Effects of HIV / AIDS on occupational health and safety

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Executive summary

The estimated prevalence rate of HIV infection among adults in the southern region of Africa was ≥20 per cent at the end of the year 2000. The effect of HIV/AIDS on safety, health, and occupational diseases other than tuberculosis has been postulated. For this reason the need to obtain data on the association of HIV/AIDS with safety and health in the workplace to enable the industry to assess the impact of the pandemic and formulate best practice interventions.

In this study, the impact of HIV/AIDS on occupational health and safety, excluding tuberculosis, was assessed by means of a literature review, interviews with mine medical doctors, organised labour (NUM) and government (Department of Mineral and Energy) and two retrospective studies. At a pre-project workshop with organised labour, government and industry it was agreed that the following should be focused on:

- Cognition;
- Hearing loss;
- Heat tolerance;
- Recovery from injuries; and
- Functional work capacity.

Cognitive impairment and changes in brain structure are common among HIV-positive patients. Cognitive impairment in HIV/AIDS has been described as the deterioration of concentration, verbal abstraction and learning capacity. It has also been characterised by psychomotor slowing, the impairment of memory and attention disturbances in processing speed, and behavioural changes. Screening for cognitive impairment using validated psychometric instruments can provide valuable information on the cognitive functional status of individuals. The Dover system is an ideal screening tool as it can be easily sustained over a long period of time. At present there are mines in South Africa making use of the Dover system for medical testing, recruitment, and selection.

Twenty to fifty per cent of HIV-infected individuals may present with sensorineural hearing loss. The causes of hearing loss may be HIV itself, opportunistic infections, tumours, or medication, i.e. antiretroviral medication and some of the treatments used to treat opportunistic infections. When the effect of hearing was adjusted for age and length of service in the occupational medical retrospective study, HIV-positive mineworkers had significantly more hearing loss than the HIV-unknown group at the gold and platinum mine. However, in the mining industry there are important confounders which the retrospective record review study could not account for. These included noise, depth of mining, and/or poor living conditions. The importance of these factors can only be investigated in a prospective study.

Since many mining activities are made up of hard physical work, HIV may affect mineworkers ability to perform their work safely. The increased energy requirements to perform their work may contribute to decreasing lean body mass and may hasten the progression of HIV. The effect of hard physical work on HIV progression has not been investigated, but suggestions from the literature motivate the need for further research into this. Another concern is how the mining environment and nutritional status of the HIV-positive mineworker affects not only his functional capacity but also the progression of HIV. Labour feels that the working environment may be contributing to the progression of HIV.

Acute intermittent illness and heat stress can temporarily lower heat tolerance. There is some literature to suggest that heat-related illness may be a factor in the progression of HIV, and HIV-positive individuals with AIDS may be more prone to heat-related illnesses. Important gaps that could not be addressed in the literature or the occupational medical retrospective study were the impact of HIV/AIDS on the performance of work in heat; the risk of HIV-infected workers developing occupational heat disorders; and the effects of antiretroviral therapy on heat tolerance.

Survival rates following trauma and surgery have continued to rise as the overall health of HIV-infected individuals has improved through advances made in antimicrobial and antiretroviral
therapies. From the literature it appears that severity of the traumatic insult (reflected by the ISS) rather than the severity of the underlying HIV-associated immunodeficiency (measured by CD4+ count) was the major risk factor for the development of post-traumatic infections. There were more complications in the HIV-positive population than in the control group after a traumatic event. Pulmonary and infectious complications in the HIV-positive patients were associated with greater mortality. The retrospective study on recovery from injury was unable to provide any important information because the HIV status of only 10 per cent of the mineworkers presenting with hand injuries was known. If a prospective study design were used, a bigger study population with known HIV status may have been obtained, and important information regarding the cause of injury, duration of the operation etc. could have been obtained for all types of injuries.

HIV may affect the muscles at any clinical stage and some of the first manifestations, for example, polymyositis, presents with muscle weakness. With advanced stages of HIV, a decrease in lean body mass and muscle strength and a decreased ability to perform activities that are part of daily living have been shown. Antiretroviral treatment may also affect muscle strength and body composition. Fatigue has been reported as one of the most common complaints among HIV-positive people. A significant correlation shown between HIV stages and VO\textsubscript{2} max/kg was shown. Pathophysiological mechanisms like anaemia, peripheral neuromuscular disease, and abnormalities in the diffusing capacity of the lung found in the course of HIV infection could play a role in functional impairment. Interviews with South African mine medical officers highlighted that effects on physical functions were noted, especially in the late stages of disease in mineworkers working in hot environments and doing hard physical labour. These medical officers were also concerned that many of the effects of HIV on physical function and cognition went undetected at annual medical examinations, especially for certain occupations. The occupational medical review showed that HIV-positive mineworkers weighed significantly less, took more sick leave and had more medical incapacities than the HIV-unknown group.

There was only anecdotal evidence among the South African mine medical doctors interviewed on how HIV/AIDS impacts on occupational health and safety. Effects of HIV in the late stages of disease on physical and functional work capacity were noted, especially in mineworkers working in hot environments and doing hard manual labour. Many of the effects of HIV on physical function and cognition went undetected at annual medical examinations, for reasons that may be attributed to the resources utilised in a medical certificate of fitness. Tuberculosis was the greatest concern among the doctors interviewed. Labour is very concerned with the perceived early medical incapacitation of mine employees diagnosed with HIV. Labour feels that if the working environment is contributing to the progression of HIV, then changes to environmental conditions should be made so that it is safe for HIV-positive mineworkers to work at most, if not all, job activities and in most workplaces. The government has a number of key principles in dealing with AIDS in the mining industry. Among them the dismissal of any worker on the basis of HIV status is strictly prohibited in terms of the Labour Relation Act.

In summary, it is well established that silicosis and HIV infection together confer a multiplicative risk for the development of TB, which contributes significantly to the burden of occupational disease in the mining industry. There is also a suggestion that the mining work environment (heavy physical work, heat, noise etc.) has the potential to hasten the progression of HIV/AIDS, especially if poor nutrition and living conditions are also present. HIV/AIDS and noise-induced hearing loss (NIHL) both cause sensorineural hearing loss. This relationship has to be investigated further to determine the risk HIV/AIDS has on NIHL assessments. From the literature it appears that severity of the traumatic insult (reflected by the Injury Severity Score) rather than the severity of the underlying HIV-associated immunodeficiency (measured by CD4+ count) was the major risk factor for the development of post-traumatic infections. Most studies on the surgical outcome of HIV-positive patients have either focused exclusively on asymptomatic HIV infection or full-blown AIDS or have analysed these patients together as one group but have not compared the two groups with respect to outcome. Future research should consider the mechanism of injury, and the immune status must be known in order that the true impact HIV has on recovery from injuries can be determined. The constraints to this research are the challenges and concerns raised by different stakeholders.
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Glossary

**AIDS Wasting Syndrome (AWS)**

The involuntary weight loss of 10% per cent of baseline body weight plus either chronic diarrhoea (two loose stools per day for more than 30 days) or chronic weakness and documented fever (for 30 days or more, intermittent or constant) in the absence of a concurrent illness or condition, other than HIV infection, that would explain the findings.

**Acquired nemaline myopathy**

Non-progressive muscle weakness most evident in the proximal muscles, with characteristic threadlike rods seen in some muscle cells.

**Auditory brainstem response (ABR) test**

A test for hearing and brain (neurological) functioning. The ABR test involves attaching electrodes to the head to record electrical activity from the auditory nerve (the hearing nerve) and other parts of the brain.

**Anabolic hormones**

Hormones that cause increased body and muscle size. An example of an anabolic steroid hormone is testosterone.

**Androgen**

A steroid, such as testosterone or androsterone that controls the development and maintenance of masculine characteristics.

**Audiogram**

A graphic record of hearing ability for various sound frequencies.

**Auditory brainstem response (ABR)**

An auditory evoked potential that originates from the auditory nerve. Electrodes are placed on the head, and brain wave activity in response to sound is recorded. ABR can detect damage to the cochlea, the auditory nerve, and the auditory pathways in the stem of the brain.

**Brain stem auditory evoked potentials (BAEP)**

See auditory brainstem response.

**Central hearing loss**

Hearing loss caused by a problem along the pathway from the inner ear to the auditory region of the brain or in the brain itself.

**CD4**

Glycoprotein predominantly found on the surface of helper T cells. In humans, it is a receptor for HIV, enabling the virus to gain entry into its host.

**CD4/CD8 ratio**

Another measurement of immune function, normal being approximately greater than 1.2.

**Cognition**

The mental process of knowing; cognition includes awareness, perception, reasoning, and judgment.

**Conductive hearing loss**

Hearing loss caused by a problem in the outer ear or middle ear. Conductive losses usually affect all frequencies to the same degree. These losses are not usually severe.
Cytokines
Small molecules that are the core of communication between immune system cells, and even between these cells and cells belonging to other types. They are actively secreted by immune cells as well as other cell types. Cytokines that are produced by immune cells form a subset known as lymphokines. Their action is often local, but sometimes can have effects on the whole body. There are many known cytokines that have both stimulating and suppressing action on lymphocyte cells and immune response. Some of the better known cytokines include: histamine, prostaglandin, TNF-α, IL-1, and IL-6.

Encephalitis
An acute inflammation of the brain, commonly caused by a viral infection.

