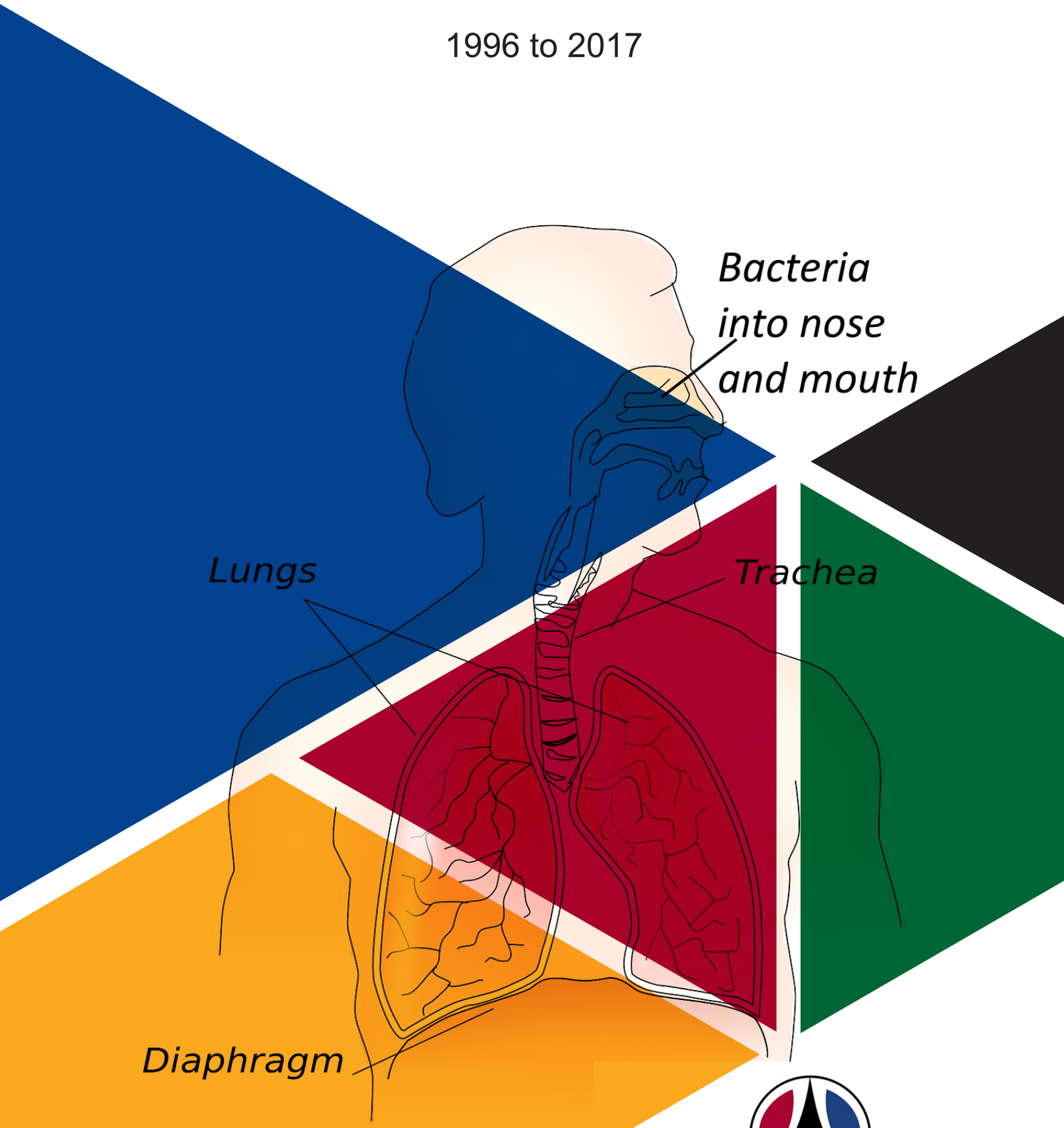
Compendium of Research Project Summaries on Occupational Diseases

1996 to 2017



MHSC

Mine Health and Safety Council

FOREWORD

The Mine Health and Safety Council (MHSC) is a public entity that is mandated, in terms of the Mine Health and Safety Act (MHSA), to advise the Minister of Mineral Resources on research programmes, regulations, standards, policies and procedures focused on minimising the occupational health and safety (OHS) risk at mines. The Council is also tasked with promoting a culture of health and safety in the mining industry.

The MHSC office executes the operational deliverables of the Council, including the provision of secretarial support to the Council and all its committees, managing occupational health and safety research programmes, finances, communications and promotions, and liaising with other statutory bodies on matters relating to occupational health and safety at mines.

MHSC provides a platform for stakeholder engagements on OHS matters.

In the South African Mining Industry (SAMI) it has been found that more deaths are still reported as a result of occupational diseases. Hence the mining sector has increasingly been giving more attention to health matters which was also as a result of the promulgation and implementation of the Mine Health and Safety Act as amended.

Considering that one of the MHSC's role in the SAMI is that of overseeing research, therefore one such research area that is overseen by MHSC the is termed as the Research Thrust area 8: Occupational Diseases.

Research Thrust area 8 focusses on identifying research that will have outcomes that are aimed at improving the health of mine workers in all commodities through the identification of implementable controls for the prevention of health problems caused by exposure to a workplace health hazards such as:

1. Chemical hazards (e.g. asbestos dust; welding fumes; smoke; mists (e.g. spray painting); gases etc); or
2. Physical hazards (e.g. illumination such as poor/ excessive lighting; noise; vibration; temperature; radiation etc); or
3. Biological hazards (e.g. viruses, bacteria, fungi etc); or
4. Ergonomics related hazards (e.g. heavy lifting; un-natural posture and repetitive motion etc).

This research thrust area also takes into account research that is aimed at identifying the effect of HIV/AIDS and TB on occupational diseases such as Silicosis. It is worth noting that through research it has been found that the risk of developing TB is as high as three (3) times for individuals with silicosis and with the combined effect potentially being eighteen (18) times. The industry has since instituted rigorous HIV and TB programmes over the past 10 years.

Furthermore, to assist the SAMI to develop comprehensive programmes in dealing with HIVAIDS, TB and Occupational lung diseases (HATOLD), it is important to mention that the Tripartite Stakeholders under the auspices of the MHSC, have played an important role in conducting research that led to the development of a policy on the integrated management and reporting for HATOLD in the SAMI. The policy will go a long way in providing guidance on the management and reporting of HATOLDS programmes in an integrated manner.

As the MHSC, we are committed to promote OHS in the Mining Industry, including issues relating HIV, AIDS, TB and Silicosis. Issues of HIV and TB has always been at the forefront of our initiatives and we will continue to ensure that research on occupational diseases is enhanced. This publication highlights the research work done in this area in the last 20 years.

Thabo Dube

Chief Executive Officer
Mine Health and Safety Council

December 2017

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1. GUIDELINES FOR THE PERFORMANCE OF EMERGENCY WORK IN HOT ENVIRONMENTS

By Kielblock A.J. and Schutte P.C., CSIR: Mining Technology, Ref:GAP 045, 1996

SUMMARY:

Certain mining activities, such as emergency work and rescue operations, have to be undertaken in environments where the heat loads often exceed limits prescribed for routine work. Project SIMGAP 045 deals with the formulation of guidelines to work under such conditions. The evaluation of commercially available cooling garments also formed part of the project.

The formulation of heat stress limits was based on the criterion that a heat exposed individual should experience a negligible risk of developing dangerously elevated body temperatures. The risk criterion was set at a probability of less than one-in-a-thousand to exceed a rectal temperature of 39,5 C.I.

In order to provide a database for risk assessment, certain physiological responses of heat tolerant men were determined at various combinations of thermal conditions and work rate in a climatic chamber. These physiological responses were analysed statistically to predict survival rates and tolerance times as a function of thermal conditions and work rate.

Environmental data recorded in this study were translated into the Wet Bulb Globe Temperature (WBGT) index terms and compared with the Israeli Discomfort Index (DI). (DI is the arithmetic mean of wet-bulb temperature and dry-bulb temperature and could for all practical purposes be regarded as another version of the WBGT.) The relationship between DI and tolerance time at various probabilities was modelled by using a second degree polynomial regression.

From a practical viewpoint it was decided to use the DI index, especially in view of the relative ease of mental calculation, but also in that it makes more allowance for high dry-bulb temperatures which, of course, become a reality of many emergencies. Instead of DI, the term AEmergency Heat Stress Index≅ or AESHI≅ has been decided upon.

The EHSI has been adopted as a guideline for emergency work in abnormally hot conditions and recommended limits, based on experimentally determined limits but rounded up in the interest of convenience, are given in Figure 1. (A similar graph for use with body cooling garments has also been prepared).

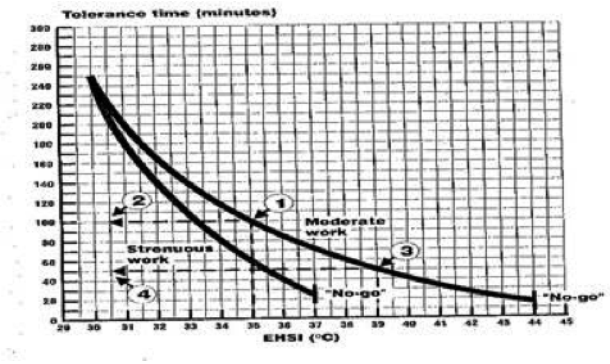


Figure 1: Graph to determine tolerance times

CONCLUSION:

Of the various approaches investigated to determine safe exposure times, a modification of the Israeli Discomfort Index, termed the Emergency Heat Stress Index (EHSI), would be the most suitable for local application.

Presently available cooling jackets, although offering much in terms of ergonomics and infrastructural acceptability, do not make a significant impact in terms of the primary criterion, namely to reduce the heat strain experienced by the wearer.



2. RADIATION PROTECTION

By van der Linde A. and Roberts D.A., CSIR: Mining Technology, Ref: GEN 004, 1996

SUMMARY:

The objective of this project was to develop a system of assessing the radiation dose received by individual occupationally exposed workers in the mining industry and further to examine the options and ramifications of limiting that radiation dose. Work in this project focussed on the development of measuring capabilities and measuring techniques, data handling, predictive analysis and system development. These categories were further sub-divided into seven logically independent areas, namely, radiation spectrometer, personal dosimetry, environmental parameters of radon, a data base, radon modelling, water reticulation system modelling and the removal of radionuclides from water.

The portable radiation spectrometer (RSR) is an instrument for measuring individual short lived radon daughters, long lived % emitters and external Y radiation. It has Council for Nuclear Safety (CNS) approval for use in South African mines for some of the incorporated methods employed by the instrument with application being made for other techniques as they become available. The instrument has been designed for use in the harsh environment of South African mines and has SABS certification as intrinsically safe.

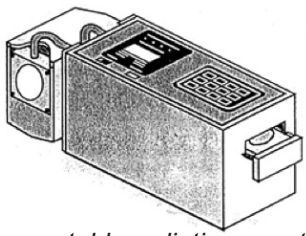


Figure1: The portable radiation spectrometer

The instrument consists of a box of dimensions 250 mm x 100 mm x 125 mm and weight 1,5 kg with an LCD display and keypad on the front panel for operator interaction. The measuring techniques are mostly automatic with minimum operator intervention; the operation and computation being controlled by a microprocessor. Data accumulated by the instrument are stored in the instrument=s memory for later retrieval by PC with an immediate display on the instrument=s LCD screen of the current value of WL. The instrument is supplied with a user-friendly PC program which enables data retrieval with a minimum of simple steps.

Various techniques of personal dose monitoring such as Gravimetric Track Etch (GTE) (Figure 2), the ALGADE (French) system and the SABS thermoluminescent detectors have been evaluated.

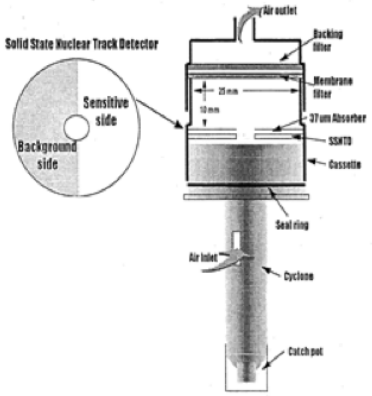


Figure 2: Schematic presentation of the GTE filter, cassette

It is desirable to optimize the removal of Uranium and Radium from mine service water. Uranium is a problem due to toxicity and radiation hazard, whereas Radium is a problem due to radiation hazard. Simulations of dosing of mine service waters was effected using JESS, a sophisticated suite of programs for speciation modelling, developed as a collaborative venture between the CSIR in South Africa, and Murdoch University in Western Australia.

In simulating the addition of Na2CO3 (soda-ash) and Ca(OH2) (lime) to the Carletonville, West Rand, Klerksdorp and Welkom mine service water, it was

found that the addition of soda-ash did not generally reduce the uranium concentration in solution. The addition of lime was predicted to greatly diminish the uranium concentration in solution. If the Carletonville solution is dosed with lime, and the solids removed, a reduction in temperature from 25 EC to 6 EC reduces the solubility of the major minerals (calcite and dolomite), whereas the solubility of Radium Sulphate is increased.

CONCLUSION:

The potential health hazards associated with radiation exposure in mines could be controlled by implementation of the newly developed radiation dose limitation system. The portable radiation spectrometer is suitable to use in mines with its capability of rapidly measuring radon from all exposure pathways.

The Gravimetric Track Etch (GTE) System could be used to assess both radiation and dust levels from a single measurement. The data base >RADBASE= can be used by individual mines as a radiation data management system for logging of radiation data and calculation of doses. Radionuclides can be chemically removed from mine water by use of existing mine water treatment systems. The application of modelling to predict radon levels will alleviate the practical limitations associated with environmental measurement techniques.



3. DEVELOP MEANS TO ENHANCE THE EFFECTIVENESS OF EXISTING HEARING CONSERVATION PROGRAMMES

By Franz R.M., van Rensburg A.J., Marx H.E., Murray-Smith A.L. and Hodgson T.E., CSIR: Mining Technology, Ref: GEN 011, 1996

SUMMARY:

This project was aimed at providing means to enhance the effectiveness of mines= hearing conservation programmes and thereby limit the detrimental effects of noise. The outputs documented include the determination of noise emissions and exposure levels, with and without hearing protection (this aspect is essentially a risk assessment process), characterization of frequency spectra for machinery nois and the development of educational/motivational materials for use in mines= hearing conservation programmes. (The latter includes video programmes, handouts for trainees and guidelines for trainers.) Reference materials for the safe allocation of hearing-impaired workers and recommendations for the formulation of long-term noise control policies are also provided. From the results obtained, it is evident that the majority of mine workers are exposed to noise levels capable of causing hearing impairment. Examples of emission and exposure levels for occupations in collieries and gold mines are given in Figure 1 and 2, respectively.

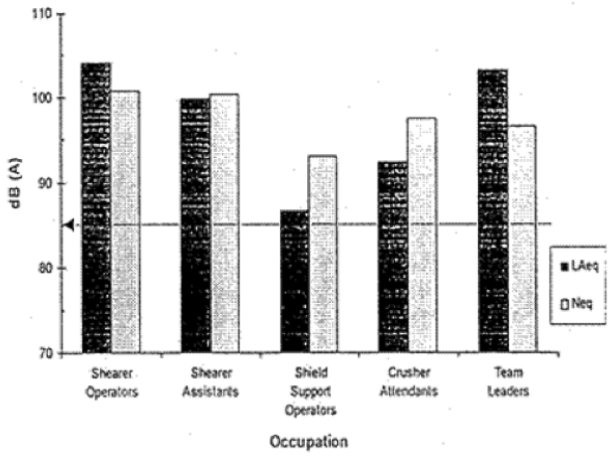


Figure 1: Emission and exposure levels for occupations in longwall coal mining

The mechanized longwall system surveyed consisted of a double-ended drum shearer to cut the coal, and 140 hydraulic roof supports installed over a distance of 200 m. Figure 1 displays values determined for LAeq/Neq in longwall mining, which ranged from 86,7 dB/93,1 dB for shield support operators to 104,1 dB/100,8 dB for shearer operators. The shield support operators= mean Neq was 6,4 dB greater than mean LAeq at the shield support with the longwall shearer running in the distance. As was the case for roofbolter operators, the apparent anomaly is attributable to emissions from noisier machinery, in this instance the shearer as it passed the shield support operator.

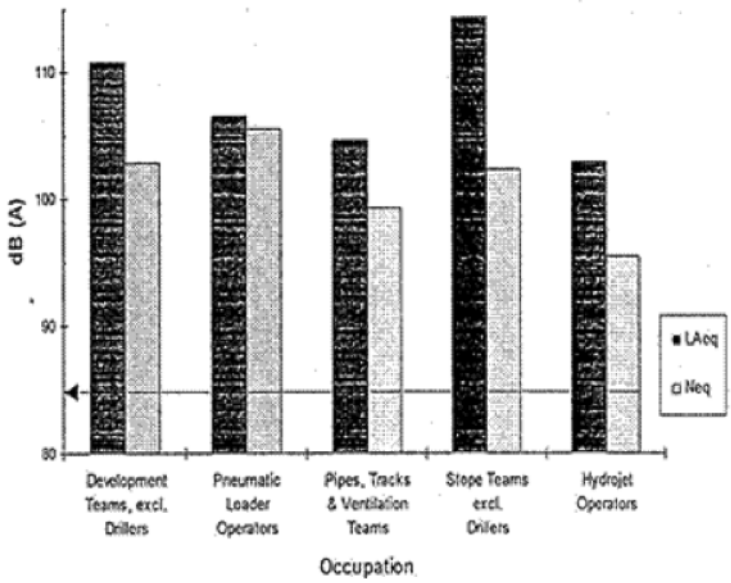


Figure 2: Mean emission and exposure levels for personnel in development ends and stopes: gold mines

Although drill crews are excluded from this section on the basis of their separate treatment, the effect of drilling operations is very much apparent in the LpA and LAeq values determined for development and stope teams. The considerable difference of 12,6 dB between mean values for LAeq (114,3 dB)

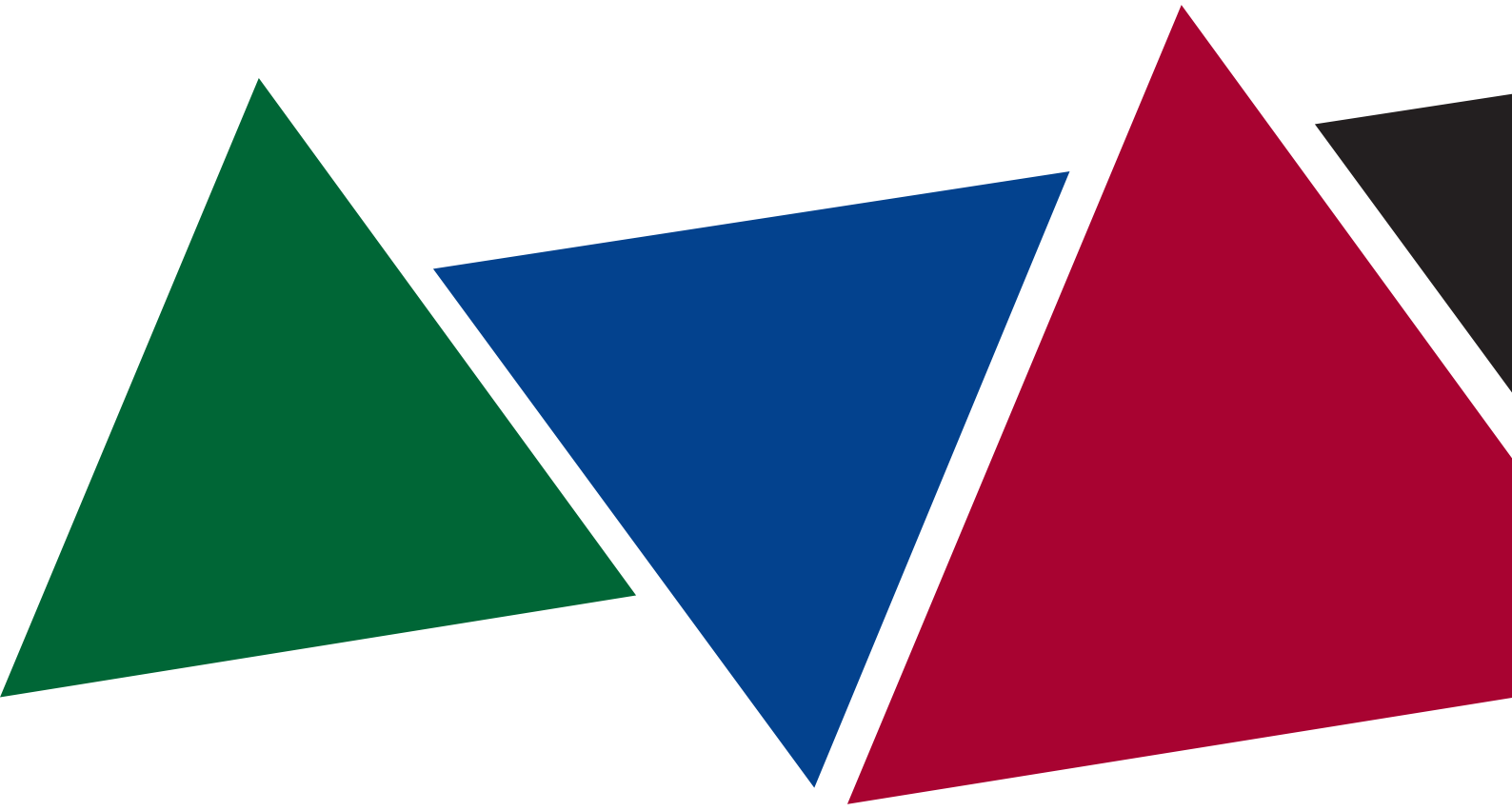
and Neq (102,3 dB) in respect of stope workers, as compared with a corresponding difference of 8,2 dB for development ends (LAeq of 110,8 dB and Neq of 102.,8 dB), would appear to indicate that stope workers are more often away from the face while drilling is in progress. It may, in some instances, also be indicative of intermittent or more dispersed drilling operations in stopes.

