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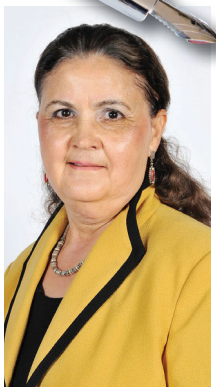
Guest editorial . . .

60 years of the National Institute for Occupational Health (NIOH)



Sophia Kisting, Guest Editor

This year, the NIOH celebrates 60 years of dedicated engagement in occupational and environmental health and safety (OEHS). The NIOH is a public health institute with a proud history of OEHS innovation, research, teaching and training, as well as service delivery. The Institute contributes to the reduction of the decent work deficit, works towards the prevention of exposure to workplace hazards, promotes workers' health and safety, and strives to contribute to increased workplace productivity and sustainable enterprises. More recently, environmental pollution and climate change have received greater attention.

The Institute has grown into a national, regional and international reference centre, providing specialised services to our government departments, and to workers and employers and their organisations. It serves all industrial sectors, including the public service and the informal economy, and promotes workplace ethics. It supports the protection of human rights at work, and efforts towards greater workplace equity. The NIOH continues to be a WHO Occupational Health Collaborating Centre and has strengthened collaboration with countries in Africa and with institutes from around the globe. The NIOH is in the process of becoming part of the National Public Health Institutes of South Africa (NAPHISA) and contributes to building bridges with all OEHS professional organisations and tertiary institutions throughout the country.

The papers included in this issue speak to the diverse nature of the work of the NIOH. We acknowledge the efforts and commitments of the NIOH staff members who wrote the papers. We believe that the creation of new knowledge through research is of critical importance to overcome inequality and to help build sustainable enterprises and more sustainable economies.

The world of work has changed immensely in these 60 years, and we are faced with different opportunities and challenges. One of the most important challenges is the absence of a national policy on OEHS. Workplace injuries and diseases continue to contribute extensively to the burden of disease in South Africa. The majority of these diseases and injuries can be prevented, and often remain undocumented and mostly not compensated. Hours of work and the arrangement of working time have been under increasing pressure for change. Globally, there is a new look at ways to arrange hours of work, including more flexible working hours and shift systems more closely tailored to our circadian rhythms. An examination of underlying reasons for workers not being able to adhere to rigid eight or 12 hour shifts, e.g. lack of adequate public transport, should be undertaken. Absenteeism and presenteeism occur in all sectors of the economy and the financial and human cost is enormous. More scientific research is required to inform efforts to address the underlying problems that need attention to ensure effective and inclusive change.

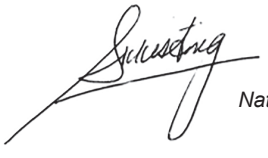
An ILO publication "Women at Work, Trends 2016" examined data for 178 countries and concludes that inequality persists between women and men in the global labour market. The report concludes that women are more likely to become, and remain, unemployed, have fewer chances to participate in the labour force and, when they do, they often have to accept lower quality jobs. The report further states that women continue to work longer hours per day than men in both paid and unpaid work, and many are employed in more informal work arrangements. The report further states that, on average, women carry out at least two and a half times more unpaid household and care work than men. In sub-Saharan Africa, over 60% of all working women are in agriculture, often in activities which are time- and labour-intensive, and which may be unpaid or poorly paid. Youth unemployment remains a global concern but young women face the highest risk of unemployment which, in some regions, is almost double that for young men.

Of the 36.9 million people living with HIV (PLHIV) in 2014, the vast majority were of working age and over 60% were workforce participants. In spite of significant progress over the past 15 years, the HIV/AIDS epidemic and the associated tuberculosis epidemic continue to have a profound impact on workers. Several reports have indicated that gender inequalities remain amongst the most important drivers of the epidemic, and are linked to gender-related economic disparities. The proposed 90–90–90 treatment target for 2020 means that 90% of PLHIV should know their HIV status, 90% of people who know they are HIV-positive should be accessing antiretroviral treatment, and 90% of people on treatment should have suppressed viral loads. Workplaces can contribute significantly to attain this target. The frequently heard call of PLHIV: "Nothing about us without us!" underscores the importance of the participation of those directly affected.

The Sustainable Development Goals (SDGs) were adopted by the United Nations in 2015. SDG eight calls for the promotion of inclusive and sustainable economic growth, full and productive employment and decent work. Key aspects of decent work are widely embedded in the targets of many of the other 16 goals. The SDGs provide workplaces with golden opportunities to implement gender-inclusive preventive practices in OEHS within all industrial sectors, facilitating sustainable economic growth and decent work for all.

Technological advances contribute to the ongoing changes in the world of work in the 21st century. This presents us with progress but also with new OEHS risks related to new technologies, such as exposure to nanoparticles. At the same time, many countries, including our own, are still trying to cope with epidemics of largely preventable work-related diseases, such as silicosis, tuberculosis and asbestos-related diseases, that have plagued workers since before the industrial revolution.

In conclusion, we most warmly acknowledge the important role of all current and past NIOH staff members and world of work role-players who, throughout the many decades, contributed to making the NIOH the vibrant and inclusive centre of OEHS excellence it has become.



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Danuta Kielkowski: an obituary

Our beloved occupational health colleague and friend, Danuta Kielkowski, passed away at home on Sunday 3 July 2016, after struggling with illness for the last 18 months. Danuta was known to many of us as the quiet, gentle and talented occupational health epidemiologist who headed up the Epidemiology and Surveillance Section of the National Institute for Occupational Health from 1989 to 2014, and the Cancer Registry from 2010 to 2014, before her early retirement.

Danuta received her MSc in Physical Anthropology in 1977 from Jagiellonian University in Krakow, Poland, and moved to South Africa with her husband in 1981. Luckily for the occupational health fraternity, they landed up in Johannesburg, and Danuta soon found a job in the Epidemiology Unit of the then National Centre for Occupational Health, under the directorship of Prof. Tony Davies, in 1983. The Unit was new and Tony Davies employed several, what he called "bright young scientists", to work under the guidance of Prof. Margot Becklake. Many brilliant minds passed through the unit and worked with Danuta, including the likes of Rodney Ehrlich, Umesh Lalloo, Anthony Zwi, Freddy Sitas, Mary Ross and many others who are now world-renowned scientists. Danuta stayed at the NIOH, becoming Head of the Unit just six years later, in 1989, and remaining there until the end of her career.

Dr Danuta Kielkowski, 2013
Photo: Guy Hall

Danuta accomplished many things during her career. She is the reason that South Africa has a comprehensive death certificate, listing several causes of death. Changing the SA death certificate earned Danuta her PhD from Wits in 1996, for which she worked diligently and persistently – persuading government officials and policy-makers alike that the change was necessary. She was a leading researcher in improving vital registration, including data quality, ICD coding and reporting of mortality in relation to occupational and industrial groups. Her other research interests included asbestos-related diseases, cancer mortality and reproductive health. She published extensively in various scientific journals, and received many awards for her research. At the time of her death she was an Honorary Senior Lecturer in the Wits School of Public Health, and an Extraordinary Professor at the School of Health Systems and Public Health, University of Pretoria.

Danuta and her husband left many relatives in Poland in the early 1980s, including Danuta's mother and brother whom she visited as often as possible. Her daughter, Katherine, married and moved to Australia, and had two sons of her own. Danuta visited them often too. She loved to travel, whether to the Northern Cape to walk across the asbestos-contaminated veld doing research, or to Canada to meet with funders for cancer research. Her dream was to move to Australia to be with her daughter and grandsons. Sadly, that did not happen, and Danuta left us before she could realise that dream. I have no doubt that many of you have fond memories of her, including her delicious baked cheesecake! My own memories stretch over three decades; I vividly remember the laughter we shared and the many places we visited together.

Rest in peace, Danuta. You will always be remembered.

Gill Nelson (Editor-in-Chief: Occupational Health Southern Africa)

When Danuta retired, Dr Sophia Kisting, Director: NIOH, had this to say:

"After 30 years of dedicated service at the NHLS, Dr Danuta Kielkowski (PhD) retired in December 2014. Dr Kielkowski provided invaluable expertise, first to the Epidemiology Section at the NIOH and thereafter as Deputy Director of the NCR. Danuta's work on death certification and occupational disease surveillance, as well as her asbestos and reproductive health research, are just some of the highlights of her long and productive career. She made an invaluable contribution to the growth and strengthening of occupational epidemiology in South Africa, in the Africa region and beyond. She has published widely on occupational health and her scientific rigour has contributed immensely to new knowledge in public health in South Africa and beyond. Above all, Danuta exemplifies the beautiful spirit of national and international collaboration to address major health concerns through collective research. She has published extensively in peer reviewed journals but also wrote technical reports which had a direct impact on public health policy. She has supervised, nurtured and enthused numerous young epidemiologists and is widely respected for the collegial and inclusive manner in which she shared her skills."

From the National Institute for Occupational Health Annual Review 2014/15 (http://www.nioh.ac.za/assets/files/NHLS_Annual_Report_2015_NIOH.pdf)

"I think I joined NCOH soon after she arrived, which is where we met, both of us rookie epidemiologists, neither of us really knowing much about the field. At that time the Epidemiology Unit was run by Professor Margaret Becklake and we had a lot of fun calibrating lung function machines. She was the one who reminded me years later that one of the reasons I stopped smoking was that my lung function was 10% less than predicted. She carried on working on asbestos-related diseases and on death certification while I went overseas to study but I'll always remember her tenacity. We sat together one day in 1994 with a pair of scissors and sticky tape and redesigned what we thought the new death certificate should look like. This had a field for population group, which was previously deleted by the former government, education (a first) and questions on smoking (a world first), and a proper listing on causes of death. But, despite getting permission from the then Minister of Health (Dr N Zuma), it took three years of sometimes fraught negotiations with the Department to get the new death notification forms re-issued. On several occasions when Debbie Bradshaw or I were given a red card, Danuta persistently kept the issue at play. And we are all grateful for that. South Africa now has the largest study on tobacco-related deaths in the world. Tianjin Province in China has copied the method, and Mexico is interested in doing the same. I kept in touch with Danuta over the years – she was a great chatter, and was so pleased and proud to be visiting her daughter in Sydney and to see her first grandchild."

Freddy Sitas
Director: Evidence Translation at Cancer Australia

Upcoming events

LOCAL MEETINGS

DATE	MEETING	TOPIC	PLACE	MORE INFORMATION
31 Aug - 1 Sep 2016	MineSAFE 2016	Improving health, safety and the environmental impact in the mining and metallurgy industry	Emperors Palace Convention Centre, Johannesburg	E-mail: raymond@saimm.co.za Website: http://www.saimm.co.za/saimm-events/upcoming-events/minesafe-2016
2 - 3 Sep 2016	MMPA 19th Annual Conference	TBA	TBA	E-mail: candiceu@mpas.org.za Website: www.mmpasa.org/wp
19 - 22 Sep 2016	PHASA Conference	Achieving the sustainable development goals: Transforming public health education and practice	East London Convention Centre	E-mail: Thembisa.ngcobo@mrc.ac.za Website: http://www.phasaconference.org.za
26 - 28 Oct 2016	SAIOH Annual Conference	Caring for our wellbeing	Blyde Canyon, Mpumalanga	E-mail: info@saioh.co.za Website: www.saioh.co.za
2 - 4 Nov 2016	SASOHN 36th Annual Conference and AGM	Cruising the 7 C's	Boardwalk Convention Centre, Port Elizabeth	E-mail: office@sasohn.co.za Website: www.sasohn.co.za
18 - 22 Nov 2016	World Psychiatric Association International Congress	Psychiatry: Integrated Care for the Community	CTICC, Cape Town	E-mail: carina@soafrica.com Website: http://www.wpacapetown2016.org.za/
26 Nov 2016	SASOM AGM and Conference	Current issues in Occupational Health	Glenburn Lodge, Muldersdrift	E-mail: info@sasom.org Website: www.sasom.org

HEALTH AWARENESS DAYS, WEEKS AND MONTHS

AUGUST

1 - 7	World Breastfeeding Week
23 - 28	World Water Week
9	Women's Day (SA)
12	International Youth Day
19	World Humanitarian Day
23	International Day for the Remembrance of the Slave Trade and its Abolition
29	International Day Against Nuclear Tests

SEPTEMBER

14 -19	Africa Engineering Week
8	International Literacy Day
15	International Day of Democracy
16	International Day for the Preservation of the Ozone Layer
18	World Water Monitoring Day
21	International Day of Peace / World Alzheimer's Day

INTERNATIONAL MEETINGS

DATE	PLACE	MEETING	MORE INFORMATION
31 Aug - 2 Sep 2016	Basel, Switzerland	44th International MEDICHEM Congress	E-mail: martin.kuster@novartis.com Website: http://www.medichem.org/
5 - 7 Sep 2016	Barcelona, Spain	25th EPICOH Conference X2016	E-mail: epicoh2016@mondial-congress.com Website: www.epicoh2016.org
6 - 8 Sep 2016	Barcelona, Spain	8th International Conference on the Science of Exposure Assessment in Epidemiology and Practice	E-mail: epicoh2016@mondial-congress.com Website: www.epicoh2016.org
14 - 16 Sep 2016	Brussels, Belgium	International Conference on Sustainable Employability - Building Bridges between Science and Practice	E-mail: philippe.kiss@securex.be Website: http://www.incose.eu
19 - 21 Sep 2016	Manchester, UK	Occupational and Environmental Exposure of Skin to Chemicals (OEESC) Conference	E-mail: conferences@bohs.org Website: http://oeesc2016.org/
19 - 21 Sep 2016	Wuppertal, Germany	Work, Age, Health and Employment - Evidence from Longitudinal Studies - Interdisciplinary Conference	E-mail: wahe2016@uni-wuppertal.de Website: http://wahe2016.uni-wuppertal.de/
23 - 25 Sep 2016	New Delhi, India	3rd International Conference on Occupational and Environmental Health (ICOEH 2016)	E-mail: secretariat@conferenceoeh.com Website: www.conferenceoeh.com
25 - 28 Sep 2016	New York, USA	MANGANESE2016 - 28th International Neurotoxicology Conference: Manganese Health Effects on Neurodevelopment & Neurodegenerative Diseases	E-mail: roberto.lucchini@mssm.edu Website: http://events.mountsinaihealth.org/event/manganese2016
25 - 28 Sep 2016	Amsterdam, The Netherlands	4th WDPI Conference, Work Disability Prevention Knowledge	E-mail: events@vumc.nl Website: http://www.wdpi2016.org/
29 - 30 Sep 2016	Singapore	2nd Singapore International Public Health Conference & 11th Singapore Public Health and Occupational Medicine Conference 2016 (SIPHC 2016)	E-mail: siphc@ams.edu.sg Website: http://www.phconference.org/
2 - 5 Oct 2016	Särö, Sweden	Occupational Respiratory Diseases	E-mail: siv.jansson@niva.org Website: http://www.niva.org
2 - 6 Oct 2016	Merida, Mexico	XIV International Congress of Toxicology	E-mail: I.Hernández-Ochoa.ict2016@cinvestav.mx Website: www.ict-mexico2016.org
25 - 27 Oct 2016	Copenhagen, Denmark	Safety and Risks of Engineered Nanomaterials (ENM)	E-mail: siv.jansson@niva.org Website: http://www.niva.org
27 - 29 Oct 2016	Kusadasi / Aydin, Turkey	10th International Joint Conference on Occupational Health for Healthcare Workers: Health & wellbeing in the health care sector; addressing current threats to workers	E-mail: alp.ergor@deu.edu.tr Website: http://70.38.12.36:8905/
29 - 31 Mar 2017	Gothenburg, Sweden	6th International Conference on the History of Occupational and Environmental Health	E-mail: cecilia.andreasson@amm.gu.se Website: www.medicine.gu.se/icoh-history
13 – 15 Apr 2017	Chengdu, China	2017 International Conference on Environmental Pollution and Public Health (EPPH 2017)	E-mail: epph@engii.org Website: http://www.engii.org/epph2017/

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Component resolved diagnosis as a tool for differentiating true latex allergy from clinically insignificant IgE sensitisation

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ABSTRACT

Introduction: Accurate diagnosis of occupational latex allergy is important to clinically manage affected workers, implement exposure interventions, and prevent job change or job losses. Traditional immunological tests involve whole allergen extracts; however, newer diagnostic platforms use purified allergens and genetically engineered recombinant analogues. Allergen extracts are heterogeneous mixtures known to cross-react with proteins of other origins, complicating the identification of the primary allergen source.

Methodology: A total of 41 latex sensitised dental healthcare workers determined by ImmunoCap (k82) from a previous study (N=421) were included in this investigation. Demographic information and clinical and occupational histories were obtained through a self-administered health questionnaire. Eight recombinant allergens from Hevea brasiliensis (Hev b 1, 3, 5, 6.01, 6.02, 8, 9 and 11) were used for the determination of specific IgE responses and two markers of cross reactive carbohydrate determinants (horseradish peroxidase (HRP), and bromelain (MUXF3)) was analysed with the Pharmacia ImmunoCap system, using sera from these workers. Frequencies of sensitisation were calculated for the various latex groups. Parametric analysis (anova), using log transformed data was applied to assess variation of the means between the various latex sensitivity categories.

Results: The prevalence of latex sensitisation in the study population was 9.7% (41/421). The mean age of the subjects was approximately 30 years. The majority of the k82-sensitised workers were non-smokers and females, whilst the opposite was true for the k82-negative category, with 78% being ex-smokers and males. Eighty percent used gloves at work, of which a third was powdered latex gloves. Amongst those that were latex-sensitised, only 22 reported allergic symptoms (respiratory and or skin). Based on the Hev b allergen and CCD specific IgE (sIgE) levels, only about 50% (22/41) demonstrated true latex allergy which accounts for 5.2% of the initial total study population. Approximately 2% (7/421) had asymptomatic latex sensitisation and 3% (12/421) accounted for false positive reactions.

Conclusion: Although composite latex k82 is efficient in demonstrating sensitisation in exposed individuals due to its high sensitivity, it lacks specificity. The use of component resolved diagnosis (CRD) provided a useful approach in confirming a latex allergy diagnosis. CRD adds value to allergy management through early identification of offending allergens, resulting in reduced severity of reactions and delayed disease progression.

Keywords: latex allergy, recombinant allergens, cross-reactivity, occupational allergy

INTRODUCTION

Natural rubber latex (NRL) allergy in healthcare workers (HCWs) appears to have decreased in industrialised countries as a result of the success of preventive avoidance practices. However, exposure to latex still poses a risk in developing countries and to workers in certain industries such as healthcare that have not adopted powder free latex glove avoidance measures. Recent studies have shown increased latex sensitivity (7.1%) and latex allergy (5.9% - 8.3%) among South African HCWs compared to unexposed workers (1.8%).[1-2] Gloves should contain less than 50 µg of extractable protein per gram of glove to qualify for South African state tenders, which is aligned to international recommendations similar to the European Union.[3] However, NRL allergens in latex-containing gloves used in South African health institutions are present at sufficiently high levels to pose an allergic health risk[4-5] and are an important risk factor for the development of asthma and rhinitis.[6]

Clinically insignificant or asymptomatic IgE sensitisation may result from non-specific absorption of IgE to the allergosorbent,

particularly relevant when total serum IgE is elevated. Specific IgE antibodies are known to bear carbohydrate moieties on their components and, as a result, mimic sensitisation and pose a diagnostic challenge.[7] Clinical irrelevance may also arise from cross-reactive carbohydrate determinants (CCDs) due to the existence of multiple epitopes between allergens from different sources,[8] such as banana, kiwi, avocado, chestnut or other fruit.[8-9] It is therefore important to determine whether the worker has true latex allergy or is cross reacting to an agent with similar epitope. In addition, discrimination between true latex allergy and clinically insignificant IgE sensitisation[10] will help identify, and subsequently adequately treat, latex sensitive individuals.[11] For a better understanding of latex allergy and to improve diagnosis of occupational latex allergy, it is necessary to characterise the important allergens using single recombinant allergens that are reproducible and of high quality.[12] To date, 15 allergens (rHev b 1, 2, 3, 4, 5, 6.01, 6.02, 7, 8, 9, 10, 11, 12, 13, 14 and 15) have been identified from NRL Hevea brasiliensis, of which most (rHev b 1, 3, 5, 6.01, 6.02, 8, 9 and 11) are available in recombinant form and commercially available; rHev b 7, 10, 12 and 15 have been produced in E.coli in fusion with maltose-binding protein.[13]

The aim of this study was to determine the role of eight single recombinant Hevea brasiliensis (Hev b) latex allergens and CCDs in differentiating between true latex allergy and cross reactivity with clinically non-significant allergens.