Encephalopathy
Encephalopathy alters brain function and/or structure. It may be caused by an infectious agent (bacteria or virus) or mitochondrial dysfunction, brain tumour or increased intracranial pressure, prolonged exposure to toxic elements (including solvents, drugs, radiation, paints, industrial chemicals, and certain metals), chronic progressive trauma, poor nutrition, or lack of oxygen or blood flow to the brain. The hallmark of encephalopathy is an altered mental state. Depending on the type and severity of encephalopathy, common neurological symptoms are progressive loss of memory and cognitive ability, subtle personality changes, inability to concentrate, lethargy, and progressive loss of consciousness.

Fitness
The state or condition of being physically sound and healthy, especially as the result of exercise and proper nutrition. The state of being suitably adapted to an environment.

Heat acclimatisation/tolerance
Heat acclimatisation is the adaptations the body undergoes in response to a change in external environments. Among these changes is temperature.

Heat stroke
Hyperthermia, also known as heat stroke or sunstroke, is an acute condition resulting from excessive exposure to heat. The homeothermal regulatory mechanisms become overwhelmed and unable to effectively deal with the heat, and body temperature climbs uncontrollably.

Hyperlipidemia
An excess of lipids (fats) in the blood.

Hyperphagia
Abnormally increased appetite for and consumption of food, thought to be associated with a lesion in or injury to the hypothalamus.

Hypogonadal
Men with 30-50 per cent decrease in secretion of testosterone, a potent anabolic hormone.

IL-1, IL-6 and TNF α
See Cytokines.

Insulin resistance
A state of diminished effectiveness of insulin in lowering the levels of blood sugar, usually resulting from insulin binding by antibodies, and associated with such conditions as obesity, ketoacidosis and infection.

Lipoatrophy/lipodystrophy
Manifest as the excess or lack of fat in various regions of the body. These include but are not limited to sunken cheeks and "humps" on the back or back of the neck. They are often seen as a symptom or a side-effect of antiretroviral medication. Often present with peripheral fat wasting.

**Lymphocyte**
A type of white blood cell involved in the human body's immune system. There are two broad categories of lymphocytes, namely T cells and B cells. Lymphocytes play an integral role in the body's defences against infection.

**Macrophages/microglia cells**
These are the primary cells in the brain that are infected by the HIV virus and their infection leads to cognitive degeneration. Upon entry into the central nervous system the macrophage cells are infected. When the macrophages fuse with the microglia cells they produce high levels of the virus in the brain.

**Malaria parasitamia**
Parasitemia is the quantitative content of the malaria parasite in the blood. It is used as a measurement of parasite load in the organism and an indication of the degree of an active parasitic infection. Systematic measurement of parasitemia is important in many phases of the assessment of disease, such as in diagnosis, and in the follow-up of therapy, particularly in the chronic phase, when cure depends on achieving a parasitemia of zero.

**Maximal oxygen uptake**
The maximum capacity for oxygen consumption by the body during maximum exertion, i.e. VO$_{2\text{max}}$. Also known as aerobic power or maximal oxygen intake/consumption. VO$_{2\text{max}}$ is a commonly used determinant of aerobic (cardiovascular) fitness. Aerobic fitness relates to how well your cardiovascular system works to transport and utilise oxygen in your body. The better your aerobic fitness the higher your VO$_{2\text{max}}$. The most accurate way to measure your VO$_{2\text{max}}$ is to perform a maximal exercise stress test in a laboratory. VO$_{2\text{max}}$ is usually expressed in ml*kg$^{-1}$*min$^{-1}$, sometimes in ml*min$^{-1}$.

**Myopathy**
Any of various abnormal conditions or diseases of the muscular tissues, especially one involving skeletal muscle.

**Myositis**
Inflammation of a muscle, especially a voluntary muscle, characterised by pain, tenderness and, sometimes, spasm in the affected area.

**Myalgia**
Painful muscles

**Neuropsychiatric**
A disturbance of mental function due to brain trauma, associated with one of more of the following: neurocognitive, psychotic, neurotic, behavioural, or psychophysiological manifestations, or mental impairment.

**Neurotropic virus**
Having an affinity for or growing towards neural tissue. The rabies virus, which localises in neurons, is referred to as a neurotropic virus.

**Opportunistic infections**
Infections that usually don't cause disease in a person with a healthy immune system, but can affect people with a poorly functioning or suppressed immune system because of immunodeficiency or immunosuppression caused by:

- Malnutrition;
- Recurrent infections ;
- Receiving an organ transplant;
- Chemotherapy for cancer; and
- AIDS.

**Otoacoustic emissions**
Inaudible sounds from the cochlea when audible sound stimulates the cochlea. The outer hair cells of the cochlea vibrate, and the vibration produces an inaudible sound that echoes back into the middle ear. This sound can be measured with a small probe inserted into the ear canal. Persons with normal hearing produce emissions. Those with hearing loss greater than 25-30 dB do not.

**Polymyositis**
Inflammation of several voluntary muscles simultaneously.

**Psychometric test battery**
The branch of psychology that deals with the design, administration, and interpretation of quantitative tests for the measurement of psychological variables such as intelligence, aptitude, and personality traits. Also called “psychometry”.

**Psychomotor slowing**
Slowed psychic activity or motor activity, or both.

**Sensorineural hearing loss**
Hearing loss caused by a problem in the inner ear or auditory nerve. A sensorineural loss often affects a person’s ability to hear some frequencies more than others. This means that sounds may be appear distorted, even with the use of a hearing aid. Sensorineural losses can range from mild to profound.

**Resistance exercise programmes**
Defined as any technique that uses progressive resistance to increase muscular strength.

**Retrocochlear**
Diseases of the acoustic nerve. Retrocochlear refers to the eighth cranial nerve and cerebellopontine angle as opposed to the cochlea.

**Zidovudine (AZT)**
A nucleoside analogue used to slow replication of HIV. AZT is approved as one of the drugs used for the initial treatment of HIV infection.

**World Health Organization HIV clinical staging system**
The World Health Organization has developed a disease-staging system for HIV infection that is not dependent on testing.

**Clinical Stage 1:**
1. Asymptomatic
2. Generalized lymphadenopathy

Performance scale 1: asymptomatic, normal activity

**Clinical Stage 2:**
3. Weight loss <10 per cent of body weight
4. Minor mucocutaneous manifestations (seborrheic dermatitis, prurigo, fungal nail infections, recurrent oral ulcerations, angular cheilitis)
5. Herpes zoster within the last five years
6. Recurrent upper respiratory tract infections (i.e. bacterial sinusitis)

And/or performance scale 2: symptomatic, normal activity
Clinical Stage 3:
7. Weight loss >10 per cent of body weight
8. Unexplained chronic diarrhoea, >1 month
9. Unexplained prolonged fever (intermittent or constant) >1 month
10. Oral candidiasis (thrush)
11. Oral hairy leucoplaikia
12. Pulmonary tuberculosis
13. Severe bacterial infections (i.e. pneumonia, polymyositis)

And/or performance scale 3: bedridden <50 per cent of the day during last month

Clinical Stage 4:
14. HIV wasting syndrome
15. Pneumocystic carinii pneumonia
16. Toxoplasmosis of the brain
17. Cryptosporidiosis with diarrhoea >1 month
18. Cryptococcosis, extrapulmonary
19. Cytomegalovirus disease of an organ other than liver, spleen or lymph node (e.g. retinitis)
20. Herpes simplex virus infection, mucocutaneous (>1 month) or visceral
21. Progressive multifocal leucoencephalopathy
22. Any disseminated endemic mycosis
23. Candidiasis of esophagus, trachea, bronchi
24. Atypical mycobacteriosis, disseminated or pulmonary
25. Non-typhoid Salmonella septicemia
26. Extrapulmonary tuberculosis
27. Lymphoma
28. Kaposi's sarcoma
29. HIV encephalopathy
1 Introduction

1.1 Background

The estimated prevalence rate of HIV infection among adults in the southern region of Africa was ≥20 per cent at the end of the year 2000 (Corbett et al., 2002). Corbett et al. (2004) performed a cross-sectional HIV and TB disease survey of 1 773 systematically recruited mineworkers and found the HIV prevalence to be 27 per cent.

The effect of HIV/AIDS on safety, health, and occupational diseases, has been postulated. The need to obtain comprehensive data on the association of HIV/AIDS with safety and health will enable the industry to assess the impact of the pandemic and formulate best practice interventions.

The occupational medicine practitioner conducting a pre-employment examination or annual periodical examination must be certain, firstly, that the mineworker is fit to perform specified work at a mine and, secondly, that no disease or impairment is present that could either be significantly aggravated by the occupation or the working environment. At a pre-project workshop with labour, government and industry it was agreed that the following areas should be focused on in the current study: cognition, hearing loss, heat tolerance, recovery from injuries and functional work capacity.

1.1. Objectives

1. A literature review that will provide the project team with data on the impact of HIV/AIDS on:
   • Functional capacity;
   • Cognition;
   • Hearing loss;
   • Heat tolerance; and
   • The recovery from trauma-related injuries.


3. Interviews with stakeholders and mine medical officers were conducted.

4. A retrospective record review was carried out in an attempt to address the gaps in the literature for the above areas except cognition.