CONCLUSION:

Results of the risk assessment process indicated that the majority of mineworkers are exposed at levels capable of causing hearing impairment. In some instances these exceed the potential for exposure reduction by means of personal protection.

Despite their limitations personal protection strategies offer a means of controlling exposure while engineering solutions are developed and implemented. The efficacy of personal protection strategies is reliant on workers' appreciation of the noise hazard and their motivation to protect themselves.

The use of computer software for the monitoring of mines' hearing conservation programmes (as required by SABS 083) should facilitate the review process and identify areas for further enhancements to improve efficacy.



4. THE DEVELOPMENT OF AN OCCUPATIONAL DISEASES DATABASE, TO BE MANAGED BY THE DEPARTMENT OF MINERALS AND ENERGY, TO RECORD MORBIDITY AND MORTALITY OF OCCUPATIONAL DISEASES IN THE SOUTH AFRICAN MINING INDUSTRY

By Torres N.G., Boyce J.E., Dr Barnes D.F., Dr White N. and du Plessis A., GMSI, Ref:GEN 505, 1997

SUMMARY:

This research report addresses a need for a centralised database to record the occurrence of occupational diseases in the South African mining industry, together with the morbidity and mortality of such diseases. The database will be used by the Director: Occupational Medicine of the Department of Minerals and Energy, for research purposes. This research will help to identify and classify problem areas in occupational disease management, so that appropriate preventative measures can be investigated.

The occupational diseases database has been designed, together with the programs required to use it, and the layout of suitable data-entry forms for the use of the mining industry in submitting details of disease occurrences. A data format has also been documented for transferring data electronically from those mines that have data-capture software for diseases.

The design was based on discussions with representatives of Employers, Labour and Government, and was completed by November, 1998.

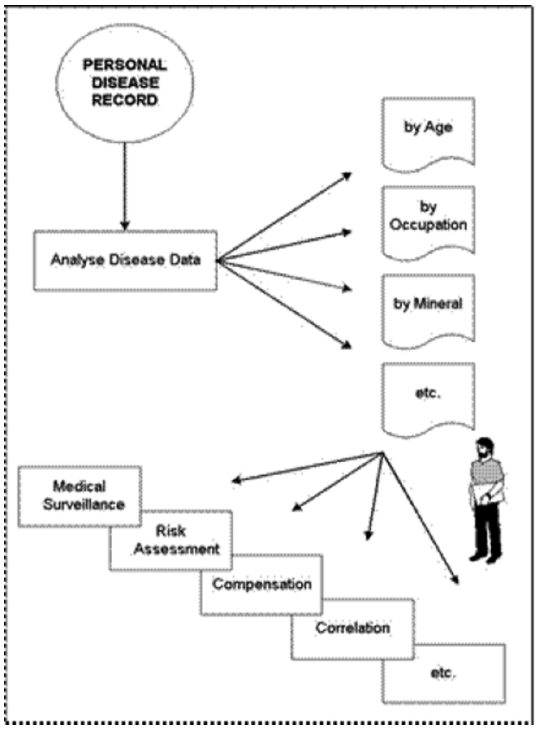


Figure 1: Analysis of Disease Data

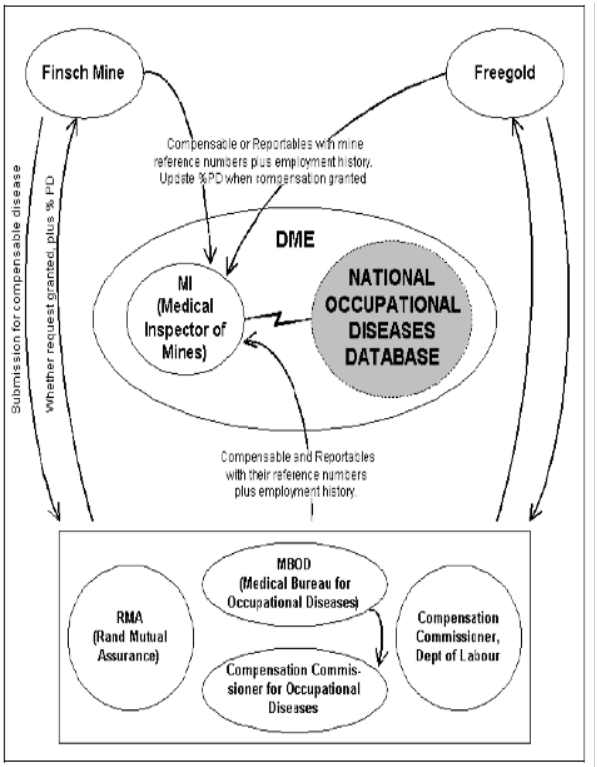


Figure 2: Data Flow

CONCLUSION:

With the occupational diseases database, it will now be pos-sible to analyse diseases in the mining industry by various parameters, including age, occupation, years employed in the industry and commodity sector. This analysis can be used to improve medical surveillance programmes, risk assessments, and compensation procedures.

At present, it is not possible to analyse any correlation between diseases and causative factors. It is therefore recom-mended that a project be initiated to design and implement an occupational hygiene database system for this purpose. This should lead to the improvement of the occupational hygienic condition of working environments found in the mining industry, thus reducing the incidence and severity of occupational illnesses.

5. HAZARDOUS METALS IN MINERAL PROCESSING PLANTS IN SOUTH AFRICA : THE RISK OF OCCUPATIONAL EXPOSURE

By SIMRAC, Ref: Health 603, 2000

SUMMARY:

The presence of heavy metals and exposure of employees thereto in mineral processing plants in South Africa have not been studied and described in a format that can be used as a general reference document. This document provides a review of different process steps in mineral processing and the associated health hazards from heavy metals. It should be particularly useful for those who are new in the field, and for the relatively uninformed who have to perform duties that require some understanding of the processes and background to health risk assessment. In providing these perspectives, the following aspects were considered to be of primary importance:

- To provide an understanding of the paradigm of human health risk assessment in the occupational environment;
- To identify heavy metals that would be of interest in mineral processing plants;
- To review the context of target-organ toxicity of heavy metals in the quantification of exposure and health risks, taking into account the concepts of speciation and bioavailability;
- To provide information on the elements of occupational health risk management, providing general principles for survey design, sampling philosophies, and interpretation methods.
- To put the principles listed above in context with selected mineral processing plants in South Africa.

The overall paradigm of health risk assessment was followed in the investigations, i.e. according to the steps of hazard assessment, dose-response assessment, exposure assessment, and risk characterisation.

The first step in the investigation was to select those metals that could be placed in the category of "heavy metals". A list was compiled on the basis of toxicological properties of the elements, and comprised of 33 elements. The elements were chosen with the objective of health risk management in mind, rather than on the basis of the classical definition of "metals".

To assess the potential for exposure to heavy metals, the various industries must be well understood.

The following types of mineral processing plants were studied:

- Carbon steel process with blast and basic oxygen furnace;
- Carbon steel process with direct reduced iron and electric arc furnace;
- Typical copper recovery circuit;
- Typical ferrochromium production process;
- Typical ferromanganese production process;
- Bacterial oxidation circuit for the pre-oxidation of refractory gold ores;
- Carbon-in-pulp circuit for gold recovery;
- Nickel, copper, and cobalt refining process;
- Typical phosphate rock production process;
- Platinum group metal refining;
- Typical stainless steel process;
- Typical titanium dioxide production process;
- Vanadium pentoxide production: the salt-roast process;
- Vanadium slag production process; and
- Typical circuit for zinc recovery from concentrate.

The dose-response assessment (toxicological assessment) was based on literature information reviewed for the various metals. The primary routes of exposure to toxicants in the occupational environment are via inhalation, ingestion, and dermal contact. Most metallic compounds occur as solids, fumes, or in mists, and are frequently associated with particulates in the occupational exposure scenario. Particle size determines where in the respiratory tract inhaled particles are deposited and hence can exert their toxic effects. Metals seldom interface with biological systems in the elemental form.

They occur as compounds that vary with the ease with which they can pass through biological membranes. An extensive literature review was conducted, covering surveys of the most prominent international publications on the subject. The large volume of data is summarised in tables. To place the information in

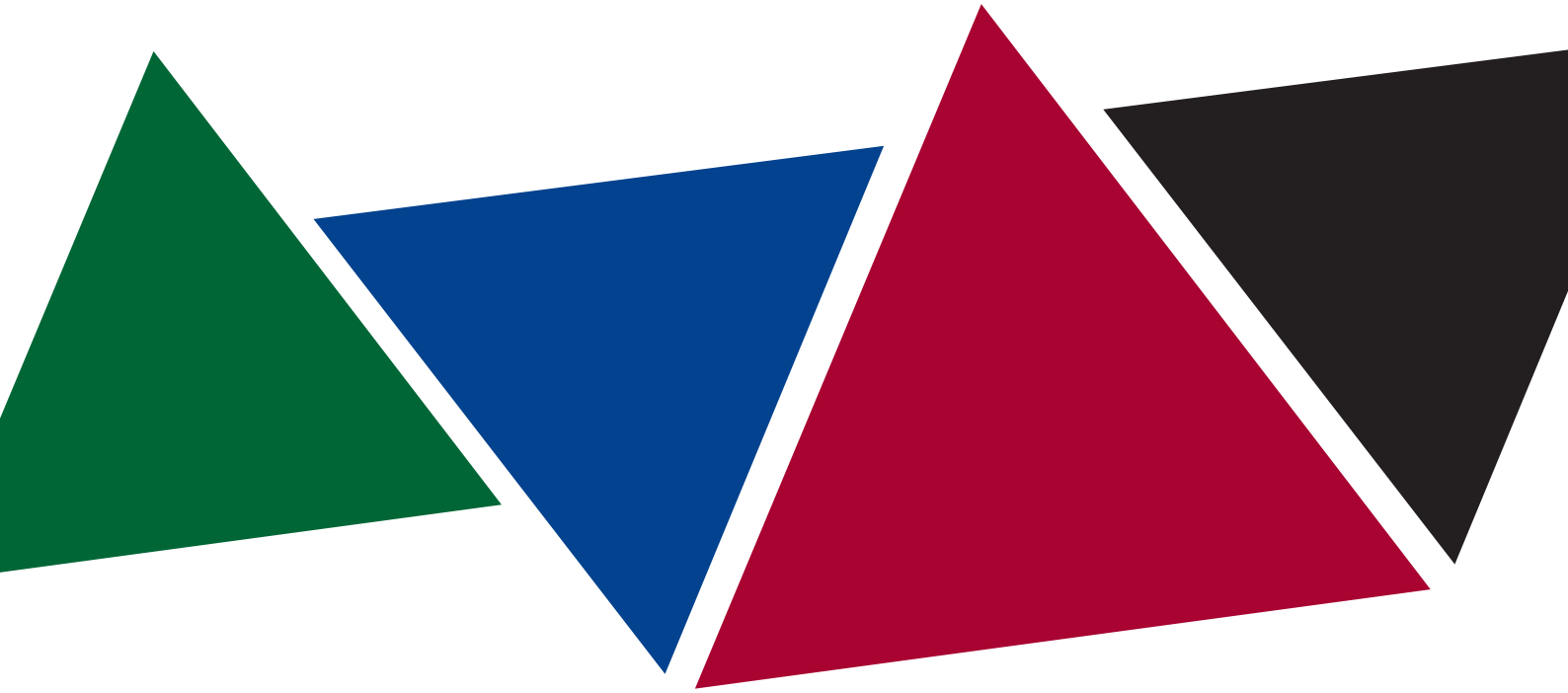
context, concise descriptions of the target organs of the body that are relevant to metal toxicity are also presented. Because several of the metals are present in more than one processing plant, toxicological information is presented together in one section of the report. The most relevant information is however highlighted in the sections that deal separately with each plant.

The exposure assessment part of the studies is also handled in the descriptions of the 15 selected mineral processing plants. The approach however does not follow the conventional occupational hygiene process of sampling and chemical analysis. It is limited to the identification of zones of exposure, and recommendations for monitoring. Because the protocols for occupational exposure monitoring are more related to the substances of interest than the particular processing plants, the methodologies for monitoring are presented together in one section in the report. Reference has however been made to appropriate monitoring in the sections that deal separately with each plant.

Risk characterisation is presented in the paradigm for quantitative human health risk assessment. Risks were not quantified for the various exposure scenarios, but the overall approach to risk assessment is presented. It indicates in which areas the highest risks might be expected, and consequently, where risk management should be applied. Human health risk characterisation is generally divided into the evaluation of carcinogenic and non-carcinogenic risks.

Carcinogenic risks are interpreted in terms of excess lifetime cancer risks. In the occupational exposure range the estimated cancer risk is assumed to be linear and proportional to dose. Risks are assumed to be additive per target organ across chemicals and pathways, unless data are available that would support synergistic or antagonistic effects. Risks are expressed as excess cancer risk, i.e. risk not taking into account any existing risk as a result of background exposure to substances that have the same carcinogenic properties.

Noncarcinogenic risks are evaluated by comparison with reference concentrations. If the ratio of the air concentration to the reference concentration (hazard quotient) exceeds one, there is a potential that adverse health effects may occur. For multiple chemical exposures, hazard quotients are summed per target organ, unless data are available to demonstrate synergistic or antagonistic effects. This is based on the assumption that the response of a target organ to multiple toxic agents is additive in a linear relationship. It is measured in terms of a hazard index, which is the sum of the hazard quotients for the individual substances.



6. CLINICO-PATHOLOGICICAL STUDY TO REDUCE THE RATE OF MISSED AND MISDIAGNOSIS OF PULMONARY TUBERCULOSIS IN THE SOUTH AFRICAN MINING INDUSTRY

By Dr Murray J., Dr Back P. , Prof. Lowe P, Coetzee L., 2000

SUMMARY:

Tuberculosis, declared a global emergency by the World Health Organisation in 1991, is a major infectious disease in the South African mining industry and deaths from tuberculosis (TB) exceed those due to mine accidents (Dr M A la Grange, Chamber of Mines). TB is a potentially curable disease and misdiagnosis has important implications for the individual, spread of TB in the community and compensation in terms of the Occupational Diseases in Mines and Works Act (ODMWA). Improved management can only occur if the diagnosis is correctly established, targeting areas for intervention.

The National Centre for Occupational Health (NCOH) examines the lungs of deceased mineworkers in terms of ODMWA and is thus in a unique position to assist with strategies for improving the accurate and timeous diagnosis of pulmonary TB (PTB). The objectives of the study were to correlate the ante- and postmortem diagnoses of PTB, review medical data from a representative group of mine medical services to assess current clinical practice, and identify possible reasons for discordant diagnoses and strategies for improving clinical practice.

There were 1858 autopsies performed during 1999 (excluding cases from Anglo Gold which did not participate in the study) of which 350 were study cases with a clinical diagnosis of PTB as a major factor in the cause of death and/or an autopsy diagnosis of PTB. Clinicians correctly ascribed PTB as the cause of death in 27% of cases, failed to diagnose PTB in 44% and incorrectly ascribed PTB as the cause of death in 29%. Poor clinico-pathological correlation is not unique to the mine medical services but also occurs in medical centres in America, Britain etc.

Clinical practice was assessed by reviewing the medical records from 8 different medical centres representing gold, coal and platinum mining commodities. Of these patients, 76% were known to be HIV infected and of those who had CD4+ cell counts, 90% had advanced AIDS.

Autopsies showed lungs with extensive TB even though surveillance chest radiographs taken only months prior to death were normal.

In patients in whom the clinical diagnosis of PTB was not made, important factors influencing the missed diagnosis of TB were the presence of miliary TB, the simultaneous presence of a second lung disease such as bacterial pneumonia and omission of accurate laboratory diagnostic tests such as sputum smears and culture for TB bacilli.

About half of the cases, in whom the clinicians had correctly diagnosed TB, presented with advanced disease and had had a rapidly terminal course. In this group and in the undiagnosed group there were missed 'windows of opportunity' for the clinicians to have made an earlier diagnosis as many patients had attended the mine clinics and/or hospitals in the preceding three months. Cases were identified with extensive TB at autopsy who had been on prolonged treatment for TB. These patients (and especially those who also had previous TB) are at risk of being drug resistant; drug susceptibility testing had not been performed for the majority of them.

Of the patients for whom clinicians incorrectly ascribed PTB as a cause of death, 72% had been treated for TB for over 30 days. They appear to have responded to TB treatment and sequential development of other diseases, many of which would have been amenable to treatment if diagnosed, accounted for the discrepancies in ante- and postmortem diagnoses.

About 250 health care workers attended the clinico-pathological conferences held to disseminate the study findings, present illustrative cases and discuss best practice clinical strategies, as the study progressed.

A wide range of health care workers attended and the doctors appear to have subsequently incorporated at least some of the suggestions made into their practices as indicated in their responses to the evaluation questionnaire distributed to them .

CONCLUSION:

The considerable effort made to reduce fatalities due to mine accidents must be duplicated to reduce deaths due to a disease which, in theory at least, could be eradicated with the application of present knowledge.

Recommendations:

- More frequent medical surveillance for groups of employees at high risk for TB
- Improving the skills of nurses both with regard to case finding and monitoring of patients while on treatment for TB
- Actively excluding TB in all patients admitted to hospital with respiratory signs and symptoms, including use of sputum culture for TB, even if they show some response to treatment for bacterial pneumonia
- A training course on the interpretation of chest radiographs
- Empirical treatment for suspected miliary TB while awaiting culture results
- All employees found unfit for continued employment to be actively investigated for TB before leaving the mines. Special attention to be paid to men with advanced AIDS
- Deterioration in their condition should not be ascribed to progressive HIV infection without considering the possibility of TB
- Testing for drug susceptibility in all previously treated patients and those who fail to respond to treatment
- The NCOH should continue to provide autopsy reports if requested by the clinician, to enable them to undertake reviews of their performance



7. PROPOSED RATIONAL STRATEGIC CRITERIA FOR ROUTINE MEASUREMENT OF EXPOSURE TO RESPIRABLE DUST IN SOUTH AFRICAN MINES

By Biffi M., Belle B., Unsted D., CSIR: Division of Mining Technology, Ref:SIMHEALTH 604b, 2000

SUMMARY:

Dust has been recognized as the most serious occupational health hazard across the South African Mining Industry. The need to address this problem in its totality requires the creation of effective monitoring systems designed to estimate the exposure of workers to dust for epidemiological purposes. Dust monitoring systems employed in South Africa up to now have proved to be inadequate to characterize workers' exposure to respirable dust for the purpose of providing a basis on which epidemiological studies may be structured and to provide a database of information for medical surveillance.

As part of the background work to this project, extensive research into the pathogenic effects of dust failed to deliver conclusive evidence as to which dust property or combination of properties is responsible for the pathogenesis of respirable dust. An important assumption made in defining the sampling criteria outlined in this report is that, due to this lack of this knowledge, it is assumed that full shift gravimetric sampling should be employed as a surrogate measurement of exposure.

The criteria presented in this report are based on subdividing the exposed workforce into a number of sectors within the South African Mining Industry. Each sector is representative of similar mineral/ore/commodity production defining to a broad extent exposure as a function of the mining method. Each sector is divided further into sub-sectors that relate to various, broadly similar activities within the production and beneficiation cycle.

It is assumed that the full shift samples collected as part of this programme are associated with an occupational group defined in this manner - although it is accepted that gravimetric sampling alone is not the most accurate surrogate for dust exposure. However, this method may be useful to gather data representative of the respirable fraction of the dust inhaled by workers and could be used to validate some of the assumptions made. This data, together with the "fingerprinting" of samples done in parallel with the gravimetric sampling, could provide a meaningful base from which information may be generated for future monitoring programmes.

It is stressed that the strategy defined by these criteria must be underpinned by a series of parallel and coordinated pilot studies aimed at increasing the volume of meaningful information required to obtain valid and accurate information on exposures.