METHODS

Forty-one latex (k82) sensitised dental workers from a previous study (N=421) were included in this investigation.[14] Latex symptoms were determined through a self-administered health questionnaire. Questions included history of respiratory and skin symptoms after contact with latex products, including personal protective equipment (PPE) in the workplace; history of reaction to cross-reactive latex antigens, such as banana, kiwi, avocado, chestnut or other fruit; and use of latex products in the workplace. Respiratory symptoms constituted a positive answer to the question, "After handling latex products have you experienced any of the following: itchy eyes, runny or blocked nose, coughing, wheezing, difficulty breathing?" Skin symptoms included a positive answer to the question, "After handling latex products have you experienced any of the following: itchy skin, skin rash, cracking or chapping hands, redness, hives?" The sera IgE reactivity to eight single recombinant latex allergens (Hev b 1, 3, 5, 6.01, 6.02, 8, 9 and 11) and markers of CCDs (horseradish peroxidase (HRP) and bromelain (MUXF^3) was analysed with the Pharmacia ImmunoCap system. Both markers will be referred to as CCDs throughout this paper. Maltose-binding protein (MBP) was included in the analysis as a negative control. The single Hev b allergens and CCD markers were also measured in 45 subjects that were negative to composite latex (k82). The measurements were performed according to the manufacturer's instructions. A value of ≥0.35 kUa/L was considered

Table 1. Demographic characteristics of the dental workers with positive and negative IgE reactions to composite latex (k82)

Characteristic	Specific IgE response to latex k82			
	Positive (n=41)		Negative (n=45)	
	n	%	n	%
Gender				
male	10	24.4	35	77.8
female	31	75.6	10	22.2
Smoking status				
current smoker	3	7.3	9	20.0
ex-smoker	4	9.8	11	24.4
non-smoker	34	82.9	2	4.4
Atopy	39	95.1	12	26.7
Other allergies				
exotic fruit allergy	6	14.6	8	17.8
insect allergy	4	9.8	1	2.2
Symptoms				
respiratory symptoms	12	29.3	-	-
skin symptoms	20	48.8	-	-
other symptoms	2	4.9	-	-
Bronchial reversibility post bronchodilator	2	4.9	2	4.4
Glove use	36	87.8	34	75.6
Glove type				
powdered latex	13	31.7	20	44.4
powder-free low latex	11	26.8	7	15.6
non-latex	3	7.3	1	2.2
combination	9	22.0	6	13.3

a cut-off for distinguishing between positive and negative results.

Statistical analysis was performed using Stata9 computer software (StataCorp, 2011, Texas, USA). Frequencies were calculated for the various latex sensitised categories. In addition, the means for the single latex allergens were reported for ease of interpretability in the bar charts. The individual IgE antibody data points were log-transformed to conform to the model assumptions of normally distributed variables with equal variances, as the individual data were skewed. Parametric analysis (anova) using log-transformed data was applied to assess variation of the means between the various latex sensitivity categories. Fisher's exact test was used for assessing variation on categorical data, depending on sample size. The results were regarded as statistically significant when $p \leq 0.05$.

The study was approved by the University of the Witwatersrand Human Research Ethics Committee (Medical) (clearance certificate no. M040403).

RESULTS

Demographic and clinical characteristics

The demographic and clinical characteristics of the 41 individuals with a positive IgE reaction to composite latex allergen (k82) and 45 individuals with a negative reaction to k82 are summarised in Table 1. The mean age of the subjects in the two groups was 29.5 and 28.5 years, respectively. The majority of the study participants in the k82 positive category were non-smokers and females, whilst the k82 negative category were mainly ex-smokers and males (78%). Eighty-one percent of the subjects used gloves at work, of which approximately a third used powdered latex gloves; 20% used low latex or a combination of glove types. Among those that were sensitised to the composite extract, 22 (54%) had allergic symptoms (respiratory and or skin) with skin symptoms being more prevalent. The prevalences of sensitisation to exotic fruit and insects were 14.6% and 9.8%, respectively. Although, 29.3% of the latex-sensitised workers reported respiratory symptoms, only 5% displayed clinically significant bronchodilator responses (Table 1).

Prevalence of specific IgE reaction to Hev b allergens and CCDs

The concentration of the eight Hev b allergens and CCD markers were <0.35 kUa/L in the negative controls. The maltose binding protein was also negative in all subjects tested. The major Hev b allergens identified in subjects that were sensitised to composite latex (k82) were 5, 6.01, 6.02; Hev b 8 was the most common. The prevalence of sensitisation to CCDs was also high among individuals with positive k82 responses (Figure 1).

Classification of latex phenotypic categories

The symptomatic (i.e. those with respiratory or skin responses) and non-symptomatic individuals were divided into categories with positive and negative CCD allergen responses, resulting in four distinct groups (I, II, III, IV) (Figure 2). Category I individuals had elevated IgE levels to Hev b 5, 6.01, 6.02 and 8 as opposed to CCD markers which were negative. Category II individuals were sensitised to both latex and CCD markers; however, the specific IgE levels to latex was higher than the CCD levels. The third category (III) identified was those who did not report symptoms, but were CCD negative although sensitised to Hev b 8. In comparison, Hev b 8, as well as both CCD markers, were identified in the fourth category (IV). However, the CCD levels were higher than the Hev b 8 levels in this category.

Category I consisted of 37% (15/41) workers, of which 87% (13/15) were atopic and reported both respiratory and skin symptoms when in contact with latex products, with elevated IgE levels to Hev b 5, 6.01, 6.02 and 8 (minimal), and negative responses to CCD markers. This category was regarded as true latex allergic. The log-transformed data showed a statistically significant difference ($p<0.05$) between the mean levels of CCD markers across the four categories (Figure 3). All four Hev b allergens were detected in workers with skin symptoms, whilst only Hev b 6.01 and 8 were detected among those with respiratory symptoms and with higher IgE levels (Table 2).

Workers in category II demonstrated sensitisation to both Hev b allergens and CCD markers in conjunction with symptoms when in contact with latex (Figures 2 and 3). All 41 workers were atopic. The IgE concentration levels in response to Hev b 6 were much higher than the CCD markers, hence it can be deduced that these workers were truly allergic to latex with some degree of cross reaction. The major allergens identified in these subjects

Table 2. Mean sIgE levels of major Hev b allergens and CCDs by symptom type for category I and II workers with positive responses to composite latex allergen

Allergen	Respiratory symptoms						Skin symptoms					
	Cat I			Cat II			Cat I			Cat II		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
NRL extract (k82)	9	7.2	6.9	3	7.4	11.8	14	4.6	5.4	6	4.0	8.0
rHev b 5: acidic protein	7	0.9	1.4	3	0.01	0.01	11	0.3	1.0	6	0.01	0.01
rHev b 6.01: prohevein	6	2.1	2.8	3	5.8	10.0	9	1.4	2.4	6	2.9	7.1
rHev b 6.02: hevein	7	1.6	1.8	3	3.8	6.5	10	0.8	1.5	6	1.9	4.6
rHev b 8: profiling	6	1.4	3.3	3	0.01	0.01	10	1.3	2.6	6	3.4	6.3
MUXF3 (bromelain)	3	0	0	3	0.3	0.1	5	0	0	6	0.4	0.1
HRP (horseradish peroxidase)	3	0	0	3	0.8	0.6	6	0	0	6	1.06	0.8

were Hev b 6.01 and 6.02. Again, the concentration of latex sIgE was highest in the subjects with respiratory symptoms (Table 2). Hev b 8 featured slightly more prominently in these subjects and, when stratified by symptoms, appeared in those with skin symptoms only. A statistically significant difference between reported symptoms was demonstrated between category I and category II workers, with symptoms being more frequently reported in the former group. The log transformed data showed a statistically significant difference between the mean levels of CCD markers across the four categories.

Workers in categories III and IV were all sensitised to latex k82 allergen, and were all atopic but asymptomatic. Only Hev b 8 was measurable in category III with negligible IgE levels for both CCD markers (Figure 3). This category was therefore classified as asymptomatic latex-sensitised. In contrast, Hev b 8 as well as both CCD markers were identified in the category IV workers. The IgE levels in response to CCD markers were higher than the Hev b 8 levels in this category (Figure 1), indicating a false positive reaction to latex.

In summary, the prevalence of latex sensitisation was 9.7% (41/421). Based on the Hev b allergen and CCD concentrations, only about half of these (22; 53.7%), equating to 5.2% of the total population, fell in category I and category II and demonstrated true latex allergy. Approximately 2% (7/421) of this population had asymptomatic latex sensitisation and 3% (12/421) accounted for false positive reactions.

Common risk factors

Self-reported allergies to exotic fruit and insects were more common in the asymptomatic latex sensitised group (category III). IgE antibody responses to Hev b 8 and common inhalants were not significantly correlated. A significant difference was demonstrated when classifying the four categories by the type of gloves used and allergy to insect and exotic fruits (Table 3). Chitinase latex allergens (Hev b 11) are commonly associated with exotic fruits.[3] Non-powdered gloves were not associated with a lower prevalence of latex sensitivity or allergy. Interestingly, there was no IgE response to the Hev b allergens in Category IV, using powdered gloves as opposed to the other categories (Table 3). In addition, allergy to exotic fruit was more commonly reported in the control category followed by workers in categories I and III. Insect allergy was most commonly reported in workers in category II. Neither exotic fruit nor insect allergies were reported by category IV workers (Table 3).

DISCUSSION

This study identified four distinct phenotypic categories in workers sensitised to composite latex (k82), indicating that the clinical relevance of the immune response needs to be carefully assessed in conjunction with clinical history to correctly diagnose workers with true latex allergy. The immunological assessment is also enhanced, using component resolved diagnostics (CRD) with well-defined single latex allergens. To date, 15 latex allergens are recorded in the International Union of Immunological Societies

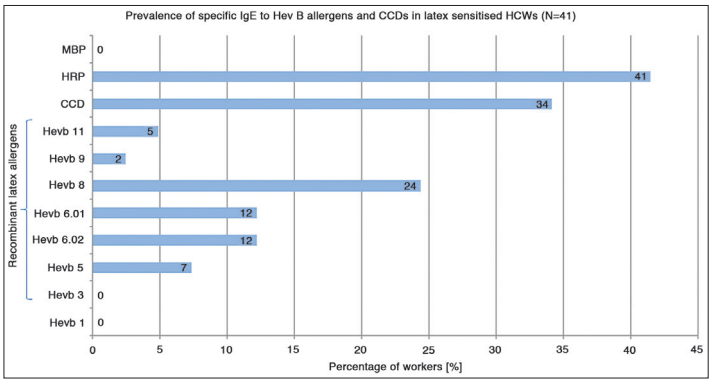


Figure 1. Prevalence of specific IgE responses to Hev b allergens and CCDs in latex-sensitised healthcare workers (HCWs) (n=41)

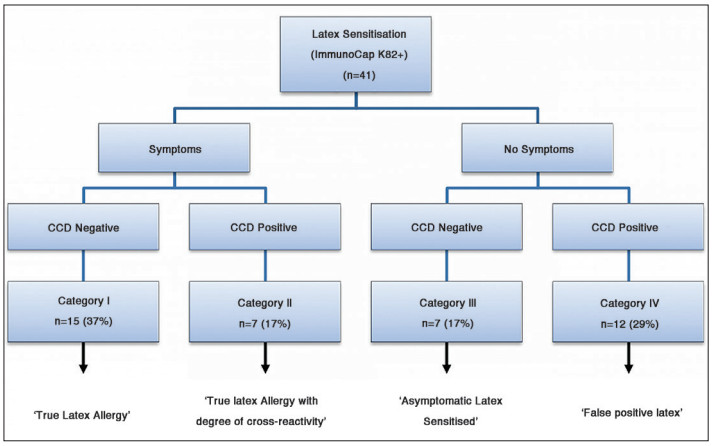
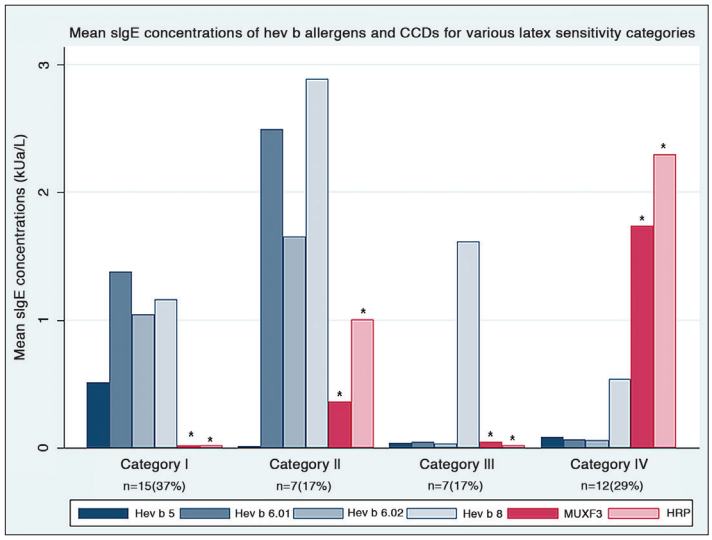


Figure 2. Diagram showing four phenotypic categories classified according to symptoms and CCD levels



*indicates statistically significant differences between categories

Figure 3. Latex sensitivity categories (I-IV) based on IgE antibodies in response to Hev b allergens and CCDs irrespective of clinical symptom differentiation

Hand dermatitis in a nurse who is allergic to latex and thiuram in latex gloves

(IUIS) nomenclature list,15 of which eight were commercially available from Laboratory Specialities (Pty) Ltd (LabSpec – Thermo Fisher Scientific) at the time of the investigations. CRD based on traditional sIgE assays and multiplex microarray techniques have demonstrated that panels of NRL allergens that include (Hev b 1, 3, 5, 6.01 and 6.02) identify almost all NRL allergic patients.[16] However, we have shown that Hev b 1, 3, 9 and 11 have little or no value in the demonstration of IgE responses in South African dental health workers with composite latex sensitivity. Similarly, Kurup et al. demonstrated that Hev b 1 and 3 had minimal value in latex allergy in HCWs amongst other Hev b allergens such as 4, 7 and 10.[10] From the current study, it is evident that the major Hev b allergens identified were 5, 6.01, 6.02 and 8. In another study in the textile manufacturing industry of the Western Cape, workers with exposure to latex showed similar results.[15] Immunoglobulin-E response in these workers was directed to Hev b 5, 6.01 and 6.02. In a recent study,16 workers exposed to NRL gloves who experienced asthma symptoms had high levels of NRL sIgE or rHev b 5, 6.01 or 6.02 antibodies which also showed a high predictive value for a positive specific inhalation challenge (SIC), strongly suggesting a diagnosis of NRL-induced occupational asthma. Using these findings, it is probable that the diagnosis could be made without performing a SIC in subjects with a high NRL IgE (i.e. > 5.41 KUA/L) or, more efficiently, in those with a high sIgE sum score for rHev b 5 plus rHev b 6.01 or 6.02 (i.e. >1.46 KUA/L).[16] In the current study, four workers had sIgE NRL levels above 5.41 KUA/L, making such a diagnosis of NRL occupational asthma possible. An additional two workers had sIgE levels above 1.46 KUA/L for rHev B 5 and 6.01 or 6.02 but their sIgE levels in response to NRL were lower than 5.46 KUA/L. Five of the six workers had true latex allergy based on our analysis. Recent investigations have shown that an improved ImmunoCap with Hev b 5 amplified latex extract (k82) showed superior sensitivity and should be the starting point in evaluating latex sensitisation.

The concentration of Hev b 8 was higher than the other major Hev b allergens and CCD markers identified in category II and III workers. Allergies to exotic fruit and insects were also more commonly reported in these workers. The allergen Hev b 8 is very low in latex sources, resulting in a low capacity for IgE induction and hence the homology between latex and other plant profilins results in the high prevalence of rHev b 8-IgE levels in subjects primarily sensitised to pollens or fruits.[17-19] It is possible that these subjects were not originally sensitised to the allergen tested, but that the allergen epitopes recognised are cross-reactive. This has been previously demonstrated in pollen-allergic patients not originally sensitised to latex where some glycan epitopes present in the latex extract can bind to anti-glycan IgE present in the patient's serum, resulting in positive latex results.[20]

Category I workers reported both respiratory and skin symptoms when in contact with latex products. Although these workers reported allergies to exotic fruit and insects, the concentration of CCD markers was low, indicating unlikely cross reactivity. Workers in this category were thus classified as true latex allergic and accounted for 37% of the composite latex sensitised individuals. In

Table 3. Comparison between glove type, exotic fruit and insect allergies among the various latex sensitivity categories

Description	Latex sensitivity phenotypic category								Controls		p-value
	Cat I (n=15)		Cat II (n=7)		Cat III (n=7)		Cat IV (n=12)		(n=45)		
	n	%	n	%	n	%	n	%	n	%	
Atopy	13	87.7	7	100.0	7	100.0	12	100.0	12	26.7	
Use latex gloves (n=51)	9	60.0	6	85.7	4	57.1	5	41.7	27	60.0	
Latex glove type											
Powder (n=33)	2	13.3	4	57.1	2	28.6	5	41.7	20	44.4	<0.05
Non-powder (n=18)	7	46.7	2	28.6	2	28.6	0	0.0	7	15.6	
Exotic fruits											
Allergic (n=14)	3	20.0	1	14.3	2	28.6	0	0.0	8	17.8	>0.05
Non-allergic (n=72)	12	80.0	6	85.7	5	71.4	12	100.0	37	82.2	
Insects											
Allergic (n=5)	1	6.7	2	28.6	1	14.3	0	0.0	1	2.2	<0.05
Non-allergic (n=81)	14	93.3	5	71.4	6	85.7	12	100.0	44	97.8	

Fisher's exact test was used to determine statistical significance

contrast, category II workers were sensitised to latex and reported clinically relevant symptoms but also demonstrated elevated levels of IgE in response to CCDs. The workers had IgE antibodies to both protein (peptide) epitopes and carbohydrate (glycan) epitopes and, in such cases; the relevance of the epitopes needs to be assessed. The IgE levels in response to Hev b 6 were much higher than in response to the CCD markers. There may be some cross-reactivity, possibly to the reported exotic fruit or insect allergies; however, since the level of Hev b 6 is more pronounced, the peptide epitope is more relevant, suggesting that these individuals are truly allergic to latex. In workers that are sensitised to the allergen tested, the presence of IgE in reaction to both glycans and peptides can result in a higher test result, indicating a more severe sensitisation than is actually the case.[21] This is also the case in the current study where category II workers showed higher IgE levels in response to the single Hev b allergens than category I workers.