5. A review of all tools to assess cognitive function was carried out to identify a suitable tool to assess cognitive function of mineworkers.
2 Literature review

The purpose of the literature review was to determine the information available on the impact of HIV/AIDS on fitness/functional capacity, cognition, wound healing, hearing, and heat tolerance, which impact may directly or indirectly affect occupational health and safety.

2.1. Impact of HIV on functional capacity

2.1.1. Definition of functional capacity

A pioneer in the fitness movement defined fitness as “the ability to handle the body well and the capacity to work hard over a long period of time without diminished efficiency” (Cureton, 1947). More recent publications, such as exercise physiology textbooks (de Vries, 1986; Astrand et al., 1986), provide similar descriptions; for example, Lamb defines fitness as “the capacity to meet successfully the present and potential physical challenges of life” (Lamb, 1984). Fitness can be divided into four components: muscular strength and endurance, body composition, flexibility, and cardiovascular-respiratory capacity. Muscular strength is the force generated by a muscle or muscle group during one maximal effort (de Vries, 1986; Lamb, 1984). Muscular endurance refers to the ability to perform many repetitions at submaximal loads (de Vries, 1986; Lamb, 1984). The degree to which a body part moves or can be moved around a joint determines flexibility (de Vries, 1986; Lamb, 1984). The cardiovascular-respiratory capacity is determined by heart, lung and muscle cells, which use oxygen as fuel. Maximal oxygen uptake (VO\textsubscript{2} max) is used to measure cardiovascular-respiratory capacity and is often considered the best single measure of an individual’s overall functional capacity (Palgi et al., 1984). The following sections will attempt to demonstrate how HIV/AIDS may impact on functional capacity, as described in the literature.

2.1.2. Muscular strength and endurance and HIV

Resistance exercise programmes, nutritional counselling and support, appetite stimulants and anabolic hormones have been shown to increase muscle strength and lean body mass (Arey & Beal, 2002; Grinspoon & Mulligan, 2003; Roubenoff & Wilson, 2001; Roubenoff et al., 1999).

Nine papers addressing the issue of muscular strength and endurance in relation to HIV were identified in the literature. Four of these dealt with early-stage infection, and three papers dealt with advanced disease. Three papers reported results from patients on highly active antiretroviral therapy (HAART). Of these studies, none were conducted on the South African population.

Early stages of HIV infection

HIV may affect the muscles at any clinical stage (Authier et al., 1997) and some of the first manifestations of HIV infection are polymyositis (Authier et al., 1997) or acquired nemaline myopathy (Authier et al., 1997). The mechanism of HIV myopathy is T-cell-mediated cytotoxicity rather than direct infection of the muscle cells by HIV (Authier et al., 1997; Illa et al., 1991; Dalakas et al., 1990). HIV-associated myositis can occur at any stage of HIV infection (Johnson et al., 2003). Patients present with muscle weakness and/or elevated muscle enzymes (creatine kinase (CK)) (Johnson et al., 2003). Patients respond well to immunosuppressive therapy and have a relatively good prognosis.

Advanced stages of HIV

Patients with AIDS wasting syndrome often have a decrease in lean body mass and muscle strength and decreased ability to perform activities that are part of daily living (Arey & Beal, 2002). Factors that may contribute to wasting include inadequate intake, malabsorptive disorders, metabolic alterations and infection/inflammation (Grinspoon & Mulligan, 2003). Wasting is correlated with androgen levels in hypogonadal\textsuperscript{1} men with AIDS Wasting Syndrome.

\textsuperscript{1} Men with 30-50 per cent decreased secretion of testosterone, a potent anabolic hormone.
Testosterone is also known to have a stimulatory effect on growth hormone secretion, which may further decrease lean body mass in this group of hypogonadal men, with low testosterone levels, with AIDS (Grinspoon et al., 1996).

Patients on HAART

Cardiorespiratory insufficiency observed in one study (Keyser et al., 2000) resulted from HIV-related or pharmacologically mediated skeletal muscle dysfunction (Dalakas et al., 1990). Lower work capacity and reduced VO\textsubscript{2max} in patients with lipodystrophy or elevated p-lactate levels who are treated with highly active antiretroviral therapy could be caused by mitochondrial dysfunction, but may also be caused by impaired physical fitness (Roge et al. 2002). Zidovudine\textsuperscript{2}-induced myopathy is due to mitochondrial toxicity that results in an energy shortage within the muscle fibres even when muscle strength is normal (Roge et al., 2002). Patients present with muscle weakness, wasting, myalgia, fatigue, and elevated muscle enzymes (i.e. creatine kinase (CK)).

Summary

HIV may affect the muscles at any clinical stage and some of the first manifestations of HIV infection are polymyositis, resulting in muscle weakness and elevated creatine kinase levels. With advanced stages of HIV, decrease in lean body mass and muscle strength and decreased ability to perform activities that are part of daily living have been shown. Antiretroviral treatment may also affect muscle strength. These effects may have an adverse outcome on mineworkers in their performance of hard physical work.

2.1.3. Body composition and HIV

Body composition refers primarily to the distribution of muscle and fat in the body, and its measurement plays an important role in physical function and work. Excess body fat may lead to obesity and increases the risk of disease. With physical work, excess fat hinders performance as it does not contribute to muscular force production, and is additional weight that requires energy to move about. Lean body mass (LBM) loss results in decreased muscular force production and workers become easily fatigued.

Eight papers addressing the issue of body composition in relation to HIV were identified in the literature. Three dealt with early stage infection, one dealt with advanced disease. There were four papers that reported results from patients on HAART. Of these studies, none were conducted on the South African population. Only one study took the form of a review.

Early stages of HIV infection

In a longitudinal study of 486 persons in the early stage of HIV disease (the mean CD4 cell count during the study was 383 cells/mm\textsuperscript{3}), LBM and total body weight (TBW) were recorded and losses in LBM and TBW were associated with a significant change in physical function (Wilson et al., 2002).\textsuperscript{3} LBM loss (i.e. muscle loss) can occur at an early stage of HIV infection as a result of increased resting energy expenditure (REE) and reduced energy intake (Ott et al., 1993; Crenn et al., 2004). Crenn et al. (2004) assessed the stable weight of asymptomatic male patients in the early stage of HIV infection (n=8) and found that increased protein turnover contributed to the increase in the REE. However, there was no significant loss of lean body mass as a result of moderate hyperphagia.

Advanced stages of HIV

People with advanced HIV disease (CD4+ T cells <200 cell/mm\textsuperscript{3}) have reduced muscle and fat (Grady et al., 1996) (n=106).

Patients on HAART:

HIV-positive patients on HAART may develop HIV-associated adipose redistribution syndrome (HARS), which results in subcutaneous lipoatrophy, and abdominal obesity (i.e. lipodystrophy)

\textsuperscript{2} One of the HAART medications.

\textsuperscript{3} This was not found to be true for the women who took part in the same study.
(Saint-Marc et al., 2000) (n=154) and metabolic alterations including hyperlipidemia and insulin resistance (Salomon et al., 2002). Lipodystrophy may be related to long-term protease-inhibitor (PI)-based antiretroviral therapy, especially with stavudine (Heath et al., 2001) (n=1035). HIV-positive patients with lipodystrophy also have a significantly greater REE (per kg of lean body mass) than PI-treated and PI-naïve patients without lipodystrophy (Kosmiski et al., 2001) (n=14).

Summary

There are decreases in both lean and total body masses in HIV patients, both in early and late stages of HIV infection. Body composition is also affected by antiretroviral treatment. These effects have an adverse outcome on mineworkers who perform hard physical labour.

2.1.4. Flexibility and HIV

Initially it was thought that there was a possible association between HIV/AIDS and rheumatic or definable autoimmune disorders. However, a review of the literature suggested that this may be true only for a small number of illnesses dominated by the reactive arthritidies (Solinger, 2003). Some of the joint manifestations presented in the literature are: early HIV-related arthralgias (starting around one year after HIV seroconversion); drug-related arthritis (with, for example, lamivudine); and rheumatoid arthritis (Wegrzyn et al., 2003). Reiter-like illness4 was the most common arthropathy in HIV-positive patients in Zimbabwe (Wegrzyn et al., 2003). There was no literature available to the authors on how joint disease in HIV-positive patients affected functional capacity.

2.1.5. Cardiovascular-respiratory capacity and HIV

Cardiorespiratory endurance is defined as resistance to fatigue during sustained physical activity and is assessed with the use of treadmill exercise testing to determine VO$_{2\text{max}}$, which provides results that can be compared with known energy requirements for activities for daily living, demanding activities (McArdle et al., 1996), and population-referenced ranges of functional capacity (American College of Sports Medicine,1995).

Eleven papers addressing the issue of cardiovascular-respiratory capacity in relation to HIV were identified in the literature. Ten dealt with early and advanced stages of HIV infection. There was one paper that reported results from patients on HAART. Of these studies, none were conducted on the South African population.

Early and advanced stages of HIV infection:

Fatigue has been listed as the most common complaint among HIV-infected people, measured with the use of a number of subjective tools (Breitbart et al., 1998; Fernando et al., 1998). Fifty-four per cent of HIV-positive individuals reported life-quality-limiting fatigue in one study (Breitbart et al., 1998) (n=427). HIV fatigue was shown to interfere with important activities like employment, driving (Darko et al., 1992) (n=112), and instrumental activities of daily living (ADL) (O’Dell et al., 1998) (n=876, controls=2567).