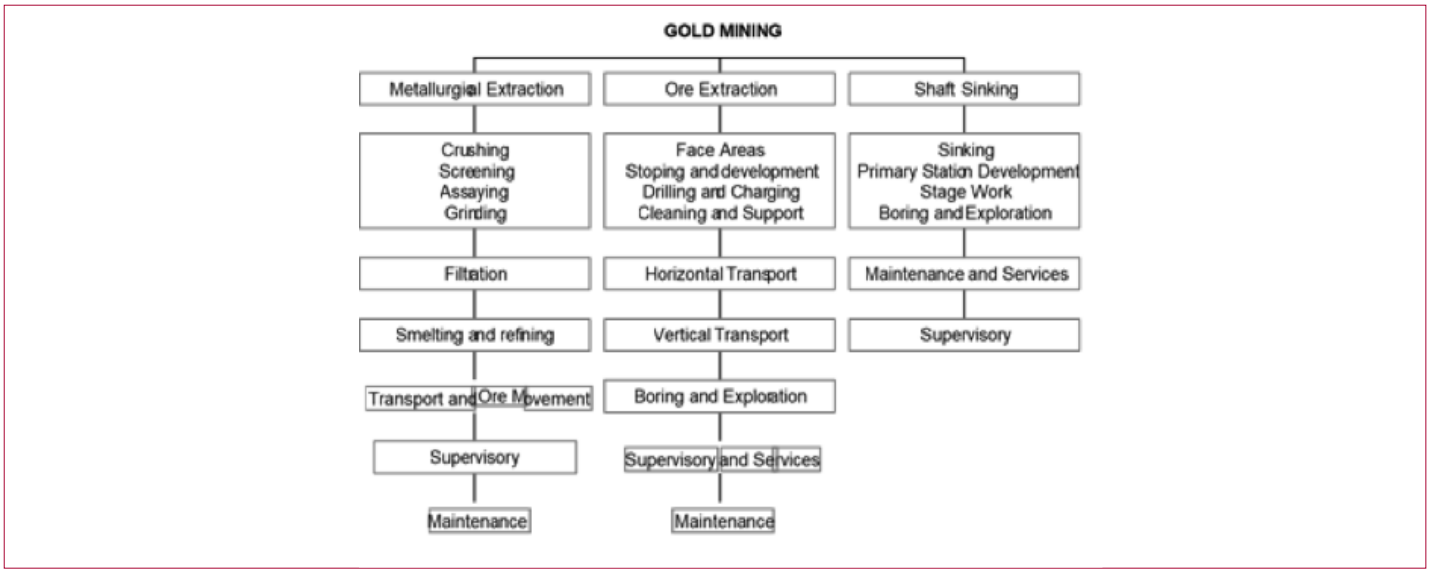


Figure 1: Example of worker exposure group break-down

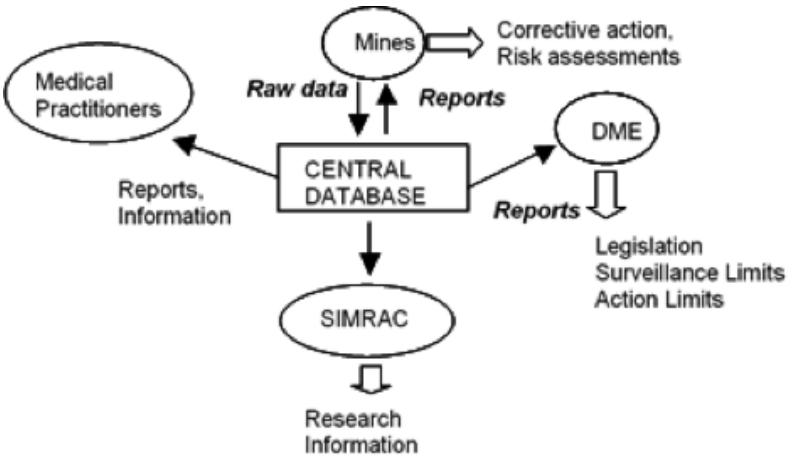


Figure 2: Information and data flow for proposed Management System

CONCLUSION:

The work presented in this report discusses criteria only for a proposed method of sampling. It is recommended that these criteria be encompassed into a more detailed set of guidelines that will facilitate the implementation of a new sampling strategy on every mining operation.

The criteria for routine sampling discussed in this report are part of the efforts necessary to reduce workers' exposure to dust and ultimately reduce the incidence of occupational lung diseases. The strategies proposed are supportive of an overall initiative aimed at achieving these objectives. The creation of a managed centre of data and information should be seen as the nucleus for much broader research efforts and intervention activities.

Within an industry that experiences a high incidence of occupational respiratory diseases (primarily silicosis and tuberculosis) superimposed a high prevalence of HIV/AIDS amongst mineworkers, it is felt that this wider, more co-ordinated and revitalized research programme will address adequately the impact of these diseases. It is important, therefore, that the creation of such a system not be seen in isolation and that it should be structured to allow for the expansion necessary to accommodate the need of future initiatives.

The strategies, leadership and co-ordination required for these initiatives should be sourced from a central body representative of all stakeholders. Furthermore, although important, the determination of workers' exposure is but a part of a properly structured and effective drive designed at characterizing the emission of dust from a number of mining activities and at designing effective suppression methods that will eventually reduce workers' exposure.

The generation of information about workers' exposures to respirable dust is the basis on which knowledge linking exposure to outcome is structured. A process designed at studying and minimizing emission of dust into the environment must complement any initiative that may arise from this work.

Recommendation:
It is proposed that all data collected from each mine be stored in a single data management system. This system will be used to analyse the data and to produce reports that will reflect trends of exposures for mines, mining sectors and the Mining Industry as a whole. The data management system will also enable medical practitioners and researchers to assign surrogate exposure levels to every worker given the worker employment history.

8. DEVELOPMENT OF LUNG FUNCTION REFERENCE TABLES SUITABLE FOR USE IN THE SOUTH AFRICAN MINING INDUSTRY

By Ehrlich R., White N., Myers J., Thompson M.L., Churchyard G., Barnes D., DeVilliers D.B., University of Cape Town, Aurum Health Research, Anglogold Health Service, Ref: HEALTH 610, 2000

SUMMARY:

Lung function testing by spirometry - the measurement of Forced Vital Capacity (FVC) and Forced Expiratory Volume in One Second (FEV1) - is used in the mining industry for baseline, medical surveillance and compensation purposes. Reference equations are needed to enable practitioners to assess the normality or otherwise of measured values. The aim of this review was to recommend reference equations suitable for the South African mining industry, for both cross-sectional and longitudinal use and for black and white mineworkers (given widely observed racial/ethnic differences in FVC and FEV1).

Reference equations should be derived from recently conducted studies in unexposed, non-smoking populations of similar origin to the participants in the lung function testing programme. A number of South African studies were reviewed, including a large as yet unpublished study of goldminers by Hnizdo et al. As the latter study included a large proportion of dust exposed and smoking employees, it was not considered suitable as a source of reference equations. However, it did provide a database of lung functions of in-service mineworkers against which candidate reference equations could be tested for their validity in defining the statistically appropriate proportion of "abnormals".

For black in-service mineworkers, a study of non-smoking, healthy bank workers in Johannesburg by Louw and Goldin provided the best statistical fit as well as meeting the criteria for suitable reference equations. For white in-service mineworkers the commonly used reference equations published by the European Community for Coal and Steel (ECCS) based on European populations best satisfied these criteria. Application of the ECCS equation to black mineworkers was found to produce a large proportion of "false positive" abnormal values, with potentially adverse effects in the form of unnecessary investigations and reduced job security.

In respect of women employees, the only available study of black South African women, by Mokoetle et al. of university workers in Johannesburg, appeared a reasonable choice, while retaining the ECCS equation for white women.

Recommendation of these equations is subject to the qualification that their programming into spirometers does not preclude use of a single (sex-specific) equation for all mineworkers if a practitioner so chooses, as long as the differential performance characteristics are taken into account in making administrative or clinical decisions.

CONCLUSION:

Longitudinal monitoring has the advantage that each employee is used as his own "control" in evaluating change in lung function and judging the impact of dust or other factors. With some qualification, cross-sectional equations can be used for longitudinal purposes. The best available method is to generate "percentile curves" on which the individual's lung function is charted, so as to pick up early departures from the expected path. A conceptually superior method would be to develop "adaptive" (truly longitudinal) reference norms which maximise the information from past and current lung functions of the whole cohort.

Recommendation:
Development of such norms will require further research, starting with a study of dose-response effects of dust on lung function in a cohort of miners. If this shows a clear exposure impact, a non-exposed cohort will need to be studied.

9. IDENTIFICATION OF HEALTH HAZARDS RELATING TO TOXIC SUBSTANCES IN SILICON SMELTERS: THE RISK OF OCCUPATIONAL EXPOSURE

By van Niekerk W.C.A., Coombs W.M., Simpson W.S. and Retief W.L., INFOTOX (Pty) Ltd, Ref: HEALTH 610

SUMMARY:

Silicosis is a debilitating lung disease, believed to be caused by the inhalation of crystalline silica. Despite the control of exposures in more recent years to levels that are considered to be below the threshold for onset of respiratory disease, pneumoconiosis in the silicon industry continues to occur sporadically on a worldwide basis.

The fact that levels of exposure to crystalline silica do not correlate clearly with the manifestation of pneumoconiosis, infers that the causation and pathogenesis are not completely understood, and the disease can therefore not be managed effectively. Simply measuring airborne levels of crystalline silica does not appear to provide all the clues that are necessary to explain the cause-effect relationship. A more holistic approach is required, taking into consideration not only crystalline silica, but also other airborne substances that might be causative agents, either as initiators or promoters of the disease.

To provide these perspectives, SIMRAC Project Health 709 was initiated. The main objective was to study possible causes for lung disease in silicon smelters, based on the observation that crystalline silica intrinsically does not appear to be the only agent leading to the development of pneumoconiosis. The basis for the study was to acquire and document the relevant background information that is necessary for an understanding of health risks associated with toxicants in silicon smelters. This involved descriptions of unit processing steps and operational parameters, identification of sources of chemical hazards, descriptions of toxicology, guidelines for sampling and chemical analysis for exposure assessment, and a framework for health risk management. The intention of the study was of a generic nature, not referring to a specific silicon producing company. Any similarity between descriptions in this document and a specific company in South Africa is therefore not intentional.

It is common knowledge that silica (SiO2) is the most abundant inorganic component of the earth's crust. The most prevalent form of silica is quartz, the main constituent of common sand. However, both in nature and in the laboratory, other forms may also be produced. A special type of microamorphous silica is obtained when silicon monoxide (SiO) is oxidised, and results in the formation of fibrous silica. This largely amorphous material is produced as a by-product during thermal treatment under reducing conditions of quartzite to produce silicon metal.

Whilst there can be no doubt as to the efficacy of inhaled crystalline quartz as an agent for causing metabolic disorders, normally described amorphous silica might not be totally amorphous, but might also constitute very finely divided crystalline silica particles. Some authors believe that it is no longer sufficient to characterise the biological potency of silica fume by its crystalline content alone. The reason is that silica fume has been shown to be fibrogenic, some reports indicating fibrogenicity comparable to crystalline silica.

It appears to be a fallacy to focus any assessment of silicosis in a smelter environment on exposure to crystalline silica per se while assuming that silica fume, which is largely amorphous, has little adverse effect on the lung. When the available toxicological and epidemiological information is assessed in context, there is convincing support for a link between exposure to silica fume produced in silicon smelters and the development of silicosis. Most of the inconsistencies in the interpretation of health effects relating to amorphous silica appear to be a result of:

- Generalisations between the different forms of amorphous silica;
- Disregarding the presence of microcrystalline silica (probably cristobalite) in silica fume, and
- Underestimating the role of ultra fine particles in the overall particulate toxicity.

As explained, the underlying cause of silicosis when exposure to crystalline silica is believed to be below the occupational threshold level should be sought elsewhere, and this raises silica fume as a likely candidate for causing pneumoconiosis. Exposure levels to silica fume can be high, and it is possible that the use of respiratory protective equipment is not effective under the conditions of extreme heat in the furnace area. In addition, the type of protective equipment for silica fume needs to be specific. Furthermore, it is possible that routine X-ray diffraction analysis of ultra fine silica fume fails to identify crystalline silica, due to peak broadening or for other reasons.

A weakness in the current health risk management approach in silicon smelters lies in the classification of silica fume as general amorphous silica (dust), and consequent management of exposure against an occupational exposure limit that may be too high for adequate protection. The toxicological and epidemiological literature is quite convincing in classifying silica fume as a causative agent for silicosis. It has been shown that particles in the ultra fine range have higher than expected toxicity when compared to similar particles of a larger size, and silica fume cannot be managed in the same way as general airborne amorphous forms of silica.

As an additional concern, it should be noted that concurrent exposure to coal tar pitch volatiles may lead to serious health effects, both as a result of direct inhalation of fumes, and also through inhalation in the particulate-associated form. Because coal tar pitch volatiles as a chemical class consist of many polynuclear aromatic and phenolic compounds, quantitative assessment of risk requires that the individual toxicants be determined. This will enable quantification of both cancer and noncancer risks.

CONCLUSION:

This SIMRAC study has led to the hypothesis that silica fume is likely to be associated with the development of silicosis in exposed individuals. Overall, where there is continuing occurrence of pneumoconiosis in silicon smelters at low levels of exposure to crystalline silica per se, it is recommended that exposure to silica fume be assessed and managed on a basis that is closer to guidelines that control exposure to respirable crystalline silica. Guideline concentrations between 0.1 to 0.3 mg/m3 might be considered. Setting a standard for controlling exposure to silica fume in the industry would however require an appropriate stakeholder participative process, where such factors as technical and financial feasibility, and socio-economic factors will have to be considered.

Also, the standard should be supported by appropriate implementation and health risk management protocols. Silicon Smelters (Pty) Ltd in Pietersburg (South Africa) has initiated an independent research project to clarify some of the issues around pneumoconiosis (Project Thuso). This involves new occupational hygiene studies, as well as a review of the medical records of workers. New medical examinations may also be conducted in certain cases.

Recommendation:
It is recommended that the findings of this SIMRAC project be combined with the research at Silicon Smelters, to test the hypothesis tabled in this report against available data on exposure to silica fume and associated health outcomes.



10. STRATEGIES FOR REDUCING THE BURDEN OF TB INFECTION AND DISEASE IN SOUTH AFRICAN GOLDMINERS: THE ROLE OF PREVENTIVE THERAPY

By Dr Corbett L., Dr Churchyard G. and Prof. Williams B., 2001

SUMMARY:

Compared to many other infectious conditions, the dynamics of TB infection and disease are well understood and quantified. Two of the key aspects are first that a latent stage of TB infection, without any manifestations of disease, can exist for many years, and secondly, that following infection the lifetime risk of TB disease is low in the absence of predisposing factors (estimated at about 10% for healthy individuals).

We have used pre-existing models and have adapted estimates of the important constants governing TB transmission to provide the framework for a model of TB infection and disease in gold miners, and the impact of interventions including isoniazid preventive therapy (IPT). Unique features of TB in miners that have been taken into account include ongoing active case finding (annual radiograph), and an unusually high risk of progression to TB disease following TB infection, due to silica exposure as well as HIV infection. By modifying disease constants to take these factors into account, and then simulating an HIV epidemic, we have been able to closely reproduce observed serial data of TB incidence in miners, both at the workforce level and among “cohorts” of HIV-positive and HIV-negative miners.

Our model suggests that:

a. TB transmission among miners is more intense than occurs in equivalent general populations, or non-silica exposed miners
b. Because of the high transmission rates, an unusually high proportion of miners are latently infected with TB
c. HIV infection greatly increases the risk of progression to TB disease following TB infection. In the context of high TB transmission rates and a high percentage of miners latently infected with TB infection, the impact of the HIV epidemic has been profound.
d. The upward TB incidence trends of the last decade can be reversed by a number of different possible interventions, or combinations of interventions.

The interventions include the treatment of latent TB with IPT. Two main alternative strategies were considered:

1. mass untargeted therapy given during a brief period. For example, 6 to 9 months of IPT taken by 80% or more of the workforce during a 1 year period so that transmission is curtailed at the same time as the prevalence of active and latent TB infection are reduced
2. employment-long IPT targeted to individuals known to be at high risk of TB

Other alternative, and potentially complementary interventions were also modelled:-

- more frequent active case finding
- widespread use of highly active antiretroviral therapy
- reduced HIV incidence
- less dense housing

Although not specifically modelled here, it is likely that reducing silica dust exposure would also have an impact on TB susceptibility. Strategies varied both in rapidity of onset to maximum impact and in their durability:

- mass untargeted IPT has the most rapid impact, but needs to be combined with another ongoing intervention, or periodically repeated, in order for the benefit to be sustained.
- long-term lasting improvements to TB control can only be achieved by interventions that change the underlying constants that govern the dynamics of TB transmission: e.g any intervention that reduces susceptibility to TB disease once infected (ARVs used effectively, ongoing IPT targeted to high risk miners, HIV or dust prevention), or reduce the intensity of transmission (increased active case finding, change away from hostels).

A potential for a paradoxical negative impact on control was observed when widespread antiretroviral therapy (ARV) was modelled.

In our model ARVs increased HIV prevalence in the workforce considerably unless a simultaneous reduction in HIV incidence was modelled. Furthermore, the results suggests that the impact of ARV use on TB control may depend critically on whether or not treated men are maintained in the early, rather than mid or late-stages of HIV disease. If the prevalence of HIV increases and the numbers of HIV-positive employees in the mid or late stages of immunosuppression is increased, for example by intermittent therapy aimed at symptomatic individuals, then it is likely that overall TB incidence rates will increase as a result of the intervention. If, however, the effect of ARVs is to maintain HIV-positive employees with an essentially normal immune system, then TB incidence will decrease despite an increasing HIV prevalence rate.

11. HANDBOOK ON OCCUPATIONAL HEALTH PRACTICE IN THE SOUTH AFRICAN MINING INDUSTRY

By Dr Guild R., Prof. Ehrlich R.I., Dr Johnston J.R., Prof. Ross M.H., Advantage Consulting (Pty) Ltd, Ref: HEALTH 612, 2001

SUMMARY:

The "Handbook on Occupational Health Practice in the South African Mining Industry" provides managers, union officials, engineers, health and safety practitioners, occupational hygienists and occupational medical and nursing practitioners with practical tools to prevent occupational illness and disability.

Information on the identification, assessment and control of hazards and related diseases in the mining industry was to be integrated into a single authoritative manual that contained best practice guidelines.

This was to serve as a practical guide, an audit tool, a planning tool, a referral document to other information sources, a vehicle for technology transfer and an education tool.

The project delivered 15 000 copies of the book within budget at a cost of R90 per book.

CONCLUSION:

This document describes the process, outcome and some of the project management tools utilised in the process.

12. RANGING OPEN PATH REMOTE METHANE DETECTION/ MONITORING DEVICE

By Dr Kononov V.A., Spottiswoode B.S., Germishuizen F., CSIR Miningtek, Ref: GEN705, 2001

SUMMARY:

The main conclusion of project COL601 was that the method of underground open path, remote flammable gas measurement, in its existing form, does not comply with the current safety regulations. The problem with the method used lies in the fact that it provides an integrated measurement of gas concentration along the path, or, in other words, a percentage of gas concentration per metre.

Therefore, it was proposed that a time Ranging Open Path Remote Sensing (ROPRES) device should be developed. This technology enables the distribution of flammable gas concentration along the open path to be determined, thus ensuring that the safety regulation requirements for routine methane monitoring and early warning are met.

The employed technology is a form of Differential Absorption Light Detection and Ranging (DIAL). In essence, short impulses of two wavelengths of infrared laser light are projected along the path of interest. This light is backscattered off the dust particles in the air and is collected by a receiving telescope. One wavelength, the primary, is matched to a strong absorption line of the gas species of interest. The other, the reference, is unattenuated by this gas but lies at a wavelength close enough to the primary wavelength to ensure that differences in transmission characteristics are negligible. The methane concentration at any particular distance from the sources can be resolved from the two received signals by analysing their ratio at a time corresponding to that taken for the light to travel from the transmitter to the area of interest and back to the receiver.

It is impossible to apply current DIAL technology directly for use underground, as the best spatial resolution of such a system is only about 15-30 m. This limitation is due to both optical timing aspects and to a lack of backscattering particles in the atmosphere. A theoretical study was undertaken to determine the expected backscattered radiation from the dust of a typical mining atmosphere. The results of this were used to specify system requirements.

CONCLUSION:

The study demonstrates that due to the substantial amount of airborne dust in the mine atmosphere and due to the advent of a new convolution-based DIAL technique, a proposed system fit for underground application (1-2m spatial resolution) is feasible. The hardware and processing software for the ROPRES system has subsequently been developed and tested in laboratory conditions.

A testing rig was designed and built in order to conduct a laboratory test of the device. The rig consists of a 8 m long 800 mm diameter rotating steel tunnel sealed at both ends with polyethylene membranes and filled with a mixture of methane and air. Fans installed in the tunnel serves to circulate the introduced dust and to provide a homogeneous methane mixture. Methane concentration is monitored by a methane sensor. A modified NLC's laboratory laser was used for testing.

Subsequent tests have confirmed theoretical results in that the amount of backscattered radiation in a mining atmosphere is sufficient for obtaining 1-2 m spatial resolution. Thus, the concept of ranging open path remote flammable gas detection/monitoring has been verified.

Recommendations:
As the next step, the development of an autonomous device for laboratory and underground tests is proposed.

13. ANALYSIS OF OCCUPATIONAL LUNG DISEASE IDENTIFIED AND COMPENSATED IN DIFFERENT MINING SECTORS BY COMPARISON OF AVAILABLE DATA BASES WITH AUTOPSIES CONDUCTED UNDER THE OCCUPATIONAL DISEASES IN MINES AND WORKS ACT (ODMWA)

By Dr Murray J., Dr Banyini A., Ms Coetzee L., Dr Back P., NCOH
Ref: SIMHEALTH 706, 2001

SUMMARY:

The Occupational Diseases in Mines and Works Act (ODMWA) makes provision for the autopsy examination of the cardiorespiratory organs of deceased miners and ex-miners for the purposes of compensation.

High rates of occupational lung disease are found in currently employed and ex-workers autopsied at the National Centre for Occupational Health. The contribution of the autopsy service in the compensation process has, however, not been comprehensively evaluated.

Three institutions are involved in the compensation process namely the National Centre for Occupational Health (NCOH), the Medical Bureau for Occupational Diseases (MBOD) and the Compensation Commissioner for Occupational Diseases (CCOD).

At the NCOH, the cardiorespiratory organs are examined, potentially certifiable occupational disease is identified and an autopsy report is sent to the MBOD Certification Committee. At the MBOD, the Certification Committee reviews service & medical records and previous compensation. The deceased is certified as either no compensable disease (NCD), Tuberculosis only, First degree or Second degree. Cases in the latter three categories are referred to the Compensation Commissioner who verifies service, personal details, previous compensation and then pays compensation.

The objectives of the study were:

1) to determine the outcome in terms of compensationpaid for each case certified at autopsy with occupational lung disease, and
2) to determine the status of and to identify thedeficiencies in information collection, availability of data and current database formats pertaining to deceased persons at the NCOH, the MBOD and the CCOD.

