee for possession and use of cannabis at work. The onus will be on the employer to show that the level of intoxication has an adverse effect on the employee's job, or has the potential to have an adverse effect, and can make the workplace unsafe. According to Mr Malherbe, this is a factual issue that the employer must prove on a balance of probabilities, and there must be a distinction between intoxication and the mere presence of cannabis in the blood.

- *Can an employer test its employees for cannabis use?*

Testing is permissible if an employer's business requires it, especially if dangerous machinery is used; but an employee must be aware that testing might be carried out and the testing must be conducted in an ethically and medically appropriate manner.

There are many unanswered questions and much hinges on the way Parliament amends the legislation.

## CONCLUSION

Our members acknowledged the 'known' exhibitors and advised that the Conference would not be the same without them; and appreciated and welcomed the 'new' exhibitors and the interaction and learning opportunities provided. SASOHN Western Cape extends heartfelt thanks to all exhibitors and sponsors for their support and attendance at the Conference, without whom it would not be possible. As service providers to the industry, they fulfilled our needs to keep pace with new ideas, trends and information relating to occupational health.

Feedback was also received from members regarding the incorporation of the session sponsors and the value of these presentations in terms of the types of products and their uses being made known to them. The Conference was well attended by our SASOHN members and the information shared was, as always, well worth the attendance.

Visit [www.occhealth.co.za](http://www.occhealth.co.za) to see more photographs from this event.

Report by:

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## MMPA NEWS



# MMPA welcomes you to a greater 2019

This year, the Mine Medical Professionals Association (MMPA) is focused on ramping up and delivering great value to its members. We are quite ambitious in our goals on a number of fronts. We will work aggressively to reach out to more medical professionals in South Africa and to grow our membership, and we aim to become more visible as an organisation. To this end, we will be leveraging more on digital platforms, including social media, to increase visibility and raise awareness about the activities of the MMPA. We will continue building momentum on what we achieved in 2018. As we grow, we will learn from our mistakes and apply lessons learnt to have a more successful year.

We held a number of symposiums in 2018, and strongly believe that we can increase attendance of these events. We will continue the quarterly symposiums and have our Annual Congress later this year. In addition, the MMPA will

co-host the OSHAfrica 2019 conference. We aim to have a beautiful and eventful 2019.

In summary, the year 2019 is the year of GREATER!

- GREATER visibility
- GREATER awareness
- GREATER membership
- GREATER value

Visit [www.occhealth.co.za](http://www.occhealth.co.za) to see more photographs from this event.

Report by: Dr Nothando Moyo-Mubayiwa

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# SASOM 2018 Annual General Meeting and Conference



The South African Society of Occupational Medicine (SASOM) Western Cape Chapter hosted the SASOM Annual General Meeting (AGM) and associated Conference at the Protea Hotel by Marriott, in Stellenbosch, Western Cape, on 24 November 2018.

## CONFERENCE PROGRAMME

The Conference brought together close to 80 delegates, presenters, session chairs, organisers and exhibitors, under the theme of 'Research informs action', and was accredited for six Continuing Education Units (CEUnits) by the South African Medical Association (SAMA). The last SASOM ExCo meeting of the year was held on Friday evening, 23 November, and the AGM followed the close of the conference, on Saturday 24 November.

Dr Gregory Kew, Chair of the SASOM Western Cape Chapter and main organiser of the scientific programme, officially opened the Conference and welcomed all participants.

The first session was chaired by Dr Amy Burdzik, an occupational medicine specialist from the University of Cape Town (UCT), who introduced the first four presenters.

Emeritus Professor Rodney Ehrlich, a Senior Research Scholar from the School of Public Health and Family Medicine at UCT, gave the opening presentation, titled 'Grappling with the question: what is an occupational disease?' As eloquent as always, Prof. Ehrlich gave a comprehensive account of the legal definition of 'occupational disease' being an important

component of both primary protection of workers and their social security. He expanded on the special niche that occupational medicine practitioners have in terms of understanding the relevant toxicology and exposure-response relationships, in combination with an understanding of the rule of presumption and burden of proof in compensation systems. These aspects become more complex in light of the blurring of boundaries that exists between occupational disease, public health, and work-health economics.