Significant correlation could be established between HIV stages and VO2 max/kg ($r=0.72$, $p<0.0001$), as well as HIV stages and maximum work rate ($r=0.78$, $p<0.0001$) (Pothoff et al. 1994) (n=75). In another study, impairment of exercise capacity was also shown to be associated with HIV disease progression but there is great variability in exercise capacity at any given stage of HIV (Stanton et al., 1994) (n=728). Pathophysiological mechanisms like anaemia, peripheral neuromuscular disease, and abnormalities in the diffusing capacity of the lung found in the course of HIV infection (Pothoff et al., 1994) could play a role in exercise impairment. In a case-control study, soldiers with HIV were compared with HIV negative soldiers (controls). The HIV-positive soldiers complained that they were unable to perform mandatory physical training exercises. However, from history taking, physical examination, and chest x-rays there was no evidence of opportunistic infection. Findings suggested a limitation in oxygen delivery to

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4 Reiter’s syndrome is a disorder that causes three seemingly unrelated symptoms: arthritis, redness of the eyes, and urinary tract symptoms.
exercising muscles, as a result of occult cardiac disease in this group (Johnson et al., 1990) (n=32). In the literature (Mon Suez et al., 1988), 29-41 per cent of patients with AIDS had cardiac disease, which included dilated cardiomyopathy, pericarditis, cardiac tamponade, marantic endocarditis, aspergillus fumigatus endocardidits (Henochiwicz et al., 1985), and metastatic Kaposi’s sarcoma (Corboy et al., 1987).

**Patients on HAART**

Keyser et al. (2000) (n=17) found that decreased aerobic deficit in HIV-positive people was a result of peripheral tissue oxygen extraction or utilisation limitation. These authors suggested further studies to determine whether aerobic exercise training can attenuate or reverse this effect and also to investigate the possible role played by HAART in peripheral tissue oxygen extraction or utilisation.

**Summary**

Fatigue has been reported as one of the most common complaints among HIV-positive people. A significant correlation shown between HIV stages and VO2 max/kg was shown. Pathophysiological mechanisms like anaemia, peripheral neuromuscular disease, and abnormalities in the diffusing capacity of the lung found in the course of HIV infection could play a role in exercise impairment. These effects may have an adverse outcome on working capacity of affected mineworkers.

### 2.1.6. Effect of exercise on HIV/AIDS

Previous studies evaluating the effects of exercise on patients with HIV/AIDS have yielded conflicting results (Krueger-Kalinski et al., 2001). Two systematic reviews found that progressive resistive exercise with or without aerobic exercise appeared to be beneficial for adults living with HIV/AIDS. Aerobic exercise interventions especially may lead to improvements in cardiopulmonary fitness (Nixon et al., 2001; O’Brien et al., 2004).

### 2.2. Impact of HIV on cognition

#### 2.2.1. Introduction

Cognition includes information processing, understanding, learning, and the capacity to assess and evaluate information before reacting to it (UNAIDS 1997), all of which functions allow us to make sense of the world in which we live. Cognition allows us to solve problems and achieve goals that are important to us (Bandura, 2001; Nevid et al., 2000; Benedict et al., 2000).

The brain is the centre of cognitive processing. Different parts/areas of the brain control different cognitive functions. For example:

- Broca’s area of the brain controls language development and writing.
- Wernicke’s area of the brain controls speech fluency and comprehension.
- The frontal lobe of the brain is representative of the higher order or executive functions and motor performance.
- The occipital lobe controls vision and sight.
- The temporal lobe is associated with the integration and coordination of auditory functions, (Gregory, 2000) memory and emotions (Krech et al., 1982).
- The motor strip is in control of voluntary movement.

Some of the different parts of the brain referred to here are illustrated in Appendix A.

Cognitive functioning is also associated with neuropsychological functioning. Neuropsychology deals with how the different structures of the brain influence human behaviour (Gregory, 2000). Therefore, neuropsychological abnormalities also affect cognition.
Cognitive impairment and changes in brain structure are common among HIV-positive patients. During the advanced stages of AIDS the rate of neuropsychological impairment increases steadily with the progression of the disease (Heaton et al, 1995). McDaniel et al. (1997) reported that 30 to 60 per cent of individuals living with HIV suffer from AIDS-induced dementia during the later stages of the disease. Unfavourable psychosocial, and environmental factors also place tremendous psycho-physiological burden on patients and, to a certain extent, actually hasten cognitive impairment (Bandura, 2001).

Two studies also show that 50 per cent of those infected with the HIV virus would have some form of mild cognitive impairment (Paul et al., 2002) during the course of the disease. The severity of impairment is dependent upon the personal coping mechanisms of the individual and the rate at which the disease progresses.

2.2.2. HIV and the brain

The HIV virus infects not only the immune system, but also the central nervous system (CNS) and the brain (Moore, 2002). HIV can be detected in the brain within two weeks of initial infection and the virus directly infects the supportive cells of the brain (Paul et al., 2002).

The primary cells targeted by the HIV virus upon entry into the CNS are the macrophages/microglia cells of the brain (Rausch and Stover, 2000; Paul et al., 2002). The presence of the HIV virus is common in the sub-cortical regions of the brain, especially in the basal ganglia and the white matter pathways, and is associated with difficulty in motor functioning, which includes fine motor ability and speed, as well as information-processing speed and attention (Moore, 2002).

2.2.3. HIV and cognitive impairment

Cognitive impairment in HIV/AIDS has been described as the deterioration of concentration, verbal abstraction and learning capacity. It has also been characterised by psychomotor slowing, the impairment of memory and attention disturbances in processing speed, and behavioural changes. Cognitive impairment has also been widely associated with forgetfulness (Moore, 2002; Paul et al.; 2002; Tozzi et al., 2003).

The concentration of the virus in the brain determines which cognitive functions are most affected. There are several different domains of cognitive functioning that could be affected during the progression of the disease. These include language and intellectual functioning, psychomotor functioning, reaction times, spatial ability, decision making, memory, attention, planning and organisational ability, and inhibitory control (Krikorian and Wrobel, 1991). These changes interfere with independence, employment and the quality of life of the person living with HIV or AIDS (Kresina et al. in Moore, 2002). The deterioration of neuropsychological functioning seems to be progressive in nature. Therefore, neuropsychological evaluations have become an important part of HIV and AIDS health care in order that cognitive deterioration in individuals can be monitored (Moore, 2002).

Two forms of cognitive impairment related to HIV have been investigated and documented – a severe form, known as AIDS Dementia Complex (ADC), and a mild form, which results in minor cognitive motor disorder (MCMD) (Tozzi et al., 2003). ADC develops from serious impairment to certain cognitive functions such as memory, recall and the speed of information processing. ADC and MCMD can interfere with daily activities. ADC results in noticeable impairment of behaviour in activities such as handling money, driving, and getting dressed, while MCMD results in mild impairment with regard to complex or difficult activities (Tozzi et al., 2003). For more detail, refer to Appendix B.

2.2.4. Risk factors enhancing cognitive impairment as a result of HIV/AIDS

Cognitive impairment results from the presence of the HIV virus in the brain. Although current research supports this, it is not always possible to distinguish between disturbances that result directly from the presence of the virus in the brain and those that occur because of opportunistic
illnesses, the patient's existing medical conditions (Moore, 2002), or/and other risk factors. Elements from the physical environment and society in general could also impact on the deepening cognitive crisis. Environmental and genetic factors also contribute towards the development of mental illness (Kopnisky et al., 2003).

2.2.4.1. Smoking

Smoking is a learned social habit. Although more research is required to show the direct links between nicotine intake and Aids Dementia Complex (ADC), current smokers who are HIV positive are more likely to develop ADC than those who have never smoked (Valcour et al., 2004). Nicotine impacts on attention and working memory but since the data available are limited, more studies are required for conclusive proof (Valcour et al., 2004)

2.2.4.2. Aging

Aging has been linked to increased cognitive dysfunction (Valcour et al., 2004). Aging results from mitochondrial abnormalities and oxidative stress in seronegative adults, while in seropositive adults these factors also cause aging and enhance brain damage (Wallace, 1999; Tong et al., 2002 in Valcour et al) which indirectly impacts on the cognitive functioning of the individual.

2.2.4.3. Medication

HIV-positive patients are prescribed a large number and variety of medications during the course of their infection. Some of the prescribed medicine that may be effective for treating or preventing medical conditions may produce neuropsychiatric side effects (McDaniel et al., 1997).

The following antiretrovirals may affect cognition:

- Zidovudine has been associated with insomnia, agitation, confusion, depression, mania, somnolence, anxiety and irritability.
- Zalcitabine has been shown to result in fatigue, while fatigue, insomnia, anxiety and depression have been reported with lamivudine.
- Malaise, insomnia, anxiety and depression have been reported with stavudine.
- Insomnia has also been associated with Indinavir.
- Confusion is associated with Sazquinavir (Sacktor, 1988).
- Medication taken by HIV patients for opportunistic infections can cause neuropsychological dysfunction. Trimethoprin and sulfamethoxazole have been linked to depression, insomnia, fatigue, hallucinations, anxiety, and apathy. Pentamidine has been associated with fatigue, confusion, anxiety and memory loss (Sacktor, 1988).