The study population consisted of miners and ex-miners who came to autopsy at the NCOH during the 1999 calendar year.

CONCLUSION:

The findings of the study revealed that:

- Only 7% (n=31) of deceased's dependants who qualified for compensation were known to have been paid out by February 2001
- Of the men who came to autopsy, 19% (n=446) were certified as having a new or upgraded compensable disease in the 1st /2nd degree categories
- During the period under study, 2 378 cases were analysed
- The NCOH and MBOD are predominantly computerized
- At the CCOD a manual system is in place. There is no common database or linkage system between the three institutions. The lack of integration and system performance hampers the effectiv functioning of these institutions

Recommendations:

- Upgrade management systems at the CCOD
- Utilize available information at The Employment Bureau of Africa (TEBA) and Rand Mutual
- Assurance to trace dependants and effect payment
- Review and streamline the excessive and complicated documentation required from the dependants of the deceased
- Put in place an integrated computer information system at the NCOH/MBOD/CCOD. (A National Department of Health tender to address this has been issued)

14. ROCK DRILL NOISE AND VIBRATION MEASUREMENTS KROONSTEEN ARTIFICIAL STOPE

By Heyns P.S., Business Enterprises at University of Pretoria, Ref: Health 806, 2002

SUMMARY:

Business Enterprises at University of Pretoria was approached by The Wits Health Consortium (Pty) Ltd to conduct a series of noise and vibration tests on four rock drills in an artificial stope close to Brits.

The tests entailed mapping of sound pressure levels for each drill, as well as measurement of vibration levels along three axes for each of the hand held drills.

These tests were conducted on 20 November 2003. Eventually six different rock drill configurations were considered:

- A quiet drill with standard and cladded drill steel
- A pneumatic drill with standard and muffled configurations
- A hydraulic drill
- An electrical drill

SIMPROSS guidance was accepted not to report the specific details of the drills used for this comparative study.

CONCLUSION:

A series of sound pressure level and vibration measurements was conducted on six different rock drill configurations. Very high sound pressure levels were recorded (as high a 114.4 dBA) in some cases. There are, however, significant differences in the sound pressure levels produced by different drills.

These differences are in some cases of the order of 20 dBA. The measured sound pressure levels must be evaluated against the legally recognised safe limit of 85 dB for time-weighted 8 hour equivalent exposure. Actual noise levels will, however, vary in the underground stopes, dependent on local conditions. The machine-to-machine comparative levels are expected to be consistent with these tests.

Many variables could have affected the results (e.g. the precise position (shading effect) of the operator, the penetration state at the moment of measurement, unevenness of operation etc.) and care should be taken in drawing conclusion from one single measurement in experimental circumstances. The results have therefore been presented as profiles, which provide a better appreciation of the differences between configurations than single noise level values at particular positions.

15. THE IMPACT OF HIV AND ANTI-RETROVIRAL DRUGS ON THE AUDITORY SYSTEM IN SOUTH AFRICAN MINES: THE OUTPLAY OF BEING AN HIV POSITIVE MINER IN SOUTH AFRICA

By MOTHEMELA M.S., NTULI N.S., HLAYISI V., SONO K., Ref: SIM 140802, 2002

SUMMARY:

In South Africa, the incidence of HIV/AIDS has increased rapidly over the past decade from almost zero in 1990 to about 5.0 million people living with HIV/AIDS in 2001. The incidence and prevalence of this epidemic has increased since 2001 to date indicating an estimated 5.7 million (12%) people to be infected with HIV. There is a body of evidence indicating that between 21 - 49 percent of HIV positive individuals present with hearing loss and

further that the prevalence of hearing loss in HIV positive individuals is higher when compared to that in HIV-negative individuals. This poses a big threat to the mining industry because there is already an inherent risk for hearing loss in the sector as a result of noise. The literature has also presented results that imply that taking ARV drugs can result in hearing loss, possibly compounding noise, HIV/ pulmonary tuberculosis (PTB) drugs and age as risk factors for hearing loss. All of the studies reviewed for the current study, except one, sampled their study populations from health facilities and not from active mineworkers. It was therefore considered necessary to understand the relationship between the combined risk factors and hearing loss in a sample of South African mineworkers.

The main aim of the study was to determine the impact of HIV infection and ARV therapy on the auditory system of South African mineworkers.

The study population was sourced from attendees at occupational health clinics at three mines, platinum, gold, and coal, in South Africa. A total of 199 participants (158 HIV positive, 36 HIV negative and 5 unknown) were enrolled at baseline. Three follow-up visits were conducted at the three mines, unfortunately with a high rate of loss to follow-up.

The findings are that this study did not indicate any association between hearing loss and HIV infection or ARV therapy. However, what was striking was that while the prevalence of hearing loss amongst the HIV-positive group (47,5%) corroborated the figures reported in the literature, the prevalence amongst the HIV negative group (51,4%) was much higher than expected.

CONCLUSION:

Even though the prevalence of auditory manifestation in people living with HIV may be higher than in those who are HIV-negative, in mineworkers, this difference may be minimised to levels below statistical significance owing to noise exposure. There is a possibility that noise may distort the impact of HIV/ ARVs in mineworkers, suggesting that an HIV-negative mineworker may still be worse off than an HIV-positive individual in the general population in terms of risk for hearing loss.

Also, judging from the high proportion of participants who had education up to secondary school, the profile of a traditional mineworker may be changing. Mineworkers are younger and more educated than in the past. This profile may predispose them to high recreational noise levels, as a result of listening to loud music via headphones, adding to the effect of occupational noise. The findings of this study emphasized that noise is still the overwhelming contributor towards hearing loss and, therefore, efforts to minimize exposure should be strengthened. While literature in support of ARV drugs being ototoxic is very conflicting, there is strong published evidence that the prevalence of auditory adverse effects are higher in HIV-positive groups than in HIV-negative groups. Therefore, strategies towards HIV / PTB awareness and prevention should still take priority. Prompt initiation of treatment in those who are diagnosed with HIV-positive infection should be encouraged.

Guidelines should be adjusted to incorporate high frequency audiometry at least three-monthly for the first year in those miners who are on ARV therapy. HIV-positive patients should be educated on symptoms of adverse auditory effects so that they report these as soon as possible. Mine managements could enforce six-monthly high-frequency audiometry as part of medical surveillance for all HIV-positive mineworkers.

16. CRITERIA FOR THE SAFE USE OF COMMERCIAL VEHICLES TO TRANSPORT PERSONNEL IN THE UNDERGROUND ENVIRONMENT

BY Giliomee C.L., Dr Nell S., Prof. Fourie G.A., Land Mobility Technologies (Pty) Ltd, GA Fourie and Associates, Ref: GEN 702, 2002

SUMMARY:

Statistics from the SAMRASS database indicates that vehicle related accidents account for a significant number of accidents, injuries and fatalities in mines.

This report details the research done into the use of commercial vehicles (bakkies) in the underground mining environment. The research was prompted by concern from the DME about the use of nonflameproof vehicles in fiery mines. Although flameproofing is of primary concern in this document, general safety requirements for bakkies used underground are also addressed.

Two SABS standards pertaining to flameproofing and braking respectively were evaluated and DME documentation relating to the use of bakkies underground are also discussed. General vehicle safety, from a vehicle engineering point of view, is also addressed. The research indicated that although the SAMRASS database is very comprehensive, there is not distinguished between bakkies and other personnel transporting vehicles, which makes the accident statistics difficult to interpret. The accident statistics may therefore be misleading, as far as nonflameproof bakkies are concerned.

It was also concluded that all the mines visited during this project follow a different approach when selecting, implementing and maintaining nonflameproof (as well as flameproof) bakkies. It appears as if some of the mines do not go through the same development and research effort, as did the pioneers of non-flameproof bakkies.

All the mines have a good driver training program in place and monitor the use of bakkies carefully. It is also very noticeable that at most mines, although the non-flameproof vehicles are still new, few accidents and almost no fatalities or injuries were recorded since the introduction of non-flameproof bakkies. From the response of the mines to the questionnaire it can be concluded that the mines will go a long way to retain exemption to use these vehicles.

Some of the industry role players are very skeptical about the non-flameproof vehicles and most of them feel that proper guidelines and specifications should be provided for these vehicles.

The SABS 868 flameproofing standard has been revised several times and it was found that some of the issue levels contains conflicting information. This standard also makes no provision for non-flameproof vehicle requirements. The SABS 1589 braking standard used for underground trackless mining vehicles was found to be less strict than that used for commercial vehicles, such as bakkies, in terms of stopping distance and mean fully developed acceleration.

The DME documentation regarding non-flameproof vehicles was revised several times the in past few years and although none of the documents provided sufficient guidelines, it was found that the documentation became less prescriptive with regards to braking, temperatures and emissions.

Non-flameproof vehicles found at the mines are generally in very good condition and conform to strict safety standards, although healthy and safety can be improved in various areas.

CONCLUSION:

According to the Mine Health and Safety Act (MHSA) (Act 29 of 1996), the manager must draw up codes of practice (paragraph 9), supply training (paragraph 10) and assess and respond to risks (paragraph 11). This will entail performing a Hazard Identification and Risk Assessment (HIRA) for each new vehicle model introduced in the mine. This report supplies some examples of significant risks and suggests possible ways to address it, but since each mine is unique, a thorough HIRA has to be performed for all non-flameproof vehicles.

17. INVESTIGATE A POSSIBLE SYSTEM FOR "MAKING SAFE"

BY Ottermann R.W., von Wielligh A.J., Burger N.D.L., Handley M.F., Fourie G.A., RE @UP, University of Pretoria, Ref:GEN801, 2002

SUMMARY:

The primary output of this phase1 of the project was to develop a list of alternative designs for "making safe" that may be considered by SIMRAC. Workers responsible for "making safe" in mines will use the device or system, which has to be safe and reliable and reduce the exposure to fall of unsupported ground hazards, and therefore saving life and limb. This project looks at the actual "making safe" and not the detection of loose rock, which is addressed in projects GAP 820 and GAP 822. During phase 2 of the project a working prototype or prototypes will be developed for underground evaluation.

A significant proportion of rockfall accidents occur during re-entry into a workplace, when the initial inspection and "making safe" procedures are carried out to stabilise the rock before work in the area begins. The reason is that "making safe" is one of the most stressful and dangerous activities an underground miner can undertake. The operator often is unable to work at a safe distance and is sometimes forced to work directly underneath unstable rock when attempting to "make safe". The equipment currently used is archaic and there is a need to devise a simple system to enable operators to stabilise the rock effectively and efficiently from a safe distance before work begins in the area. Furthermore, current methods are physically demanding on the operator, which can lead to poor concentration, improper completion of tasks, and accidents.

A literature and international survey on existing systems was conducted. During a problem survey different mines (gold, platinum and coal) with different stoping widths were visited to investigate and identify the problem. A functional analysis was done from which a specification was drawn up. Different concepts for "making safe" were generated and evaluated against the system specifications. These concepts were presented to SIMRAC.

The ideas developed during this project are to be used by workers responsible for "making safe" in mines. The equipment is designed to reduce exposure to falls of ground, and to assist in reducing stress and fatigue of the operator. The concepts chosen as the preferred concepts are:

- A "lightweight pinch-bar" where the bar is manufactured of composite materials.
- "Mechanical jaws": A hand held and operated mechanical system, which makes use of hydraulic pressure activated jaws to pry rocks loose.

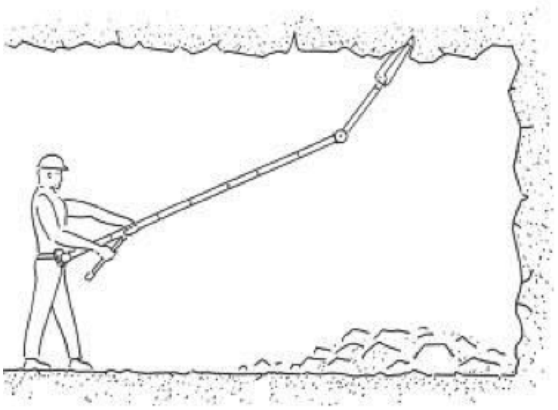


Figure 1: "Mechanical jaws" in operation



Figure 2: Layout of "mechanical jaws"

CONCLUSION:

It is recommended that both preferred concepts, a "lightweight pinch-bar" and "mechanical jaws" be further developed into prototypes, which can be tested and evaluated.

18. ASSESSING HAZARDS CREATED BY FUMES, GASES AND UV RADIATION DURING WELDING/CUTTING IN THE SOUTH AFRICAN MINING INDUSTRY

By Dees G., Renshaw M., van der Merwe J., Hilton D., Yousefi V., Marais V., Bosch C., Harvey K., Afrox, NCOH, Ergosaf, BOC, Ref: Health 605, 2002

SUMMARY:

Health 605 assessed the hazards that welders are exposed to during the course of welding operations.

The two phases to the project were an observational study of the types of welding being undertaken and an airborne pollutant exposure survey. Observations revealed that there is a range of mining situations with different types and duration of welding processes commonly being practised and of personal protective equipment (PPE) being used. A total of 16 welders were observed in Gold, Platinum, Manganese, Coal, Chrome and Base metals mining operations. Airborne particulate fumes and gases were collected for laboratory analysis. Both personal and area (strategic) sampling were undertaken.

The study reviewed the health effects of welding fumes and the risk of exposures in relation to the type of materials used in welding, the welding method, the ventilation characteristics and the use of PPE. Points of concern were observed. The majority of the welding operations were being performed in well-ventilated workshops by multi-skilled employees. None of these workers welded for more than 25% of the working time. Most of the welding operations involved Manual Metal Arc welding on mild steel base metal. As far as total fumes are concerned, the exposure of only 3 welders (from 16) exceeded the occupational exposure limit for total welding fume of 5mg/m3.

In general welders were not aware of the health hazards of welding. The experience level of the welders was highly variable and it was striking to note the poor welding techniques of even those welders who claimed adequate prior experience and training.
UV radiation measurements taken during arc welding indicated that the exposure time to reach the TLV for UV radiation incident upon the unprotected skin and eye will be of the order of 10 seconds or less.

CONCLUSION:

The observations made indicate that welding in the mining operations researched is largely being performed in well-ventilated workshops. The majority of the welding is Manual Metal Arc Welding of mild steel. The welders perform welding operations for a maximum of only 25% of the workday.

Of all the operations observed, none of the respiratory protective equipment were being worn. The use of maximum current, to perform the weld more quickly was the normal welding method used. Training on the health and safety aspects of welding is essential for all welders. Only experienced welders should weld hardfacing steels.

The present occupational exposure limit of 5mg/m3 for total welding fume is for use with mild steel welding. Where constituents in the fume are of concern then fume analysis is required e.g. in stainless steel welding (chromium and nickel present in the fume) and galvanised steel welding (zinc and lead present in the fume). Unprotected persons working close to a welder may be overexposed to UV radiation in a short period of time. Appropriate eye and skin protection must be provided to such persons.

Limitations:
The researchers in this study did not include welding in poor ventilated areas / confined areas.

19. RESPIRATORY HEALTH OF SOUTH AFRICAN COAL MINERS IN MPUMULANGA PROVINCE, EXPOSED TO RESPIRABLE COALMINE

By Naidoo R., Robins T., Seixas N., University of Natal and University of Michigan (USA), Ref: Health, 2002

SUMMARY:

The respiratory health effects of coaldust exposure have been well documented in the international literature. The relationship of coal dust exposure to outcomes such as emphysema or significant declines in lung function in the absence of CWP remains controversial. There are no previously published studies investigating the respiratory health of coal miners in South Africa. The current study was designed to investigate whether such dust related health problems present among South African coal miners.

The specific objectives of the study included:

- Estimating the prevalence of coal worker's pneumoconiosis (CWP), reduced levels of pulmonary function, and chronic obstructive lung disease (emphysema and chronic bronchitis) among living and deceased South African coal miners;
- Investigating dose response relationships between these health endpoints and respirable coal dust, controlling for potential confounders such as cigarette smoking; and
- Developing a set of evidence-based recommendations for the South African coal mining industry to address any risk for workrelated adverse respiratory effects.

Parallel assessments of living and deceased coalminers were conducted. A review was conducted of all coalminer autopsies performed by the National Centre for Occupational Health between 1975 and 1997 and captured on a computer database known as PATHAUT. A validation study by 3 pathologists verified the findings in the PATHAUT database. Of the 5714 cases that were eligible for analysis, 3176 (40.93%) had exclusive coal exposure.

The assessment of the living workers was conducted on a sample of miners (including both active miners and those who had left the industry), who had been employed for at least one year in underground mining between the years 1985 and 1998 in one of three mines in Mpumalanga owned by the participating mining corporation.

A total of 896 workers participated in the study, of whom 212 were ex-miners and 684 were currently employed. Associations were investigated between measures of exposure and respiratory outcomes, based on questionnaires, lung function testing (spirometry) and chest radiographs.

Exposure estimations were derived through the use of historic dust sampling data together with dust samples collected by the research team in each of the mining operations. Cumulative exposure to respirable dust was estimated for participating miners through a combination of these historical and current exposure samples, written work histories, miner interviews and other record review.

Although the study found an overall moderate to low prevalence of coaldust related diseases among the study population, important dust related findings in declines of lung function were observed. The analyses also suggested that a "healthy worker survivor effect" and a "healthy smoker effect" may have blunted the observed dose response relationship.

Some of the specific key findings were:

- On autopsy, amongst those exclusively exposed to coal, the prevalence of CWP and silicosis was 6.95% and 10.22% respectively, and moderate to marked emphysema 6.45%.
- Chronic bronchitis symptoms were reported in 11.30% of the worker sample. 2.93% of workers reported having had previous TB. Ex miners reported significantly more symptoms than current miners. Prevalence of symptoms decreased with increasing cumulative lifetime dust exposure. An increase in prevalence is noted when only ex-miners are assessed.
- Better lung function outcomes were seen in current miners compared to the ex-miners and in underground workers compared to surface workers.

Current smokers had better lung function than ex-smokers, with no difference seen between current and never smokers. These findings suggest both a "healthy worker effect" and "healthy smoker effect" present in the data.

- The effect of coal dust exposure on declines in lung function was equivalent to a loss of five years of breathing capacity over a lifetime of employment. This was irrespective of the age of the coalminer, his smoking status or past history of TB. For a 40 year old, 170cm tall man, dust exposure alone has an effect of a 1.33ml loss in FEV1 per year per mg/m3 dust exposure. Over a 30 year working life period, such a coalminer has the effective breathing capacity of a non exposed worker five years older. Smoking contributed a marginally bigger loss of lung function amongst the miners.
- The prevalence of pneumoconiosis diagnosed by chest x-rays was 2.59%. Pneumoconiosis prevalence increased with increasing cumulative exposure. Lung function was worse for those with higher grades of pneumoconiosis.
- Autopsy diagnoses of TB was present in 5.21%, CWP: 7.37%, silicosis: 10.86%, significant emphysema: 6.45% (all emphysema: 31.33%), cancer 2.24%, among those with exclusive coal exposure. All outcomes, except TB, showed an increasing trend with increasing years of exposure. A miner in the higher exposure category had a 15 times greater chance of developing emphysema compared to a worker in a lower exposure category, adjusted for the effects of smoking.
- Smoking was associated with TB, silicosis, emphysema and cancer, with higher prevalence in ex smokers compared to current smokers. Smokers were three times as likely to have emphysema as never smokers, a risk lower than that related to coal dust exposure status.
- There was a 5.68 greater odds of silicosis amongst those with high exposure compared to low exposure. While controlling for smoking, the highest exposed workers had a 9.59 increased odds for developing significant emphysema. When controlling for dust exposure, current smokers had a 3.60 increased odds of developing significant emphysema compared to never smokers.

CONCLUSION:

Under currently prevailing conditions in the South African coalmining industry, dust exposures contribute to the development of respiratory disease. The contribution of smoking to these outcomes appears to be roughly of comparable magnitude to dust.

Recommendations:

Given the evidence of dust-related adverse health effects in this study, the following key recommendations appear warranted :

- Substantially increased engineering controls designed to minimise exposure.
- Statutory occupational exposure limits for exposure to respirable dust should be enforced to aid progressive reduction.
- Education campaigns for miners emphasising the hazards of exposure to respirable coal dust and the importance of:
- cessation of smoking for those with such exposures.
- Rigorous respiratory medical surveillance programmes, as per the Mine Health and Safety Act, are instituted and maintained.
- Review of the dust sampling strategies employed on the mines.
- Further research investigation of the healthy worker and healthy smoker effects that may be influencing the data.

20. THE OCCURRENCE OF HAND ARM VIBRATION SYNDROME IN SOUTH AFRICAN GOLD MINES AND IDENTIFICATION OF THE POTENTIAL EFFECTS OF WHOLE BODY VIBRATION

By Nyantumbu B., Dr Phillips J.L., Dr Dias B., Dr Kgalamono S., Dr Curran A., Dr Barber C., Dr Fishwick D., Ms Allan L., National Center for Occupational Health, South Africa; Health and Safety Laboratory, United Kingdom, Ref: Health 703, 2002

SUMMARY:

Introduction: Hand Arm Vibration Syndrome (HAVS) is caused by regular exposure to vibrating hand tools. The condition was first reported in 1911 in mineworkers. HAVS has been described in the mining industry of many countries. As HAVS affects the hands, the performance of daily activities including work becomes difficult. In South Africa (SA) no cases of HAVS have been reported despite the use of rock drills in the mining industry for nearly a century. SIMRAC Gen 503 reported high levels of vibration from rock drills used in the SA mining industry, raising the suspicion that HAVS may be occurring but is not being recognized.