The second presentation, titled 'Ethics in occupational health practice', was delivered by Dr Izak Loftus, Senior Partner and Chief Operating Officer at PathCare Laboratories, Somerset West. Dr Loftus described how medical ethics have become pivotal to medical practice, and that they play an important role in the doctor-patient relationship. He covered basic principles of biomedical ethics, the interaction with legislation, and professional rules of conduct; and alluded to the Code of Ethics of the International Commission on Occupational Health (ICOH). In occupational health, there are unique ethical dilemmas that go beyond medical ethics, as is the case when dealing with issues of dual or multiple loyalties.

Dr WAJ (Jack) Meintjes, an occupational medicine senior specialist at Stellenbosch University and Tygerberg Academic Hospital, followed with a presentation, titled 'Physiological cardiorespiratory changes with immersion and diving'. He reviewed the 'normal physiological responses' associated



**'Rose amongst the thorns' – Dr Gregory Kew - occupational medicine specialist, Chair of the SASOM Western Cape Chapter, and main organiser of the Conference – is flanked by the two session chairs, Dr Shamila Fakie (left) and Dr Amy Burdzik (right), both occupational medicine specialists from the Cape Province**

*Photograph: Claudina Nogueira*



**'To the victor, the spoils' – Dr Sophie Kisting (right), Executive Director of the NIOH, receives her prize from Ms Cheryl-Ann Buirski of PathCare, the exhibitor company that donated a 'potjie' hamper for a raffle at the Conference**

*Photograph: Claudina Nogueira*

with immersion and diving, and illustrated these by means of video material of actual diving incidents, which held the audience's attention and led to an animated discussion. As a specialist advisor on various national and international professional platforms related to diving, he presented his own personal experience and involvement in numerous case studies over the years, highlighting the potential impact that workplace exposures associated with diving can have on the health and safety of employees.

Prof. Mohamed Jeebhay, Head of the Occupational Medicine Division of the School of Public Health and Family Medicine at UCT, delivered the last presentation of the morning session, titled 'Recent developments in occupational asthma research'. Drawing on his expertise and vast research experience in occupational allergy, he discussed various clinical and epidemiological approaches to identifying important environmental and host risk factors for occupational allergy and asthma in the South African setting. Prof. Jeebhay also presented studies highlighting preventive approaches that illustrated the effectiveness of exposure standards, workplace interventions, medical surveillance programmes, and education and training of workers and managers.

The afternoon session was chaired by Dr Shamila Fakié, an occupational medicine practitioner in private practice. She introduced Dr Shahieda Adams, a senior lecturer and occupational medicine specialist in the Occupational Medicine Division at UCT and the Western Cape Department of Health. Her presentation, titled 'Occupational cancer: a leading cause of work-related mortality', brought the message home that mortality from both cancer and occupational cancer is on the increase, in part due to longer life expectancy and decreases in other causes of mortality. Despite the rapid increase in the number of chemicals in the workplace and emerging occupational hazards, there has been a steady decline in the recognition of new carcinogens. There are specific epidemiological challenges related to the study of occupational cancer, making it difficult to ascertain true estimates of the disease burden. More specifically, data on the occupational cancer burden remain limited for low- and middle-income countries.

