

National Institute for Occupational Health Research Day 2018



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

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

PRESENTATION ABSTRACTS

Testing for allergy to chemical preservatives in occupational settings

A Fourie (presenter), T Singh

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

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

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

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



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

Photograph: Guy Hall



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

Photograph: Guy Hall.

Methanol exposure – should we worry?

B Southon (presenter), P Matatiele, B Kgarebe

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

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

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

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

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

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

F Made (presenter), D Brouwer

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

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

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

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

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

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

G Mizan (presenter)

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

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

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

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

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

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

N Ndaba (presenter), S Kgalamono, D Rees

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

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

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

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

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

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

Biobanking: a game changer for scientific research

M Maseme (presenter), B Duma

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

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

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

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

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

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

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

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

G Riley (presenter), P Matatiele, B Kgarebe

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

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

coupled with a diode-array detector.

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

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

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

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

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

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

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

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

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

Dissolution of functionalised nanoparticles in simulated biological and environmental fluids

O Mbanga (presenter), E Cukrowska, M Gulumian

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

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

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

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

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

Mercury – a potential South African problem?

L Mochaki (presenter), B Kgarebe, P Poongavanum

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

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

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

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

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

The performance of particle-size selective samplers in wet conditions

K Renton (presenter)

Introduction: The primary health concern of respirable crystalline silica (RCS) particles is the fibrogenic capacity that can lead to the development of silicosis through the accumulation of dust in the lungs and the tissue reactions to its presence. A study of South African miners estimated that there was a 77% risk of developing silicosis after working for 37 years in gold mines, at an average exposure concentration of 0.4 mg/m³ respirable crystalline silica. Assuming a linear dose response, the risk of contracting silicosis would still be about 20% for a working lifetime exposure at the Department of Minerals and Energy (DME) occupational exposure limit of 0.1 mg/m³. In order to control RCS, accurate measurements need to be made to ensure that when

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

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

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

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

POSTER PRESENTATION ABSTRACTS

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

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

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

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

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

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

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

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

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

B Dabula (presenter), P Matatiele, B Kgarebe

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

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

chromatography-mass spectrometry (GC-MS).

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

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

Women in South African mines

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

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

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

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

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

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

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

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

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

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

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

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

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

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

T Maeteletja (presenter), J Manganyi, J Wichmann

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

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

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

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

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

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

M Magogoty (presenter), M Gulumian

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

B Nkosi (presenter), B Nyantumbu-Mkhize

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

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

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

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

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

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

Occupational exposure assessment of engineered gold nanoparticles – a pilot study

L Ntlailane (presenter), X Masoka, M Gulumian

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

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

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

which was not used on the day of the assessment. Particle-number concentration measured during synthesis and harvesting of the nanoparticles did not show a significant increase compared to background, at a p-value of 0.324 and 0.795, respectively. The 2 714 particles/cm³, eight-hour time-weighted average at an exposure duration of 142 minutes and 1 413 particles/cm³ for 50 minutes of both tasks was below the recommended nano reference value of 20 000 particles/cm³ by Van Broekhuizen et al. Size distribution of the peak concentration as measured by a size-selective monitor consisted of nanoparticles in the size range 7.5-35 nm. The elemental mass concentration ranged from 0.01-0.16 µg/m³ of Au, with a task of adding citrate having the highest personal exposure at 0.14 µg/m³, exposed for 44 minutes. The smallest particle size observed by electron microscopy (EM) was approximately 20 nm. Elemental composition analysis identified Au, confirming the presence of the aerosols in the air.

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

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

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

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

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

using Epi-info software.

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

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

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

D Rangongo (presenter), N Claassen

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

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

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

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

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

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

N Sanabria (presenter), M Gulumian

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

Methods: Investigations were conducted to assess the interference

of gold nanoparticles (AuNPs) in various assay systems.

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

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

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

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

Asbestos exposure in patients with malignant mesothelioma: a case series

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

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

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

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

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

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

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

M Vetten (presenter), M Gulumian

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

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

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

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

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

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