The objectives of the study were to:

- To determine the prevalence of HAVS in gold miners.
- To assess the severity of HAVS.
- To identify vibrating hand tools associated with HAVS.
- To build sustainable capacity in SA for the diagnosis of HAVS.

A cross-sectional study of 311 randomly selected mineworkers was conducted. They underwent clinical assessment for HAVS. Fifteen mineworkers were excluded. The results were based on 296 mineworkers comprising 156 subjects with occupational exposure to vibration and 140 controls with no occupational exposure. RESULTS: A prevalence of 15% was found in the subjects. Eight percent had neurological and vascular symptoms, 5% had neurological and 2% had vascular symptoms. Five percent of controls had signs and symptoms that mimic HAVS.

CONCLUSION:

HAVS occurs in SA gold miners. The prevalence and severity were low. HAVS was associated with operating rock drills. The study has achieved a successful technology transfer and built a sustainable capacity to diagnose HAVS in SA.

21. TWO PHASE LONGITUDINAL OR PROSPECTIVE STUDY OF THE NERVOUS SYSTEM EFFECTS OF OCCUPATIONAL ENVIRONMENTAL MANGANESE EXPOSURE ON MINEWORKERS OR PROCESSING PLANT WORKERS AT TWO MANGANESE MINES IN THE NORTHERN CAPE PROVINCE

By Prof. Myers J., Dr te Water Naude J.M., Dr Abie Zogoe H.B., Prof. Thompson M.L., Dr Hotazel F.M., Naik I., Theodorou P., Daya M., Tassell P., Occupational and Environmental Health Research Unit (OEHRU), School of Public Health and Primary Health Care, University of Cape Town, AFROHC, National Centre for Occupational Health, Department of Biostatistics - University of Washington, USA., Ref: HEALTH 71, 2002

SUMMARY:

Occupational exposure to airborne manganese dust has been shown to produce adverse effects on the central nervous system. Concerns have also been expressed about very low level environmental exposures to Manganese resulting in revisions of both occupational and environmental recommended exposure limits.

A study was conducted amongst manganese mine employees (both white and blue collar) at two towns in the Northern Cape Province to investigate the nervous system effects of medium to low occupational manganese exposures with a view to shedding light on the potential neurotoxic effects of environmental exposures. A cross-sectional study was conducted as a phase 1 baseline of a potential longitudinal study examining the relationship between manganese exposure and nervous system outcomes. There were two mining companies (A & B). The different facilities included four underground mines with surface processing plants, one surface sinter plant and two residential/office locations.

Some 800 employees were examined during 2000/2001, 311 from Company B and 489 from Company A.

Exposures to manganese were to have been obtained by means of an independent occupational hygiene survey, but this proved to be very expensive and on exploration of the records of mandatory routine occupational hygiene measurements of dust and manganese in these facilities, it turned out that there was a rich source of occupational hygiene data already in existence. Occupational hygienists on the research team advised use of the routine data instead of embarking anew on an independent survey. Data were usable from 1995 when the GME required sampling of total as opposed to respirable dust in Company A.

Company B had a different arrangement with the GME whereby they were measuring respirable dust for "risk workers" and total dust for others. "Risk" or underground workers did not have a manganese concentration determined. Although this situation was rectified in 2001 via the GME it was not possible by the end of the study to accumulate sufficient dust data points to recover any meaningful exposure index for Company B and consequently only Company A exposure data and indices derived from these were used.

The workers were subjected to a brief physical examination, and tests from three neurobehavioural test batteries (SPES, WHO NCTB, LURIA-NEBRASKA) were performed. Blood samples were taken for manganese content. Findings of a similar study of more highly exposed workers in a South African manganese smelter indicated that a large proportion of the tests that had originally been planned were non-contributory, and this allowed substantial reduction of the number of test items performed.

Standard laboratory procedures and methods (NIOSH) were used for dust and manganese measurement. STATA version 6 was used, specifically multiple linear regression for continuous variable outcomes and multiple logistic regression for dichotomous outcomes.

Rural manganese miners, who were exposed overall at the ACGIH TLV for manganese, had lower levels of

formal education and smoked and drank less. Blood manganese mean levels (8.7 SD = 7.3) at were intermediate between unexposed referents (6.4 SD = 1.7) and the smelter workers (12.5 SD= 5.6), and closer to the unexposed referents.

There was no association between blood manganese levels and dust exposure levels. No obvious clinical abnormalities consistent with clinical manganism were detected.

Multivariate analyses showed that no outcome (symptom, clinical sign, neurobehavioural test) was associated with any measure of exposure including blood Manganese.

The absence of findings is not likely to be caused by problems of test validity as educational level and age which are known to be consistent predictors were found to determine test results.

The validation study shows that the IOM head reads systematically higher than the GME head for dust collection, and as the dust concentration increases the systematic difference increases, with poor overall reliability. The GME head has good reliability. Laboratory A produced systematically higher results than laboratory B with good reliability.

The absence of nervous system effects indicates that there is unlikely to be a subclinical neurotoxicity problem at exposure levels near the ACGIH TLV in these manganese miners, despite some underestimation of exposures.

CONCLUSION:

Results are consistent with the smelter study which similarly found no convincing effects at exposure levels on average 4 times higher, ranging as high as 5mg/m3 for certain groups.

Recommendations:
We recommend that there is no need for screening programmes for early effects of manganese neurotoxicity, and also therefore no point in proceeding to the next phase of the study as originally envisaged or intended rather than of the things.

There is, however, need for occupational hygiene surveillance to be rationalized and put on a more rational and less wasteful footing and to be geared to prevention by easily yielding information that could be integrated with medical surveillance programmes. With regard to the latter a simple medical screening process developed from the smelter study could be introduced for suspect cases of clinical manganism.

22. ANALYSIS OF EMERGENCY CARE PROVIDED FOR INJURED MINERS IN THE SOUTH AFRICAN MINING INDUSTRY, AND RECOMMENDATIONS FOR THE PROVISION OF EMERGENCY CARE

By Moorman J., Paolini A., Buchan K., Academy of Emergency and Critical Care , Ref: HEALTH 801, 2002

SUMMARY:

A literature review of emergency medical and trauma care services identifies time as the most critical factor affecting the outcome of severely injured patients. In the mining industry, delays in access to definitive care are often unavoidable due to the remoteness of many mining operations and working places. In geographically isolated areas, the quality of pre-hospital care and the management of the emergency care system are equally important.

The primary aim of this project was to assess and make recommendations on the provision of a comprehensive emergency medical service in the South African mining industry to ensure that all the required systems are in place to deliver a skilled emergency response to all incidents. In turn, this will increase the number of survivors and miners who return to work. A detailed review of the emergency medical care services in the mining industry in Canada, Australia and the United States was conducted.

The provision of emergency care is seen as an integral part of occupational health and safety services. There is a shift from providing prescriptive standards to a process of risk assessment and the provision of services that are pertinent to each mining operation. There is also an increasing emphasis on the monitoring and evaluation of services through a process of self-evaluation, the use of positive performance indicators and audit. The use of inspections and review by authorities remains important in ensuring compliance with legislation.

An audit was undertaken of the emergency care services provided in the South African mining industry. The methodology involved a combination of interviews with key stakeholders in the mining industry, visits to selected mines and the administration of a telephone questionnaire.

The results showed that the emergency services available on the mines vary enormously from highly sophisticated outsourced services to almost no service at all. Overall, there is a sense that emergency services are less than optimal and that delay in injured miners receiving appropriate care is contributing to fatalities and severe injuries. Areas of particular concern are the adequacy of first aid training of miners, both in terms of the content and method of training, the adequacy of the ambulances used by some mining operations and the fact that few occupational health staff have any trauma training at all.

In some instances, severely injured miners are transported long distances accompanied by persons with no trauma qualifications. Other concerns relate to coordination and management of emergency medical care and the general lack of adequate monitoring and evaluation of the system.

CONCLUSION:

This project has highlighted the need for further research in this area. The fatality and injury statistics published for the year 2001 and the first six months of 2002 show an increase in the fatality and injury rates. Although this clearly cannot be attributed to a poor emergency response, the lack of evaluation of the current system does not lend itself to assuring the mining industry that the emergency response to incidents is optimal.

Recommendations:
The following recommendations are made for the provision of emergency care in the mining industry.

- Management and coordination of both first aid training and the emergency care services should be the responsibility of the same person and preferably under some medical direction. Occupational health practitioners should play this important role.

- Health care workers and miners should be appropriately trained to provide an optimal emergency response.
- Health care workers, including occupational health practitioners, should receive training in the management of trauma, such as the Basic Trauma Life Support course.
- All miners should receive some first aid training but there should be a hierarchy of training. All miners should receive basic first aid training. One in fifty employees should receive intermediate first aid training. One in two hundred employees should undergo advanced first aid training and one in five hundred employees should become mining emergency care assistants. Recommendations are also made for training content.
- The first aid equipment should be reviewed and should be in line with the training provided.
- Monitoring and evaluation of the system are essential and recommendations are made for both national and mine levels. Evaluation will require the collection of relevant data to assess emergency response and to identify areas of weakness and concern.

The recommendations have financial implications for mines, and for smaller mining operations, the costs may be substantial. However, innovative ways should be investigated to provide services and co-operating with other mining operations, the private sector and government services for regional service provision.

23. DEVELOPMENT OF PERCENTILE CHARTS FOR SEMI-QUANTITATIVE TRACKING OF LUNG FUNCTIONS OVER TIME IN THE SOUTH AFRICAN MINING INDUSTRY

By Prof. Myers J., Dr te Water Naude J.M., Prof. Thompson M.L., Prof. White N., Occupational and Environmental, Health Research Unit (OEHRU), School of Public Health and Primary, Health Care, University of Cape Town, Department of Biostatistics-University of Washington, USA., Ref: HEALTH 805, 2002

SUMMARY:

HEALTH 610, entitled “Development of lung function reference tables suitable for use in the South African mining industry”, made far-reaching recommendations pertinent to the practice of spirometric surveillance in SA mines. It recommended inter alia that the optimally valid reference equations it identified be used and be operationally implemented. Health 805 was envisaged as a first step towards achieving better spirometric practice in the mining industry.

The principal aim was the development of percentile charts for semi-quantitative tracking of lung functions over time. It was intended to optimise medical surveillance by graphing successive spirometric measurements. Optimisation would take place in two ways: maximal use of existing historical lung function data for a particular worker, and early identification of lung function loss by examination of the graphical trajectory over time. Three innovative computer-based products were developed for use in small (tens of workers), medium (hundreds of workers) and large (thousands of workers) mines, respectively. SpiroCharter was developed for small mines for hardcopy use, although generated by computer.

The other products are computer-based: SpiroTracker for medium mines was developed in Microsoft Excel, and SpiroAccess for large mines is under development in Microsoft Access.

Development methods for the products are outlined, including discussion of iterative methods, development of algorithms for calculating expected values, and change in these values. The utility of the underlying equations and algorithms was examined both conceptually and operationally. The products were piloted in appropriate mining facilities across the country. The products are then illustrated, and are also attached to this report in CD-ROM format.

Intellectual property considerations are yet to be fully sorted out. SpiroCharter is easily copyrighted. SpiroTracker has proved impossible to protect due to the nature of the Excel program. SpiroAccess is still under development and the programming requires

finalisation as well as copy protection, which is feasible for Access programs.

The project took an unexpected direction in that what was originally intended as a chart-based tracking system developed into a multi-level computer-based set of products. This developmental work, which included piloting and iterative feedback from potential end-users took up most of the time allotted. However, the main aim of the project has been achieved with the production of SpiroCharter, which is available for immediate use and is submitted in both hardcopy and electronic format in this report. Subject to intellectual property concerns, SpiroTracker is similarly available, while SpiroAccess requires some additional development.

CONCLUSION:

What remains to be done includes marketing of the products and training in product use within the mining industry.

It is hoped that these products will contribute towards an improved surveillance culture on the mines. It is intended that these products be accessible and affordable to operate. Improved surveillance in the final analysis will depend on the will of mine management to engage in meaningful and effective monitoring of occupational hazards and the health of mineworkers. Specifically, this will depend on making full use of all available occupational hygiene and medical data.

24. TECHNOLOGY TRANSFER OF SIMRAC PROJECT HEALTH 611 TO ENHANCE CLINICAL PERFORMANCE: PROCESS-BASED PERFORMANCE REVIEW FOR THE DIAGNOSIS OF PULMONARY TUBERCULOSIS

By Dr Murray J., Dr Wong M., Dr Hopley M., Prof. Lowe P., NCOH , Ref: Health 611, 2002

SUMMARY:

The purpose of this project was to identify, produce and distribute appropriate material to facilitate implementation of best practice with regards to TB in the mining industry. Although improvement in knowledge is essential, a structured, constructive and ongoing evaluation of health care workers' clinical performance is crucial to the success of the TB program. Feedback based on autopsy findings in individual patients is an invaluable resource. Although primarily focussed on TB, the process of performance based review will also contribute to improved clinical practice related to other diseases, particularly respiratory conditions related to HIV infection.

The results of this study, although not unique to the mining industry, indicated a need to provide the health care workers with an effective means of developing successful practice habits to improve clinical performance.

This project has developed innovative methods and technology to meet the needs of the end-users (doctors as well as allied health care workers such as nurses and laboratory technologists). A review of the literature identified process based performance review, undertaken by clinicians' themselves, to be one of the most effective ways of developing successful practice habits. Process based performance review involves the identification of clinically important actions that ought to have been carried out in a particular condition, followed by a periodic review of whether these actions have actually been carried out.

A single page flow sheet for review of medical records together with knowledge of the autopsy findings was produced. The flow sheet format was chosen because this provides an efficient mechanism for constructive evaluation of clinical actions and has actually been shown to change clinicians' behaviour. The flow sheet identifies essential components in the history, physical examination and investigation for TB. The literature pertaining to these topics was reviewed and concise one page topic summaries prepared to accompany the flow sheet.

The process of performance based process review as developed by this project is sustainable and participation is incentive driven through the mechanism of continuing professional development points, which are a legal requirement for ongoing registration with the Health Professions Council of South Africa.

CONCLUSION:

The products (a manual in paper format and a CD version of the performance review process, four posters and a bookmark) were piloted with doctors from the gold, coal and platinum industries and from small and large medical centres. They have been distributed and enthusiastically welcomed by the end-users.

Recommendations:

- Process based performance review should be an ongoing process at the mine health care centres
- The reviews should be monitored and evaluated to assess their impact
- The topic summaries should be updated as new information is published

25. A PILOT STUDY TO ASSESS THE HEAT TOLERANCE OF FEMALE MINERS

By Schutte P.C., Kielblock A.J., de Villiers D.B., Dias B., CSIR Mining Technology, Ref: HEALTH 817

SUMMARY:

It is generally believed that, under conditions of high ambient temperature, thermoregulation in women is 'less efficient' than in men. Furthermore, individual characteristics of males and females can have a significant influence on the responses to physical work at high environmental thermal loads. A fundamental question that remains is whether any of the differences in thermoregulatory capacity are of a magnitude that would justify discrimination on the basis of gender. The current pilot study was commissioned by SIMRAC in order to respond to this question.

The heat tolerance of a group of 27 female mineworkers and a group of 17 male mineworkers, who acted as controls, was assessed by means of Heat Tolerance Screening (HTS). The analysis of the data was aimed at comparing the physical characteristics and oral temperature responses of the female mineworkers who had passed the HTS with those of the female mineworkers who had failed the test, as well as with those of the male control group. Regression analysis was used to examine the relationship between the oral temperature responses during the HTS and variables consisting of the physical and physiological features measured prior to the HTS.

Information from participating Heat Tolerance Screeneing centres indicated that the failure rate of female mineworkers is not as high as initial test results had suggested. Based on current statistics, approximately 4% of the females tested failed the HTS. The corresponding figure for male mineworkers ranges between 0,5% and 4%.

The results highlighted the importance of individual anthropometric characteristics in the response to heat stress. Factors such as body mass, BMI, body surface area and body surface area to mass ratio played an important role in the outcome of heat tolerance screening procedures. These factors are interlinked. Physical work capacity (aerobic capacity) is also a key factor in determining individual heat tolerance.

In terms of existing recommendations and standards (Department of Minerals and Energy), all employees who work under "conditions conducive to heat stroke" should be screened for gross or permanent heat intolerance by means of the HTS procedure. Based on the findings of the present study, there is no fundamental reason why such a requirement should not be extended to female mineworkers destined to work under similar conditions. Current recommendations regarding the assessment of overall fitness for work in heat should be followed without exception, especially those dealing with individuals who fail the heat tolerance screening test.

Within the context of recruiting a labour force to undertake physically demanding work in hot

environments, gender matching is irrelevant. The reason is that health risk is defined irrespective of gender. Concessions for gender or any other physical or physiological feature, for example age, work capacity or BMI, are therefore entirely inappropriate: to make allowances, especially for gender, by imposing less stringent HTS to achieve better pass rates would simply reduce the health risk assessment to a meaningless level.

The introduction of a screening procedure to determine physical work capacity (aerobic capacity) should be considered as part of the assessment of overall fitness for work in heat. Information obtained during such a procedure could form part of a "risk profile" for any employee destined to enter "hot" working environments in the execution of his or her duties and responsibilities. The above information could, in turn, be used to devise proactive risk management strategies.

In view of their smaller physical work capacity (aerobic capacity) and physical strength, female mineworkers may experience undue physiological strain when performing "strenuous" tasks while working underground. Since no information is currently available on the physiological strain experienced by female mineworkers, it is recommended that this aspect be investigated and the results obtained be compared to those obtained for male mineworkers involved in similar tasks. In addition, if the recruitment of female labour is regarded as important, the development of realistic work-hardening programmes seems to be a logical, if not crucial, subject for further research.

As a second phase of the study the body temperature responses of a group of female mineworkers using the standard block-stepping routine during the HTS were compared with their corresponding responses while using stationary bicycle ergometers during the HTS. In the comparison of these exercise modes, the hypothesis that there was no statistically significant difference between the oral temperature responses of subjects using block stepping and those of subjects using the bicycle was tested.

The results obtained from the comparison of the two modes of exercise employed to provide the physical work component during the HTS procedure showed that the mean increase in body temperature does not differ significantly for the two modes. However, there seems to be a tendency for the increase to be higher for block stepping than for cycling. This would need to be further investigated as it may be due solely to chance in view of the small sample size used.

CONCLUSION:

In view of these research results, it is recommended that the block stepping routine currently used remain part of the HTS and that bicycle ergometers be used only in exceptional cases, and only when recommended by a medical practitioner. Persons using the latter mode of exercise during the HTS should be closely monitored on an individual basis to ensure that the required work rate is maintained for the full duration of the HTS.

26. Body Cooling Systems

By Schutte C., de Klerk C. and Matesa J., CSIR Mining Technology , Ref: SIM 020702, 2002

SUMMARY:

The project reviewed body-cooling garments commercially available in South Africa, with reference to design, principle of operation, functional performance, and their potential for practical application in the South African mining industry. Current research and development activities in the field of personal bodycooling systems, locally and internationally, were also covered.

27. A RANDOMIZED CONTROLLED STUDY OF THE EFFECTIVENESS OF ANNUAL AND 6-MONTHLY SCREENING WITH MASS MINIATURE RADIOGRAPHY (MMR) FOR THE ACTIVE CASE-FINDING OF CARDIOPULMONARY TB PATIENTS

By Prof. Churchyard G.J., Dr Roux S., Sr Mahlatsi N., Mosenogi P., Khotle L., Dr Grant A.D., Dr Fielding K., Dr Corbett E.L., Prof. Hayes R., Prof. Chaisson R., Aurum Health Research Orkney RSA, London School of Hygiene and Tropical Medicine London UK, Johns Hopkins University, Ref: Gen 524, 2003

SUMMARY:

Despite an expanded tuberculosis (TB) control programme, TB case rates in the gold mining industry have risen progressively during the 1990s to levels of over 3,000 per 100,000 men per year. Deaths while on TB treatment now account for twice as many deaths among gold miners each year as deaths from mine accidents. The increase in TB case and fatality rates among South African gold miners corresponds with the evolving HIV epidemic.

The mining industry has used a radiological screening programme (RSP) to screen for pneumoconioses and mycobacterial diseases for decades. In a gold mining workforce, in the Free State Province, the proportion of TB cases detected by the RSP declined from 77% in 1990 to 49% in 1996. Although radiological screening has been used for decades, the efficacy of the RSP has never been formally evaluated. Both 6-monthly and annual radiological screening have been used in different companies and no data were available as to which approach was the more effective, particularly with an emerging HIV epidemic in the workforce.

The aim of the study is to determine the effectiveness of 6-monthly compared to annual radiological screening.

The design of the study was a randomised controlled trial. Study participants were individually randomised into one of two arms comparing 6-monthly (intervention arm) with annual screening (control arm) over a period of two years conducted at a single gold mining company in the Free State Province of South Africa.

The results showed that a total of 10997 and 11015 miners in the intervention and control arms respectively.

Almost a third of miners were lost to follow up, largely due to retrenchments. The two groups were similar with respect to median age, occupational group, duration of follow up and proportion lost to follow up and reason for loss to follow up.

The proportion of TB cases detected by the RSP was similar in the control and intervention arms (28% and 29% respectively, p=0.67). The proportion of sputum culture positive pulmonary TB cases, detected by the RSP or self presentation, that were smear negative did not differ significantly between the control or intervention arms (16% and 14% respectively, p=0.56).

The prevalence of TB detected through the RSP was not significantly different between the intervention and control arms at the time of the final annual screening radiograph (0.65% [46/7075] and 0.91% [65/7111] respectively, p=0.07). TB incidence was similar in the control and intervention arms (2.72 and 2.90 per 100 person years respectively, p=0.3).