The next presentation, titled 'Workers' compensation for occupational tuberculosis (TB) in health workers (HWs) in South Africa: a survey and qualitative study', was delivered by Dr Nicholas (Nick) van de Water, a newly qualified occupational medicine specialist from UCT and the Western Cape Department of Health, and a SASOM ExCo member. Dr Van de Water discussed the findings of a case series of 300 claims for occupational TB in HWs sampled from an employer database, 51 of which presented for interviews. Since HWs face an increased risk of contracting TB, including drug-resistant forms, effective workers' compensation for occupational TB is vital. A total of 59% of interviewees reported the process of submitting cases for compensation to be marred by poor administration and communication by all parties. Only one interviewee had received all the compensation benefits to

which he/she was entitled; and the experience of contracting TB was marked by stigma, surprise and financial stress. This case series highlighted the numerous deficiencies that continue to plague the system of Compensation for Occupational Injuries and Disease (COID). Dedicated facility- or district-based occupational health units, with adequately trained staff trusted by employees, are required to support HWs who contract TB.

Dr Blanche Andrews, an occupational medicine registrar at Stellenbosch University and Tygerberg Academic Hospital, and an occupational medicine advisor at Sanlam, presented 'Hepatitis B vaccinations among employees at Tygerberg Academic Hospital'. She discussed findings from an exploratory retrospective descriptive study, which described hepatitis B vaccination and needlestick injury information for a six-year period (2009 to 2014), and explored the direct costs associated with hepatitis B vaccination. Dr Andrews concluded that initial direct cost estimations indicated that the pre-vaccination approach may need a larger budget, but this would need to be explored more thoroughly via a cost economic-analysis evaluation.

Ms Claudina Nogueira, SASOM ExCo member and ICOH Vice President for Scientific Committees (2018-2021), gave a short presentation on ICOH as a global occupational health professional society, and the benefits of ICOH membership. She also reminded the audience of the joint SASOM-MEDICHEM Conference (scientific programme under development) in Johannesburg, South Africa from 31 July to 3 August 2019; and the next ICOH Triennial Congress, ICOH2021, to be held in Melbourne, Australia, in March 2021. A number of conference delegates showed interest in becoming ICOH members, and completed application forms, taking advantage of the presence of ICOH members to endorse their applications.

Dr Gregory Kew closed the proceedings by thanking all delegates, presenters, exhibitors and co-organisers for the success of the Conference. SASOM is grateful to the following companies for exhibiting at and supporting the Conference: Amtronix (Pty) Ltd, Drug Detection Technology, eMoyoDot Global (Pty) Ltd, Homemed (Pty) Ltd, Med Distributors (Pty) Ltd, Occupational Therapy in Occupational Health (OTOH), PathCare, Prism Inter Africa (Prismia), Sanofi-Aventis South Africa (Pty) Ltd, and SSEM Mthembu Medical (Pty) Ltd.

### **SASOM ANNUAL GENERAL MEETING 2018**

At the AGM, Dr Jenny Sapire, SASOM National Secretary, highlighted the following activities and outcomes for the past year:

The elected SASOM office bearers for 2019 are: Prof. Daan Kocks (Chair), Dr André Kotzé (Vice Chair), Dr Jenny Sapire (Secretary), and Dr Adriaan Combrinck (Treasurer).

As at 31 October 2018, SASOM had 351 members in good standing, including nine honorary life members and



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five corporate memberships. Honorary life membership was awarded to Drs Murray Coombs and Chris van Selm in 2018.

Ms Jenny Acutt retired at the end of March 2018. Mr Jaco Botha has been appointed as the SASOM National Project Coordinator. Contact details are unchanged.

The Department of Labour's (DOL's) 'Occupational Health Forum' continues to be active with Prof. Daan Kocks, Dr Jenny Sapire and Dr Adriaan Combrinck addressing needs, as they arise, with the other stakeholders, viz. the South African Society of Occupational Health Nursing Practitioners (SASOHN) and the Southern African Institute for Occupational Hygiene (SAIOH). ExCo members, Prof. Kocks and Dr Funeka Ngcakani, are also members of the DoL Technical Committee tasked with redrafting the Hazardous Biological Agents Regulations.