2.2.4.4. Psychological disorders affecting cognition

The psychological status of an infected person has been shown to influence the variability of HIV-1 disease progression. There is a high risk of psychiatric and psychological disorders among HIV-infected individuals, with a prevalence rate of between 30 and 50 per cent (Gallego et al, 2002). Many of the disorders result from adjustment problems to their HIV status. The mental illnesses could also be caused directly by HIV or other opportunistic pathogens in the CNS, by the medication, toxicity of antiretroviral drugs, antibiotics or by other complications (Gallego et al., 2000). There are many psychological factors that increase the rate of cognitive impairment in HIV/AIDS patients; these are discussed further in Appendix C.

2.2.5 Assessment tool for cognitive impairment

The need exists to identify the best assessment tools for our local population by looking at tools used nationally and internationally. The tool to determine cognitive impairment should ideally be sensitive enough to identify significant cognitive dysfunction and, at the same time, be valid and reliable.
Psychometric assessment tools focus on testing a person’s cognitive abilities and determine strengths and weaknesses in the person’s pattern of thinking and how these would affect their daily lives. Tests can be carried out on various areas of cognitive functioning, from job performance to the ability to carry out tasks related to daily living (www.cpa-apc.org). Different psychometric test batteries that have been used nationally and internationally will be researched and this information will be used to set up a test battery for the mining population. A “test battery” refers to a group of tests that have been selected to assess the different domains of cognitive functioning.

The development of a psychometric test battery needs to be sensitive to early changes in cognitive functioning. In constructing a test battery we also need to be mindful of the differences that exist within South African society. In constructing a test battery culturally relevant testing should be noted, together with the validity of normative data (Foxcroft and Roodt, 2001, in Moore, 2002). All tests that have been selected must also be classified and registered by the Health Professions Council of South Africa. If the test user wishes to use a test that has not been developed in South Africa, or is not on the list of classified tests, the test may be submitted to the Board of Psychology for classification and validation (www.hpcsa.co.za).

Psychometric testing of HIV-infected patients is important, especially during the asymptomatic stages, since cognitive impairment has usually been denied despite a reported prevalence of neuropsychological dysfunction amongst HIV-positive people (Hinkin et al., 1996 in www.cpa-apc.org).

2.2.5.1 The test batteries used by international research organisations

According to the San Diego HIV Neurobehavioral Research Centre (HNRC), attention, speed of information processing, simple motor functioning, psychomotor skills, learning efficiency, abstraction and cognitive flexibility were the ability areas most affected by cognitive impairments associated with HIV-1 disease (Heaton et al., 1995). Researchers at San Diego HNRC have also developed one of the most comprehensive test batteries for use on asymptomatic patients. For a full list of tests in the battery, please refer to Appendix D.

The National Institute of Mental Health in 1989 also recommended a battery of tests to be used as screening tools. These tests were developed by a group of clinicians and researchers to assess areas of intelligence, depression, anxiety, learning ability, visual and auditory abilities, as well as vocabulary (www.cpa-apc.org). Please refer to Appendix D for a list of tests in the test battery.

2.2.5.2 The test battery used locally

The following test battery was also referred to by Moore (2002) in a South African study on the neuropsychological functioning of AIDS patients. Moore (2002) developed the following test battery for use in her study:

- Hamilton Depression Scale
- Trail Making Test
- Co-ordination Test (SAT 78)
- Rey-Osterrieth Complex figure test (ROCF)
- Tower of London Procedure (TOL)
- Adult Neuropsychological Questionnaire
- Folstein’s Mini Mental State Examination

For a full description of the tests please refer to Appendix E.

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5 Cultural differences are the different beliefs and traditions and lifestyles people have been socialised into within their families. Social differences are the social stratification differences and the type of community we belong to. Societies differ greatly in terms of size, opportunities offered, financial value, etc. Educational differences are the quality of education received at different schools, especially relevant considering South Africa’s recent history of apartheid.
2.2.5.3 Psychometric test battery for the mining industry

Underground work is characterised by mechanical tasks and the operating of large mining machinery. It is an environment that requires alertness, concentration, coordinated reactions, excellent judgment and decision-making skills for avoiding accidents and injuries. These are the cognitive skills crucial for a safe, healthy, and productive environment.

An appropriate battery to be used in the South African mining industry should ideally focus on cognitive factors that are crucial to skills development and enhancement. Currently, skills assessment takes place at a technical level in the mining industry but the test battery that is developed should not be used as part of the training programme, as the reason for the psychometric testing is not to assess workers’ job knowledge but to engage their cognitive functioning in relation to the skills that are utilised in the workplace.

The slowing of reaction times to various environmental stimuli and attention problems has been a fairly common finding among adults who have been infected with HIV/AIDS. The slowing down of reaction time has been noted across tasks with various information-processing demands. Slowing is also noticed in activities that require choices to be made from a variety of options (Hardy & Hinkin, 2002).

This generalised slowing in reaction times in patients can be measured with the determination unit. The determination test is able to identify changes in reaction times and to record the number of errors made in each subsequent test. The test also checks for attention deficits in an environment that presents changes in visual and auditory stimuli, similar to an underground environment. The determination test also runs with stringent time restrictions which make decision making in a short space of time vital. The determination unit also assesses psychomotor functioning. The determination test presents a number of visual and auditory stimuli within a short space of time. Visual stimuli are colours that flash on the screen. The person being tested needs to respond by pressing the corresponding colour button on the response panel. The auditory stimuli are presented as a high and a low tone. When a high sound is heard the respondent should register an answer by pressing on a black horizontal button on the work panel. When a low sound is heard a grey horizontal button has to be depressed. Two upright rectangular blocks on the bottom left and right of the computer screen light up from time to time. When the right side lights up the respondent must use his right foot and depress a pedal; likewise, when the left block lights up the left foot should be used to depress the left pedal.

The internal reliability for all the main variables presented in the determination test vary from \( r=.98 \) to \( r=.99 \). South African norm tables using engine driver information are available for local use, and studies by Neuwirth and Dorfer (2000) show that the determination unit distinguishes differences between the test candidates and the norm sample.

Schutte and Franz (2000) used the determination test to assess cognitive impairment during heat stress. The test was sensitive enough to calculate decreased levels of concentration and spatial perception. The lowered accuracy levels were interpreted as the reduced ability to make correct decisions by fully attending to all the information provided.

The second test to be included in the test battery together with the determination test is the Cognitrone test. The Cognitrone test is used to measure decision making and other executive functioning, such as judgment, and how receptive a person is to minute changes in the environment. The cognitrone test is also used to predict concentration levels and attention span, which are essential components of underground work. During the cognitrone test test takers have to compare the congruence of figures. Four pictures are presented on the screen with a fifth picture below them. The aim of the exercise is to compare the fifth picture with the four above it. If an exact match is found a green button is pressed on the response panel. If there is no match then the red button is pressed.
The Cognitrone test usually gives an unlimited time for the completion of the exercise; however, the ideal time to complete it is between 10 and 20 minutes. Any time longer than this is reflective of a concentration deficit. The reliability of the cognitrone test is very high, above $r=.95$. A number of validity tests have also been carried out that show the Cognitrone test to be valid for the purposes for which it is intended. The Cognitrone test is available in different versions. Version S9 is suitable for use on South Africans as it has been developed with relevant and applicable norms for our country.

The determination test and Cognitrone test together would provide a comprehensive battery of psychometric tests to assess the most critical factors in cognitive impairment associated with HIV/AIDS in mineworkers. As they are computerised skills-assessment tests, no limitation exists in terms of language. Both tests use pictures, sound and symbols, which are universally accepted, and they do not have any cultural bias towards any group of people. Administering a computerised test also saves time on the scoring of test results and saves space in terms of data storage. Together, both tests would cover the different areas of cognitive functioning as described by the San Diego HNRC.

The Determination test and the Cognitrone test are a part of the Dover Suite of tests. The Dover Suite of tests is a collection of computerised psychometric and skills tests. The Dover system allows the test user to combine tests of their choice, such as the Cognitrone and Determination tests, into a test battery in order to accurately assess particular skills. The Determination test and the Cognitrone test are among the many tests that are available in the Dover suite. Dover testing uses computerised assessment methods designed to accommodate all age groups and different education levels from no education to formal and tertiary schooling and for which prior exposure to computers is not compulsory. For these reasons, the Dover assessment tests are perfectly suited to the mining environment in South Africa as they can be fairly applied to all people. Another advantage is that these tests do not need to be administered in a group, like many of the paper and pencil tests do; individual candidates can be tested when they are available. It is a culture-free and fair method that can used to assess the skills and competencies required by operators in the underground (conventional and mechanised) and surface mining environments (www.doversystems.co.za). Test takers are given time to practise on the equipment while being coached on the test they are about to take.

2.3. HIV and hearing loss

There is an increased awareness that HIV may cause hearing changes (Larson, 1998). Abnormal audiologic findings, especially in the high frequencies (i.e. 4000Hz and 8000Hz), have been found to be significantly elevated relative to other frequencies in HIV-infected individuals (Castro et al., 2000; Sooy, 1987; Chandrasekhar, 2000). In a recent South African study, the most prevalent degree and type of hearing loss found was slight to mild and sensorineural in nature (Fuzani, 1999). Although no pathological evidence exists, it has been hypothesised that, since HIV is a neurotropic virus, hearing loss may be due to direct involvement of the eighth cranial nerve, i.e. the auditory nerve (Sooy, 1987) or by HIV infection of the brain parenchyma; i.e. AIDS encephalopathy or AIDS dementia may also cause hearing loss (Gurney & Murr, 2003). Cytomegalovirus (CMV), cryptococcal infection and Kaposi’s sarcoma of the eighth cranial nerve are other inner ear pathologies that can also present with hearing loss (Chandrasekhar et al., 2000).