The mortality rate during the first two months of TB treatment was significantly lower in the intervention arm compared to the control arm (10.1 and 22.5 per 100 person years respectively, unadjusted hazard ratio 0.45 [0.22 – 0.92], p=0.024) (Figure). The mortality rate, from TB diagnosis to end of follow up, was significantly reduced in the intervention arm compared to the control arm (Control arm: 19.0 per 100 person years and Intervention arm: 14 per 100 person years, unadjusted hazard ratio 0.73 [95% CI 0.55 – 0.97], p=0.03).

TB cases in the intervention arm, compared to the control arm, had less extensive radiological disease (based on zone score) at diagnosis (p=0.05), but not at the end of TB treatment (p=0.7).

CONCLUSION:

The large individually randomised study, comparing radiological screening once a year to twice a year, has failed to demonstrate a significant difference in the proportion of TB cases detected by the intensified RSP, but did demonstrate a significant reduction in the mortality rate during the first two months of TB treatment.

Although the proportion of TB cases detected by the radiological screening programme has decreased over the past decade in parallel with the increasing HIV epidemic, a sizeable proportion of TB continues to be detected by the RSP. Companies doing 6-monthly radiological screening should continue to do so and those using annual radiological screening should consider the cost benefit of deaths averted by doing 6monthly radiological screening. Intensification of the active case-finding programme through the use of a screening tool with a high sensitivity, such as sputum cultures, warrants further investigation.

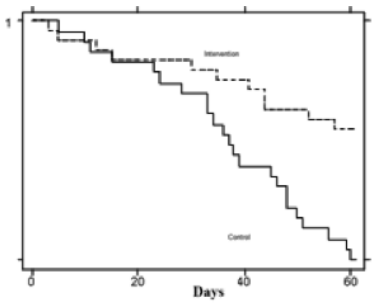


Figure 1: Survival estimates during the first 2 months of TB treatment

28. SILICOSIS PREVALENCE AND EXPOSURE RESPONSE RELATIONSHIPS IN OLDER BLACK MINEWORKERS ON A SOUTH AFRICAN GOLDMINE

By Dr Churchyard G., Dr Pemba L., Sr Magadla B., Dekker K., Vermeijs M., Prof. Ehrlich R., Prof. Myers J., Dr te Water Naude J., Prof. White N., Aurum Health Research, Welkom; Occupational Hygiene, Anglogold, South Africa; Occupational and Environmental Health Research Unit, School of Public Health and Family Medicine, University of Cape Town; Respiratory Unit, Department of Medicine, University of Cape Town, Ref: HEALTH 606, 2003

SUMMARY:

The study aimed to measure the prevalence of silicosis among older black goldminers on a South African goldmine and to investigate the exposure response relationship with silica dust exposure.

520 black goldminers over 38 years of age were interviewed and had chest radiographs taken. Silicosis was defined as International Labour Organisation (ILO) Classification profusion of 1/1 or greater. Cumulative exposure was calculated for each individual using TWA dust concentrations from

two sources: personal sampling of a separate group of 112 workers and a database of routine surveillance measurements. Quartz fractions were measured by x-ray diffraction. The 85 different occupations in the sample studied were reduced to 24 occupational categories by grouping occupations with similar exposures in a job exposure matrix.

The mean length of service was 21.8 years (range: 6.3 – 34.5), the (mean) average intensity of dust exposure 0.37 mg/m3 (range: 0 - 0.70) and of quartz exposure 0.053 mg/m3 (range: 0 – 0.095).

Among the 520 miners examined, the prevalence of silicosis (reader 1) was 18.3 percent [95% confidence interval (CI) 15.0 – 21.9].

CONCLUSION:

Significant trends were found between all of the exposure variables and the prevalence of silicosis, the strongest being for cumulative quartz exposure (odds ratio 3.2, 95% C.I 1.9 – 5.4) or each 1 mg-year/m3 increment across a range from 1 to 3 mg-years/m3. Weaker but significant trends were observed for average intensity of quartz and respirable dust. Only one case of silicosis was found in the group with 15 years or less of service.

29. A PROSPECTIVE STUDY TO ASSESS THE PREVALENCE AND WORK-RELATED RISK FACTORS IN THE DEVELOPMENT OF MUSCULOSKELETAL DISORDERS IN THE SOUTH AFRICAN MINING INDUSTRY

By Schutte PC, Dias B, Smith AJB and Shaba MN, CSIR Mining Technology , Ref: Health 702, 2003

SUMMARY:

The objective of the study was to assess the prevalence of work-related musculoskeletal disorders (WMSD) in the South African mining industry and to identify work-related factors that may pose a risk of WMSD developing. Aspects covered in the project report include the findings of a literature review dealing with WMSD; the results of a retrospective record review of WMSD; the results of a prospective study to determine the prevalence of WMSD; the identification of work categories and tasks that pose a risk of WMSD; and, finally, recommendations for controlling or reducing the risk of WMSD. Three mines were used as project mines: one gold mine, one platinum mine and a colliery.

The platinum mine had the highest WMSD prevalence rate (3,4-18,2%), followed by the colliery (7,4-8,4%) and then the gold mine (2,1-5,2%). From the results obtained in the study, there is evidence of different musculoskeletal presentations at the different mines. At the gold mine backache is by far the most common presenting musculoskeletal complaint (82,1%).

At the platinum mine and the colliery the corresponding figures were 37,8 0% and 66,2% respectively. Back complaints at the gold mine were followed by complaints of pain in the hip region (5,5%) and the foot region (4,6%).

At the platinum mine the second highest number of complaints was for knee pain (17,%), followed by ankle pain (9,%) and neck pain (9,1%). At the colliery neck pain (13,5%) and foot pain (8,1%) were also common presentations.

CONCLUSION:

The results of the ergonomics assessments conducted indicated that many of the known musculoskeletal injury risk factors, usually in combination, are associated with the typical mining tasks. Risks factors identified included awkward body posture, manual material handling, repetitive motions, force and vibration. Of these, working in an awkward posture and manual material handling are considered to be the major risk factors.

30. FEASIBILITY OF USING OTO-ACOUSTIC EMISSION METHODS FOR SCREENING EARLY HEARING IMPAIRMENT IN SOUTH AFRICAN MINEWORKERS

By De Koker, Clark, Franz and Mackay, The Hearing Centre, Ref: Health 802, 2003

SUMMARY:

Health 802 investigated the possible use of otoacoustic emission (OAE) testing for the presymptomatic diagnosis of inner ear damage and identification of individuals who are particularly susceptible to NIHL, to better enable preventive interventions. Prevention should be regarded as the only cogent means of combating NIHL, since it is sensory-neural in nature and, hence, irreversible.

Results indicated that oto-acoustic emission testing is far more sensitive than conventional audiometry and, therefore, offers a more prospective means of identifying NIHL-susceptible individuals and presymptomatic inner ear damage in noise-exposed workers. The latter was found to be prevalent among subjects in the study group (25 per cent according to DP tests, and 96 per cent according to TE tests) and, to a lesser extent, among normative subjects despite their relative youth and lack of occupational exposure to noise.

CONCLUSION:

An important conclusion of this study is that many if not most noise-exposed workers with normal audiometric results, in all likelihood, already have cochlear damage. The sensitivity and repeatability demonstrated for DPOAE methods indicate their potential usefulness in identifying such damage before it progresses to the point of functional or compensable hearing loss.

Recommendations:
Recommendations are made for the implementation of DPOAE screening tests for prospective employees to identify NIHL-susceptible individuals and prevent their exposure to hazardous noise. In view of the fact that a DP screening test requires only 30 seconds and can be performed by a trained audiometrist, it is also recommended that once the instrumentation is in place for preemployment evaluations, DPOAE testing be routinely applied to noise-exposed workers at the time of periodic screening audiometry, along with DP diagnostic testing and case management interventions for employees with abnormal DP screening results.

An investigation of current implementation costs for OAE testing found that instrumentation for DP screening would require a capital investment of between R 40 000 and R 100 000, depending on the choice of instrument and available options. This excludes costs for a test booth and dedicated computer (both of which may already be in place), construction of a test room (where none is available), and annual instrument calibration, which would be on a par with conventional audiometers.

31. DEVELOPMENT AND EVALUATION OF GUIDELINES AND MATERIALS FOR THE TECHNOLOGY TRANSFER OF X-RAY READING SKILLS TO MEDICAL PRACTITIONERS IN THE MINING INDUSTRY

By Prof. White N., University of Cape Town Lung Institute, Occupational Medicine Clinical Research Unit, Ref: Health 803, 2003

SUMMARY:

Health 803 was a project concerned with the development of self-directed, interactive distance learning materials for health practitioners who are concerned with Radiological Occupation Lung Disease Surveillance (ROLDS) in the South African mining industry. Augmentation of proficiency in ROLDS is essential to the implementation of forthcoming regulations concerned with this matter in terms of the Mine Health and Safety Act.

The project has developed a CD-Rom based interactive program with visual and audio components, including a simulation of ROLDS and compared the performance of practitioners using the product alone with those receiving the product and contact training. This product was proven successful, particularly in the screening component of ROLDS.

It is available to health practitioners to earn CPD accreditation and is being refined to circumvent some of the quality limitations experienced in the first version. Although mainly concerned with radiology of gold and coal miners, this program will be further developed to include asbestos related diseases. Further developments will facilitate the use of, and broaden the scope of this interactive product.

The CD-Rom is available through SIMRAC for heath practitioners performing ROLDS in the South African mining industry. It is highly recommended for current surveillance readers in the industry as a means of earning ROLDS CPD points and will be particularly appreciated by newcomers to the field. Outside of the mining industry, this product will be distributed by UCT Lung Institute, Occupational Medical Clinical Research Unit, PO Box 34560, Groote Schuur 7937, tel. 021-4066850, fax 021-4066851 email (Professor White) nwhite@uctgsh1.uct.ac.za.

32. REVIEW OF OCCUPATIONAL HEALTH SERVICE PROVIDED IN THE SMALL AND MEDIUM CLAY MINING INDUSTRIES IN SOUTH AFRICA

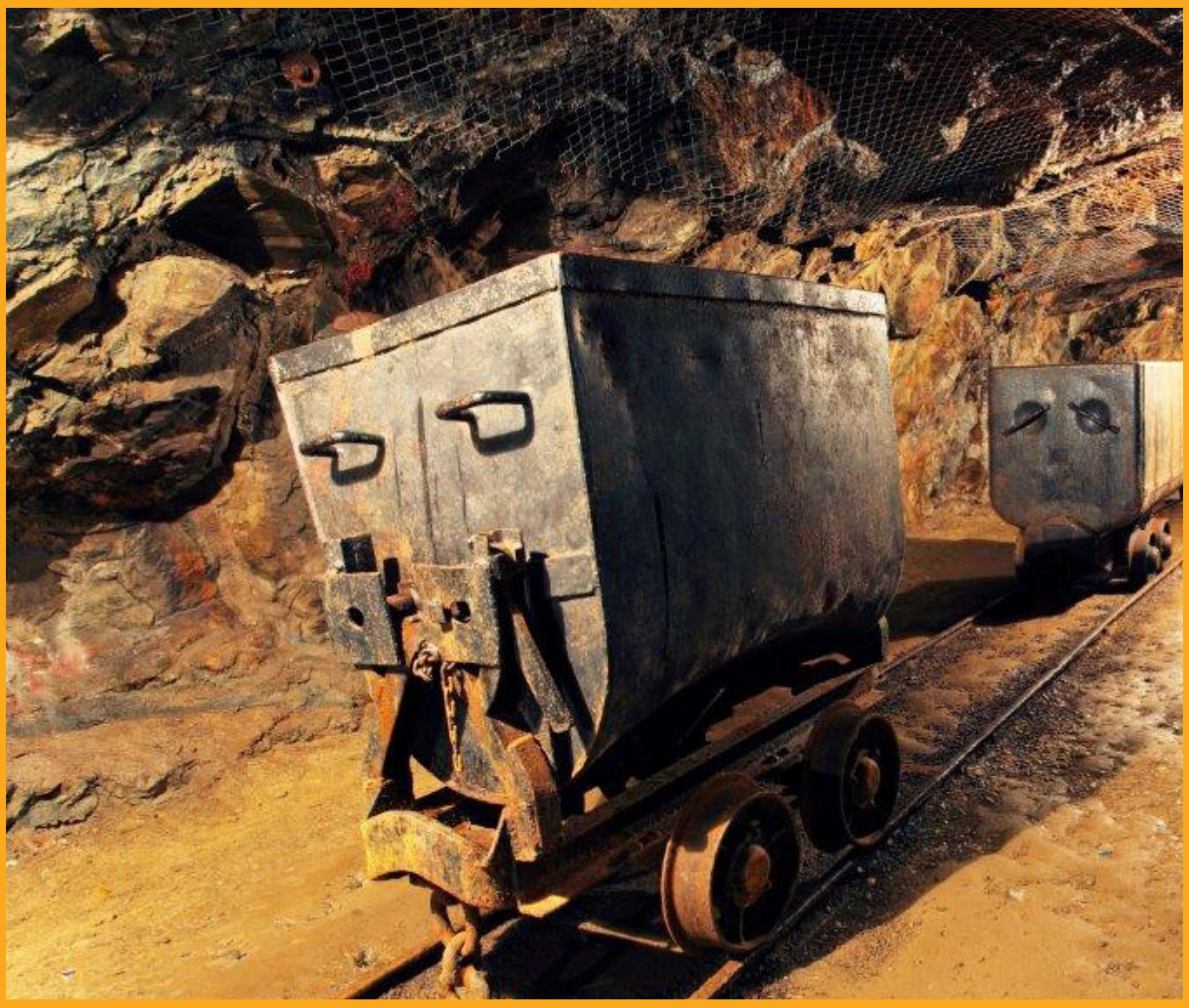
By Dr Dlamini M., Dr Mashao K., Dr Ndelu L., Dr Worku Z., Lapheke Care cc, 2004

SUMMARY:

The aim of the study was to review occupational health services in small to medium clay and sand mining industries, defined as employing less than 300 workers.

Although the total number of these industries sampled was small, limiting the findings the study, the following issues were highlighted by the study:

- The provision of occupational health in small to medium mines may not be completely possible due to cost and human resources constraints
- Conforming to legislation in terms Mine Health and Safety Act, has financial implications which most of these mines may not afford
- There is need by the small to medium mines to look at pooling of resources in order to conform to the requirements of MHSA e.g. risk and hazard identification and management as well as risk based medical surveillance.



33. MONITORING AND EVALUATION OF SUSTAINED CLINICAL PERFORMANCE AND TUBERCULOSIS MANAGEMENT IN THE SA MINING INDUSTRY

By Dr Murray J., Dr Wong M., Dr Hopley M., Prof. Lowe P., NIOH, Chris Hani Baragwanath Hospital,
Ref: SIM 02-08-02, 2004

SUMMARY:

SIMRAC GEN 509 enabled the Pathology Department at the National Institute for Occupational Health to upgrade the structure of the autopsy data capture sheet to produce comprehensive annual reports and conduct specific problem-orientated data analyses. It was then possible to quantify the high proportion of pulmonary tuberculosis in miners that appeared to be undiagnosed during life (˜ 60%).

SIMRAC Health 611 clearly demonstrated that significant problems exist with regard to the diagnosis of pulmonary tuberculosis (PTB). Clinicians failed to diagnose PTB in 62% of cases coming to autopsy. The results, although not unique to the mining industry, indicated a need to develop practice habits, which would improve clinical performance.

SIMRAC Health 808 explored an effective method for improving the diagnosis and management of PTB by identifying, producing and distributing appropriate educational material for implementation of best practice. A review of the literature identified process based performance review, undertaken by clinicians themselves, to be one of the most effective ways of developing successful practice habits. The products (a manual in paper format and a CD version of the performance review process, four posters and a bookmark) were piloted with doctors from the gold, coal and platinum industries and from small and large medical centres. They were workshopped and enthusiastically welcomed by the end-users.

The overall aims of SIM 02-08-02 were to entrench the TB Performance Based Process Review (PBPR) and to evaluate the impact of this programme. During the course of the project, many doctors and other health professionals were trained on the PBPR programme through attendance at various presentations, as well as at on-site mine visits.

Disappointingly, and despite the efforts of the study team, the mine doctors did not independently participate in the review exercise and submit the review forms. This was primarily due to time constraints and other clinical responsibilities. The literature confirms that these are common reasons for doctors not participating in quality improvement programmes.

CONCLUSION:

Nevertheless, the programme appears to have, at least in part, made an impact on the proportion of missed cases of PTB, which decreased from 65% in 1999 to 54% in 2003 in the mining industry. The platinum industry was targeted in particular, as it has the highest rates of PTB, and the greatest decrease was found in these mines (from 65% to 47%). The doctors themselves were supportive of the programme and stated that it has changed their clinical practices with regard to diagnosing PTB.

Recommendations:

- In order to continue this trend in the improvement of PTB diagnosis, the PBPR programme should continue to be marketed in the mining industry. Mine doctors should be encouraged to access the information on the website.
- Those hospitals where the greatest improvement took place were notable for the enthusiasm displayed for the PBPR programme by the senior staff members. Thus the support of senior doctors at mines hospitals should be garnered to ensure improved clinical practice with regard to the diagnosis of TB.

34. DEVELOPMENT OF SENSITIVE TOOLS FOR ACTIVE CASE FINDING OF TUBERCULOSIS (PHASE I)

By Girdler-Brown B.V., Murray J., Weyer K., Thooe S., Business Enterprises at the University of Pretoria, Ref: SIM 030802, 2004

SUMMARY:

This literature review and workshop were arranged in order to determine a research agenda for mass workforce-wide active case-finding for pulmonary tuberculosis in South African mines.

The review has focused on mass screening methods rather than other methods of active case finding such as contact tracing. Over 400 articles were obtained as well as unpublished data from South African researchers. The articles were divided into categories according to themes and these were read by the research team members who then presented their findings at a 2 -day workshop.

The attendees at the workshop debated the relative merits of the screening methods available and came to a number of conclusion that have been incorporated into this report. The literature review found that there was very little published research into methods of mass screening for TB. There was a great deal of published research, however, into diagnostic tests that might be used for mass screening purposes, and this body of literature has been reviewed. Symptoms questionnaires have not been standardised or formally evaluated.

Chest X -rays were not, in general, recommended for mass screening purposes, although the possibility that an increased frequency of chest X -ray screening might lead to a reduced case fatality rate was believed to be worth further investigation. Skin tests were not useful for screening for active disease. Sputum smears might have potential as a screening method in spite of low sensitivity, but not as a mass screening method.

Among the novel methods, those that were based on detection of three antigens specific to Mycobacterium tuberculosis showed most promise for the future. These tests are either in the form of an interferon-gamma production system or a patch test that is applied to the skin. The interferon-gamma systems are probably too impractical (and expensive) for mass screening purposes. The skin patch test, however, may prove to be useful.

CONCLUSION:

The patch test is currently undergoing rigorous evaluation in this country (as a possible definitive diagnostic test rather than as a screening test) and the results will be available at the end of 2005.

Recommendations:

- It was recommended that the question of using the patch test as a screening tool be re-visited once those results are known.
- The main recommendation at this stage is that, before mass screening methods for active disease are researched further, mines should work to improve the standard of delivery of the tried and proven methods for case detection and management. Thereafter, it might be worth carrying out research into new mass screening casefinding methods.
- Further research is carried out into the status of current practice in the mines and the nature of the decision-making and policy-making processes as far as TB is concerned. In addition, the methods whereby such decisions are implemented and the attitudes and practices of health care workers should also be investigated.
- There are also two second level priorities that were identified. The first is that consideration be given to repeating the chest X-ray screening study, with randomisation of mines or shafts, rather than randomisation of miners, in order to see whether the observed benefit of a lower case fatality rate can be duplicated. The other is that a study be conducted with a view to improving the quality of sputum bacteriology services in the mines

35. MARKERS FOR PREDICTION AND EARLY DETECTION OF PNEUMOCONIOSIS

By Dr Murray J., Dr Gulumian M., Nelson G., Darwin L., Prof. Borm P., Prof. Castranova V., Prof. Vallyathan V., Prof. Donaldson K., NIOH, WHC, University of Edinburgh, Institut fur Umweltmedizinische, Forschung gGmbH (IUF), Ref: SIM 030803, 2004

SUMMARY:

The debate regarding the risk of developing silicosis at various exposure levels continues. The assessment of the efficacy of these dust-allaying measures will depend on an assessment of the incidence of adverse health outcomes due to silica dust exposure, rather than the prevalence of silicosis.

Silicosis is the currently used health outcome for silica dust dose-response assessments and clinical detection is dependent on radiology. Early evaluation of the health outcomes of dust allaying interventions is not currently performed. The use of biomarkers can greatly enhance the process of risk assessment. In the past few years, many aspects of the previously unknown pathological mechanisms in the pathway from silica exposure to the development of silicosis have been elucidated.

If scientifically acceptable existing biomarkers for silica dust exposure can be identified, industry could utilise these for the early detection of adverse health effects, rapid evaluation of dust-allaying projects that may be introduced in the near future, and timely implementation of intervention strategies.

The objectives of the project were to:

1. Undertake a comprehensive literature survey to identify biomarkers for the early detection and / or prediction of silicosis
2. Develop a systematic framework for the evaluation of studies on biomarkers
3. Conduct a meta-analysis of data, if appropriate
4. Hold a workshop of international experts, primarily to evaluate the potential for conducting a Phase II study.
5. Develop an outline of a proposal for a Phase II evaluation of any promising markers(s) identified.

The relevant literature was identified, and each study was scrutinised, using a systematic review form. A total of 171 papers and articles related to biomarkers for silicosis were identified, and reviewed by international experts.