Liaison with other organisations, on national, regional and international levels, is a continuous activity. Organisations include the International Occupational Medicine Society Collaborative (IOMSC), the African Regional Association of Occupational Health (ARAOH), Occupational Safety and Health Africa (OSHAfrica), the Council for Health Service Accreditation of Southern Africa (COHSASA), the Compensation Commissioner (CC), the national DoL, and the Health Professions Council of South Africa (HPCSA). Co-opted SASOM ExCo members report on activities of entities they represent, such as ICOH, the South African National Institute for Occupational Health (NIOH), the South African Society of Travel Medicine (SASTM), and the Mine Medical Professionals Association (MMPA).

ICOH's 32nd International Congress on Occupational Health (ICOH2018) was held in Dublin, Ireland, from Sunday 29 April to Friday 4 May 2018. SASOM sponsored (fully or partially) four ExCo members viz. Profs. Daan Kocks and Mary Ross, Dr Adriaan Combrinck, and Ms Claudina Nogueira to present/participate in the Congress which brought together more than 2 000 delegates from around the globe. SASOM renewed its affiliate membership of ICOH for the new triennium (2018-2021); Ms Nogueira was elected as an ICOH Officer in the post of Vice President of Scientific Committees; and Prof. Kocks is the new ICOH National Secretary (NS) for South Africa, succeeding Dr Adriaan Combrinck who served as the previous NS for two triennia (2012-2015; 2015-2018). Dr Combrinck received an ICOH special award for NSs for enrolling the most new ICOH members on the African continent.

SASOM endorsed the ICOH2018 Congress' international call to support the promotion of health strategies to prevent TB. On 26 September 2018, in New York City, USA, world leaders endorsed the United Nations (UN) Political Declaration on TB, 'United to end TB: An urgent global response to a global epidemic'. Due to intense efforts over the past year by ICOH and other partner organisations, the

suggested language related to TB in workers was successfully included in the endorsed UN Declaration which now identifies 'healthcare workers, miners and others exposed to silica' as high-risk vulnerable groups.

The SASOM Annual Congress, themed 'Occupational Health - Looking back to move forward: Old lessons inform solutions for new issues', with the participation of a record number of exhibitor organisations, was held on 22 and 23 June 2018 at the Protea Hotel by Marriott, Kempton Park, Gauteng. The Congress was attended by 150 participants, including delegates, invited speakers and session chairs.

SASOM was invited to participate in the SAIOH 2018 Annual Conference in October; Prof. Daan Kocks presented on 'Organising of occupational medicine practitioners in southern Africa'.

A new interactive and dynamic SASOM website was launched on 5 October to replace the previous outdated version. Mr Jaco Botha, SASOM National Project Coordinator, initiated the process with a newly appointed web designer and the support of Prof. Daan Kocks and Dr Adriaan Combrinck. The previous version was not able to cater for special needs, such as 'membership only' login, complimentary individual access to the SASOM Guidelines in electronic format (only for members in good standing), and public/general access to FAQs and contemporary updated occupational medicine/health information.

### **SASOM MEMBERSHIP FOR 2019**

SASOM members are reminded that the renewal of their annual membership (or the submission of new applications) is due by 31 January 2019 to ensure receipt of all the *Occupational Health Southern Africa* journal issues for the year. Access to the 'Members Area' on the SASOM website will also only be granted to paid-up members with effect from 1 February 2019. Please access the website for more information: [www.sasom.org](http://www.sasom.org).

Visit [www.occhealth.co.za](http://www.occhealth.co.za) to see more photographs from this event.

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All aspects of safety, security and health at work are brought together at A-OSH EXPO, across the spectrum of safety, security, health-at-work, and environmental issues. The show helps to match up the sector's leading product and service providers with Africa's OHS professionals and business leaders, providing a platform for knowledge exchange and relationship building, and giving delegates and exhibitors access to the latest thinking, products, trends and legislation.

Held over three days, A-OSH EXPO features a number of highly popular free-to-attend seminar theatres, which provide in-depth content on critical industry issues.