Fourteen papers addressing the issue of hearing loss in relation to HIV were identified in the literature. Eight dealt with early-stage infection and nine dealt with advanced disease. There were four papers that reported results from patients on HAART. Of these studies, three were conducted on the South African population.

Early stages of HIV infection

Twenty per cent to fifty per cent of HIV-positive patients have sensorineural hearing loss (Sooy, 1987). Twenty-one per cent of neurologically asymptomatic HIV-positive individuals without AIDS
had abnormal results on bedside hearing tests compared to nine per cent of HIV-negative controls in one study (Marra et al., 1996). Real et al. (1987) state that sensorineural hearing loss may, in some cases, be the presenting complaint of undiagnosed HIV infection.

Khoza and Ross’s (2002) (n=150) study on HIV-positive patients attending an HIV clinic in Gauteng, South Africa, found that 23 per cent of the subjects presented with hearing loss. This finding was consistent with that of other studies, where 39 per cent of patients that were HIV-positive and syphilis-negative with no neurological symptoms had hearing loss on pure tone testing (Birchall et al., 1992.), and where a hearing loss of more than 25 dB HL on pure tone testing was reported in 49 per cent of HIV-positive subjects (Soo, 1987).

Khoza and Ross (2002) found that the most common type of hearing loss was sensorineural with the deterioration of patients’ immunological status. However, mixed hearing loss was also seen, confirming other studies that hearing loss in HIV-positive individuals can be of any type, i.e. conductive, sensory/neural or central (Chandrasekhar et al., 2000) (n=50). The hearing loss in Khoza and Ross’s (2002) study ranged from mild to severe. Only 14 per cent presented with sloping or high-frequency hearing loss, and the remainder presented with flat or irregular audiograms, suggesting other causes of hearing loss, like meningitis or otitis media, which affect low and mid frequencies as well (Booth, 1997). Patients presenting with SNHL almost always have a medical history of meningitis, infections, ototoxic medication use for TB or other opportunistic infections, or noise exposure (Khoza & Ross, 2002). Those with CHL or MHL had histories of chronic suppurative otitis media or otitis media with effusion (Khoza & Ross, 2002)

**Advanced stages of HIV**

About one third of AIDS patients may present with subacute encephalitis and classically present as having AIDS-dementia complex (Birchall et al., 1992). Encephelitis and dementia have been associated with abnormalities in evoked potentials (Birchall et al., 1992). Brain stem evoked responses (BSER) is a non-invasive way of testing the integrity of central auditory pathways and localising lesions within them (Birchall et al., 1992). However, only pure tone audiometry and not BSER showed a correlation with clinical stage of disease, and only in advanced cases (Birchall et al. 1992). Abnormal brain stem auditory evoked potentials (BAEP), suggesting retrocochlear involvement, were a common audiological disorder, especially in the advanced stages of disease (Castro et al., 2000) (n=30).

An increase in the occurrence of SNHL with HIV progression has been shown and may be due to the decline in immune status and increased susceptibility to the neurotropic nature of the disease and to opportunistic infections and their treatment (Chandrasekhar., 2000; Khoza & Ross., 2002; Real et al., 1987; Friedmann & Arnold, 1993; Schuknecht, 1993). Hearing loss has been described as being of sudden onset (Real et al., 2000) (especially with SNHL) or of gradual onset (especially with conductive and mixed hearing loss).

**Patients on HAART**

There are also reports that antiretroviral medication (Castro et al., 2000; Marra et al., 1996; Fruit et al., 1999) and drugs used for HIV-related conditions (for example Azidothymidine (AZT)), opportunistic infections (Gurney & Murr, 2003) and their treatment, adversely affect auditory function (Bankaitis & Schountz, 1998).

**Summary**

Hearing loss in HIV/AIDS-infected mineworkers may not be entirely due to HIV/AIDS but to a combination of factors that explain the different presentations and severity of hearing loss.

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6 Aseptic, cryptococcal and viral
7 Viruses (cytomegalovirus, hepatitis B, herpes simplex, herpes zoster), toxoplasma, syphilis-otosyphilis and neurosyphilis
8 Dideoxynosine (DDI), dideoxycytidine (DDC), didanosine, zidovudine, zalcitabine and stavudine
9 Pentamide, acyclovir, aminglycoside antibiotics, erythromycin, flucytosine, pyrimethamine, trimethoptim-sulfamethoxazole, amphotericin B, rifabutin and vincristine
10 Pneumocystis carinii, Candida albicans, Staphlococcus aureus, Mycobacterium tuberculosis, Toxoplasma gondii, Cryptococcus neoformans, Treponema pallidum, Herpes simplex, Varicella zoster, Cytomegalovirus, Jamestown Canyon virus
These include: noise, depth of mining (which results in Eustachian tube dysfunction (E de Koker, personal communication)) and/or poor living conditions. Eustachian tube dysfunction and poor nutrition/living conditions are also associated with increased middle ear pathology (E De Koker, personal communication). However, for the mining industry this has grave consequences, especially against a backdrop of the steep compensation costs for noise-induced hearing loss. It is unknown how industry will determine the percentage hearing loss due to noise exposure and the percentage due to HIV-related conditions/treatment. Evaluation to determine the aetiology of hearing loss will require a complete audiogram, speech and impedance audiometry, acoustic reflex testing, and retrocochlear testing (ABR). One publication even suggested cerebrospinal fluid analysis to detect infectious antigens (Moazzez & Alvi, 1998).

2.4. Impact of HIV on heat intolerance

2.4.1. Introduction

Manual work constitutes a major component of tasks performed in South African industries. In deep mining, this manual labour is often performed in hot environments. The consequences of high environmental heat loads can be expressed in terms of: impaired work capacity; errors of judgment, with obvious implications for safety; and the occurrence of heat disorders, especially heat stroke, which is often associated with severe and irreversible tissue damage and high mortality rates. Aetiology of heat illness includes: failure to observe appropriate limitations on the volume and intensity of physical activity relative to environmental conditions; infections; lack of heat acclimatisation; an inadequate level of endurance training; obesity; lack of sleep; failure to provide adequate fluids and minerals prior to and during activity; and the administration of drugs that limit heat dissipation (e.g. alcohol, amphetamines, and benzodiazepine antidepressants) (Shibolet et al., 2003).

Current heat stress limits in industrial settings are based on the physiological responses of healthy, medically fit individuals. Most individuals would, in a qualitative sense, exhibit similar response patterns to heat. The actual response pattern for any given individual is a function of a variety of factors (Havenith, 1997), including nutrition, hydration, maximum work capacity, age, gender and body dimensions. The assessment of risk is directed at the individual through risk-based medical and physical examinations (Schutte, 2003) (see Section 3.2.1).

The exposure of HIV-infected individuals and individuals with AIDS to the same heat stress limits found in the industrial setting could increase their risk of developing heat disorders to an unacceptable and dangerous level (Schutte, 2003). Acute intercurrent illness and heat stress can temporarily reduce heat tolerance (Keren et al., 1981). Fever, which is common among HIV-infected individuals, is a well-accepted factor predisposing heat intolerance. Fever is produced by the effects of endogenous pyrogens (such as IL-1, IL-6, interferon and tumor necrosis factor) on the CNS, and body temperature is regulated at a higher temperature than normal. This means that the same amount of work will produce the same amount of heat storage, but at a higher and more dangerous body temperature (Schutte, 2003).

2.4.2. Heat exposure and the overall immune response

Psychometric scales have shown heat exposure to be a significant source of stress (Shephard et al., 1999). The result of acute and chronic stress on the immune system may be increased susceptibility to infections (Shephard et al., 1999). Suppression of immune responses has been shown to be a long-term effect of stress (Shephard et al., 1999). Serum levels of IgG were decreased during an arduous 42-day period of work under very hot conditions (Eberhardt et al., 1972). There is a decrease in CD3+, CD4+ counts and CD4+/CD8+ ratio in response to an increase in core temperature (Shephard et al., 1999). Bouchama et al. (1991) demonstrated that heat stroke victims with an average rectal temperature of 41.4°C showed a 34 per cent decrease in CD4+ cell count but a 214 per cent increase in CD8+ count.

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11 Treponema pallidum and cryptococcal antigens
In summary, mild heat exposure has little effect on immune response. However, moderate heat may initially enhance the immune response, but prolonged or extreme heat exposure can depress cellular response. Information on the effect HIV/AIDS will have on the immune response for the mineworker working in a hot environment was not available for this study, but the information set out above suggests there may be an additive response, which warrants further research.

2.4.3. HIV and fever

Fever is a primary disorder of thermoregulation and is a common clinical sign in many infectious diseases. Fever results in an upward displacement of the level at which the body temperature is regulated and, therefore, the body is still able to regulate its temperature (Kielblock, 1982).