CONCLUSION:

Although the literature on silicosis-specific biomarkers is fairly extensive, no definitive conclusion have been reached. Previous studies have been cross sectional rather than prospective in design, and many of the studies have used animals or cell systems. Furthermore, often only one or two biomarkers have been evaluated in any one study, precluding a comparative assessment. By analysing several biomarkers from a single individual at a single point in time, more information may be obtained about the nature of the exposure than from use of a single biomarker.

Recommendations :
Based on these factors, an outline for a Phase II proposal has been developed for further evaluation of 10 of these markers.

In selecting markers for the Phase II proposal, attention was paid to biological relevance, temporal relevance towards effect, background variability, confounders, reproducibility and predictive value, and practicability

The primary objective of the Phase II proposal is to determine which of the 10 biomarkers has/have the highest sensitivity and/or specificity in detecting changes in response to silica exposure, or susceptibility to silicosis? A prospective cohort study is necessary to answer this question, with annual follow up for at least five years. The biomarkers chosen can be measured in serum or whole blood.

36. THE PREVALENCE AND TRENDS OF SMOKING IN SOUTH AFRICAN PLATINUM MINERS

By Cheyip M., University of the Witwatersrand , Ref: SIM 030804, 2004

SUMMARY:

Background: In association with other occupational exposures like silica dust and radon, cigarette smoking impacts on the health of miners, especially with regard to the risk of developing COPD, PTB and lung cancer. These compensable diseases place a great burden on both miners and mines. The prevalence of smoking among black miners in South Africa is unknown and data for white miners are not recent.

The objective of the study was to determine the prevalence of smoking and smoking trends in miners in a platinum mining company from 1998 to 2002 and to describe some important factors associated with their smoking habits.

This was a cross-sectional study using medical surveillance data about employees of a platinum mining company from 1998 to 2002.

The results indicated that over 80000 repeated records of over 25000 miners were studied over the five-year period. The prevalence of ever smokers was 44.4%. Miners were less likely to smoke in 2002 than in 1998 (OR 0.23, CI 0.21 – 0.25).

Over this period, smoking prevalence dropped from 43.3% to 31.3%. The decrease was evident in most socio-demographic groups. There was also a decrease in cigarette consumption over time ($p<0.001$). Multivariable analysis showed that whites were more likely to “always” and/or “ever” smoke than blacks (adjusted OR=2.4, CI 1.79 – 3.20 and OR 2.5, CI 1.98 – 3.27, respectively).

CONCLUSION:

Even though there has been a decline in smoking prevalence since 1998, the relatively higher prevalence in platinum miners compared to that of the general population, and the additional effect of occupational exposures, are still a public health concern. There is need to establish smoking cessation and prevention programmes and to continue collecting detailed smoking information during annual surveillance programmes that could be used to monitor the effectiveness of such programmes.

37. WORK RELATED MUSCULOSKELETAL DISEASES

By Dias B., CSIR Mining Technology , Ref: SIM 02 08 04, 2005

SUMMARY:

The objective of the study was to identify work-related risk factors that may pose a risk of WMSD developing. In Health 702, aspects covered in the project report included the findings of a literature review dealing with WMSD; the results of a retrospective record review of WMSD; the results of a prospective study to determine the prevalence of WMSD; the identification of work categories and tasks that pose a risk of WMSD; and, finally, recommendations for controlling or reducing the risk of WMSD. Three mines were used as project mines: one gold mine, one platinum mine and a colliery. SIM 020804 is an extension of Health 702. Data on the questionnaires and examination has been cleaned and descriptive analysis has started. Thirty-three controls and 42 cases were excluded for analysis due to inconsistencies.

	Before data cleaned			**After data cleaned**		
	Controls	Cases	Total	Controls	Cases	Total
Coal Mine	85	86	171	81	80	161
Gold mine day	335	336	671	327	315	642
Gold mine night	19	19	38	18	15	33
Platinum mine day	271	272	543	256	261	517
Platinum mine night	33	39	72	29	37	66
Total	743	752	1495	711	708	1419

Table 1: Number of cases and controls before and after data cleaning.

	Controls	Percentage
Conjunctivitis	3	0.4
Painful eye	6	0.8
Foreign body in eye	3	0.4
Headache	25	3.5
Weakness/malaise	36	5.1
Urinary tract infection	19	2.7
Sexually transmitted disease	11	1.5
Allergy	2	0.3
Skin abscess	11	1.5
Urticaria	7	1.0
Cellulites/dermatitis	59	8.3
Fungal foot infection	3	0.4
Chest pain	36	5.1
Lower respiratory infection	31	4.4
Upper respiratory infection	50	7.0
Influenza	123	17.3
Cough	69	9.7
Otitis media	5	0.7
Painful ears	8	1.1
Abdominal pain	36	5.1
Gastroenteritis	61	8.6
Peptic ulcer disease	18	2.5
Constipation	2	0.3
Malaria	4	0.6
TB	2	0.3
HIV related	1	0.1
Hypertension	24	3.4
Diabetes mellitus	5	0.7
COPD/asthma	3	0.4
Epilepsy	4	0.6
Thyroid	2	0.3
Liver-jaundice/cirrhosis	2	0.3
Rectal disease	7	1.0
Dizziness	17	2.4
Nephritis	1	0.1
Dental	2	0.3
Injury	2	0.3
Other	10	1.5

Table 2a. Diagnosis of controls presenting to the health care centers.

	Percentage
Neck	5.5
Shoulder	1.8
Elbow	0.6
Wrist	1.2
Hand	0.2
Upper back	8.2
Lower back	53.3
Hip	3.7
Knee	8.5
Foot	8.9
Body pains	0.2
Joint pains	0.9
Osteoarthritis	0.5
Muscle pain	2.8
Shoulder and neck	0.2
Neck and wrist	0.2
Neck and lower back	0.3
Shoulder and lower back	0.2
Upper and lower back	2
Lower back and hip	0.7
Lower back and knee	0.3
Lower back and foot	0.2

Table. 2b. Classification of cases presenting to the health care centers.

Controls	**No**		**Yes**
		Past year	More than a year
Neck	579	104	18
Shoulder	587	113	4
Elbow	690	10	2
Hands	690	11	1
Forearm	672	27	3
Upper back	476	223	2
Lower back	395	301	5
Groin	686	14	
Knee	638	62	2
Foot	684	17	1
Numbness/tingling	561	137	3

Table 3. Number controls presenting with a Musculoskeletal disorder (Within the last year or longer)

CONCLUSION:

Presently the introduction and methods are being compiled. The data is in the UK and analysis is incomplete and wiil resume in due course.

38. SILICOSIS, EXPOSURE AND MEDICAL SURVEILLANCE (SEAMS) AND SPIROMETRY AND MEDICAL SURVEILLANCE (SAMS)

By Myers J.E., te Water Naude J.M., Thiede M., Thompson M.L., Occupational and Environmental Health Research Unit, School of, Public Health and Family Medicine, University of Cape Town, Ref: HEALTH 020803, 2006

SUMMARY:

This report covers the work of the project originally called Silicosis, Exposure and Medical Surveillance (SEAMS), which was later converted to Spirometry and Medical Surveillance (SAMS) at the insistence of SIMRAC. The SEAMS phase took place in the first 2 years and the SAMS phase occurred in the final year. The work was originally scoped to last 4 years, but was foreshortened by SIMRAC to take place over 3 years from April 2002 to March 2005. The objectives of the project were to:

1. Develop the longitudinal study as distinct from crosssectional monitoring mechanisms for lung function in the South African mining industry and the tools to implement them, and
2. Develop a model integrated surveillance system for respiratory health, medical surveillance and occupational hygiene dust surveillance.

SEAMS – years 1 & 2
The first report produced was a critique of the South African Mines Occupational Hygiene Programme's Guideline on Airborne Pollutants and Codebook. It was found that the system as presented was too complicated and unwieldy to be practical, as well as too difficult to be implementable.

Related to this, the second report - Technical hitches presented by the occupational hygiene data of Health 606, December 2002 – showed that occupational hygiene data as currently collected were inaccessible for surveillance purposes, as it took too much time and effort to utilise the data for timeous feedback purposes. The report of March 2003 entitled Trends in dust levels at a gold mine near Orkney in the North West province, provided evidence to show that dust levels were not improving, despite the advent of gravimetric measurements by the occupational hygiene services, which occurred in the 1990's. These reports informed the subsequent exposure-response research which followed.

In order to integrate the dust and disease surveillance limbs, as required by the second objective, the project looked to various ways of measuring a dose-response relationship. This was the subject of a workshop of senior researchers and which gave rise to the report entitled Workshop report on the feasibility of establishing a goldminers' research cohort. (September 2003). As it turned out, it was not possible to measure a dose-response relationship by any study design other than cross sectional. The project then concentrated on maximising whatever data were available and this resulted in significant research on the impact of silica dust.

These reports - Tuberculosis and silica exposure in South African goldminers, and Silicosis prevalence and exposureresponse relations in South African goldminers - have respectively been accepted and published in Occupational and Environmental Medicine, an important international journal in the field of occupational health.

The main policy implications of this research were as follows:

1) There is an urgent need for improved dust control strategies on the South African goldmines, because of the silicosis and tuberculosis epidemics, made more urgent by the multiplicative interaction between silicosis and HIV infection in increasing the risk of pulmonary tuberculosis
2) There is a need for increased tuberculosis surveillance in groups exposed to higher dust and silica levels on the mines.
3) Dust and quartz control must be part of the PTB control strategy.

SAMS – year 3

The SAMS project aimed to develop tools for spirometric surveillance. Three mines were commissioned as study sites – one for each level of sophistication of the surveillance tools. The smaller 2 sites with the tools designed for small and medium sized mines were unenthusiastic about the tools, whereas the top of the range tool performed with distinction once the initial glitches were sorted out.

The tools were products under the broad name of SpiroSuite, individually named SpiroCharter, SpiroTracker and SpiroAccess, respectively designed for small, medium and large mines. SpiroCharter was paper-based and was implemented in a small mine. SpiroTracker was computer-based (with manually entered data) and was implemented in a small mine also, as a medium-sized mine would not have accepted the extra workload involved with manual entry of the spirometry data. SpiroAccess was the top of the range product, being fully electronic, and was tested in a large gold mine. SpiroAccess was a great success, in that the objective of engineering and implementing a fully computerised system was achieved, in strong contrast with the other 2 products, whose limitations were shown up as too onerous and time-consuming. The burgeoning widespread use and availability of personal computers and pc-based spirometry indicates that SpiroAccess is the only product in this range worth investing in.

CONCLUSION:

Apart from improving the SpiroSuite programmes and implementing them in operational situations and a preliminary health economic analysis based on general assumptions as to the cost characteristics of spirometric surveillance in these settings, there was little opportunity for a study of medical surveillance practices across time. This occurred because the foreshortened time horizon, with consequent contraction of meaningfully attainable objectives with respect to medical surveillance issues. It was not possible to examine issues beyond the applicability of SpiroSuite in working settings on the one hand, and a general notion of the cost implications of existing surveillance systems prior to the application of SpiroSuite.

Recommendations:

The main recommendations of this research project follow:

1. There is an urgent need for improved dust control strategies on the South African goldmines
2. The practice of occupational hygiene should be simplified and improved, and should be systematised
3. The medical and occupational hygiene surveillance systems should be linked, as was envisaged in the Mine Health and Safety Act
4. The practice of spirometric surveillance should include an automatic ability to access and compare with the previous spirogram, as enabled by a product like SpiroAccess, as well as being able to flag lung function loss both currently and longitudinally
5. Workers exposed to higher silica levels should be flagged to receive extra surveillance for both silicosis and tuberculosis.

39. RESPIRATORY DISEASE IN THE SOUTH AFRICAN PLATINUM MINING INDUSTRY

By Girdler-Brown B., Murray J., Wichmann J., Robinson F., Nelson G., Downs K., School of Health Systems and Public Health, University of Pretoria, National Institute for Occupational Health & the School of Public, Health, University of the Witwatersrand, School of Health Systems and Public Health, University of Pretoria, School of Health Systems and Public Health, University of Pretoria, National Institute for Occupational Health , Ref: SIM 030806, 2006

SUMMARY:

This investigation was launched because little information has been collated and published about lung health in platinum miners. The aim of the study was to document in one place the existing knowledge about factors affecting the risk for occupational lung disease (OLD) among platinum group metal (PGM) miners, supplemented by a cross-sectional study of the burden of OLD among current PGM miners in South Africa.

Literature review was conducted on the geology of the areas where platinum is mined as well as the occupational hygiene exposure limits for the substances found in the rock formations, with relevance to occupational lung disease. The emphasis has been on silicon (as crystalline silica), radon and asbestos, although almost nothing has been written about these elements with regard to lung disease in platinum miners, especially the last two. The occupational hygiene reports from platinum mines for evidence on exposure to air-borne pollutants were examined. An investigation on information relating to compensation paid for occupational lung disease in platinum miners using official sources of information, the PATHAUT autopsy data base and a sample of autopsies from one large mine. Lastly, a cross-sectional study of 969 miners seen for routine occupational health surveillance at a large platinum mine was carried out.

It was found that although the platinum is being mined in igneous rock which may contain variable quantities of crystalline silica, there was little or no generalisable information available about the silica content of the rock as opposed to the platinum bearing seam. The researchers were unable to find any analyses of asbestos or radon radiation measurements for the mines but were told that a “radon survey” was conducted several years ago and had found no cause for concern.

Although we had reservations about the methods used (as per government guidelines) to measure the airborne pollutants, even with re-calculation these were very low indeed. There were some exceptions. Firstly, it appears that crystalline silica is not being measured routinely when the dust levels are considered too low to make its analysis worthwhile. Secondly, oil mist exposure limits are being exceeded from time to time.

The autopsy sample revealed very high prevalence of old TB among deceased platinum miners (43/131), as well as a smaller number of cases (4/131) with silicotic changes. The TB appeared not to be related to previous gold mining history, and 3 of the 4 (and perhaps the fourth as well) of the silicotic cases had previous gold mining exposure.

We had reservations about the completeness of the work histories submitted with the autopsy requests. There were also 2/131 cases of lung cancer, one associated with asbestos, and neither of these miners had a record supplied indicating work outside the platinum mines.

CONCLUSION:

The cross-sectional study revealed 3 cases of silicosis (out of 969), all three occurring in ex gold-miners. There were 15/969 miners on TB treatment, with no statistically significant association with previous gold mining detected. This equates to a likely incidence rate of over 2 000 per 100 000 person-years. The prevalence of COPD as based on GOLD scores was extremely low: so much so that we consider the results implausible.

Recommendations:

- A survey to document the silica and asbestos composition in dust and rock samples.
- Dust specimens to be analysed for α-quartz and the level stated whenever possible.
- DME guidelines to be made clearer re: the time

adjustment for estimating TWAs.
- Strengthening of the systems for documenting work histories for current miners as well as for deceased miners whose organs are submitted for autopsy.
- Improvements to the integration, responsiveness and accessibility of the compensation database.

40. PREVALENCE OF LATENT TB INFECTION AMONG SOUTH AFRICAN GOLD MINERS

By Dr Hanifa Y., Prof. Churchyard G., Dr Grant A., Dr Fielding K., Dr Corbett E.L., Prof. Karim S., Aurum Institute for Health Research & CAPRISA, University of Kwa Zulu-Natal, London School of Hygiene & Tropical Medicine, Ref: SIMRAC 05-08-01, 2006

SUMMARY:

Tuberculosis (TB) has largely contributed to illness and death among gold miners in South Africa for decades. TB control is failing in spite of a well-implemented TB control programme that not only meets international targets but also already has an active case-finding programme. HIV is a major cause for this failure of TB control.

A proof of concept, cluster randomised study among South African gold miners (henceforth referred to as the parent study) has commenced. The parent study, as part of Health 701 (Effect of community-wide isoniazid preventive therapy on tuberculosis among South African gold miners), aims to demonstrate that community-wide isoniazid preventive therapy (IPT) in addition to the standard TB control programme is an effective way of rapidly reducing the burden of TB infection and disease, and can improve TB control in high HIV prevalence areas.

The effectiveness of community-wide IPT as a strategy to reduce TB incidence is likely to be influenced by the prevalence of latent TB infection (LTBI) among the mining workforce. Determining the prevalence of LTBI helps us to understand the results of the parent study, and will assist with modelling the predicted effect of community-wide TB preventive therapy on TB incidence in the long term.

The objectives of this study were to determine, in a representative sample of gold miners:
- The prevalence of LTBI as measured by tuberculin skin tests (TST).
- Factors associated with a positive test for LTBI (defined as TST response 10mm).
- Prevalence of radiological TB disease and silicosis (defined as ILO score 1/0).

The results showed that the 520 participants recruited for the study, read 429 TSTs (105/130 <30y; 324/390 30y). The overall distribution of TST responses is shown in the figure. Using the mirror method the estimated prevalence of LTBI is high at 89%, and similar to a 1968 survey of new recruits to a gold mine in Orange Free State.

A high percentage (45.5%) of HIV-positive participants had a zero TST response compared to 13% and 13.5% with zero TST response in the HIV-negative and status-unknown participants respectively. In participants with TST >0, there was no significant difference between size of response by either HIV status or age stratum. The strongest risk factors associated with a positive TST were HIV status and current underground work. Participants who worked underground had four times the risk of a positive TST compared to those who never worked underground.

CONCLUSION:

The prevalence of silicosis was high. The prevalences were 3.8%, 3.9%, 8.1% and 10.3% in shafts 1, 2, 3 and 4 respectively.

41. POST TRAUMATIC STRESS DISORDER IN THE SOUTH AFRICAN MINING INDUSTRY

By Zungu L.I., Malangu N.G., University of Limpopo (Medunsa campus), Ref: SIM 05 08 03, 2011

SUMMARY:

Mining is regarded as a high risk occupation with an increasing number of traumatic accidents. Yet there is a paucity of data relating to PTSD in the mining sector in local and international published studies. The aim of this project was to investigate the existence of and the management of PTSD in the South African mining sector in order to develop interventions for early diagnosis and appropriate management of PTSD in the sector.

The objectives of the study were to:

1. Identify and describe the existence and prevalence of PTSD (Phase 1)
2. Identify and describe risk factors, determinants and manifestations of PTSD (Phase 2)
3. Review the systems of treating and managing PTSD in the mining sector (Phase 2)
4. Develop best practice guidelines to improve the management of PTSD in the South African mining industry

It should be noted that the report on the findings of **phase 1** of this project was completed in 2009 and it is available from the MHSC website. The main finding from the literature review was that no study was found that reported on the PTSD situation in the South African mining industry. Based on the review of records, 29 cases of PTSD were uncovered during that time and these were analysed in order to describe the socio-demographic and other factors of the mineworkers involved. The main findings were that the majority of those who had PTSD were males, Black Africans, and underground mineworkers.

This report focuses mainly on the findings for **phase 2** of this project. The main findings from the literature review of local and international studies were that the main causal factor in PTSD is the nature and severity of the traumatic event; however it should be acknowledged that individuals differ on how they respond to trauma. Although, the prevalence of PTSD in the mines was not established, the prevalence of PTSD ranges from 6 to 56% in various groups of the South African population surveyed.

Based on the findings of the confirmed PTSD cases from the study sites and from those reported to RMA, it is evident that PTSD is a reality in the mining industry and that other mental health conditions are also prevalent. Although its prevalence could not be established due to lack of the population base; 451(66.9%) out of a total of 671 PTSD cases reported to RMA over a period of 5 years (i.e. 2006 – 2011) were from the mining sector.

The main determinant of PTSD in the mines was a work–related factor which was the advent of a traumatic mines accident. The majority of cases of PTSD resulted from rock falls accidents, mines blasts, and being struck by an object. The other important work-related factor was being a being an underground worker, particularly a driller.
Socio-demographic risk factors identified were being a female and younger than 40 years old. While other personal health related factors were pre-existing or co-existing health disorders notably depression, hypertension, and anxiety. These three conditions were comorbid with PTSD.

Qualitative interviews showed that following a month after witnessing and being involved in a traumatic mine accident, participants complained of symptoms of feeling like the traumatic event was happening again, had trouble sleeping, disturbing dreams or nightmares, experienced feelings of being alone, had anger outbursts and sometimes felt worried, guilty or sad. Such symptoms matched those that define PTSD.

With regard to the management systems in place, it was found at the study sites that there are systems in place for the treatment of PTSD. However, there was a lack of a standardized procedure for PTSD assessment, diagnosis and treatment at two sites. Another important finding with regard to the treatment

given for PTSD at one study site was that the drugs prescribed were not the most appropriate based on current evidence. Data from PTSD claims lodged by mineworkers showed that the majority of claimants were from Gold and Platinum mines. Though, overall 67.4% of liabilities of claims were accepted, 10.6% were rejected while 22% were undecided pending further investigations.

CONCLUSION:

Findings of phases 1 and 2 of this project clearly indicate the existence of PTSD and other comorbid mental health disorders among mine workers. It is also evident that a lack of a standardized system for appropriate PTSD screening, diagnosis and management that is contextualized for the mining sector exists.



42. NOISE-INDUCED HEARING LOSS AND SILICOSIS PREVENTION AUDIT TOOLS FOR USE IN THE SOUTH AFRICAN MINING INDUSTRY

By Edwards A.L., Geldenhuys P., Grové T., Khoza N.N., Milanzi L., CSIR, Ref: SIM 10 06 01, 2011

SUMMARY:

In 2003, at the Mine Health and Safety Summit, set milestones for the South African mining industry that were aimed at reducing and eliminating noise-induced hearing loss (NIHL) and Silicosis amongst miners. In an effort to progress towards these milestones SIMRAC commissioned the SIM 06-06-01 project in 2007/2008 to establish baseline noise and dust levels in the industry. The project also aimed to evaluate the compliance of the industry with legislation and with best practices for prevention of NIHL and Silicosis.