Workers in Category III had evidence of latex sIgE responses but no evidence of latex allergy. Only Hev b 8 could be detected in these workers, which has been previously implicated in asymptomatic sensitisation to NRL, particularly in pollinosis (allergic rhinitis) patients.[22] This category was therefore classified as asymptomatic latex sensitised. Hev b 8 was also prominent in the fourth category of atopic asymptomatic workers which displayed IgE antibodies to both Hev b 8 and CCD markers. Since the IgE levels of the CCD markers were clearly higher than the Hev b 8 levels, it is very likely that the response to latex is due to IgE antibodies to CCDs which might be competing with residual IgE for free IgE receptors. The prevalence of anti-CCD IgE has been estimated to be 10-15% in patients with grass pollen allergy and increases up to 60% in patients with concomitant sensitisation to pollen from trees, grasses and weeds.[8] Twenty of the twenty-one workers with CCD sensitisation in the current study were atopic, however, we were unable to differentiate between sensitisation to common aeroallergens due to the limitations of the Phadiatop test, so this could not be analysed further. Generally, sera-containing anti-carbohydrate and anti-profilin (Hev b 8) IgE antibodies display a broad spectrum of cross reactivity not restricted to pollen and venoms, but also involving fruit and vegetables.[8] In addition, individuals sensitised only to cross-reacting plant profilins (Hev b 8) have a reduced risk of clinical sensitivity.[3] Surprisingly, category IV workers did not report any allergies to exotic fruit or insects which rules out the possibility of these allergens acting as an early marker of sensitisation in this category. Although the Hev b allergens and CCD markers assisted in identifying the major allergens in the different categories, no inhibition controls were conducted to conclusively demonstrate the cross-reactivity.

Interestingly, category IV workers used powdered latex gloves; therefore it is possible that the IgE response to CCD markers in this category was the result of exposure to cornstarch in the gloves. Cornstarch powder consists primarily of cross-linked carbohydrates, ranging from 1 to 3 µm in diameter, making them ideal candidates for transfer of allergen to the respiratory tract and subsequent induction of sensitisation or allergic reaction.[23] Cornstarch plays a dual role in latex-induced hypersensitivity, first as an allergen carrier and second as an adjuvant, increasing airway responsiveness, as demonstrated in the guinea pig model.[24] The role of possible adjuvants in hypersensitivity reactions has been previously questioned and warrants further investigation.[25-27] This is particularly important when individuals are exposed to multiple agents commonly encountered in work environments. Whether cornstarch on its own or bound to other agents (e.g. endotoxin) increases airway responsiveness is uncertain. The cornstarch/Hev b-protein coupling may induce memory-B cell recognition of carbohydrate epitopes and affect cross-reacting immune responses,[28] which is similar to the response observed in category IV workers. Category IV workers clearly portray a false positive reaction to latex allergens.

CONCLUSION AND RECOMMENDATIONS

Although composite latex k82 is efficient in demonstrating sensitisation in exposed individuals due to its high sensitivity, it lacks specificity. The use of CRD provides a useful approach in confirming a latex allergy diagnosis. However, although a wide variety of single latex allergens are available; the panel of recombinant allergens for diagnosis does not cover the entire NRL IgE response. This study has demonstrated that CRD adds value to allergy management through early identification of offending allergens, avoidance of allergen exposure, and appropriate treatment, which will result in decreasing the severity of reactions and delaying disease progression, resulting in better clinical outcome. The need for CRD is becoming popular since whole allergen extracts used in skin prick tests differ by manufacturers, leading to possible discrepancies in results. Furthermore, classical latex extracts are no longer readily available, and there is therefore a need for validated substitutes. Future

Laboratory analyst wearing appropriate gloves

work is needed to assess the value of specific panels for immunological testing of high risk groups in the diagnostic work-up of NRL-induced occupational asthma.

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DECLARATION

The authors declare no conflicts of interest.

LESSONS LEARNED

- Composite latex allergen (k82) is highly sensitive in demonstrating sensitisation in exposed individuals; however, it does not differentiate between true sensitisation and cross reactivity
- Clinically irrelevant results may be due to cross-reactive carbohydrate determinants (CCDs) as a result of reactivity to similar epitopes from different allergen sources
- Component resolved diagnosis (CRD) using major latex allergen components (Hev b 5, 6 and 8) can add value to the diagnosis and management of latex allergy in high-risk dental healthcare workers

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Nanotoxicology at the NIOH and its relevance to particle toxicology and occupational health

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ABSTRACT

Nanotechnology offers a wide array of potential applications in the biomedical, industrial and environmental sectors. However, as this technology progresses and engineered nanomaterials (ENMs) are used commercially, it has become critically important to protect the worker during the development, synthesis and production of these ENMs. Recently, nanotoxicology and the risk assessment of ENMs have become a strategic thrust for the National Institute for Occupational Health (NIOH). In addition, the Toxicology Department at the NIOH has participated in the health risk assessment of particles and fibres in the workplace. In this paper, a brief introduction of ENMs and nanotoxicology is presented, along with its importance in occupational health. Some of the challenges faced during the health risk assessment of ENMs are presented and the role of the NIOH in this field in South Africa is discussed.

Keywords: **engineered nanomaterials, health risk assessment, nanotoxicology**

NANOTOXICOLOGY AND TYPES OF NANOPARTICLES

The International Standards Organization (ISO) defines engineered nanomaterials (ENMs) as nano-sized objects, with one or more external dimension in the nano-scale.[1] Therefore, the study of the phenomena and manipulation of materials at atomic, molecular and nano-molecular scales is termed nanoscience. Following this line of thinking, the term nanotechnology refers to the design, characterisation, production and application of structures, devices and systems by controlling the shape and size at nanometre scale for their applications. These applications may include information technology, energy, environmental science, medicine, food safety and transportation.[2-4] Traditionally, toxicology refers to the study of adverse effects of chemicals on humans, animals and the environment. Recently, nanotoxicology has been proposed as the study of the adverse health effects caused by ENMs.[5]

ENMs are distinguished by their shape, e.g. (1) nanoparticles (NPs), where all three dimensions are in the nanoscale, (2) nanofibres, where two dimensions are in the nanoscale, including nanowires, nanotubes and nanorods, or (3) nanoplates, where one dimension is in the nanoscale. The shape may affect the toxicity of ENMs, e.g. silver nanoplates were reported to have a higher toxicity level in comparison to nanospheres or nanowires.[6] Other shapes include dendrimers which are highly branched or star-shaped polymer macromolecules (with nanometer-scale dimensions). These are currently being investigated for biomedical applications,[7] including medical imaging, tissue targeted therapy, drug delivery and gene transfection,[8] for instance, as carriers for penicillin,[9] and in anticancer therapy.[10] Another example is quantum dots which are nanocrystal particles that can act as markers in biological cellular imaging in living cells and tissues. These are used in exploratory medical diagnostics and therapeutics as well as in the self-assembly of nano-electronic structures.

Nanomaterials may also be classified by similarities in the chemical composition, i.e. carbon-based, metals, metal oxides or organic nanomaterials. The carbon-based ENMs are used and may be grouped as single- (SCNTs) double- (DCNTs) or multi-carbon nanotubes (MWCNTs). The uses include electronics, optics and applications as additives to various structural materials, including baseball bats, golf clubs, car parts and steel.[11] Metal oxides are also frequently used, e.g. titanium dioxide (TiO_2), zinc oxide (ZnO) and iron oxides. Applications include chemical polishing agents for semi-conductor wafers, scratch resistant coatings for glass, and cosmetics and sunscreens.

The most commonly encountered nanomaterials in the work place and/or environment include TiO_2,[12] cerium dioxide,[13] silicon dioxide (SiO_2),[14] zinc oxide (ZnO),[15] and silver nanoparticles,[16] as well as carbon nanotubes (CNTs).[17] The main concern with ENMs, compared to their larger counterparts, involves their ability to translocate from the site of deposition to other organs, such as brain, blood, liver, spleen and kidneys. The translocation and the accumulation of ENMs depend on the physicochemical properties of the ENM, as well as the route of exposure, dose and exposure period.[18] Toxicokinetics describes the absorption, distribution, metabolism and excretion (ADME) of chemical toxicants. In contrast, toxicodynamics describes the adverse effects that a toxicant

has on an organism, i.e. the interactions between different types of ENMs and cells in relation to their physicochemical properties, such as size, shape, aspect ratio, surface chemistry and activity of the nanomaterials.[19] Therefore, toxicokinetics and toxicodynamics should be considered in order to assess their short-term toxicity, as well as their long-term pathogenicity.

HEALTH RISK ASSESSMENT OF ENMS

Health risk assessment of chemicals, which is defined as the systematic scientific characterisation of potential adverse health effects resulting from (human) exposures to hazardous agents or situations,[20] is conducted to establish permissible exposure levels and to assess the health risks of a particular exposure.[21] Health risk assessment conducted in occupational settings is often referred to as occupational risk assessment and, similar to all other forms of risk assessment, its process comprises four components: hazard identification, dose response assessment, exposure assessment and risk characterisation. These four aspects, as they relate to nanotoxicology, are discussed.

"The shape may affect the toxicity of ENMs"

Hazard identification

The hazard identification step aims at determining if a chemical has an inherent potential to cause harm in an experimental animal or the human body.[22] In many countries there are prescribed and validated batteries of tests that are used to assess the toxicity of chemicals. The applicability of these protocols to ENMs has, however, been questioned[23] because of inconsistencies in toxicity data between studies. These inconsistencies have been attributed to physicochemical properties of ENMs that interfere with the assay systems through emission, absorbance and scattering of light, adsorption and catalysis.

The physicochemical properties of ENMs have been shown to influence their mechanism of toxicity.[23,24] Currently, there is no exact method for identifying which physical or chemical property influences or determines the toxicity of ENM.[25] However, a recent review has summarised the possible correlation of ENM physicochemical properties to a biological effect, although the findings are not conclusive.[26] Therefore, adequate characterisation of the physicochemical properties of ENM is imperative, although this is unfortunately not performed in many studies.[25] Where possible, characterisation should not only be performed in their native media/state but also in a media representative of the biological environment (e.g. those from lung, skin and gastrointestinal tract).[23] This is due to the physicochemical properties of ENM being potentially altered in the biological environment, such as ENM size through aggregation, degradation and changes to their surface charge and chemistry, which could further affect the toxicity of the ENM.[27-31]

In traditional hazard identification studies, the norm is to assess the toxicity using mass as a dose metric. However, due to the unique properties of ENMs, there is a need for alternative and/or appropriate dose metrics (e.g. particle number dose or surface area dose). For example, ENMs exhibit a much higher surface area due to their small size, making them potentially more reactive and toxic compared to their larger counterparts.[3,32] It was also reported that better correlation between dose and biological response is observed when assessing the targeted dose rather than the exposure or administered dose.[30] For this reason, a number of models and tools have been developed for *in vitro* dosimetry of ENMs.[33]

Due to the numerous factors that might affect toxicity, comparability of results requires standardisation of test organisms, exposure periods, dose ranges, dose-metrics and methods of exposure.[34] For this reason, efforts are being made to identify and validate methods for characterising and assessing the toxicity of ENMs. In addition, to aid in the comparison of studies, a review by Hristozov 2009 suggests that it would be beneficial to report data in more than one dose metric.[34]

In addition to the assessment of toxicity using *in vitro* and *in vivo* systems, Quantitative Structure-Activity Relationship (QSAR) models are often used for hazard identification. However, the application of QSAR models to predict ENM toxicity requires development of new QSAR models that can accommodate size- and shape-dependent properties of ENMs.[35,36]

Research is underway to address these challenges in order to obtain reliable and validated data for the first step of the risk assessment process. International collaborations such as the Organisation for Economic Co-operation and Development (OECD)'s Working Party on Manufactured Nanomaterials (WPMN), and NANOSOLUTIONS, are attempting to address some of these issues.

Dose response assessment

The dose-response assessment step, which evaluates occurrence of adverse effects at particular exposure levels,[37] aims to identify either the greatest concentration of a substance that causes no response (i.e. No-Observed-Adverse-Effect Level (NOAEL)) or the lowest concentration that causes a response (i.e. Lowest Observed-Adverse-Effect Level (LOAEL)).[38,39] In occupational risk assessment, the NOAEL or LOAEL is used for setting Occupational Exposure Limits (OELs) or Derived No Effect Levels (DNELs), which are required for the control of workplace exposure levels.

As was the case with the hazard identification step, derivation of OELs or DNELs is hampered by: (1) the lack of universal agreement regarding the correct dose-metric for ENMs,[31,40,41] where surface area is reported to be the most appropriate in some cases[42] and particle number in other cases;[43] (2) inconsistencies in results between different toxicological studies (*in vitro* and *in vivo*) as well as the lack of proper physicochemical characterisation of ENMs within these studies; and (3) the heterogeneity in size, shape, functional groups and composition of ENMs that may be encountered in the workplace,[44,45] with the result that a generic approach may have to be used for groups of ENMs.[44] In the absence of OELs, the OECD recommends applying a safety factor to the existing OELs for non-nano forms (i.e. respirable and alveolar dust fractions).[46] However, existing OELs for non-nano forms are in units of mass, which may not be applicable for ENMs.

Physiologically-based Pharmacokinetic (PBPK) models

"The main concern with ENMs, compared to their larger counterparts, involves their ability to translocate from the site of deposition to other organs, such as brain, blood, liver, spleen and kidneys"

are also often used for dose-response assessment. However, application of PBPK models to ENMs requires new models and approaches for defining and determining some parameters, such as partition coefficients and kinetic data for ENMs.[47]

Exposure assessment

For ENMs, the exposure assessment step, which determines the magnitude, frequency and duration of exposure,[37] is conducted by monitoring exposure in the ambient environment of the occupational setting or measurement of the internal dose in workers through the use of biomarkers. In the cases where measurements cannot be made, exposure models can be used to estimate exposure.[48,49]

Similar to hazard identification and dose-response assessment, occupational ENM exposure monitoring is currently hindered by the lack of consensus on the appropriate dose metric. Although particle number and surface area have been proposed as more suitable dose metrics for ENM exposure assessment, current surface area measuring devices are theoretically adapted to sphere-shaped particles only. The degree of aggregation/agglomeration of ENMs in the atmosphere which, in turn, alters particle number and surface area, further complicates the use of these dose metrics.[32]

Despite these challenges, several guideline documents have been published to assist investigators regarding the most appropriate exposure assessment strategies. For example, the OECD 'Harmonised Tiered Approach to Measure and Assess the Potential Exposure to Airborne Emissions of Engineered Nano-Objects and their Agglomerates and Aggregates at Workplaces' presents a harmonised, tiered approach for conducting workplace ENM exposure assessments.[46]

In occupational health, biomonitoring is the systematic measurement of chemical or biochemical markers in fluids, tissues or other accessible samples from individuals exposed to, or with past exposure to, chemical risk factors.[50] Compared to ambient occupational exposure assessment, biomonitoring generally allows for a more informative and accurate assessment of an individual's true occupational exposure level by taking into account: (1) all exposure routes; (2) inter-individual variability in absorption, metabolism, and excretion; (3) the individual's true workload; and (4) recent versus past exposure.[51] It also provides information on the changes that NPs undergo when coming into contact with biological environments.[52] Despite these advantages and recent studies addressing ENM-related biomarkers,[51] there is still a significant lack of ENM biomonitoring data, in part because of the inherent heterogeneity of the physicochemical properties of NPs which, in turn, leads to inconsistent toxicological/toxicokinetic data, thereby complicating the identification/validation of suitable biomarkers.

Similar to ambient occupational monitoring and biomonitoring, prediction of exposure to ENMs of the workplace also faces some challenges, the most important being the applicability of models originally designed for conventional substances to ENMs.[53] As ENMs behave markedly differently from conventional substances, new models need to be developed – an exercise that is hampered by the lack of comprehensive knowledge of the behaviour of ENMs. Nevertheless, as the mechanisms involved in the fate and transport of ENMs from source to receptor that affect occupational exposure are increasingly being understood, conceptual models are being developed for predicting such exposure in the workplace.[54]

Risk characterisation

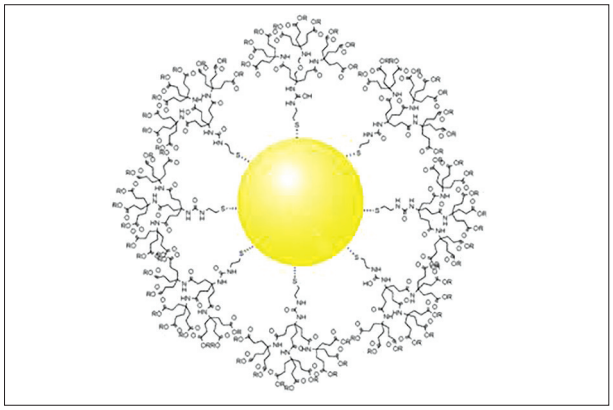
In occupational risk assessment, the exposure assessment step is followed by risk characterisation, where the exposure estimates are used in conjunction with OELs to characterise the health risk to workers. However, the greatest challenge in the risk characterisation of ENMs stems from lack of OELs for most ENMs, with only a few OELs for ENMs having been proposed so far, including for fullerenes and carbon nanotubes (CNT),[55,56] titanium dioxide nanoparticles[56,57] and silver.[58] For this reason, the OECD also recommends conducting a combination of qualitative and quantitative assessments by comparing ENM concentrations at the emission source with background concentrations, and then putting control measures in place to mitigate ENM exposure. However, measuring the background of ENM synthesis may, in itself, be complicated by other confounding incidental nanomaterials such as outside sources or workplace activities that are unrelated to NP synthesis.[47] A possible way to address the issues with background measurements involves simulating the workplace and work activities in a controlled environment, such as a laboratory, to control for background aerosol levels that are unrelated to the NP in question.[59] The lack of OELs for risk characterisation has also resulted in the development and use of risk management tools, such as control banding techniques.[60,61]

NANOTOXICOLOGY PROJECTS AND FACILITIES AT THE NIOH

Projects

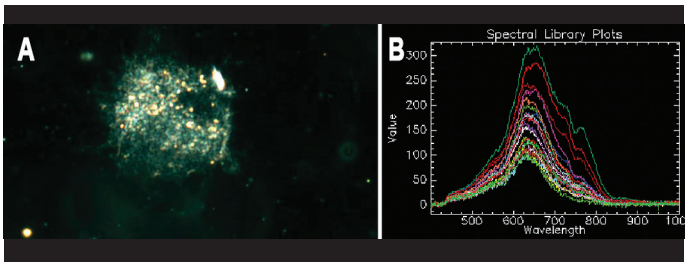
The Toxicology Department at the NIOH has been actively involved in nanotoxicology research since 2010 when the South African proposal to include gold nanoparticles (AuNPs) in the OECD's Working Party on Manufactured Nanomaterials (WPMN) programme was accepted. The WPMN aims to promote international co-operation on human health and environmental safety of manufactured nanomaterials, and to ensure that hazard, exposure and risk assessment of ENMs is of a high scientific standard and is internationally harmonised.[62]

Within this project, *in vitro* and *in vivo* toxicity studies were performed to test AuNPs as per recommendations by the OECD, thereby filling the knowledge gap necessary for human risk assessment. In addition, the project, which is funded by the Department of Science and Technology (DST) in South Africa, provided feedback to the OECD on the applicability of the test guidelines to ENMs.