Sven Smit, portfolio director at Specialised Exhibitions Montgomery, says high-risk work environments in the mining, agriculture, industrial and construction sectors – which have historically played strong roles in the economy – mean that OHS is a crucial focus for government, business and employees. He notes, "These sectors have historically had a strong presence at A-OSH EXPO each year, and the show's personal protective

equipment (PPE) exhibitors have always been able to showcase the best that is on offer. A-OSH EXPO 2019 has already lined up key sponsorship from well-respected PPE companies, Dromex and BBF."

Platinum Sponsor Dromex is a major player in the supply of technology solutions to personal protective equipment and, together with its international partners which are all leading industrial players, is active in the fields of textile, chemical, and environmental sustainability research and development.

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Visitor entrance to A-OSH EXPO 2019 is free. The 2018 show drew more than 3 300 targeted visitors, of whom 76% influence purchasing decisions. There were 115 exhibitors. For more information please visit [www.aosh.co.za](http://www.aosh.co.za).

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# 10 steps to checking your spirometry result

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The 10-step process of checking your spirometry result, outlined in Figure 1, ensures that best practices for data validation, interpretation and record keeping are adhered to in the assessment of every spirometry test. This 10-part series briefly outlines each step, one-by-one.

## STEP 2: REFERENCE VALUES AND ETHNICITY

### Reference values

Reference values are predicted values against which a subject's blow is measured. Reference values are based on equations that take into account age, height and sex and, specify, both the average "predicted" value and the fifth percentile lower limit of the normal range (LLN).

### Selecting reference values

A vast number of reference equations have been produced, studying different populations. To ensure consistency, the reference values used should be standardised throughout the population. All of one subject's spirometry test results should be evaluated relative to a single set of reference values, regardless of which reference set is selected.

### Comparing results with a normal range

There are two methods of comparing a subject's measured values with predicted values; these are:

1. The classic 'older' way: % predicted = measured / predicted x 100
2. The new way: z-score = (measured – predicted) / standard deviation

The (LLN) z- score is a more accurate way to assess spirometric values than the fixed 80% rule. A z-score is the number of standard deviations that a certain value is above the mean value of the data set. (The z-score will be negative if the value is lower than the mean.) A spirometry value is considered too low if it is more than -1.64 standard deviations from the predicted value (which is the same as the lower fifth percentile). The advantage of the z-score is that it permits comparison of values between different populations and across ages.



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## 10 STEPS TO CHECKING YOUR SPIROMETRY RESULT

- |         |                                   |
|---------|-----------------------------------|
| Step 1  | Calibration and patient data      |
| Step 2  | Reference values and ethnicity    |
| Step 3  | Acceptability and usability       |
| Step 4  | Repeatability                     |
| Step 5  | Lower levels of normal / Z-scores |
| Step 6  | Best test / Best Curve            |
| Step 7  | Interpretation                    |
| Step 8  | Grading                           |
| Step 9  | Recording and reporting           |
| Step 10 | Trends and record keeping         |

**Figure 1. The recommended 10-step process to ensure your spirometry result derives from best practices for data validation, interpretation and record keeping**

### Adjustment for race

It is well known that pulmonary function differs between ethnic groups. For a given standing height, non-Caucasian men, on the average, have longer legs than Caucasian men, and a correspondingly shorter trunk size; and therefore slightly smaller lungs, explaining most of the differences between predicted values for Caucasian and non-Caucasian men.

Most spirometers internationally 'correct' or 'adjust' for race in one of two ways: by using a scaling factor for all people not considered to be 'white'; or by applying population-specific norms. To enable the spirometer, the operator must select the race of the individual, and indicate their age, sex and height. Determination of race (or population) designation varies. All designations of race or ethnicity are based on self-report, and subjects, including bi- or multiracial individuals, should choose the racial/ethnic group that best characterises them.

It may be difficult to determine whether to apply a correction factor if the individual is of mixed ethnic background and his/her ethnic group cannot be determined. In this instance, interpretation and the final clinical decision will take this into account. If a correction factor is applied, this must be reported and must also be consistently applied in subsequent tests.



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