The SIM 06-06-01 study developed research data collection tools that would form the basis of an audit that could be conducted by a mine, to benchmark their compliance with both national and international standards for best practice in the two fields of NIHL and Silicosis prevention. However, the study recommended that the research data collection tools should be customised and revised to be used as audit/performance measurement tools that were practical and accessible for use by the mining sector. The audit/performance tools would facilitate the standardised evaluation of compliance with the current legislation by both the Mine Health and Safety Inspectorate (MHSI) and by mines in all commodities and of all sizes.

Lastly, SIM 06-06-01 drafted training materials and guidelines for the use of the research data collection tools. However, the recommendation was that the materials be made more user-friendly and be updated for the use of the revised audit/performance tools as well as to include the latest knowledge on NIHL and silicosis prevention.

1. Revision of research collection tools

The SIM 06-06-01 research data collection tools were reviewed by the research team to identify the variables that were required in a practical audit/performance tool for the purpose of evaluating compliance with the current legislation, in all sizes of mines in all main commodities, and in the Mine Health and Safety Inspectorate (MHSI). The noise research data collection tool was then revised into a NIHL prevention audit/performance tool by reducing it from 503 questions to 100 questions in 10 subsections. The dust research data collection tool was revised into a Silicosis prevention audit/performance tool by reducing it from 890 questions to 100 questions in 10 subsections. The revisions were done by removing questions relating to international standards, legislations and regulations on noise and dust. Each audit/performance tool was then evaluated and revised to ensure user-friendliness. Attempts to remove the use of ambiguous language and improve the clarity of technical terms were made. The audit/performance tools were also evaluated and revised where necessary in relation to current legislations and recent knowledge and practices in NIHL and Silicosis prevention strategies. The two audit/performance tools are reported on separately in the full report.

2. Piloting of audit/performance tools at MHSI regional offices

The NIHL and Silicosis prevention audit/performance tools were then quantitatively piloted in six MHSI regions namely Gauteng, Free State, North West, Limpopo, Kwa-Zulu Natal and Mpumalanga. The piloting at the MHSI regional offices consisted of interviews with the Occupational Hygiene Inspectors and where possible also included the Principal Inspector and the Medical Inspector. The access to computers and computer skills at the regional MHSI offices was also evaluated during the piloting.

Findings:

Excellent co-operation was received from all regions and valuable examples of current self-developed audit tools were obtained in some regions. During all the regional office piloting the NIHL and Silicosis prevention audit/performance tools were discussed and evaluated in depth and suggestions about the wording and the usefulness of the audit/performance tools were gathered. In general the need for standardised audit tools was expressed by most regions and a willingness to implement these audit tools was indicated at most regions.

One of the important findings at the regional offices was that the NIHL prevention audit/performance tool fell into two distinct sections, namely the section that was traditionally the field of the Occupational Hygiene inspector and the section that was traditionally the field of the Occupational Medicine inspector. The segregation of these two sections was seen as a potential pitfall to the effective use of the NIHL prevention audit tool since some sections would be carried out by the Occupational Hygiene inspector and other sections would be carried out by Occupational Health inspectors. Despite the inspectors being of the opinion that the pitfall could be overcome by Health and Hygiene inspectors conducting the audit together and their awareness of the need for integration, this finding highlighted the problems experienced in the MHSI and the current lack of integration of health and hygiene issues at the regional office level.

3. Piloting of audit/performance tools at mines

The NIHL and Silicosis prevention audit/performance tools were then piloted in 18 mining companies which were made up of approximately 100 shafts/business units, distributed over six provinces of South Africa. The number of mine workers employed by the mines surveyed was approximately 200 000. A sample of four small mines, four medium mines and ten large mines were represented in the sample in order to evaluate if the tools would be feasible for use in different sizes of mines and in a wide range of commodities. The commodities mined by the mines in the sample included gold, platinum, coal, diamonds, copper, titanium, aggregate and uranium.

Members of the research teams interviewed Occupational Hygiene managers from the participating mines or the consultant Occupational Hygienists used by the smaller mines, in order to pilot the feasibility of using the audit/performance tools and to establish the accessibility for all sizes of mines and types of operations. A survey of the computerised landscape in the participating mines and consultants also formed part of the piloting. Both the consultant and the Occupational hygienists were very co-operative and positive towards the use of the audit/performance tools.

Findings:

Suggestions for further refinements for the audit/performance tools to be practical and changes for more accessible language and relevance were gathered in the survey and built into the final tools. The majority of participating Occupational Hygienists felt that use of standardised audit/performance tools to be used by both the mines and the MHSI would improve the current practices because standardised tools will ensure consistent outcomes and therefore improve common understanding and vocabulary in the industry. All participants, from all commodities and sizes of operations had access to computerised infrastructure that could facilitate easy use of the audit/performance tools.

Similar findings as were identified at the MHSI regional offices regarding the NIHL prevention audit/performance tool and the segregation of the two sections of the audit/performance tool was seen in general at the mines. The Hygiene sections could not be answered by the Health staff and visa versa, again highlighting the need for the integration health and hygiene issues at the mines.

4. Investigate how the audit/performance tools can be integrated into SAMSHA

Three interviews were held with managers and custodians of the SAMSHA system to investigate the requirements for integration into SAMSHA, one of whom was the IT developer of SAMSHA and the other two who were technical experts in from the MHSI in the Safety and the Occupational Health sectors. The interviews were aimed at investigating the components, in particular details of the audit section, the current status of the SAMSHA system, and the needs for inclusion of the NIHL and the Silicosis prevention audit/performance tools into the SAMSHA system.

Findings:

The main finding was that the audit section of SAMSHA currently only contains the 2008 Presidential Audit which was not evaluated for relevance to the current two audit tools since it was felt that the two new audit tools required separate audits to ensure that the full attention was given to the two conditions, NIHL and Silicosis. The current audit section in SAMSHA requires that the inspectors in the region download audits from the central SAMSHA system and conduct the audits at the mines, either by manually filling in the form and scanning the completed form to be uploaded into SAMSHA or by completing the form on their computers in the offices and then uploading the completed form into SAMSHA. The results are then captured manually into a section of the SAMSHA database by a SAMSHA internal data capture staff member. These findings indicated that the inclusion of the SIM 10-06-01 audit/performance tools in a similar way to the Presidential audit is a feasible addition to the audit section.

However, the use of the audit tools require piloting to ensure the practicability of the tools and to identify any problems with use, as well as the necessary controls that need to be in place before the tool is used in a standardised way at all regional offices. Furthermore, the motivation for piloting the audit/performance tools is to check the potential for automating the tools and thereby eliminating human error during recapturing. This could be evaluated if the audit tools were available online, using the 3G connections and laptops that inspectors have available. In so doing, the need for entering data two to three times can be eliminated and the reliability of the data captured can be increased.

Another motivation for piloting the audit tools is the need to identify methods of overcoming the problems of segregation between hygiene and health sections in the use of the tools. The need for training of users of the audit tools will be addressed by the workshops scheduled to take place as the final output of the current project.

5. Final versions of audit/performance tools

The research team became aware of developments within the industry relating to the revision of the "Guideline for the compilation of a mandatory Code of Practice (COP) for an occupational health programme on personal exposure to airborne pollutants" and the "Guideline for the compilation of a mandatory COP for an occupational health programme for noise".

Based on the new developments and on the results of the surveys conducted at the regional MHSI offices and at the participating mines and the consultants used by other mines, the research team revised the audit/performance tools into the final versions. The audit/performance tools were named NoiseCAT and DustCAT being acronyms for 'Noise Compliance Audit Tool' and "Dust Compliance Audit Tool". The percentage-based scoring system for the audit/performance tools was developed and a pilot version of the audit tools was conducted at one mine. The audit tools were then formatted into an Excel® spreadsheet format for automatic scoring of each subsection and the overall audit tool. The DustCAT and the NoiseCAT were each finalised with 108 and 111 questions in 13 subsections, respectively.

6. Guidance notes for effective use of the audit/performance tools

A set of guidance notes for use with each of the two SIM10-06-01 audit/performance tools was drafted (See section 2.5 and 3.5 of this report). The guidance notes aimed to facilitate the ease of use by all potential users of the audit tools, both as an audit tool by the MHSI inspectors and as a performance monitoring tool by the mining industry. The guidelines outlined the purpose of the tools. A section that explained the scoring of the results was included in each manual. The recommended interpretation of the results and suggested follow up after the use of the audit/performance tools also formed part of the guidelines. However, if the recommendation to pilot the use of these audit tools is accepted, the guidance notes may need to be further reviewed based on the outcome of the piloting process after. The revisions would relate to inclusions or exclusions that are made as a result of piloting as well as possible stratifying of sections for different commodities and sizes of mines. The most important changes would be in relation to the findings of how to deal with the occupational health section and the occupational hygiene sections.

7. Training materials for best practice in NIHL and Silicosis prevention

NIHL and Silicosis prevention training materials were developed to support the MHSI in their mission to support the industry and to assist Occupational Hygiene practitioners in the mining industry with relevant materials for continuing professional development. The training materials content was informed by both the materials developed by the SIM060601 project and current knowledge on leading practices for the prevention of NIHL and Silicosis. The training materials used the sections outlined in the audit/performance tools as the basis for the subsections.

Recommendations:

The recommendations from SIM 10-06-01 are aimed at ensuring that, in both the MHSI and in the mining industry in general, the effective use of the audit/performance tools results in a transfer of research to practice and that improved NIHL and Silicosis prevention practices become part of the culture in the mining industry. The summary of the recommendations of the project are:

1. The training materials for best ppracticebe used as the basis for technology transfer of the current project and as the basis of the roll out to the industry of the revisions that are currently being concluded to the two "Guidelines for the compilation of COPs for exposure to airborne pollutants and to noise".
2. Prior to roll out of use in the regions, pilot the NIHL and Silicosis prevention audit/performance tools

at one regional MHSI office in order to ensure quality control of the tools, to determine the types of controls that need to be in place for efficient implementation and standardised use, and to provide information about how to manage the segregation of sections of the NIHL prevention tool.

3. On completion of the pilot phase, revise the guidance notes and training materials where necessary to include new information from the outcome of the piloting.

Following recommendations one and two, and in line with the proposal, conduct two regionally based workshops for delegates from both the MHSI and mining practitioners, based on the guidance notes and the training materials developed by the current project.

43. ADVERSE HEALTH IMPACTS ASSOCIATED WITH DUST EMISSIONS FROM GOLD MINE TAILINGS

By Andraos C. and Gulumian M., NIOH, Ref: SIM 100801, 2013

SUMMARY:

It is believed that pollution related to gold mine tailings storage facilities (TSFs; mine dumps) may pose risk to surrounding communities. For this project, the application of a health risk assessment paradigm will scientifically investigate a cause-effect relationship, if any, between exposure of nearby communities to gold mine tailings dust and adverse health effects experienced by these communities. It is hypothesised that the higher the exposure of communities to ambient particulate matter (PM) emitted from TSFs, the higher the incidence of respiratory diseases associated with exposure to toxic dust.

The achievements for year 2 of this project involved: (1) assessing the hazardous nature of dust particles emitted from TSFs, (2) assessing the exposure levels of surrounding communities surrounding TSFs and (3) assessing the prevalence of adverse health effects in surrounding communities. The TSFs studied included Durban Roodepoort Deep (DRD; West Rand), Crown Gold Recoveries (CGR; Central Rand), ERPM (East Rand), ERGO (Far East Rand) and Anglo Gold Ashanti (AGA; Stilfontein, Vaal River Area; Figure below).



Figure 1: Gold mine tailings storage facilities in Gauteng and Northwest provinces

The risk assessment paradigm requires that the compound or particle in question be assessed for its hazardous properties in order to determine whether exposure to the compound or particle may cause an increase in the incidence of adverse health effects in humans. The hazardous nature of tailings dust was determined by physicochemical characterisation and in vitro toxicity assessment. The analysis revealed the presence of particles in the respirable- and nano-range, which is known to be more toxic once inhaled. The dust can be classified as mesoporous material exhibiting low surface areas and blockage of surface pores. Despite low surface areas, the dust showed toxicity in human bronchial epithelial BEAS2B cells as well as high surface activities in their ability to produce free radicals.

Environmental PM dispersion monitoring: The Grimm counter was set up to measure tailings PM concentrations in surrounding areas of the DRD, CGR and ERPM TSFs during the windiest months September-October, based on seasonal variation analysis. Results showed that the average daily limit of 180 µg/m3 was exceeded eight times during the sampling period at the DRD site (Figure below). The limit was also violated three times and six times at the CGR and ERPM sites, respectively (not shown). These dust generating events leading to elevated PM concentrations well above the limit showed that ambient air quality is compromised for surrounding populations.

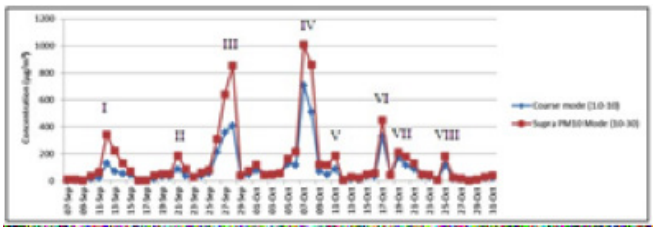


Figure 2: Daily averages of ambient PM mass concentrations for the period 7 Sept 2012 – 31 Oct 2012 at the DRD site.

Personal sampling was conducted on school children in surrounding communities to calculate the actual respirable concentration of tailings PM. As expected, the concentrations of particles collected at experimental schools (0.948 mg/m3) were on average higher than that of the control schools (0.163 mg/m3).

A cross-sectional study of surrounding communities was conducted using the International Study of Asthma and Allergies in Childhood (ISAAC) and American Thoracic Society (ATS) questionnaires for school children and the elderly, respectively. Results showed that the prevalence of asthma in school children was three times higher in experimental communities, compared to control communities. In addition, the elderly in experimental communities showed higher prevalence of asthma, hay fever, bronchitis emphysema, arrhythmia, pneumonia, and myocardial infarction, compared to control communities.

CONCLUSION:

The results from year 2 together with the results from Year 1 will be used in our risk assessment paradigm to establish a correlation between exposure to mine tailings dust and respiratory diseases in surrounding communities.

44. THE IDENTIFICATION, SELECTION AND PROMOTION OF TB LEADING PRACTICES IN THE SOUTH AFRICAN MINING INDUSTRY (SAMI)

By KARTHUR Health Management Consultants, 2016

SUMMARY:

The 2011 TB Program Review identified that there were noticeable differences in the response to TB management and the practices employed in the mining industry. Although TB management practices were either non-existent or ineffective at some mines, leading practices were also identified in the industry. This project was therefore initiated to identify current leading practices and to assess the appropriateness and relevance of these practices in the South African mining industry, with the overall objective of reducing the incidence of TB in the industry and the country.

The project commenced with desktop research on leading practices followed by a gap and situational analysis of the SA mining industry. From this initial research, in-depth interviews were conducted with a diverse group of participants, key informants and industry experts. An online survey was then developed and all mines in the industry were invited to participate. In total 71 mines representing 204 019 employees from the gold, platinum, coal, diamond, chrome, sand, limestone, iron ore and phosphates sectors, responded to the survey. The data was then collated and analysed and the findings from the analysis of the qualitative and quantitative study were disseminated and presented to all stakeholders.

A document to assist the TB working group on leading, best and promising practices was developed. This also presented guidelines on the criteria for the identification and selection of leading or best practices.

The research, survey results and criteria for identifying leading practices were then presented at a workshop. A total of 84 leading practices were then narrowed down to 50 by the workshop participants. These were researched further and then included in the compendium of leading practices.

A Monitoring and Evaluation Tool was developed to assist stakeholders with assessing their progress towards achieving the overall aim and objectives of the project.

Recommendations:
The project has identified a number of leading practices that would assist in achieving the overall aim and objectives. Throughout the project, recommendations have been made to the relevant stakeholders in their individual and joint roles.

These were reported in the research report, compendium and monitoring and evaluation documents e.g. online collection and reporting tools to improve the quality of data collection and analysis, communication of the M&E tool benchmarks and targets to the industry, the publishing of an updated and comprehensive list of operating mines on the MHSC and DMR websites.

45. POLICY ON THE INTEGRATED MANAGEMENT AND REPORTING FOR HIV, AIDS, TB AND OCCUPATIONAL LUNG DISEASE IN THE SOUTH AFRICAN MINING INDUSTRY

By KARTHUR Health Management Consultants, Pure Health Consulting, 2016

SUMMARY:

The development of an integrated HATOLD policy has seen the gathering of insights from various stakeholders and has included all commodities and mine sizes in the SAMI. It has used the principles of flexibility in not defining an operational model but rather providing employers with the standard of care that needs to be implemented and in so doing will hopefully support early adoption of this policy.

CONCLUSION:

Throughout this project the researchers were exposed to the MITHAC members on a regular basis. Multiple workshops were held with MITHAC as well as with other key stakeholders in the industry. The policy was presented at numerous conferences and workshops giving it the necessary exposure as well as increasing the awareness of the industry to the requirements.

Recommendations:

- Significant amount of consultation with MITHAC and the industry is encouraged, in future projects where policies are being developed that would significantly alter the way in which the mining industry operates
- There was an inherent acceptance of the requirements of the policy, however the mines we visited showed that implementation might be challenging for the industry. MITHAC should consider developing some simple health solutions with key partners in the private sector such as the medical schemes and hospital groups which can be design generically to help address some of the mining industry specific as well as regional health access issues.

46. ADVERSE HEALTH IMPACTS ASSOCIATED WITH DUST EMISSIONS FROM GOLD MINE TAILINGS

By Andraos C. and Gulumian M., NIOH, Ref: SIM 14080, 2017

SUMMARY:

It is believed that pollution related to gold mine tailings storage facilities (TSFs; mine dumps) may pose risk to surrounding communities. For this project, it was hypothesised that the higher the exposure of communities to ambient particulate matter (PM) emitted from TSFs, the higher the prevalence of respiratory diseases associated with exposure to toxic dust.

1. The achievements for year 3 of this project involved: Investigation of the association between exposure to PM emitted from tailings sites and prevalence of adverse health effects;
2. Investigation of environmental PM levels;
3. Investigation of whether a cause-effect relationship exists between exposure to dust and disease and
4. Compilation of practical guidelines and best practices to reduce exposure to tailings PM.

The TSFs studied included Durban Roodepoort Deep (DRD; West Rand), Crown Gold Recoveries (CGR; Central Rand), ERPM (East Rand), ERGO (Far East Rand) and Anglo Gold Ashanti (AGA; Stilfontein, Vaal River Area; Figure 1).The main findings of the study are;

1. *Exceedance of PM limits was observed and all five TSFs studied are not sufficiently remediated*

Stricter implementation of remediation strategies is required. For example, vegetation cover, which may be effective for horizontal surfaces and low- to intermediate-angled slopes but not on steeper slopes. A non-vegetative alternative includes the application of a 300 mm layer of fine rock.

2. *Presence of toxic metals and high levels of respirable crystalline silica (RCS) were detected*

Although presently there are air quality limits for PM10 established by the Department of Environmental Affairs (DEA), the presence of RCS in our PM10 and PM4 fractions may necessitate the establishment of environmental exposure limits for RCS in these fractions for South Africa. Once quality limits are set, compliance and monitoring by DEA will be crucial to ensure protection of surrounding communities.

3. *The elderly close to TSFs showed higher prevalence of asthma chronic bronchitis and cough, emphysema, pneumonia and wheeze; Adolescents close to TSFs showed higher prevalence of wheeze and rhinoconjunctivitis*

Due to the inherent limitations of epidemiological studies it is not possible to conclude that the higher disease prevalence in exposed communities

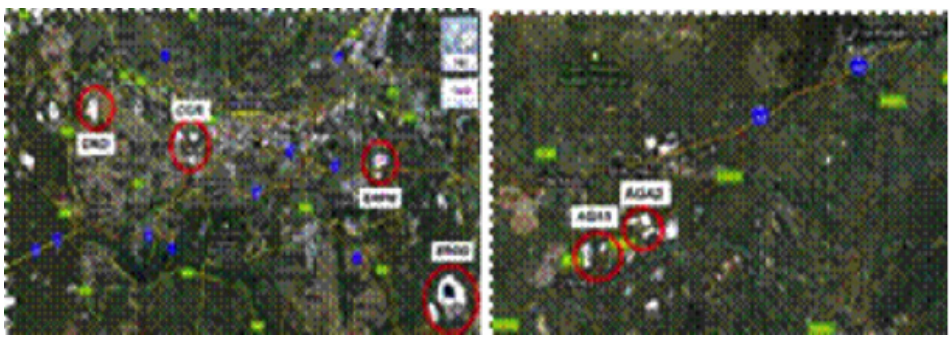


Figure 1: Gold mine tailings storage facilities in Gauteng and Northwest

compared to unexposed communities are due to tailings dust emitted from the TSFs, nor that they are exacerbated by tailings dust pollutions. However, this finding is sufficient for ensuring that adequate remediation measures are in place to control tailings dust emissions. Therefore, it is recommended that a buffer zone of at least 5 km from these TSFs be established to ensure protection from dust generated from these TSFs.

4. *Stakeholders are unaware of the possible dangers (i.e. hazard potential and exposure potential) of living next to TSFs*

CONCLUSION:

Results obtained, especially those related to size and presence of RCS in the respirable fraction in the environmental samples, are the first to be determined for South Africa and therefore should be disseminated to the scientific community, relevant governmental departments and surrounding communities

Recommendation:
It is recommended that, within the risk assessment paradigm, exposure of tailings dust from routes other than inhalation in surrounding communities be conducted.



NOTES:

NOTES:

“Every Mine Worker returning from work unharmed everyday. Striving for Zero Harm.”



MHSC

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