Gold nanoparticle with attached ligands

(Source: https://en.wikipedia.org/wiki/Gold_nanoparticles_in chemotherapy)



A) Dark field image acquired by the CytoViva HSI system of the uptake of gold nanoparticles (bright orange spots) into a bronchial epithelial cell; B) An example of a reference spectral library created by the visible and near-infrared HSI system which can be used to identify nanoparticles in a biological sample

Although much has already been achieved through this project, further *in vitro* and *in vivo* toxicity testing will be conducted and models will be proposed to assist in the risk assessment of AuNPs.

In addition, the DST Nano HSE (Health, Safety, and Environmental) Risk Research Platform has been established, within which the NIOH will play a key role in the characterisation and occupational exposure assessment of nano-objects and their agglomerates and aggregates (NOAA) in research and industrial settings in South Africa.

The NIOH also participates in the international NANOSOLUTIONS consortium which aims to develop software for the safety classification for ENMs. This is being done through investigations of their interactions with living organisms at molecular, cellular and organism levels to establish a 'biological identity' which will ideally allow for the development of software that can predict a health or environmental hazard based on the properties of the ENM. The NIOH is responsible for assessing the cytotoxicity of ENMs in relation to their uptake by Bronchial Epithelial (BEAS-2B) cells, as well as the biodurability/biodegradability (dissolution) of ENMs in different simulated biological fluids. Further information is available online.[63]

"… it has become critically important to protect the worker during the development, synthesis and production of … ENMs"

Laboratories and facilities in the Toxicology Department

The Toxicology Department is well-positioned to enhance research into the risk assessment of ENMs as it has a fully-equipped cell culture laboratory and is able to culture numerous cell lines for use in *in vitro* toxicity testing. A number of vital instruments are housed in the Department, namely the xCELLigence RTCA system, the CytoViva Hyperspectral Imaging (HSI) system, and exposure assessment equipment, such as the Aerodynamic Particle Sizer (APS) (Model 3321), the Scanning Mobility Particle Sizer (SMPS) (Model 3080), the NanoScan SMPS (Model 3910), and the Optical Particle Sizer (Model 3330). The xCELLigence RTCA system enables real-time analysis of cell attachment, proliferation and cell death, and eliminates problems with interference of the ENMs as it does not reply on optical detection or any chemical reactions.[64] The CytoViva HSI system provides dark field images of cells and tissues, allowing the observation of internalisation of ENMs.[64,65] This system has been specifically designed for imaging nano-scale objects and is integrated with a visible and near-infrared HSI system that captures unique reflectance spectra of objects under the microscope. This spectral signature of an ENM can be collected to form a reference library that can be mapped onto an unknown sample to enable the identification of nanoparticles within a biological sample. The APS, the SMPS, the NanoScan SMPS, and the Optical Particle Sizer can be taken into a work environment to monitor ENM concentration and sizes during work processes.

CONCLUSION

As the growth in nanotechnology continues, more research and tighter regulations will be required to ensure their safe development and use. Through collaborative research with both national and international institutions, the NIOH will continue to provide cutting-edge research and specialised services to ensure that the development of nanotechnology in South Africa is undertaken safely and with minimal risk to workers.

DECLARATION

The authors declare no conflicts of interest.

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Asbestos remains troublesome in South Africa after the ban

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INTRODUCTION

Discussions concerning asbestos may be emotive. Asbestos has the potential to adversely affect health, and the topic engenders fierce debate at public and academic forums. South Africa was a large producer and consumer of asbestos and, although its use is banned, the topic remains pertinent as our country has been left with a legacy of asbestos and asbestos products in the environment. This article discusses two currently controversial aspects of asbestos: its presence in asbestos cement roofs; and the relationship between asbestos fibre size and toxicity.

In the 1970s, the South African economy was based on mining and, in addition to being the world's leading gold producer; South Africa was the world's third largest producer of asbestos. Three types of asbestos were mined commercially in large quantities, namely: chrysotile (white), crocidolite (riebeckite, blue) and, unique to South Africa, amosite (grunerite, brown). The fibrous mineral was milled locally and while most of it was exported, it was used locally to manufacture products including asbestos cement products such as roof sheets.

Until 1975 there was a growing world market for asbestos due to its properties of strength, durability, insulation and fire resistance. Because of these properties, asbestos was used in the manufacture of over 3000 products.[1] With its use in fire retardant materials, asbestos gained a reputation for safety and there is no doubt that its use in fire protective materials and equipment saved many lives over the years.[2] Forty years on, however, the reputation of asbestos is very different, and it is now more commonly associated with disease and death.

The adverse health effects of inhaling asbestos fibres have been known for many years. Asbestosis was described in South African asbestos mine workers by Simson in 1928.[3] The link between exposure to crocidolite asbestos and malignant mesothelioma of the pleura of the lung was published in 1960 by Dr JC Wagner and his colleagues,[4] while working at the Pneumoconiosis Research Unit – now the National Institute for Occupational Health (NIOH).[5] More recent studies at the NIOH[6-8] have shown that there is a fibre gradient of mesotheliomagenic potential for South African asbestos (crocidolite>amosite>chrysotile). Exposure to asbestos can cause mesothelioma some 30 years or more after exposure. Treatment is not effective and patients with mesothelioma usually die within a year from the time of diagnosis.[9]

Due to health concerns, many countries have banned the use of asbestos. Denmark was the first to do so and there are now more than 50 countries that have completely banned asbestos, including those of the European Union, which finalised a ban in 2005.[10] Subsequently, the global market for asbestos shrank and asbestos mines went into decline. The last asbestos mine in South Africa closed in 2002[11] and legislation was enacted to effectively ban the use of asbestos in South Africa in 2008.[12] However, asbestos is still used in many countries; the top producers are currently Russia, China, Brazil and Kazakhstan.[13,14]

With the cessation of mining, milling and manufacturing of asbestos and its products in South Africa, new cases of asbestosis are seen less frequently. However, South Africa still has one of the highest rates in the world for mesothelioma.[5] Countries that have banned asbestos are looking at trends to determine when they will see a reduction in rates of mesothelioma.[5] In Australia, which produced about 3% of the world's crocidolite, it is expected that deaths due to mesothelioma amongst women in the town of Witternoom where crocidolite was mined, will continue until 2030.[15] Currently the autopsy database (PATHAUT) at the NIOH is showing no decrease in mesothelioma amongst deceased asbestos mine workers.[16]

Legislation regarding asbestos has ensured that there are no more workers who legally mine, mill or manufacture products containing asbestos. As asbestos was so extensively used in a vast range of products, and because of its durability, South Africa has a legacy of asbestos-containing products. Asbestos in products and the environment poses a potential health hazard to all who come into contact with it, including workers. Furthermore, the environment has been heavily contaminated through mining, milling and the transport of asbestos. Sources of contamination include mine dumps, roads, railways and ports.[5]

Since the promulgation of the Asbestos Regulations of 2001[17] which detail how work can be carried out on asbestos-containing materials, the NIOH has continued to receive samples of potentially asbestos-containing material for analysis. Samples are submitted with details such as the nature of the sample, the town of origin, the sector (e.g. mining, manufacturing or residential), and the type of activity being performed, such as demolition. This informs us about the asbestos that remains in the South African environment.[18] The majority of the samples received from 2003 to date are described as cement-like building materials. The most common associated activities were the renovation of power stations and the demolition or renovation of buildings. Construction workers are thus potentially at risk for asbestos exposure.

Asbestos-related disease (ARD) caused by non-occupational

exposure to asbestos is well-recognised. This type of exposure may take a number of forms. Examples include take-home (para-occupational) exposure usually from contaminated work clothes,[19,20] the use of asbestos in home maintenance,[21] hobby or leisure activities[22] and environmental pollution,[5] including living in proximity to non-mining-related sources of asbestos such as harbours and factories.[22] All of these types of asbestos exposure are expected to contribute to the ARD burden in South Africa, particularly the mesothelioma burden, albeit to a much lesser extent than occupational exposure.

ASBESTOS CEMENT ROOFS

Another source of non-occupational asbestos exposure of concern, particularly regarding mesothelioma, but with little evidence of risk for ARD, is living in a house with an asbestos cement (AC) roof. Despite the scant evidence of risk, potential exposure to asbestos from these roofs may be important given the very large number of people living in these dwellings. Over the past 60 years, townships such as Soweto were built in South Africa. The houses, known as 'four rooms', were constructed with roofs made of corrugated asbestos cement sheets. Chrysotile, amosite and crocidolite asbestos were used, often in mixtures, to manufacture these roof sheets.[23] In Soweto, over one million people live under or near an asbestos cement roof.[23] A 2001 Department of Housing report, cited in a Nedlac document, stated that "… . up to 1 million state-funded lower income housing units with asbestos based products, predominantly roof sheeting, exist".[24]

Exposure to asbestos from AC roofs has not been shown to be associated with mesothelioma (or other ARDs) locally. For example, none of the 123 cases interviewed for a case-control study had been exposed exclusively to AC construction materials in buildings or houses.[25] Additionally, a 2007 study of 61 Soweto houses with AC roofs found only four out of 176 air samples collected from in and near the houses to contain fibres that exceeded the detection limit of 0.01 fibres/ml. No asbestos fibres were identified using scanning electron microscopy and energy dispersive spectroscopy.[23] Internationally, the experience of AC roofs and mesothelioma has been similar. A PUBMED search using the phrase 'mesothelioma asbestos cement roofs' identified only one article: a follow-up study of 690 Norwegian lighthouse keepers that did not find any mesotheliomas among them.[26]

A recent study reporting an odds ratio for mesothelioma of 2.5 (95% CI 1.4 – 4.5) associated with living in a dwelling with an AC roof [27] is thus notable. This population-based case-control study was set in Casale Monferrato, a town in Italy, renowned for its many mesothelioma cases caused by asbestos contamination from an AC plant which closed in 1986. The odds ratio was estimated from 55 cases and 72 controls, none of whom had worked in the AC factory. The study was not confined to AC roofing, and found significant associations between other forms of non-occupational exposure and mesothelioma.

Should the findings of the Casale Monferrato study prompt re-evaluation of the merits of replacing AC roofs, bearing in mind that many are getting old and presumably weathered? There are several arguments for this intervention. First, roofing sheets can be safely removed, as has been shown by NIOH occupational hygiene measurements during and after removal of roofing sheets in Hammanskraal.[28] Second, substantial asbestos contamination of the local environs can occur if roofs are mismanaged, for example by cleaning with high pressure water[29] or with brushes with hard bristles, and from weathering[30] or hail. Third, the advice given to residents to ensure that the roofs are well maintained and coated may be neither simple nor cheap, as evidenced by the UK's Health and Safety Executive's guide to cleaning weathered asbestos cement (AC) roofing and cladding.[31] Among other things, the guide requires restriction of the work area with warning tape and notices, equipment such as approved biocide and garden-type sprayer with wetting agent, and personal protective equipment (disposable overalls fitted with a hood being one of the specified items). Finally, concern about AC roofs is a factor. The Gauteng Department of Human Settlements' 2014 statement that AC roofs were to be assessed, with a view to removal, was one response to the concern by government.[32]

Asbestos cement roofs in Soweto *Photo: D Africa*

However, the arguments against replacement of intact undamaged roofs are compelling. First, the evidence for risks to health is scant. The Casale Monferrato study[27] finding is unusual and has potential sources of bias which could produce a spurious elevated odds ratio. Among them is that controls, although selected from the town's population, had lived further from the old AC plant than cases and thus had lower environmental exposure. Also, although the odds ratio of 2.5 associated with AC roofs was calculated using subjects who had not worked in the AC factory, other occupational exposure was not an exclusion criterion; excluding these subjects reduced the odds ratio to 2.0 (95% CI 0.9-4.5) (personal communication, D Ferrante, 2016). Even if the findings of the study are valid, they might not be applicable to South Africa if the Casale Monferrato roofs were damaged to a greater extent than South African roofs. It is thus premature to conclude that there is an increased risk of mesothelioma from South African AC roofs. Affordability of replacement is a major consideration and alternatives, for example coating (encapsulating) the roofs, are likely to be cheaper. A 2001 report commissioned by the South African National Department of Housing stated that "... to replace the asbestos roofs on the 273 627 subsidised housing built since 1994 only, at an average house size of 30 m^2 and at an

average cost of R 3250 per unit, it would cost approximately R 890 million. Enclosing the roof with paint would cost approximately half of this, R369 million".[33] Safe removal and disposal of large quantities of AC roofing sheets are also considerations. Safe removal can be done but this requires close management and adherence to safe practices; and disposal can be expensive and may be impracticable on a very large scale. Preventing the re-use of AC sheets that have been removed from roofs will also be difficult.

What then should be done about AC roofs? A sensible approach may be to replace only damaged roofs, and only the damaged sheet or sheets, and to maintain intact roofs through appropriate coating using cleaning and coating processes that limit the release of fibres and properly manage waste. The 2001 Department of Housing report[33] contains a number of recommendations in support of this approach, and covers other issues that need to be addressed if this is to work. Additionally, many agencies favour handling AC sheets along these lines, for example, the Australian Health Protection Principal Committee[34] and the UK's Health and Safety Executive (HSE).[35]

In support of replacing only damaged roofs, a number of actions should be contemplated. A study of mesothelioma in Soweto residents, or another large population living in houses with ageing AC roofs, is probably warranted because the absence of reported cases does not mean that cases are not occurring. The extent of damage that should lead to replacement needs to be defined and communicated to residents and others, as does the safe management, cleaning and coating of AC roofs, and the disposal of AC waste, which should be encouraged by providing accessible disposal sites. Residents may be able to encapsulate roofs safely if they are provided with detailed instructions – as long as the methods are not too complex – particularly if free or subsidised coating materials are made available. It is to be expected that many residents are tending to the roofs themselves, so a pragmatic solution is required.

In conclusion, weathered and damaged AC roofs are a concern that needs to be managed because the absence of cases of ARD from this exposure may be a consequence of failure to look for them.

Because asbestos is still widely found in residential, environmental and industrial settings, the measurement of fibre concentrations remains necessary so that risks to health can be identified and controlled. But to ascertain risk by measuring fibre concentrations, one has to measure the concentrations of pathogenic fibres, meaning the fibres that can cause disease. In terms of the Asbestos Regulations, longer fibres termed 'regulated fibres' need to be measured,[17] on the assumption that they are the pathogenic fibres. But whether these are indeed the only disease-causing asbestos particles is an issue that has engendered some controversy over many years, and continues to do so.

THE RELATIONSHIP BETWEEN REGULATED ASBESTOS FIBRE SIZE AND TOXICITY

Asbestos fibre concentrations are determined by measuring what is generally referred to as regulated fibres, being those that satisfy specific length, width and aspect ratio dimensions. The World Health Organization defines a regulated asbestos fibre as a particle of asbestos with a length-to-diameter ratio greater than 3 to 1, a length greater than 5 micrometres (µm) and a diameter less than 3 µm.[36] This definition is incorporated into South Africa's Asbestos Regulations. Currently, there is controversy regarding the role of fibre length (e.g. long versus short asbestos fibres) in producing adverse health effects.[37]

The pathogenic effects of asbestos fibres longer than 5 µm are well-established. The seminal experimental work of Stanton and colleagues[38] – referred to as the Stanton hypothesis – formed the basis for the contention that the biologic effects of fibres depend on dimension (and durability). They found that malignant neoplasms in rats were best predicted by the number of fibres that measured 0.25 µm or less in diameter and more than 8 µm in length, although there were also relatively high correlations with other dimensions. Later, in a review of experimental studies, Lippmann[39] found that mesothelioma was strongly associated with asbestos fibres longer than 5 µm and thinner than 0.1 µm, while lung cancer was strongly associated with fibres longer than 10 µm and thicker than 0.15 µm. Subsequent studies by Davis et al.[40] found that there were considerably more tumours and fibrosis resulting from chronic inhalation of long as opposed to short chrysotile and amphibole fibres. Berman et al.[41] concluded, from a re-analysis of the data from Davis et al.'s studies, that chrysotile and amphibole fibres less than 10 µm in length had no demonstrable tumorigenic potency.

Following evidence from epidemiological, laboratory animal and in vitro studies, an expert panel convened by the Agency for Toxic Substances and Disease Registry agreed, in 2003, that asbestos fibres (<5 µm in length) are "unlikely to cause cancer"[42] and that fibres 5 µm or less should not be counted.

Others, however, have disagreed with the 5 µm limit, arguing that short (<5 µm) fibres should not be discounted in disease causation, an important consideration because exposures may be largely to fibres shorter than 5 µm.[43] In a study of human malignant mesothelioma, Suzuki and Yuen[44] found that the most common types of asbestos fibres in lung and mesothelial tissues were chrysotile fibres shorter than 5 µm. Furthermore, based on analysis of tissue fibre burdens from 168 human mesothelioma cases, Suzuki and colleagues[45] concluded ". . .that contrary to the Stanton hypothesis, short, thin, asbestos fibres appear to contribute to the causation of human malignant mesothelioma." The authors of this study showed that short fibres predominated, but they did not report whether any of the 168 cases had only short fibres, thus weakening their conclusion. Transmission electron microscopy (TEM) analysis of data from a cohort mortality study of 3 072 workers found that all size-specific categories were highly statistically significant predictors of lung cancer and asbestosis.[46] It was also found that 93% of fibres were very short, i.e.< 5 µm. Longer (regulated) fibres accounted for only 7% of lung burden.

Another argument used in support of measuring long asbestos fibres is that the current cutoff is partially grounded in practical considerations. Among these considerations is that the reliability of the optical microscopy method[47] decreases below the 5 µm length criterion.[48]

Asbestos fibres (regardless of size) constitute a significant health concern. Despite the wealth of literature on the pathogenic effect of asbestos exposure, questions on the role of different fibre sizes in disease remain only partially answered. Further research is required to determine whether fibres shorter than 5 µm are of concern to health.

Not all aspects of the asbestos legacy have been covered in this paper, such as environmental pollution, and occupational exposure through the maintenance and demolition of asbestos-containing building materials. Although South African legislation banned the use of asbestos in 2008,[12] the legacy of asbestos remains problematic.

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Industry in court: measurements matter most

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Government Medical Officers employed by the medical service of the Federation of Rhodesia and Nyasaland were required, by the police, to examine individuals suspected of being in charge of a vehicle while intoxicated, victims of sexual violence and assault, and those injured in road traffic accidents. During the subsequent court proceedings, the evidence they presented was scrutinised by the defence and cross-examination followed. New appointees rapidly became confident expert witnesses and, for me, this proved to be valuable experience.

The Harare City Council decided, in about 1980, to restrict the certification of a sulphuric acid plant, in terms of the atmospheric pollution regulations, to one year instead of the usual three, following complaints from residents of a nearby suburb about the emission of acid fumes. The emissions were due to repeated breakdowns, shut downs and start ups of an ageing plant. The company concerned decided to take the matter to court in an attempt to get the licence amended. The first witness, the atmospheric pollution control officer acting for the City Health Department, presented his findings from the analysis of lead peroxide 'candles' placed at intervals around the plant. These showed clearly that the levels of acid fumes emitted from the plant were excessive and highest towards the suburb where the complainants lived. Faced with this evidence, the company resolved not to proceed with the appeal as they had no measurements of their own to contradict the quantitative evidence presented by the health authority.