In a study by Nwanyanwu et al. (1997), the relationship between fever, malaria and HIV was investigated. Six-hundred-and-forty-three adult males working at a sugar corporation in Malawi participated in a routine physical examination and were tested for malaria and/or HIV. Fever reporters (FR) were defined as those with axillary temperatures of $\geq 37.5^\circ\text{C}$ or a history of fever in the preceding two weeks. Twenty-two per cent of the study participants were HIV-positive. FRs were significantly more likely to be HIV-positive than non-fever reporters (NFRs). HIV was shown to be significantly associated with fever but not parasitaemia, i.e. malaria. The authors concluded that fevers were more likely to be associated with HIV infection than with malaria parasitaemia. This may be because HIV-positive people are more prone to other infections that can induce fever. For this reason, the cause of fever should be sought and managed appropriately (Nwanyanwu et al., 1997).

2.4.4. HIV and heat exposure

Heat exposure may affect a person with HIV in two ways. Firstly, heat may be a factor in the progression of HIV. Plasmodium falciparum (the parasite causing malaria) has been shown to stimulate HIV-1 replication through the production of cytokines (IL-6 and TNF $\alpha$) by activated lymphocytes (Whithworth et al., 2000) (n=484). In patients with heat stroke, plasma levels of IL-1, IL-6 and TNF $\alpha$ are increased (Bouchama et al., 1991; Chang, 1993). IL-1 concentrations have been shown to be significantly increased for 16 to 20 hours following a 4$^\circ\text{C}$ increase in core body temperature sustained for 60 minutes (Neville & Saunder, 1988). Thus, heat-related illness or sustained increase in core body temperature may be a factor in the progression of HIV.

Secondly, a person with late-stage HIV may be more prone to heat-related illnesses. The California AIDS Ride was a 547-mile bicycle ride that had over 10 000 riders, including a large number of chronically ill patients, many of whom were HIV-positive. The maximum daily temperatures varied from 26.7$^\circ\text{C}$ to 43.3$^\circ\text{C}$. HIV seropositivity was not shown to increase the risk of heat illnesses. However, the number of chronic medical illnesses (many consistent with AIDS) was significantly associated with heat-related illnesses (Krueger-Kalinski et al., 2001).

2.5. Impact of HIV on the recovery from injuries

HIV/AIDS has the potential to confound the outcome of HIV-infected trauma patients as a result of co-existing HIV-related medical conditions, complex treatment regimes, and immunosuppression (Stawicki et al., 2005).

Early stages of HIV infection

Guth et al. (2005) assessed 56 HIV-positive patients admitted for trauma. Only nine patients developed complications secondary to bacterial infections after admission. Four patients developed pneumonia, three had wound sepsis, one had urinary sepsis, and the other had osteomyelitis. The blood cell count, serum albumin levels, transfusion requirements, CD4+ cell count, the presence of full-blown AIDS and injury severity score (ISS) were compared for patients with and without post-traumatic infection. Only ISS was found to be significantly higher (i.e. was twofold greater) in the infection-complicated group. The expected direct correlation between CD4+ cell count and bacterial infectious complications was demonstrated by some studies (Tran et al., 2000) while other studies did not find this association (Safavi et al., 1991;
Binderow et al., 1993). Similarly, for the outcome of HIV-positive patients admitted to ICU, APACHE (acute physiology and chronic health evaluation) II scores rather than CD4+ cell count correlated with in-hospital mortality. In San Francisco (Paiement et al., 1994), a significantly higher number of wound and distant infections were found for asymptomatic HIV-positive orthopaedic patients than for HIV-negative orthopaedic patients.

Stawicki et al. (2005) identified trauma patients (n=559) with known HIV status and randomly selected age-matched controls (n=614) from the Pennsylvania Trauma Outcome Study. HIV-positive status was associated with significantly longer length of stay in hospital, longer length of stay in intensive care, and more pulmonary, infectious/septic, and renal complication, which were significantly associated with mortality. HIV-positive patients in the study had more operative procedures than the control group.

**Advanced stages of HIV**

Initially, articles reported mortality rates of 50-70 per cent for end-stage AIDS patients for abdominal manifestations requiring surgery (Burack et al., 1989; Nugent & O Connell, 1986; Wexner et al., 1998). However, from the late 1980s onwards, mortality rates for HIV-positive patients dropped to 12-25 per cent (Whitney et al., 1994; Wilson et al., 1989) for emergency trauma surgery with no deaths after appendectomy or cholecystectomy. For AIDS patients, the mortality rate for elective surgery was 9 per cent and for emergency procedures was 46 per cent (Wilson et al., 1989).

HIV-positive patients who suffer from moderate to severe burn wounds were found to have similar clinical outcomes as HIV negative patients, as long as there were no stigmata of AIDS (Edge et al., 2001). Previously it was controversial to operate on HIV-positive patients with AIDS because of delayed wound healing (Wakeman et al., 1990) but Eriguchi et al. (1997) showed that even patients with less than 100 CD4+ cells/mm in stage IV could have curative operations and that wounds heal despite the three- to four-week delay without keloid formation.

However, in Africa, the mortality rates following trauma or surgery are higher (Poznansky et al., 1994; Kehoe, 1994) because of the high prevalence rate of HIV infection, poor living conditions, and less sophisticated medical support. Hoekman et al. (1991) conducted a study in Rwanda and found that 20 per cent of patients requiring internal fixation devices were HIV-positive and that, while the overall wound infection rate was 5 per cent, patients with AIDS had a sepsis rate of 24 per cent. In Zambia, of 147 HIV-positive orthopaedic patients requiring surgery for open fractures, 72 per cent had postoperative wound sepsis, and 28 per cent had non-union (Jellis, 1992).

Hebra et al. (1990) found that nearly half of the operations performed on HIV-positive patients were performed to treat AIDS-related complications or to facilitate the work-up of AIDS patients.

**Summary**

Survival rates following trauma and surgery have continued to rise as the overall health of HIV-infected individuals has improved through advances made in antimicrobial and antiretroviral therapies. From the literature it appears that severity of the traumatic insult (reflected by the ISS) rather than the severity of the underlying HIV-associated immunodeficiency (measured by CD4+ count) was the major risk factor for the development of post-traumatic infections. There were more complications and pre-existing conditions in the HIV-positive population than in the control group after a traumatic event. Pulmonary and infectious complications in the HIV-positive patients were associated with greater mortality in one study.

### 2.6 Standards and guidelines for fitness for work in the South African mining environment

Section 9(2) of the MHSA states that an employer must prepare and implement a Code of Practice (COP) on any matter affecting the health or safety of employees. A guideline for the compilation of a mandatory COP on minimum standards of fitness to perform work at a mine (DME Reference Number 6/3/2/3-A1) was prepared by the Occupational Medicine Sub-
Committee, which is made up of representatives of the state, employers and labour. The current
guideline is presently being updated.

Table 2.6 Schematic guideline for job placement evaluation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No</th>
<th>Mine/Works: Surface</th>
<th>Mines: Underground</th>
<th>Surface or Underground</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Frequency of examination</td>
<td>At initial placement</td>
<td>At initial placement and 3 yearly</td>
<td>At initial placement and then 3 yearly</td>
<td>At initial placement and then annually</td>
</tr>
<tr>
<td>Minimum age at employment</td>
<td>16 years</td>
<td>18 years</td>
<td>18 years</td>
<td>21 years</td>
</tr>
<tr>
<td>Colour blindness</td>
<td>-</td>
<td>-</td>
<td>Exclude</td>
<td>Exclude</td>
</tr>
<tr>
<td>Visual field at least 50/70</td>
<td>-</td>
<td>-</td>
<td>Exclude</td>
<td>Exclude</td>
</tr>
<tr>
<td>Hearing (pure tone average of 0.5; 1, 2 and 3 kHz)</td>
<td>Age: 16-39 years &lt; 15 dB loss; Age 40+ &lt; 25 dB loss. Also: &lt; 45 dB loss at 3 kHz all ages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epilepsy/neurological state affecting level of consciousness</td>
<td>-</td>
<td>Exclude for 2 years</td>
<td>Permanent exclusion</td>
<td>Permanent exclusion</td>
</tr>
<tr>
<td>Diabetes</td>
<td>-</td>
<td>Well-controlled diabetes</td>
<td>Only well-controlled NIDDM allowed</td>
<td>Exclude</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Must have sufficient cardio-respiratory function to cope with job and environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol / drug abuse screen</td>
<td>-</td>
<td>-</td>
<td>Consider testing: exclude if positive</td>
<td>Compulsory testing: exclude if positive</td>
</tr>
</tbody>
</table>

Issues that are addressed in the COP Guidelines are:

- Initial examination and baseline tests for new or prospective employees must be appropriate to the health hazards or exposures (determined in the relevant risk assessment) of the envisaged occupation and these tests must be repeated periodically.
- Different categories of fitness to work for particular categories of work are given (Table 2.6).
- Identified diseases or conditions listed may affect job placement evaluation, for example diabetes.

Kielblock (2003), however, points out that the DME Guidelines on standards of fitness emphasise the absence of disease rather than the health risk of over-exertion and/or premature
fatigue, poor nutrition and awkward shift systems in reference to mobility, work position, and material handling (Kielblock & Hofman, 2003).

3 Data-collection instruments used to determine the effects of HIV/AIDS on occupational health and safety (OHS) in the South African mining industry

3.1 The telephone survey

The object of the telephone survey with medical officers and specialists, from different mining commodities, was to determine their perceptions and observations of the impact of HIV on occupational health and safety (OHS).