In subsequent discussion, it became clear that relevant measurements of high quality and undoubted accuracy are close to being the determinant of the outcome of this type of case. Money and expert legal assistance cannot compensate for the absence of quantitative evidence in support of the case presented by the prosecution or the defence. I have said, many times during the past 30 years or so, that money and lawyers and no measurements is a recipe for disaster – assuming, of course, that the opponent has at least some money or legal aid; competent, if not brilliant, lawyers; and expert witnesses to present their measurements.

As at August 1983, when I began working at the then National Centre for Occupational Health (NCOH), now the National Institute for Occupational Health (NIOH), nothing was known about the fate of migrant miners who had returned to their rural homes, despite the findings of the Milner Commission's study of white miners,[1] Gorgas's forthright comment that tuberculosis was being deported instead of reported,[2] and John Laing's conclusion that there was more tuberculosis in the mines than was generally assumed.[3] The reasons for this were not only the neglect of industry and the government, but the prevailing carelessness about notification, statutory entitlements to benefit examinations, and legislation which obliged medical practitioners to arrange for former miners lungs to be examined. It rapidly became clear that the Medical Bureau for Occupational Diseases was not getting the cardio-respiratory organs of deceased miners as required, nor any benefit examinations, from the rural areas. These were telling examples of 'no measurements'! It is impossible to measure tuberculosis among miners or ex-miners without distinguishing between tuberculosis, pneumoconiosis and the two together.

A cursory examination of the massive hard copy printout of the annual findings of the PATHAUT database, then in its eighth year, suggested that a problem existed, at least in the case of silicosis and tuberculosis in the gold mines. Twenty-one years ago (in 1995), the Leon Commission[4] stated that:

"In South Africa no discussion of occupational disease is complete without taking into account the link between the migrant labour system and the long lag period between [workplace] exposure and disease manifestation. Many workers will develop work related disease after they have returned to their rural homes, where appropriate facilities for investigation and diagnosis may be non-existent. In the absence of well equipped and appropriately staffed diagnostic or recognition centres, which are accessible to retired miners, there will be serious under ascertainment and the social costs will be carried by the spouse and children or by the extended family, or by the community at large. The importance of under ascertainment in determining attitudes towards the problem of occupational disease cannot be over emphasised, and should be borne in mind throughout the reading of this chapter of the report. Current figures for the extent and severity of the problem of occupational disease among miners are certainly and under estimate".

Five years ago, three long-serving staff of the NIOH studied the published work dealing with occupational lung disease in the South African mining industry, and concluded that "initiatives to influence policy and thus reduce dust levels and disease … have been largely unsuccessful". Seventy-seven references are listed at the end of the paper.[5]

A factory producing mercury compounds faced prosecution by the Department of Labour, following the discovery of clinical evidence of mercury poisoning among workers and several deaths due to central nervous system toxicity. The factory had many thousands of measurements of mercury in the urine of workers written in a book. In this form, analysis was impossible. When entered into a well-designed computerised database and processed to show serial results for each individual worker, the result was impressive, showing rapid rises in urinary excretion of mercury in newly-employed workers, or those returning from leave; consistently high or very high levels in workers processing mercury; and consistently low levels in those not in close contact with the manufacturing processes. In the South African court

a plea bargain was allowed, resulting in an absurdly low penalty. The owners of the South African company were domiciled in Britain and the case brought there resulted in the payment of substantial sums to two tranches of affected workers. The existing measurements which had not been collated or analysed, provided, in skilled hands, conclusive evidence of dangerous working conditions for use by the prosecution.

Asbestos mining and manufacturing companies faced increasing pressure as a result of worldwide adverse publicity about malignant mesothelioma. Almost all of the amphibole fibre – crocidolite and amosite – was mined in South Africa and largely exported. Marianne Felix's study of the community living in close proximity to a number of amosite and crocidolite mines[6] had shown that pleural plaques were prevalent and that exposure to asbestos dust took place not only among men and women who worked in the mines and mills but among the population as a whole. The medical superintendent of the local district hospital (HC Boshoff) suggested that a doctor from the NCOH should spend six months examining former mine employees in the surrounding area since he could find no evidence that any persons had ever been examined in terms of the Occupational Diseases in Mines and Works Act.[7] Since I was due to go on sabbatical leave, pending retirement, it was a welcome opportunity. In the first campaign, from 1 April to 30 September 1996, more than 2 100 individuals applied for examination. Roughly 1 400 were men and 700 were women. In round figures, about 90% of the women had clinical signs of asbestosis.[8] The finding of such a large number and proportion of asbestosis among women formerly employed as cobbers, gave the green light for the preparation of a legal case against Cape plc. At the end of a very long drawn out case in the British courts, Cape agreed to a settlement which they found themselves unable to pay. Early in the preparation of the case, Cape plc's lawyers asked for access to information held by the NCOH on the grounds that all the relevant information about asbestos-related diseases among workers was stored there and it was not fair that this should be so. We agreed readily and, despite prior access to a great deal of information, they could not prepare a successful defence. On the basis that this very prominent industrial undertaking had no reliable evidence about the health status of their former employees, the road to the courts for the gold mining industry was clearly signposted.

The first published study of retired South African miners described the prevalence of work-related lung disease in a group of men living at Thamaga in Botswana,[9] who had worked on mines in South Africa. This showed that 26.6-31% had radiological evidence of pneumoconiosis, 26.6% had a history of tuberculosis, and 6.8% had progressive massive fibrosis. The estimated annual incidence of new cases of smear positive tuberculosis was 1 320 per 100 000.

Several unsuccessful attempts had been made in the past to draw a statistically-reliable sample of former employees of the very big and very rich and powerful corporates who owned the mines. The interested scientists decided that a random sample was essential and that a sampling frame must be found. A field team in the Transkei identified the stored records at the Libode recruiting station of the Witwatersrand Native Labour Association (WNLA) as a suitable sampling frame, and a random sample of former miners who had been recruited from the Libode District was drawn.[10] The critical measurements were made on the basis of the physical and radiological findings in 238 former miners, most of whom had worked in gold mines. The radiological diagnoses varied widely. Pneumoconiosis was reported in 22-36% and tuberculosis in 33-47% of cases, depending on the reader. Faced with these estimates, there is no need for what a witty friend of mine called 'statistical tap-dancing' – common sense tells us that a serious problem exists.

The interim results, which were published immediately, were greeted with scorn by the Chamber of Mines and they proposed a proper study, by which they meant carried out by un-biassed researchers. When this study was done, it produced an exceptionally interesting couple of papers which confirmed everything that had been said as a result of the Libode study, and added new data that increased the impact of the study.[11,12] In a previous paper,[13] I discussed the results published in these two papers in some detail, and speculated as to what can be reasonably inferred about the premature mortality of silica-exposed miners once they leave the industry.

One may lament the absence of data, regret the failure to accept the advice of eminent academics, bemoan the failure to collate and analyse existing data, condemn the attitudes which lead to gross neglect of the relevant legislation and derived regulations, and accept it as right and just that the mining companies have found themselves confronted with charges of negligence which may prove impossible to defend.

This brief essay serves to show that the concern expressed by the Leon Commission in 1995 was fair comment and, in addition, calls, once again, for a real effort to improve working conditions in South African mines with sound research evidence in the public domain to prove the claims.

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10 keys for gender sensitive occupational safety and health practice – a brief overview

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INTRODUCTION

Acknowledging the differences between men and women workers in terms of their societal roles, expectations, responsibilities, biological differences and employment patterns plays a key role in identifying the different physical and psychological workplace risks they may each be exposed to.[1] In order to create more comprehensive and effective Occupational Safety and Health (OSH) policies and prevention strategies the International Labour Organization (ILO) has created 10 key guidelines to mainstream gender in the workplace.[1] This article provides a brief overview of these gender-sensitive OSH guidelines in celebration of the National Institute for Occupational Health's (NIOH) 60th anniversary and the launch of the NIOH Gender, Health and the World of Work Programme.

JPG a female mineworker taking off her one piece worksuit before using the lavatory
Photo: Asanda Benya

GUIDELINE 1: LEGISLATION

Taking a gender mainstreaming approach to reviewing and developing occupational safety and health legislation

Gender Mainstreaming refers to a globally-accepted strategy for promoting gender equality by ensuring that this is practiced consciously in all planned activities, including policy development, research, advocacy/dialogue, legislation, resource allocation, and planning, implementation and monitoring of programmes and projects. However, other than in very specific areas, most current laws on OSH are gender-neutral (sometimes even gender-blind), i.e. they do not distinguish between women's and men's jobs or biological differences, based on the assumption that the law will apply equally to all workers.

Workplace equality legislation in South Africa[2] has done away with protective regulations which were considered a restriction to women's opportunities for participation in paid employment. There are, however, two considerations stipulated by the guideline which have to be taken into account, namely: 1) in developing countries, restrictive legislation providing protection for women from extreme working conditions and violence is warranted; 2) gender-blind legislation may overlook gender differences in exposure to hazards and risks; hence the need for a gender-sensitive health and safety approach which assesses risks with a gender perspective and encourages adoption of preventive measures sensitive to the individual needs of both sexes.[3]

GUIDELINE 2: POLICIES

Developing OSH policies to address gender inequalities in OSH practice

Gender differences need to be considered when developing occupational health and safety policies and strategies. Policies that are not gender sensitive re-enforce the existing inequalities between men and women.[1]

Gender-neutral policies assume that workplace interventions will be as effective for men as for women, which is not always the case. The national authorities that are responsible for developing OSH policies need to take into consideration that men and women are exposed to different risks, and may react differently to the same risks because of their different biological make-ups.[1,4] An example of one such difference is recorded in a study that reported

Two female underground workers *Photo: Asanda Benya*

an increase in asthmatic attacks during the premenstrual phase, and varying airway reactivity to allergens and irritants over time and with hormones.[5] These differences could make women more susceptible than men to occupational Asthma.[5] These findings emphasise that gender representation, living conditions, cultural contexts and gender roles should be taken into account at work. All these factors should be clearly addressed in the relevant policies.

In the South African context, many OSH policies are lacking when it comes to gender sensitivity. Outside the Employment Equity Act,[2] there are no policies that specifically address gender differences, as all policies are developed in a gender-neutral manner. As per the ILO guideline: going forward OSH policies, both national and company-specific, should be used as a platform for addressing gender inequalities that affect health in the workplace.[6]

GUIDELINE 3: RISK MANAGEMENT

Ensuring consideration of gender differences in risk management

Risk management and risk assessment identify and measure the risks to which workers may be exposed, and adapt the workplace to protect workers health.[1] Workplaces require inclusive risk management measures that pay attention to the specific risks faced by the different genders, persons with disabilities, or migrants.[1] Risk management also necessitates the design of specific preventive and protective measures according to the requirements of workers.[1]

Risk assessments need to take account of gender issues, differences, and inequalities by involving all workers, both men and women, at all stages of the assessment. For example women and men suffer different types of accidents at different rates in the workplace; these differences are strongly related to job and task segregation.[7,8] When the labour inspectorate sets priorities (high, medium, low) during risk assessments, both genders should benefit from the task of assessment and implementation of solutions.[9] Both genders should be encouraged by the organisation to report any occupational health and safety issues.

GUIDELINE 4: RESEARCH

Occupational safety and health research should properly take into account gender differences

Research on occupational safety and health is important in informing, promoting, and improving safety and health in the workplace. Few studies to date have specifically incorporated gender-specific factors into their designs or data analyses. Instead, gender-neutral expressions such as 'workers' and 'employees' are often used in OSH studies.

OSH research has demonstrated that women and men doing the same work may experience different risks and health outcomes.[10] Research in OSH has focused mainly on male-dominated sectors, such as the mining and engineering fields. Therefore, the

"Gender-neutral policies assume that workplace interventions will be as effective for men as for women …"

methods and research tools developed for OSH research, particularly in these sectors, might not be relevant to assess the implication of risks and hazards for women. Similarly, studies on women in OSH have focused on sectors where females dominate, such as healthcare and domestic-related work. Similarly, the research tools developed for these studies may not be relevant to assess implications for male workers in these sectors.

Encouraging organisations to fund research on gender issues in the workplace will ensure that health and safety becomes more gender sensitive.[1]

GUIDELINE 5: INDICATORS

Developing gender sensitive OSH indicators based on sex-disaggregated data

"What gets measured gets done." Occupational safety and health indicators allow industries, governments and stakeholders to evaluate, monitor, and design programmes for the prevention of occupational injuries, disease and fatalities.

Collection of OSH indicators by gender allows for gender-sensitive research, planning, implementation, and monitoring of programmes. There is a need to improve gender sensitivity in data collection by industry, and a need for more sharing of data for research, prevention of workplace incidents, and policy design. The impact of work exposures and exposures linked to gender, will become clearer when sex-disaggregated data are available for analysis.

Analysis of the data enables the investigation of biological and socio-cultural differences between men and women, and their effects on health and safety at work. The analysis of sex-disaggregated data in Germany by the NRW Institute of Health and Work identified a gender gap in occupational health which allowed new policy targets and identification of measures and approaches to OHS to be set.[11]

"Risk assessments need to take account of gender issues, differences, and inequalities by involving all workers, both men and women, at all stages of the assessment"

GUIDELINE 6: EQUAL ACCESS

Promoting equal access to occupational health services and healthcare for all workers

The WHO estimates that only 5–10% of the working population in developing countries has access to OSH services.[1] OSH services are essential to prevent and manage healthcare in the workplace and there are many models currently in place in developed countries (e.g. the French system which is focused on occupational medicine and medical examinations, and the Scandinavian multidisciplinary model which involves teams of occupational hygienists, ergonomists, safety and health specialists, psychologists and counsellors)[1]. The changing employment patterns in developing countries has resulted in more individuals being employed in the informal economy (especially women) or small enterprises – neither of which has access to OSH services. It is recommended that national and local governments, OSH service providers, employers and workers' organisations should collaborate to revise legislation on accessibility of OSH services to all workers, including shift workers, part-time workers and informal workers[1].

GUIDELINE 7: PARTICIPATION

Ensuring the participation of both men and women workers and their representatives in OSH measures, health promotion and decision-making

Health promotion is often considered a feminine issue by men.[12] This can result in an inequitable uptake and attendance of health promotion initiatives and programmes. It is reported by the ILO, the Trades Union Congress, and diversity studies that women are highly under-represented in OSH committees, decision-making bodies and high-level positions.[1,13] Additionally, there is an over-representation of men in various health-professional capacities, e.g. doctors, safety managers, toxicologists, psychologists and epidemiologists.[1] The ILO guideline recommends that women should be encouraged to participate more in OSH decision-making and safety consultations, and that this could be facilitated through equality and diversity initiatives or programmes.[1]

GUIDELINE 8: TEACHING

Providing information, education and training

Providing information, education and training is a crucial aspect of ensuring the mainstreaming of gender into OSH policies and practice.[14] Accurate information about the relationship between health and the roles played by men and women needs to be fed into policies.

Information, education, and training needs to be provided to all who play a role in mainstreaming gender into OSH, including employers, workers and worker representatives, OSH inspectors, safety practitioners, occupational health researchers and all occupational health professionals.[2]

For gender mainstreaming to be a success, it should be the role of national governments to improve on gender-sensitive information and education about hazards and risks in the workplace, paying particular attention on identifying those faced by women. It should be the responsibility of the employer to ensure that, when planning for training on OSH, health promotion and prevention in the workplace, gender-sensitive differences in health-related behaviour are considered.[2]

GUIDELINE 9: ERGONOMICS

Designing work equipment, tools and personal protective equipment for both men and women

Globally, work equipment, tools and personal protective equipment (PPE) have been traditionally designed for the male body size and characteristics.[1,15] Examples of PPE include hard hats, safety glasses/goggles, respirators, hearing protective devices, gloves, overall/coveralls/jumpsuits and safety boots. Men who do not conform to this male worker model, and women, have problems

"Few studies … have specifically incorporated gender-specific factors into their designs or data analyses"

finding suitable and comfortable PPE. Poor fitting and limited availability of PPE for women is a critical health and safety issue undermining efforts to protect worker health and safety resulting in exposure risks.[15]

Poor fit-to-work equipment and tools can force awkward working postures, leading to increased risk of musculoskeletal disorders. Mismatch between work equipment and tools contribute to employees' work accidents. This problem has been evident with global migration and women entering traditionally male industries, such as constructing and engineering.

In order to ensure the provision of suitable work equipment, tools and PPE, and incorporating women into traditional male jobs and worldwide migration, some countries have started to develop anthropometric standards, taking into account the diversity of their working populations. Australia has reported the need for an up-to-date anthropometric database for designers to improve future equipment design. Canada, responding to the need of limited availability of PPE for women, has developed a guide enabling all relevant stakeholders to meet PPE needs for women. Similar research is needed in South Africa to address these challenges.

GUIDELINE 10: WORKING HOURS

Working time arrangement and work-life balance

People are increasingly working longer hours and shift work to meet the demands of the modern world. Approximately 20% of the European and North American working populations work in shifts in the communication, hospitality, transport, healthcare, and manufacturing/industrial industries, and roughly 22% of the global workforce is reported to work more than 48 hours a week.[1]

The ILO guideline reports that shift work, with inflexible work schedules and little control over workload, is associated with high stress levels and numerous health risks,[1] a contributing stress factor is that family and social life are often disrupted resulting in individuals becoming isolated from friends and family.[1] Shift work can cause an over reliance on sleeping pills, stimulants, drugs, or alcohol in men and women.[1] This is due to the irregular sleeping patterns causing imbalances in the hormonal systems, cardiovascular systems, digestive systems and circadian rhythms of both sexes.[1] The sleep loss and resulting fatigue of shift work can result in lower performance and an increased risk of work-related accidents[1]. It is also of importance that female shift workers have an increased risk of violence due to late working hours and usage of public transport during quiet hours.[1]

Part-time employment has been shown to be twice as common in women than in men – and this places women at risk of occupational disease and injury, as part-time workers often do not receive equal OSH protection.[1] It has been reported that part-time workers have a higher injury rate than full-time workers.[1]

It is recommended that national and local authorities on OSH ensure that work time arrangements are addressed and considered seriously as an OSH issue. If this receives recognition then it should be regulated and workers should be educated on the topic to ensure adequate work-life balance.

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DECLARATION

The authors declare no conflicts of interest.

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Reproductive health hazards in laboratory work

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ABSTRACT

Laboratory workers are exposed to various occupational hazards during the course of their work, which might affect the reproductive health of both men and women, including chemical, biological and physical hazards, as well as ergonomic and psychosocial risk factors. In this paper, some of the important reproductive health hazards that might be encountered by laboratory workers are described and illustrated with research examples. Although the mechanisms by which reproductive health outcomes are produced often remain uncertain, the majority of the research reviewed concludes that there is sufficient data to warrant special consideration of reproductive health in the workplace. Specific hazards, such as exposure to chemicals and irregular work schedules, might require the implementation of special measures to protect, in particular, but not exclusively, pregnant workers.

Keywords: **reproductive health hazard, developmental health hazard, congenital malformations**

INTRODUCTION

A reproductive health hazard is a chemical, physical, biological, ergonomic, or other type of stressor that alters the ability of a couple to achieve a successful pregnancy. This alteration might include effects on reproductive organs, libido, sexual behaviour, hormonal activity or any physiological response that interferes with, or delays, conception. A developmental health hazard affects the developing organism, either before birth or postnatally. Such effects include death, morphological malformations, reduced body weight, altered growth, and impaired postnatal physical and mental development. The effects might result from exposure to risk factors of either parent prior to conception, or exposure to the offspring in the womb or postnatally.[1,2] In this paper, the term 'reproductive health hazard' encompasses both reproductive and developmental risk factors.

Laboratory workers might be exposed to various occupational health hazards during the course of their normal work, including: chemical hazards, such as organic solvents and acids; physical hazards, such as noise and radiation; biological hazards, e.g. blood pathogens and cell cultures; ergonomic hazards, including long periods of standing and tasks that involve repetitive movements; and psychosocial factors, such as abnormal working hours, fatigue and stress. Some of these hazards may specifically affect the reproductive ability of both men and women workers.

The effects of occupational risk factors on reproductive health outcomes have been highlighted in a number of studies, although the mechanisms by which these outcomes are produced often remain uncertain.[3-5]

The aim of this paper is to revisit the question of whether reproductive health deserves special consideration in the workplace, using studies conducted on laboratory workers to illustrate the points made. Due to the lack of awareness of this field, workers and safety officials are likely to be unaware of the reproductive hazards and outcomes associated with their work.

METHODOLOGY

A literature search was conducted using PubMed, with no lower date truncation. Search terms included 'reproductive health hazard', 'reproductive health risk', developmental health hazard/risk', 'congenital malformations', 'laboratory work/er', 'health hazard', 'pregnancy outcome/s', 'maternal/paternal/parental exposure' 'shift work', 'organic solvents', 'radiation', 'biological hazards', 'pathology laboratory', 'xylene', 'formaldehyde'. The studies reviewed were classified according to the following categories: chemical hazards, ergonomic and shift work, hazardous biological agents, and ionising radiation. Due to the paucity of research on reproductive health in laboratories, studies conducted in other work environments, describing reproductive health outcomes emanating from exposures similar to those encountered in laboratories, were also reviewed.

CHEMICAL HAZARDS

Some of the chemicals to which laboratory workers are exposed have been found to be mutagenic, genotoxic or teratogenic in experimental animal studies. Exposure of laboratory workers to chemicals has also been associated with cancer, reduced fecundity and other adverse reproductive outcomes.[6]

A large nationwide Danish cohort study involving 5 425 laboratory workers and 21 438 teachers found an increased risk of low birth weight (adjusted OR 1.27, 95% CI 1.08-1.45) and small-for-gestational age (adjusted OR 1.27, 95% CI 1.02-1.52) for laboratory workers when compared to teachers.[6]

"Some of the chemicals to which laboratory workers are exposed have been found to be mutagenic, genotoxic or teratogenic in experimental animal studies"

Organic solvents have been implicated in the aetiology of spontaneous abortions and malformations since the 1980s.[7] Most organic solvents readily cross the lipid barrier of the placenta and, to a lesser degree, the testes. They may also be secreted in breast milk. Thus, excessive occupational solvent exposure can pose a risk to the foetus prenatally and to the infant postnatally.[1,8]

Spontaneous abortions among women working in laboratories, as well as congenital malformations and birth weights of their children, were examined in a retrospective case-referent study in Finland. The study found significant associations between spontaneous abortions and exposure to toluene (OR 4.7, 95% CI 1.4-15.9), xylene (OR 3.1, 95% CI 1.3-7.5) and formalin (OR 3.5, 95% CI 1.1-11.2) among women who were exposed at least three days a week during the first trimester of pregnancy.[9]

Kandyala et al. (2010) reviewed the health effects of xylene and its use in histopathology laboratories. They stated that inhalation by the mother can produce fetotoxic effects such as delayed ossification and behavioural effects. It was recommended that pregnant and nursing women minimise their exposure to xylene.[10]

ERGONOMIC FACTORS AND SHIFT WORK

Ergonomic stress factors to which laboratory workers are exposed include prolonged microscope work, repetitive tasks, such as pipetting and microtome work, continuous standing at fixed-height laboratory benches, and sitting on chairs or stools that cannot be adjusted to the worker's particular needs and anatomy. Some tasks involve manual material handling, such as lifting containers of chemical reagents, as well as tasks that require micro-manipulation and fine motor skills.[11] Varying shift schedules, extended working hours and night work are common.

In a large study conducted in Montreal, the relationships between spontaneous abortion (n=5 010), stillbirth without congenital defect (n=210), and working conditions were analysed in 22 613 previous pregnancies of 56 067 women interviewed immediately after termination of their most recent pregnancies. Ratios of observed (O) to expected (E) foetal deaths were calculated for women whose work entailed various physical demands, exposure to environmental factors, such as noise, vibration and thermal stress, and exposure to chemicals. Significantly increased O/E ratios for abortion were found in women exposed to high levels of physical stress, particularly lifting of heavy weights more than 15 times a day (1.45, $p<0.01$), other physical effort (1.37, $p<0.01$) and standing for more than eight hours a day (1.18, $p<0.01$). Increased O/E ratios for abortion were also found in relation to working 46 or more hours a week (1.19, $p<0.01$), and changing patterns of shift work (1.25, $p<0.01$).[12]

A systematic review of four domains of physical activity (occupational, household, leisure and commuting) analysed 22 studies that examined the association between maternal physical activity and low birth weight, preterm birth and intrauterine growth restriction. Only two studies did not detect a significant association between physical activity and these outcomes. The review, however, supported the hypothesis that both excessive and insufficient physical activity impact negatively on pregnancy outcomes.[13]

Varying work schedules (including rotating shifts and night-work) may present special risks to pregnant women as a result of maternal hormonal disturbance arising from sleep deprivation or circadian rhythm disruption, which might impair foetal growth or lead to complications of pregnancy.[14]

A systematic review of epidemiological studies on shift work from 1966 to 2010 suggested a small elevated risk for preterm birth (RR 1.03, 95% CI 0.93-1.14), low birth weight (RR 1.27, 95% CI 0.93-1.74) and for 'small for gestational age' (RR 1.12, 95% CI 1.03-1.22). The researchers suggested that it would be prudent to permit pregnant women, insofar as job circumstances allow, to reduce their exposure to shift and night work. They also noted that the 'healthy pregnant worker effect' might have introduced bias and that the risks in women who continue to work shifts late in pregnancy might be underestimated as healthier women with uncomplicated pregnancies are less likely to modify their work schedules.[14]

HAZARDOUS BIOLOGICAL AGENTS

Biological specimens, such as body tissue, organs, blood, fluids and excreta might be handled routinely by workers, especially in pathology, biomedical and research laboratories. These specimens are potential sources of exposure to various hazardous biological agents, including infectious microorganisms such as viruses and bacteria.

Infections have been reported to cause spontaneous abortion and foetal death, preterm birth,

"Organic solvents have been implicated in the aetiology of spontaneous abortions and malformations since the 1980s"

intrauterine growth restriction and birth defects, including abnormalities of the central nervous system, ophthalmologic manifestations and congenital heart defects.[15]

Two questionnaire-based studies conducted among female biomedical research laboratory workers in Sweden found a positive association between exposure to bacteria and adverse reproductive outcomes. The first study, conducted from 1990 to 1994, found an increased preterm birth OR of 2.7 (95% CI 1.2-6.5) in laboratory workers.[7] The second compared female university personnel with and without laboratory work (249 and 613 pregnancies, respectively) and reported an increased postterm birth OR of 2.7 (95% CI 1.0-7.4) for laboratory work that involved potential exposure to bacteria.[16] It is interesting to note that both preterm and postterm births were observed by the researchers. This finding indicates that exposure to bacteria might disrupt the normal timing of labour or that different types of bacteria have different effects on reproduction.

IONISING RADIATION

Ionising radiation can injure the developing embryo due to cell death or chromosome injury. The most critical exposure period is 8-15 weeks after fertilisation; however, permanent growth retardation due to radiation is more severe after mid-gestation. The central nervous system is the most sensitive of all organ systems to the detrimental effects of ionising radiation in the later foetal stages.[17]

The effects of parental radiation depend on the dose received and the amount delivered to the gonads, while the adverse effects on the developing foetus depend on the dose delivered in utero and gestational age. In addition, specific types of ionising radiation (e.g. X-ray, α or β particles) have different routes of exposure and different energy levels. The mutagenic and carcinogenic effects of ionising radiation are not considered to have a threshold and health outcomes might be observed at any level of exposure.[1]

Kumar (2004) reviewed various studies on occupational exposure associated with reproductive dysfunction. He reported that much experimental data were available on the adverse effects of radiation on the reproductive system of both males and females from various animal species; however, only limited data were available from studies on humans with radiation exposure.[18]

Adriaens et al., in a review article on ovarian radiation sensitivity and the genetic hazard of ionising radiation, found that congenital anomalies have been observed from animal studies after exposure to high radiation doses (1-5 Gy), but reported that most epidemiological studies found little evidence of genetic diseases at the doses at which medical, occupational or accidental exposure occurred. However, the researchers concluded that the fact that genetic effects were observed in irradiated animals suggested that these could also occur in humans.[19]

A prospective cohort study conducted in Denmark during 1997-2003 investigated various pregnancy outcomes in female laboratory technicians (n=1 025) compared to teachers (n=8 037). Laboratory technicians working with radioimmunoassay and radiolabelling had an increased risk of preterm birth (OR 2.2, 95% CI 0.8-6.2 for radioimmunoassay, and OR 1.9, 95% CI 0.8-4.6 for radiolabelling) as well as an increased risk for major malformations (HR 2.1, 95% CI 1.0-4.7 for radioimmunoassay, and HR 1.8, 95% CI 0.9-3.7 for radiolabelling). The ORs for preterm birth doubled for women working on these tasks every day or several times a week. They recommended that laboratory technicians should take precautions to protect themselves when working with radioisotopes.[20]

Figa-Talamanca, in her review of occupational risk factors and reproductive health of women, reported that exposure to ionising radiation in prenatal life is a known risk factor for foetal death and congenital defects, and that it is widely accepted that women should avoid exposure to ionising radiation in the periconceptional period, as well as during gestation.[21]

DISCUSSION

Human reproduction is a sensitive and intricate process that might be affected by various factors, including those at work, home and during leisure activities. It is often difficult to isolate one factor responsible for a particular health effect. Some might act synergistically, e.g. exposure to chemicals at work, together with alcohol consumption at home.

Although the mechanisms by which reproductive health outcomes are produced often remain uncertain, many of the studies reviewed in this article concluded that there is sufficient data to warrant special consideration of reproductive health in the workplace. Specific hazards, such as exposure to chemicals (especially organic solvents), heavy physical work and irregular work schedules, might require the implementation of special measures to protect, in particular, but not exclusively, pregnant workers.[1,9,20-26] Several researchers, however, caution against overprotection of women and implementing discriminatory measures that would be disadvantageous to the economic well-being of women.[1,21,27]

"Varying work schedules (including rotating shifts and night-work) may present special risks to pregnant women"

The existing research data on reproductive health, in general, and in laboratories, specifically, is limited, particularly with regard to human studies. Chemical studies are often conducted using a single substance administered to experimental animals at high doses, while exposure in laboratories is typically to a

multitude of substances at relatively lower doses. Most human studies are retrospective and their accuracy might be affected by recall bias. Also, they often do not allow validation of crucial details regarding the extent and nature of workers' exposure to various stresses. Although several researchers have found an increased risk of adverse reproductive health outcomes related to chemical exposures in laboratories, few included the actual field measurements in their studies.[1,23,24]

Reducing occupational reproductive hazards should be part of a comprehensive health and safety programme. The first step is to conduct a reproductive health risk assessment which includes assessing the hazards, the individual worker and the work environment. Such programmes should cover all employees of reproductive age. It is important that interventions are implemented even before pregnancy is confirmed to prevent potential exposure during the crucial period of early foetal growth.[1]

Eliminating or substituting a hazardous agent with a less hazardous one is generally the most effective way of control, although it might not always be practical or feasible to do this.

Kandyala et al. examined various substitutes for xylene in histopathology laboratories and concluded that aliphatic hydrocarbon substitutes could be used satisfactorily for paraffin tissue processing during clearing and staining, as well as for frozen sections.[10]

Zanini et al. evaluated two commercial and three homemade fixatives for the substitution of formalin solution in pathology laboratories, making a strong case for a formaldehyde-free laboratory. They stated that, although formalin is relatively cheap and readily available, there are 'hidden costs' which include the necessity of using ventilation systems as well as the need for medical surveillance of workers exposed to a human carcinogen.[28]

Various institutions and organisations, such as the International Labour Organization (ILO) and the US National Institute for Occupational Safety and Health (NIOSH) have issued guidelines relating to reproductive health hazards in the workplace. The guidelines stress the general lack of information and insufficient data with regard to various reproductive hazards, and the importance of making workers aware of the potential risks, particularly when working with chemicals or biological agents, when exposed to ionising radiation, when performing physically demanding work, or when exposed to stressful work conditions.[29,30] Effective control measures and sound occupational hygiene practices that eliminate or reduce occupational health risks to all workers, regardless of their reproductive status, will inadvertently result in reduction of reproductive health risks as well.

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Occupational hygiene-related research in South Africa: development of a research repository

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INTRODUCTION

In November 2015, a small group of representatives from research, government and industry involved in occupational health (OH) in Gauteng gathered in a meeting to begin discussions about setting an OH research agenda with a specific focus on occupational hygiene.[1] A tentative list of priority areas for research were identified, however, it was agreed that a follow-up meeting should be decisive on more final recommendations. It was also agreed that a repository of past and current OH-research in South Africa would be helpful as background information. The following paragraphs describe the development of such a repository.

DEVELOPING THE REPOSITORY

It was agreed that the repository should include scientific papers, technical reports and student research projects. As a follow-up, identified researchers in universities and research institutions were requested to complete a form and list the occupational hygiene-related and/or occupational health research conducted over the last 3 years (2013-Q1 2016), i.e. the research topic and a brief description, the research type (e.g. MSc, PhD or other), and the dissemination type and full reference. In addition to the self-reporting, a literature search was conducted in Scopus. Search strings were: affiliation (e.g. university, research institute) AND year 2013-present (6 April 2016). Within the selected documents, two selections were made with the terms 'occupational' OR 'exposure'. For confirmation, the search string 'occupational' AND 'exposure' was also used. A preliminary analysis on titles and abstracts was conducted by one of the authors (DB) and verified by the other (JLdP) to include or exclude studies. Studies that met the following criteria were included:

- Occupational/environmental health studies with an exposure component
- Studies that contain data on occupational/environmental exposure
- First or last authors' affiliation in South Africa

Exclusion criteria were:

- Occupational/environmental health studies where exposure component is lacking
- Studies focused on device performance
- Purely toxicological studies
- Studies focused on pure environmental exposure without a human exposure component
- Reviews
- Studies identified as duplicates (first and/ or last author have multiple affiliations)

Since an important platform for South African occupational health research, i.e. *Occupational Health Southern Africa*, is not indexed by Scopus, volumes 19-22(2) of the Journal were also included in the search.

The included references are available from the corresponding author, on request (Tables S1 and S2 for Scopus results; Table S3 for *Occupational Health Southern Africa* results), as is the information compiled from the contributions from the universities and research institutes (Table S4). A numerical summary is presented in Table 1.

In general, there was some overlap, i.e. publications that have authors from several universities and institutions, most often due to post-graduate research. However, it also indicates cross-institutional collaborations. Numerically, the University of Cape Town (UCT) contributed the most publications. Table 1 also shows the discrepancy between the number of self-reported (peer-reviewed) publications and those retrieved through the literature search. Researchers mostly reported papers generated by their own research group, implicitly applying more strict inclusion criteria than those used in the literature search. Clearly, the figures are biased by the subjective assessment and a number of studies are in the interface between environmental and occupational exposure, or occupational and public health.

From the perspective of the repository and the research agenda, the topics addressed are more interesting than the number of (peer-reviewed) publications, since this provides direction of the strengths of the research entities and common themes. A compilation of the publications is presented as a 'heat map' (Table 2), where the topics of the excluded papers are taken into account as well as the self-reported research outputs and efforts.

If we consider the overall efforts, work-related allergy, pesticide exposure and health effects, and particulate matter in outdoor and indoor environments were most frequently addressed over

Table 1. Numerical summaries of Scopus searches (time frame 2013-April 2016) and self-reported publications

Institute	Search string "occupational" OR "exposure"				Search string "occupational" AND "exposure"					Self-reported (2013 - Q1 2016) publications (not added[a])		
	Scopus publications	"occupational"	"exposure"	Added[a]	Total	Duplicates[b]	Added[a]	Total added[a]	OHSA publications	Scopus journals	Non-Scopus journals	Other[c]
	a)	b)	c)	d)	e)	f)	g)	h)	i)	j)	k)	l)
CP-UT	758	0	73	0d	8	0d	0	0	0	na	na	na
CSIR	941	14	61	2	3	1	1	3	2	na	2	na
CUT	173	9	9	0	0	0	0	0	2	na	na	na
DUT	589	14	34	0	0	0	0	0	0	na	na	na
NIOH	53	53	34	8	18	5	0	8	3	4	2	6
NWU	3 515	231	258	6	12	2	0	6	2	4	5	1
Rhodes	2 079	20	100	3	1	0	0	3	0	na	na	na
TUT	2 181	27	90	6	4	1	0	6	1	na	na	na
UCT	9 836	321	897	11	39	8	2	13	0	4	-	4e
UKZN	6 962	121	476	5	10	2	0	5	3	2	-	3e
UP	7 176	171	510	5	11	2	0	5	1	na	na	na
Wits	7 384	217	651	6	35	6	1	7	1	1	-	-

OHSA: Occupational Health Southern Africa; CP-UT: Cape Peninsula University of Technology; CSIR: Council for Scientific and Industrial Research; CUT: Central University of Technology; DUT: Durban University of Technology; NIOH: National Institute for Occupational Health; NWU: North West University; Rhodes: Rhodes University; TUT: Tshwane University of Technology; UCT: University of Cape Town; UKZN: University of KwaZulu-Natal; UP: University of Pretoria; Wits: University of the Witwatersrand; na: not available; a added to repository; b duplicates of b) or c); c other type of publication / in progress; d papers assigned to UCT as the author was affiliated with UCT during the studies; e in progress

Table 2. Heat map of research topics addressed by the various universities and research institutions

See Table 1 for abbreviations. Three colour gradients are displayed, indicating the frequency of the topic; the shade of the colour in each cell represents the frequency. These range from "not addressed" (dark green) to "often addressed" (red). The columns represent the focus points (if any) of the university/ research institutions. The last column provides the overall picture

the reviewed period. The latter is a research topic covered by the largest number of research entities. Much attention with regard to research was paid to both communicable and infectious diseases (and associated exposures) amongst healthcare workers. Traditional clusters of dust/silica exposure assessment and lung diseases are still frequently addressed. Conversely, physical exposures, e.g. noise, heat, vibration, ultra violet and electro-magnetic field radiation, are underexposed fields of research.

The heat map also illustrates that the various research entities have clear focus research topics, e.g. UCT (pesticides, allergies, risk communication), CSIR (fatigue/ heat stress/ UV-radiation), Rhodes University (ergonomics) and North West University (NWU) (skin), whereas others cover a wider range of topics. As expected, the National Institute for Occupational Health (NIOH), being the national occupational health research institute, is active in most fields of occupational hygiene-related health research. Traditionally, between university/institute collaborations exists in the fields of work-related allergy and tuberculosis (UCT-NIOH), healthcare workers (University of KwaZulu-Natal-NIOH), and lung diseases, including silicosis and exposure to crystalline quartz dust (NIOH-Wits).

A limitation of this inventory is that current research topics could not be included in the inventory due to the time lag between conclusion of the research and publication. An additional limitation of the Scopus literature search is that neither publications in progress/ under review nor reports and other 'grey' literature are retrieved. In addition, details about research that is current or about to start, e.g. MSc and PhD projects, is not available. It is expected that NWU and Wits, with their distinct occupational hygiene education programmes, will address many of to the identified research topics in the near future.

CONCLUSIONS AND RECOMMENDATIONS

The repository is intended to provide background information to the discussions about a South African occupational health/hygiene research agenda. With all its limitations, it provides information about which current research topics are being addressed and the focus (and often the strengths) of research groups. Some of the identified research needs with regard to diseases (Brouwer, 2015) are currently already addressed, e.g. silicosis and tuberculosis, whereas research relating to musculoskeletal diseases is noticeably sparse. Currently, there is very little research with regard to occupational health in the informal sector. Exposure and health effects associated with mine dumps are being studied, although in a fragmented way, as is the potential exposure and effects of nanotechnology. Future studies to support the research priorities will most likely be based on research strengths of the various research entities and collaborations. Therefore, it is recommended that the current repository should be expanded to include current and proposed research projects, and be endorsed by the research entities to become an active source of information.

ACKNOWLEDGEMENTS

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DECLARATION OF INTEREST

The authors declare no conflicts of interests.

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Free papers online

We are pleased to inform our readers that all papers published in *Occupational Health Southern Africa*, prior to January 2016, are now freely available online. Going forward, all papers published in *Occupational Health Southern Africa* will be 'free' to anyone who is interested in downloading and reading them, six months after publication. ASSAf (the Academy of Science of South Africa) is encouraging all South African journal publishers to follow the global trend of open access. The advantages are twofold: 1) many more researchers will have access to scientific papers that were previously only available if they purchased them, and 2) researchers who publish will have their papers read and cited by a wider range, and more, of their peers.

To read more about open access, especially in the South African context, please download a paper published in 2014 in the *South African Journal of Science*; available from: http://sajs.co.za/open-access-south-africa-case-study-and-reflections/laura-czerniewicz-sarah-goodier.

High calibre visitors throng A-OSH EXPO 2016

Proving that A-OSH EXPO has a winning formula in spite of the tough economic conditions, this year's event saw a visitor number increase of 9.16% to 2 669. This can be attributed to a number of factors, including the high quality of products and services on offer from the 87+ exhibitors at the show, the range of educational content, and a number of product launches and competitions that the exhibitors ran on their stands. This year welcomed 21 first-time exhibitors on the show, from more than nine international countries.

"When combined with our co-located security and fire exhibition, Securex, the show welcomed just over 9 000 visitors in just three days, an increase of 1 200 visitors when compared to the 2015 event. This makes it the largest fire, security, and occupational health and safety show in Africa," says Joshua Low, A-OSH EXPO event director at Specialised Exhibitions.

A consistent and aggressive marketing campaign, launched soon after the 2015 event, ensured that A-OSH EXPO 2016 was top of mind for industry captains seeking and sourcing best practice occupational health and safety (OHS) products and services. A targeted educational campaign included the Saiosh Conference and the half-day FPASA InFiRES Seminar, the free-to-attend NOSHEBO Seminar Theatre, sponsored by Ansell, and the PASMA Working at Height Theatre, which were all huge drawcards. In total, 337 delegates attended the conferences and most of the free-to-attend seminar sessions were packed to capacity.

Held at Gallagher Convention Centre in Midrand, Johannesburg, from 24 to 26 May 2016, A-OSH EXPO 2016 provided industry professionals with the best possible opportunity to interact with a highly knowledgeable and experienced exhibitor base. "The Business Matchmaking initiative, sponsored by Ideco, was so successful in 2015 that we decided to utilise it again this year. It allowed visitors to set up meetings with predefined exhibitors in advance of the exhibition, allowing them to maximise their time at A-OSH EXPO," says Low.

"We saw an incredible 226% increase in African visitors this year, with 49 visitors investigating OHS solutions from local and international suppliers. The highest attendance was from Botswana, with 18 visitors, followed by seven people from Mozambique. Our exhibitors expressed a desire to increase their African footprint, so it is evident that our marketing efforts in driving cross border visitors to A-OSH EXPO have been highly successful," says Low.

Launchpad

A-OSH EXPO is regarded as the launchpad for new OHS solutions and this year's exhibition did not disappoint the visitors. Heightsafety introduced the first local SABS-approved extension placement pole for the placement of temporary vertical life lines and roof anchors. Affsaf's Safety 360 App for Android allows checklists and other HSE tools to be performed offline and then synced to the server.

CHARNAUD introduced its True Comfort long sleeve shirt which can protect a wearer in an electric arc flash up to 10.9 cal/cm^2, and Ethekwini Safety Health and Environmental Services showcased its SHE PPE range for working women, which is aligned with women's bodily structures and anthropometric data.

Dräger had a number of new products on display, including a comfort vest for chemical protection suits (CPS), drug and alcohol detection equipment, airline equipment, and gas detection equipment. Kevro's new Barron Workwear offerings included an HACCP food safety jacket, pants, rubberised rain suit with heat-sealed seams, and the SABS-approved steel toe cap safety Crusader Tekkie.

On the training side, NOSA continues to bring best practice in OHS competency to the table and the UNISA Centre for Business Management promoted its short learning programmes, including the Programme in Safety Management and the Programme in Advanced Safety Management. Bumbene's tailor-made solutions including national and international OHS management systems and products; TETA accredited skills development and training, and the HIRA process, proved popular with visitors.

Sabinet's new Legal Registers platform, in association with Standards & Legal, takes the stress out of managing sustainability and legal compliance. Similarly, ppe2go is an easy-to-use software system that saves both time and money and allows users to control the issuing of PPE stock.

The SDI Group, a first-time exhibitor at A-OSH EXO, was thrilled about the exhibition, with a substantial order signed with Lancet Laboratories, and further contracts currently in the finalisation stage with a large hotel group and G4S Security. In addition, the company has entered into a joint venture with fellow exhibitor, Heightsafety. According to the company's director of operations, Yvette Montalbano, the crossover of visitors and exhibitors from co-located Securex was excellent in terms of sales leads.

"This is our second year on A-OSH EXPO and it was even better than last year. We expanded the size of our stand and offered three prizes worth R20 000 each to visitors. This was an amazing experience and we have already set up meetings to provide our product to the likes of Eskom, I&J, the Department of Correctional Services, the Department of Environmental Affairs, the Departments of Health, Lancet, SAA Express, Sasol, Engen and City Parks," says Mark van den Bergh of Affsaf.

"To be honest I initially did not want to exhibit at A-OSH EXPO but I am so pleased my team persuaded me to be here. What amazing exposure for our company! We saw so many decision-makers and it saved so much time on the sales process. There is no way that we could transport our entire range to customer offices every time we want to make a sale but it is possible at the exhibition," commented Ernie Wallis of SHEQ Safety.

"Bookings for stand space at next year's A-OSH EXPO, being held once again at Gallagher Convention Centre from 30 May to 1 June, are brisk, so we encourage OHS product and service providers to ensure they don't miss the bus," Low concludes.

To reserve their prime spot, interested companies should contact Sven Riddle or Zelda Jordaan on: svenr@specialised.com or zeldaj@specialised.com, or visit www.aosh.co.za

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Methamphetamine update

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The scourge of "Tik" (methamphetamine) is well known. We see it on the news, read about it in newspapers and, perhaps, witness it in our neighbourhoods. Methamphetamine (Met) has become a major problem for families, communities and local governments.[1] Many law enforcement agencies have reported an increase in methamphetamine-related arrests over the last few years.

MECHANISM OF ACTION: METHAMPHETAMINE

The methamphetamine of today is said to be almost six times more potent compared to that used in the 1960s. Amphetamine and methamphetamine are CNS stimulants that have limited pharmacological use. These drugs are sympathomimetics amines in that they mimic endogenous transmitters in the sympathetic nervous system. The primary action is to elevate the concentrations of extracellular monoamine transporters (dopamine, serotonin and norepinephrine) by promoting the presynaptic release from nerve endings rather than blockade of reuptake. The methamphetamine cardiovascular activation is thought to be due to the release of norepinephrine from sympathetic nerve endings. The anorectic affect and its locomotor stimulating effect are also mediated by the release of norepinephrine.[2]

THE CLINICAL EFFECTS OF METHAMPHETAMINE

Dopamine is involved in reward, motivation, the experience of pleasure, and motor function. The rapid release of dopamine produces the 'euphoric rush' that many users experience. Repeated use leads to addiction, characterised by compulsive drug-seeking and use. Chronic use of methamphetamines leads to anxiety, confusion, insomnia, mood disturbances and violent behaviour. Individuals may also show symptoms of psychosis (hallucinations and delusions). Studies have demonstrated severe structural and functional changes in areas of the brain associated with emotion and memory, accounting for many of the emotional and cognitive problems seen in these individuals. Some of the other physical effects associated with methamphetamine use are similar to those associated with use of cocaine or amphetamine, and include increased wakefulness, increased physical activity, decreased appetite, increased respiration, tachycardia with irregular heartbeats, and raised blood pressure and body temperature. [3.2] Methamphetamine users are also shown to be at an increased risk of contracting HIV, and Hepatitis B and C.

METABOLISM OF METHAMPHETAMINE

Methamphetamine is metabolised in the liver by hydroxylation and, to a lesser extent, by N-demethylation, to amphetamine. In addition to hepatic metabolism, methamphetamine is also eliminated as the unchanged drug in urine.[2] One of the important confounding factors when testing includes the presence of isomers of methamphetamine which include, d-methampetamine and l-methamphetamine. Whilst the d-isomer is responsible for the CNS effects, the l-isomer, e.g. the common Vicks

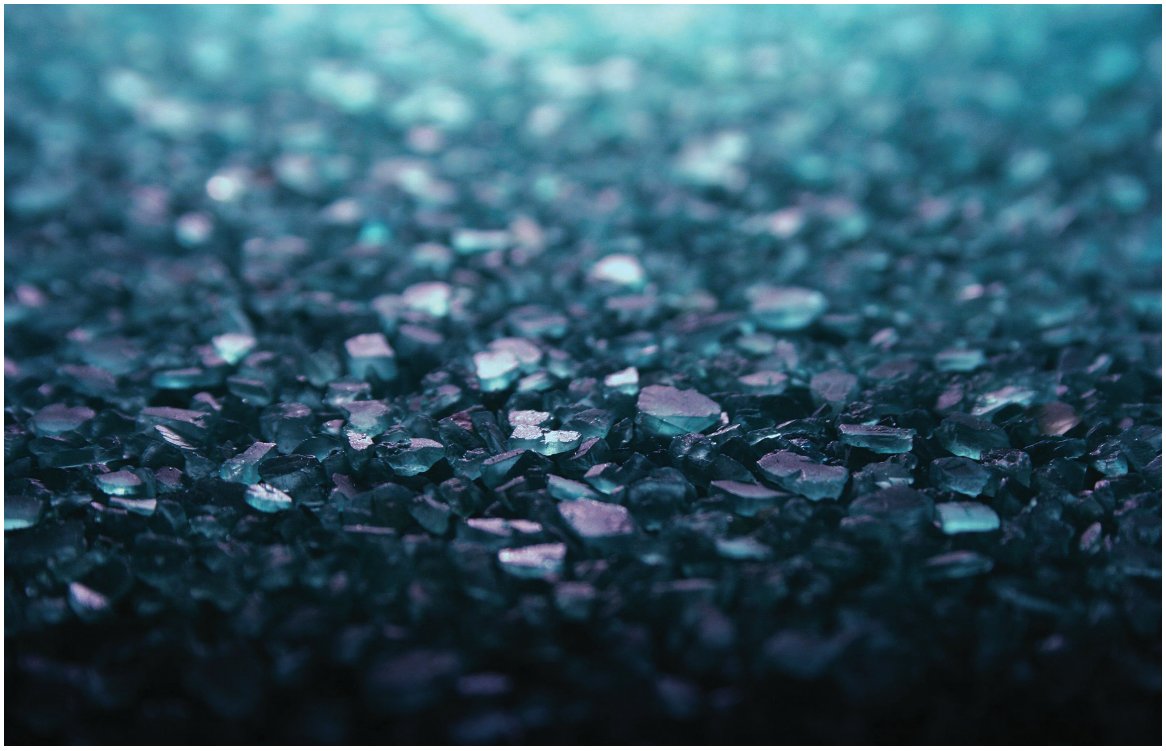

Table 1. Summary of analytical aspects related to immunoassay screening.[4]

Test drug	Drugs that cause false positive test results (platform-dependent)	Confirmatory method
Methamphetamine	Amantadine, bupropion, chlorpromazine, desipramine, dextroamphetamine, ephedrine, pseudoephedrine labetalol, MDMA, Vicks inhaler, methylphenidate, phenylephrine, promethazine, ranitidine, selegiline, trimipramine	GC- MS LC-MS-MS

nasal inhaler, acts peripherally, with no euphoric effects, gives false positives on certain immunoassay platforms due to cross reactivity. Although newer assays do not show this cross reactivity, this finding will be platform dependent. Other therapeutic agents, such as selegiline and deprenyl, used in the treatment of Parkinsonism, also produce l-amphetamine and l-methamphetamine which cross react with immunoassays.[4]

ANALYTICAL ASPECTS OF METHAMPHETAMINE TESTING

Most amphetamine assays are designed to also pick up methamphetamine and other analogues which include, methylene dioxymethamphetamine (MDMA) and methylene dioxyamphetamine (MDA). Unfortunately, other stimulants, anorexiants and chemically-related compounds, e.g. pseudoephedrine, have shown to produce false positive results, making the amphetamine/methamphetamine assay one of the most difficult tests to interpret. It is for this reason that the platform be reserved as a screening test only. Interpretation requires a detailed history which should include over-the-counter (OTC) medications, prescription and herbal medications.[4] Immunoassays from different manufacturers can have very different 'interference profiles' which must be understood.[2] Table 1 summarises some of the OTCs and prescription drugs that can cross react with immunoassay platforms. Gas chromatography (GC-MS), with chiral differentiation and liquid chromatography mass spectrometry (LC-MS-MS) form part of the confirmatory methods for methamphetamine testing. These platforms are able to discriminate the isomers of methamphetamine and also differentiate prescription drugs from the drug itself.

CONCLUSION

It is important that clinicians fully understand the limitations of methamphetamine testing. Misinterpretation can have serious consequences for employees and patients, making it necessary that the pathologist and clinical laboratory be consulted with regards to testing.

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SASOM Annual Congress 2016

This year's Congress of the South African Society of Occupational Medicine (SASOM) took place on 10 and 11 June at the Kopanong Hotel and Conference Centre in Benoni, Gauteng. The Congress was attended by 102 delegates who came from far and wide within South Africa, and from beyond our borders.

In line with the SASOM objective of advancing occupational healthcare through continuing education and discussion of academic and practical aspects of the discipline, the Congress offered participants a very comprehensive and varied programme, and the Congress organising committee takes this opportunity to thank and recognise the contributions made by the presenters, exhibitors and delegates in making the Congress a success.

Prof. Daniel Kocks, SASOM Chairperson, opened the Congress by welcoming the participants and chairing the first session. The first presentation was delivered by Mr Frank Muchiri, Senior Occupational Health and Safety Specialist, from the International Labour Organization Decent Work Team (ILO-DWT) for Eastern and Southern Africa, who spoke on the topic of the ILO response to occupational health and safety, with a special focus on Africa. This was followed by a presentation by Ms Milly Ruiters, from the national Department of Labour (DoL), on the importance and value of medical surveillance. Her talk was complemented by another presentation from the DoL: Ms Bulelwa Huna spoke on the reporting of occupational injuries and diseases according to Sections 24 and 25 of the Occupational Health and Safety Act. The inclusion of these two presentations in the Congress programme attests to the closer working collaboration between SASOM and the DoL.

The second session was in recognition of practical applications in occupational medicine. Prof. David Rees and Dr Spo Kgalamono, both occupational medicine specialists from the South African National Institute for Occupational Health (NIOH), presented on the use, value and application of the ILO classification of pneumoconiosis radiographs, and an update on the diagnosis of occupational asthma, respectively. SASOM takes this opportunity to congratulate the NIOH on the celebration of its 60th anniversary (1956-2016).

The third presentation was delivered by Dr Dingani Moyo, an occupational medicine practitioner from Zimbabwe and Board Member of the International Commission on Occupational Health (ICOH), on essential communications related to return to work following ill health.

The last session of the first day was kicked off by Dr Jan Lapere, a Social Labour Law expert and consultant in occupational health, safety and medicine, who presented on medical records in terms of changes in legislation and the practical implications. Ms Karen Michell, an occupational health and safety consultant representing the South African Society of Occupational Health Nursing (SASOHN; sister organisation

National and international organisations were represented at the SASOM Congress. From L to R: Ms Claudina Nogueira (SASOM ExCo Member, ICOH Board Member); Dr Sipho Senabe (South African National Department of Public Service and Administration); Dr Dingani Moyo (Chair of SASOM Zimbabwe Branch, ICOH Board Member); Prof. Mary Ross (SASOM ExCo Member, Chair of the ICOH Working Group on Occupational Infectious Agents); Mr Frank Muchiri (Senior Occupational Health and Safety Specialist from the ILO-DWT for Eastern and Southern Africa)

The Congress was well attended by occupational health and medicine practitioners, from South Africa and beyond

The SASOM ExCo meeting, held during the Congress, was chaired by Prof. Daniel Kocks

of SASOM), spoke on stakeholders' perceptions on the delivery of occupational health services in South Africa. The last talk of the day was by Prof. Mary Ross, an independent consultant and specialist in occupational and public health, and travel medicine, as well as Chair of the ICOH Working Group on Occupational Infectious Agents, who drew on her vast experience and expertise to present on occupational travel in Africa, where the role of occupational health practitioners overlaps with that of travel medicine practitioners in preparing employees and employers for travel in Africa.

The meeting of the SASOM Executive Committee (ExCo) was held on the evening of the first day. At the meeting, two ExCo members were bestowed with SASOM Honorary Life Membership in recognition of their valuable contributions to the occupational health disciplines: Prof. Mary Ross, for distinguished long-term service rendered as an ExCo Member; and Dr Frank Fox, for distinguished long-term service as Secretary.

The second day of the Congress started with a lively entertainment session performed by professional artists from the Occupational Health and Wellness Theatre in Johannesburg, on safety and injuries at work. This unusual introduction set the stage perfectly for the presentation that followed, which was on the management of common fractures, sprains and strains, delivered by orthopaedic surgeon, Dr Phillip de Lange. Dr Phia Kotze, a clinical psychologist, spoke on the human psyche: genes, character and personality; Dr Pierre Joubert, a neuropsychiatry specialist, spoke on medical conditions presenting with psychiatric signs and symptoms. The last two talks of the morning were by dermatology specialists: Dr Jeannette Joynt spoke on the skin and exposure to the sun – effect, treatment, prevention; and Dr Hilary Carman presented on contact dermatitis in occupational settings.

The last session of the Congress kept participants engaged on laboratory and clinical topics. Dr Barbara Sedumedi, a senior pathologist from the South African National Health Laboratory Service, presented interactively on factors that influence the quality of laboratory results; and Prof. Marthie van der Walt, a director at the Medical Research Council, presented on new insights into the interaction between tuberculosis and diabetes.

Professor Daniel Kocks declared the Congress closed on the afternoon of the second day, and thanked all who contributed to making the Congress possible. Delegates earned 17 Continuing Professional Development points for full congress attendance, from the South African Medical Association (clinical – 7 points; ethics – 10 points).

The next SASOM Conference/Academic Day will take place on 26 November, to coincide with the Annual General Meeting, at a venue to be confirmed.

Report by Claudina Nogueira
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The Congress presented participants with an ideal opportunity for networking and reconnecting

SASOHN Academic Day: Primary Health Care – from evidence to action

SASOHN held its 11th annual academic day in Johannesburg and Pietermartizburg, hosted by the Gauteng Central and KZN Inland regions, respectively. The theme of primary healthcare informed the selection of topics and speakers. These are decided upon, following members feedback on the academic day of the previous year.

Every year, an effort is made to streamline the topics in each centre. However, this is not always possible, and this year saw slight variations between Johannesburg and Pietermaritzburg, although both kept to the primary healthcare theme. The topics included lifestyle and nutrition, including management of the obese employee; eye diseases and their management; oral health; human papilloma virus (HPV) and cancer of the cervix (Ca Cx); the 90-90-90 HIV and TB project; and family planning.

Two SASOHN members presented their masters degree research – Lizette Botha presented her work on Hepatitis B and Welna Mans presented her dissertation results on the perceptions of industrial managers on the role of occupational health nurses in East Rand industries. Ms Mans reported that the majority of industrial managers perceived the role of the OHN in all the areas of practice to be important. A pleasing finding was that a minority of industrial managers did not fully understand the role of the OHN. This, however, presents an opportunity for OHNPs to participate in occupational health nursing role clarification with industrial managers.

The other SASOHN member who is at the start of her masters research and presented her literature review was Ms Lizette Botha, who spoke about Hepatitis B in Occupational Health – the inconvenient truth. Ms Botha's recommendations were that OHNPs must document the Hepatitis B procedures, test for Hepatitis B surface antibodies (HbsAb) before commencing vaccines, monitor employees' compliance with the vaccine programme, and vaccinate at 0, 1 and 6 months. It is important to do post-vaccine Hepatitis B surface antigen (HbsAg) testing and, if the HbsAg test is positive, refer for further investigation. If an employee does not develop HbsAb after two vaccine programmes, the OHNP needs to consider post-exposure prophylaxis (PEP) management following any incident of potential exposure. The OHNP can think about booster vaccines and Hepatitis B immunoglobulin post exposure.

Dr Chris Maske and Dr Vaubell from Lancet Laboratories gave inspiring presentations on HPV and Ca Cx with a take home message that Ca Cx from HPV is preventable and, in fact, can be eradicated. Occupational health nurse practitioners (OHNPs) have an important role to play here through HPV immunisation, PAP screening and education of employees. There are new guidelines coming out for HPV screening, and all OHNPs are urged to keep a look out for these and implement the guidelines into their own

Ampath Johannesburg

IEFA in Johannesburg

Dr Ricky Montalbano Johannesburg

OH practices. OHNPs are urged to ensure that liquid-based cytology is done on all PAP smears.

Dr Ricky Montalbano and Dr Enslin Uys spoke on eye injuries, diseases and their management. Both made the point that eye injuries are preventable by wearing the correct glasses – it is not a one size fits all scenario. It is important that OHNPs understand that eye injuries need to be designated into emergency treatment, urgent treatment and semi-urgent treatment, and have the competence to prioritise these injuries.

Ms Zama Mashile and Ms Elria Van der Westhuizen are both dieticians and presented sobering evidence of the obesity problem in the South African population, particularly women. The 2012 South African National Health and Nutrition Examination Survey (SANHANES) reported that women have an average body mass index (BMI) of 28.96% and 50.5% of women have a waist circumference equal to or greater than 88 cm – the upper limit for women. It has been found that 65% of South African women and 31% of men are overweight or obese. These measurements put the population at increased risk of metabolic disorders. Ms Mashile reported that 10% of all deaths can be linked to obesity. Ms Van der Westhuizen urged OHNPs to look at the National Guide for Healthy Meals in Workplaces.

Ms Laetitia Aves from the South African Military Health Service (SAMHS) presented oral health to the Johannesburg audience – more than just a nice smile. Ms Aves discussed the correlation between oral health and general health and left delegates with the following tips for good oral health: electric toothbrush, good quality floss and sugar free gum after eating and drinking.

Dr Madonsela from the Johannesburg City Health and SASOHN member, Ms Robyn de Wet, presented on the UNAIDS 90-90-90 initiative. Dr Madonsela extended a hand to OHNPs in the Johannesburg health district to partner with them on HIV testing, initiating treatment and follow up of HIV positive employees. Ms de Wet's presentation was summarised in the SASOHN page of the previous edition of the Journal. It is important for the OHNPs to implement national initiatives in order to assist the National Department of Health in meeting its goals for the country.

Ms Valerie Makhatini from the KwaZulu-Natal Department of Health gave a very informative presentation on sexual and reproductive health and current practices to the Pietermaritzburg delegates. Ms Makhatini shared a number of very useful resources with delegates and gave out some books as prizes to those who could answer her questions.

Delegates had opportunities to interact with the exhibitors and sample many products, and went away with a number of suggested interventions that they can implement in their own occupational health practices to improve the health of workers in South Africa.

Report by Penny Orton
SASOHN Education Representative
e-mail: pennyo@dut.ac.za

Thobe Dlamuka SASA Pietermaritzburg

Lindsay Zurba OCSA

Dietician, Zama Mashile, talking in Pietermaritzburg

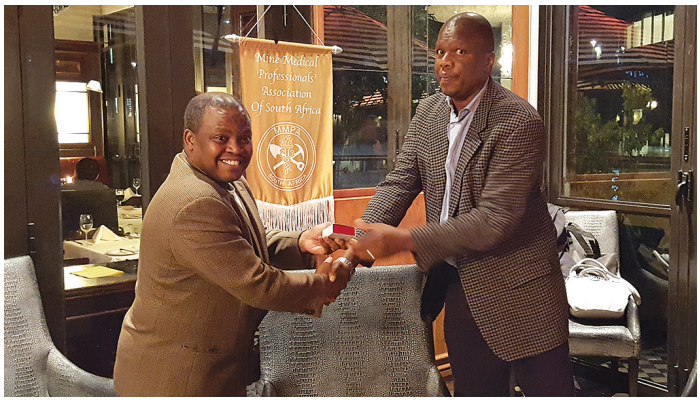
MMPA news

The MMPA has held a number of events in the last three months. In an effort to actively engage MMPA members outside the Gauteng province, the Standard Threshold Shift Workshop was held in Kimberley, Northern Cape province, and the Academic Symposium was held in Rustenburg, North West province. The Annual General Meeting was held in Sandton, Gauteng, in June.

NOISE-INDUCED HEARING LOSS WORKSHOP

In 2015, the OMPs in the Northern Cape province raised several concerns around the implementation of the Guidance Note for the implementation of standard threshold shift in the medical surveillance of noise-induced hearing loss (NIHL) (see https://www.greengazette.co.za/notices/mine-health-and-safety-inspectorate-guidance-note-for-the-implementation-of-standard-threshold-shift-in-the-medical-surveillance-of-noise-induced-hearing-loss_20160715-GGR-40142-00839 for more Government Notice No. 839 of 2016). The Guidance Note in question was developed by the Mining Occupational Health Advisory Committee (MOHAC) of the Mine Health and Safety Council (MHSC) with the primary intention of guiding the mining industry on the implementation of the STS methodology for monitoring NIHL. The occupational medical practitioners (OMPs) in the province initiated the plans to host a workshop and requested the MMPA to assist with facilitating the event. The MMPA acknowledged that the planned workshop could be best hosted through the MHSC since MOHAC had planned to host similar workshops in all provinces.

The workshop was successfully hosted on 25 April 2016 in Kimberly. It was a one-day event and the programme was designed to address the concerns raised by OMPs in the region and to allow the participants to engage on issues pertaining to NIHL. The following colleagues assisted with the facilitation of the sessions: Mr Harry Sease (Acting Principal Inspector), Dr Khanyile Baloyi (MOHAC Alternate Member), and Dr E Bohnen (OMP). To get the proceedings underway, Dr Lindiwe Ndelu (MOHAC Chairperson) outlined the purpose and the objectives of the workshop, followed by a presentation by Dr Dipalesa Mokoboto (MOHAC Convenor) on the understanding of the STS principles and implementation requirements. Dr Ike Lekota (Rand Mutual Association) gave a brief synopsis of the compensation process for NIHL, while Mr Jan Mepha (occupational hygienist) gave an insightful presentation on linking hygiene measurements to medical surveillance, with a particular focus on NIHL. The workshop was a great success even though there were some concerns that could not be resolved immediately; these were referred to MOHAC. STS workshops are planned for other regions.



Dr Vusumuzi Nhlapho (MMPA past-President) (left) and Dr Khanyile Baloyi (incoming President)

ACADEMIC SYMPOSIUM

The second event was an Academic Symposium that was held on 21 May 2016 at Impala Platinum Mines, Rustenburg. The Symposium covered a wide range of interesting topics, including TB initiatives in the mining industry (Dr Clement Ngcuka, Hain Lifescience), principles of compensation for NIHL (Dr Ike Lekota, RMA), and the management of drugs and drug policies in the workplace (Dr Tim Laurens, University of Pretoria). The event was warmly welcomed by the OMPs in the area. We look forward to hosting future events in the near future.

ANNUAL GENERAL MEETING

The Annual General Meeting was held on 9 June 2016 at the Da Vinci Hotel, Sandton. The event was well-attended and the proceedings continued well into the night. Dr Vusumuzi Nhlapho presented detailed executive and financial reports for the previous year. Some of the financial highlights are that the Association is solvent, and that significant profits were realised from the 2015 Congress. The Association is fully solvent and able to pay for its operational cost to the Mines Professional Associations Secretariat (MPAS). The Executive Council was particularly gratified that a number of activities outside Gauteng province were becoming an entrenched feature in the MMPA calendar. Of significance is that these were in addition to the flagship Congress. Dr Nhlapho emphasised the need for the MMPA to remain relevant and provide value for its members in light of the challenges that are taking place in the mining industry.

Dr Nhlapho thanked the Executive Committee members, the Secretariat at MPAS, and the entire membership of MMPA for their unwavering and steadfast support throughout his tenure as President. He outlined a number of highlights of his presidency, including an improved financial position of the MMPA, an increase in the number of academic activities, increased visibility of the MMPA, sustained and increasing support of attendance at the Congress, and a number of key strategic partnerships such as Mylan pharmaceutical company and the National Institute for Occupational Health. Dr Nhlapho has the honour of being the longest serving President of the MMPA; he indicated that the Association will always have a special place in his heart, and his willingness to actively support all its future activities as needed. On behalf of Exco, Dr Phillip du Preez, thanked Dr Nhlapho for all the hard work and dedication in leading the MMPA over the last four years.

Dr Khanyile Baloyi was elected the new President and Dr Mandla Mphuthi the new Deputy President. Dr Baloyi has been actively involved in the MMPA and has most recently served as the Deputy President. He is currently the Deputy Head of the Department of Health in the Chamber of Mines of South Africa. Dr Nhlapho wished Dr Khanyile and the ExCo well in their future endeavours.

Report by Dr Vusi Nhlapho
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SAIOH news

GET WELL WISHES FOR SAIOH PRESIDENT

SAIOH Council and members wish SAIOH's President, Mr Jaco Pieterse, a speedy recovery to full health. Jaco underwent triple bypass heart surgery a few weeks ago, and is now back home, convalescing, for approximately six weeks. Cas Badenhorst, Immediate Past President, is standing in as SAIOH President in Jaco's absence. We look forward to welcoming Jaco back to his SAIOH portfolio and responsibilities once he is fully recovered from his medical intervention.

SAIOH ANNUAL CONFERENCE 2016

Blyde Canyon Forever Resort, Mpumalanga, 26 – 28 October 2016

Get ready to clear your diaries because this year's SAIOH Annual Conference will be the best one yet. SAIOH will host its Annual Conference in the very beautiful region of Mpumalanga, "the place where the sun rises" – a province with spectacular beauty and an abundance of wildlife.

EARLY BIRD REGISTRATION IS NOW OPEN

Visit the SAIOH website www.saioh.co.za to secure your place, and for further information and instructions on abstract submission, for which the deadline is 29 July 2016. A draft conference programme will be available in due course.

SAIOH SUPPORTED AND EXHIBITED AT A-OSH EXPO 2016

SAIOH participated in exhibiting at A-OSH Expo 2016, Africa's leading occupational health and safety expo, which took place from 24 to 26 May at Gallagher Convention Centre, Johannesburg. The A-OSH Expo plays a pivotal role in assisting to identify and address workplace occupational health and safety issues, through an informed exhibition base, a collaborative educational portfolio, and the offering of many networking opportunities.

The SAIOH exhibition stand with SAIOH Council members (L to R): Oscar Rikhotso, Deon Jansen van Vuuren and Norman Khoza

WHOLE-BODY AND HAND-ARM VIBRATION EXPOSURE COURSE

Koeberg Library, Duynefontein, Melkbosstrand, 18 – 19 August 2016

All SAIOH-registered Occupational Hygiene Practitioners at Assistant, Technologist and Hygienist levels are invited to attend a two-day course presented by Mr Duane Bester who holds a BSc degree in Human Physiology and an MSc degree focusing on linear and non-linear integration methodologies and data filtering techniques for human vibration exposure.

Only 15 places are available. For more information, please visit the SAIOH website www.saioh.co.za

Reports by Claudina Nogueira
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SAIOH signs Memoranda of Understanding with AIHA and BOHS

In line with the Southern African Institute for Occupational Hygiene's (SAIOH) broad aims and objectives of nurturing the interests of its members; promoting education and training in the occupational hygiene discipline; and creating and sustainably maintaining opportunities for professional development and mentorship support, SAIOH signed a five-year Memorandum of Understanding (MoU) with both the American Industrial Hygiene Association (AIHA) and the British Occupational Hygiene Society (BOHS), in September 2015 and February 2016, respectively.

These successfully formalised agreements were the culmination of proactive interaction and liaison between representatives of SAIOH and AIHA, and between SAIOH and BOHS, during 2014 and 2015, to develop cooperation contracts that would be beneficial to all concerned.

Founded in 1939, the AIHA is one of the largest international non-profit organisations serving occupational and environmental health and safety (OEHS) professionals practicing occupational hygiene, and is a resource for those in large corporations, small businesses, and those working independently as consultants. AIHA administers comprehensive education programmes that keep OEHS professionals current in the field of occupational hygiene, and has more than 40 scientific and technical committees, task forces and working groups that deal with the OEHS challenges faced daily by occupational hygiene experts and workforces worldwide. The Association, comprising in excess of 10 000 members, is well known for its publications, *The Synergist* and the *Journal of Occupational and Environmental Hygiene.*

The BOHS is a science-based, charitable body that provides information, expertise and guidance in the recognition, control and management of workplace health risks. Founded in 1953, BOHS is the only professional society representing qualified occupational hygienists in the UK, and has over 1 800 members in 57 countries. Additionally, it is the only occupational hygiene organisation to be awarded a Royal Charter, which was granted in April 2013 in recognition of BOHS' unique and pre-eminent role as the leading authority in occupational disease prevention. The Society aims to protect the health of workers by preventing ill health in the workplace, by promoting the science and practice of occupational hygiene via membership growth, qualifications, conferences, events and campaigns. The Society's key publications include the *Annals of Occupational Hygiene* and the *Exposure Magazine.*

Dr Adrian Hirst, President of BOHS, at the SAIOH-BOHS MoU signing ceremony in Derby, UK, accompanied by Mrs Tracey Boyle, BOHS President Elect, February 2016

Dr Daniel Anna, President of AIHA, at the SAIOH-AIHA MoU signing ceremony in Falls Church, USA, September 2015. SAIOH takes this opportunity to congratulate Prof. Steven Lacey, the newly inducted President of AIHA, as of 26 May 2016

Mr Peter-John (Jakes) Jacobs, SAIOH Past President 2014 and IOHA Representative, signing both MoUs on behalf of SAIOH

SAIOH, AIHA and BOHS appreciate the importance of research and new knowledge in developing and applying preventive measures in occupational safety and health, and share a common mission to contribute to the prevention of occupational accidents and diseases. Hence, SAIOH and AIHA, and SAIOH and BOHS, plan to cooperate to use their collaborative efforts and expertise to advance the protection of workers and to promote best practices to improve worker safety and health.

It is envisaged that these cooperations will consist of the following, among other activities, which will be subject to the availability of funds and other resources:

- Exchange of scientific information and publications, i.e. potentially making the *Occupational Health Southern Africa* journal available to both AIHA and BOHS members electronically, and welcoming AIHA and BOHS submissions. In addition, SAIOH members can subscribe to the AIHA newsletter and official journal; BOHS offers reduced price access to its research journal to SAIOH members via the International Partners agreement;
- Mutual sharing of, and occasional inclusion in, the respective institutional / association newsletters;
- Identification of occupational hygiene initiatives which may lend themselves to joint collaborations between SAIOH and AIHA, and between SAIOH and BOHS, such as training courses, seminars and conferences where workplace safety and health are proactively addressed;
- Identification of opportunities for transferring and promoting knowledge and findings in the field of occupational safety and health, and exchange of information as related to technical programmes in fields of mutual interest; and
- Potential for the development of exchange programmes for visits by scientific personnel to the sites of respective entities, with the ultimate aim of building capacity and expertise in occupational hygiene.

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Classifieds

Occupational Health and Hygiene Practitioners

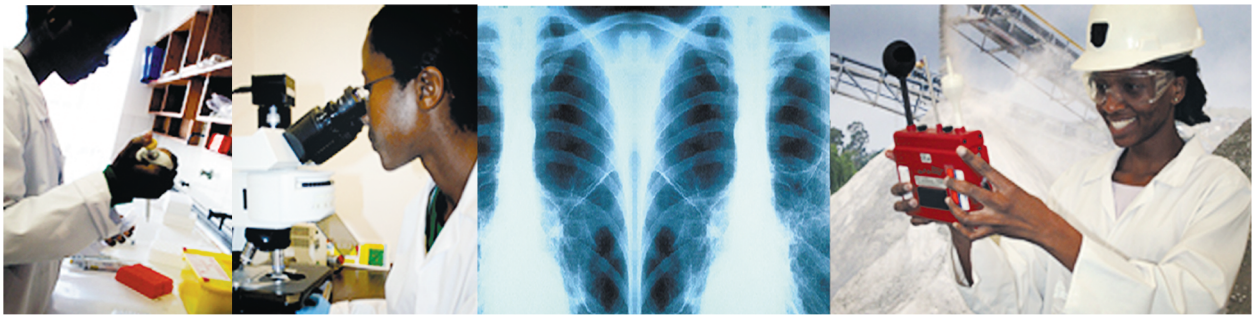
NATIONAL INSTITUTE FOR OCCUPATIONAL HEALTH

Division of the National Health Laboratory Service

60th NIOH Anniversary 1956-2016

Healthy, Safe and Sustainable Workplaces

PROMOTING DECENT WORK THROUGH CUTTING-EDGE RESEARCH, SERVICE DELIVERY AND TRAINING



Established in 1956 as a specific pneumoconiosis research unit (PRU), within the Chamber of Mines, the then PRU attained international attention in the 1960s when Dr Wagner's work led to the identification of mesothelioma as an occupational disease linked to asbestos exposure.

The functions of the institute then broadened during the 1970s to include physiology, biochemistry and occupational hygiene research - investigating occupational diseases in all industries as well as the later provision of occupational health services such as risk assessments and advice, which became increasingly sought by industry, labour and the State.

NIOH has become an internationally recognised national resource for developing and supporting effective occupational health services in South Africa and is a World Health Organization Collaborating Centre.

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