Twenty-seven mine medical officers and specialists were interviewed anonymously (Appendix F) from different sectors, including coal, gold, platinum, small-scale mines, opencast mines, precious metal mines, and quarries.

There is only anecdotal evidence among the doctors interviewed on how HIV/AIDS impacts on OHS and most of the responses were based on this anecdotal evidence. Effects on physical functions were noted, especially in the late stages of disease in mineworkers working in hot environments and doing hard physical labour. Many of the effects of HIV on physical function and cognition went undetected at annual medical examinations and were a concern, especially for certain occupations. Tuberculosis was the greatest concern among the doctors interviewed. Other concerns were that exposures at work and presentation of HIV/AIDS made it difficult for many of the doctors interviewed to diagnose work-related illnesses.

No formal research on the impact of HIV on the mines was being conducted at the time of the telephone interviews as many mine medical officers felt that the stigma and confidentiality issues made it very difficult to do so. Operational research is done but not quantified. Studies looking at the impact of HIV on mortality are being carried out but are mine-specific.

In essence, many of the respondents felt there was some evidence of correlation between OHS and HIV progression. Although not substantiated or documented, responses pointed towards evidence of clinical manifestation of these relationships. There did not seem to be a good understanding of the confounding effect of other explanatory variables in this relationship. Unfortunately, this relationship can be investigated only in an empirical epidemiologically designed study.

3.2 Discussion interviews

The object of the interviews with labour and the DME was to determine their perceptions and knowledge of how HIV/AIDS affected OHS. However, what was raised was not directly related to HIV/AIDS and OHS. The important related issues and concerns that did emerge are discussed below.

3.2.1 Labour

Labour feels that if the working environment is contributing to the progression of HIV, then changes to environmental conditions should be made so that it is safe for HIV-positive mineworkers to work at most, if not all, job activities and in most workplaces.

Labour was also concerned with the early medical incapacitation of mine employees diagnosed with HIV, which resulted in many mineworkers withholding their status or not being tested for HIV and the underutilisation of VCT and early diagnosis and management of HIV. The above
enforces the fear many employees have of knowing their status as many feel that, once their status is disclosed to management or medical staff, dismissal, retrenchment or medical incapacitation are soon to follow. This fear has resulted in a reluctance among mineworkers to take part in voluntary counselling and testing (VCT) at wellness clinics at the mines, even though labour supports the government in encouraging individuals to become aware of their health status and HIV status in order to prevent further spread of the pandemic.

### 3.2.2 The Department of Minerals and Energy (DME)

The DME did not feel that there was enough evidence to suggest that HIV directly affected OHS but felt that it was a very important issue in terms of the Labour Relations Act and the Mine Health and Safety Act.

The government has a number of key principles in dealing with AIDS in the mining industry. Among them, the following may impact on OHS (Mining Industry Tripartite HIV and AIDS summit 30 April 2003, DME)

- "The dismissal of any worker on the basis of an HIV status is strictly prohibited in terms of the Labour Relation Act.
- Medical testing of an employee is prohibited unless legislation permits or requires the testing. It is only justified in the light of, among other things, medical facts, and fair distribution of employee benefits or employment conditions.
- Similarly, the testing of employees to determine HIV status is prohibited unless such testing is determined to be justifiable by the Labour Court, which may make any order it considers appropriate to the circumstances, including imposing conditions relating to, among other things, provision for counselling, and referral for health services and the category/categories of jobs or employees in respect of which the authorization for testing applies.
- Since reasonably simple, cheap and effective steps can be taken to reduce the risk of occupational infection of HIV, employers are obliged to take such steps to create a working environment that promotes the health and safety of all employees.
- People living with HIV and AIDS should be involved in the design, implementation and monitoring of all prevention, intervention and care strategies and programmes.
- Confidentiality and informed consent with regards to HIV testing and test results should be ensured."

### 3.3 Retrospective record review

#### 3.3.1 Background

The object of the retrospective record review was to assess (and compare) audiograms, heat tolerance assessments, recovery from injury and function of mineworkers who died of AIDS-related causes with a reference group of mineworkers.

Owing to limited resources (i.e. finance and the stipulated period) a pilot retrospective study was proposed. All 105 occupational health records of mineworkers who died of HIV-related illness in 2004 were used for collecting data on hearing loss, heat intolerance and function of mineworkers, and were compared with the 106 occupational health records of mineworkers who died of other causes in 2004, i.e. injury and unrelated medical conditions.

In order to determine the injury recovery period of HIV-positive mineworkers compared to HIV unknown, several proposed methodologies were discussed with Dr J Goosen (head of trauma, University of the Witwatersrand) and Dr A Lancaster (hand surgeon at a gold mine) and it was suggested that only hand injuries should be included. Information on the type of wound, the duration of operation, whether or not the protocol was followed, and if the hand injury was debrided in theatre or whether the patient was managed in a casualty procedure room was also available. All the above are very important factors in recovery from a hand injury. Similar
information was not available for other injuries. Ethical approval was obtained from the University of the Witwatersrand before the fieldwork began. (The clearance certificate protocol number is M02-07-33.)

3.3.2 Methodology

Study design

PART 1- Occupational medical record review

A retrospective record review was undertaken of a cohort of mineworkers who died of AIDS-related causes in 2004 at the gold, coal and platinum mine with an HIV-unknown group. Audiograms, heat intolerance assessments and function over the five-year period before the mineworkers died of AIDS-related causes were compared with mineworkers who died of injuries or un-related medical causes over a similar period.

At the pre-project workshop it was agreed that the following variables from the occupational health records may give indications of functional deterioration. Information on the following was collected:

- Mass/BMI;
- Sick leave;
- Medical incapacity or job changes;
- Urine analysis;
- Heart rate and blood pressure; and
- Peak flow or/and lung function tests.

At the coal mine, mass, sick leave, and changes in job were recorded. At the gold and platinum mines, BMI, medical incapacity, urine analysis, heart rate, blood pressure, and peak flow and/or lung function tests were recorded.

PART 2-Recovery from injuries

A retrospective record review was undertaken of mineworkers admitted to a gold mine hospital for hand injuries, to determine if there was a significant difference between the number of hospital days/sick days leave, complications (i.e. sepsis/disability), time required to return to work, and change in job status/earning capacity after the injury for HIV-positive and for HIV-negative patients.

Study population

Part 1-Occupational medical record review

At the coal mine, the occupational health records of 55 deceased mineworkers were assessed. The HIV status of only 16 (29.1 per cent) was known. The occupation of the mineworkers (Appendix G), length of service, cause of death, mass, audiograms and sick leave were recorded.

The mean length of service for the HIV-positive mineworkers was 11.5 years (std deviation 6.16) and for the HIV-unknown mineworkers 10.5 (std deviation 5.93), this was not statistically significant. The causes of death for the HIV-positive group were TB (44 per cent), anaemia, kidney failure, meningitis, respiratory failure and subarachnoid bleed. For the HIV-unknown group the majority of deaths were caused by MVA (28 per cent), injury on duty (7.7 per cent), stroke, assault, heart disease, and liver and/or kidney disease.

At the platinum and gold mines, occupational health records of 156 deceased mineworkers were assessed. The HIV status of 89 of them (57.1 per cent) was known. Information on occupation (Appendix G), length of service, cause of death, BMI, audiograms, lung function
tests and heat tolerance was recorded. Occupational health records did not have information on sick leave and job changes but note was made of any medical incapacity, as this often results in a job change or termination of work. Information obtained from the gold and platinum mines was similar and, therefore, is grouped together.

The mean length of service for the HIV-positive deceased mineworkers was 18.7 years (std deviation 8.87 years) and for the HIV-unknown group was 18.39 years (std deviation 8.72 years). This was not statistically significant. The mean age of the HIV-positive deceased mineworkers was 37.4 years (std deviation 6.8 years) and for the HIV-unknown group was 39.4 years (std deviation 11.3 years). Forty-six per cent of the HIV-positive deceased mineworkers smoked and 59 per cent drank alcohol whereas 54 per cent of the HIV-unknown group smoked and 55 per cent drank alcohol.

Part 2 – Recovery from hand injuries

One-hundred-and-twenty-five records of mineworkers with hand injuries were obtained from the gold mine’s database for 2001 - 2004. All the records of mineworkers presenting with a hand injury during this period were selected. The HIV status of only 12 was known (see Table 3.3.2). The date of injury, date of surgery, length of stay at hospital, whether the wound had sepsis or not and the amount of sick leave were recorded.

Table 3.3.2: HIV status of mineworkers with hand injuries

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV positive</td>
<td>7</td>
<td>5.6</td>
</tr>
<tr>
<td>HIV negative</td>
<td>5</td>
<td>4.0</td>
</tr>
<tr>
<td>HIV unknown</td>
<td>113</td>
<td>90.4</td>
</tr>
<tr>
<td>Total</td>
<td>125</td>
<td>100</td>
</tr>
</tbody>
</table>

Data analysis

The approach for the record review analysis for recovery time from work-related injuries was to compare the recovery rate and outcomes for HIV-positive patients with the recovery rates and outcomes for those who were HIV negative.

The approach for the record review analysis of a cohort of mineworkers who had died of an AIDS-related cause and the analysis of a comparison group was to compare any significant differences in hearing loss, heat tolerance assessments and/or function in the 2 groups.

Comparisons of discrete outcomes between HIV-negative and HIV-positive workers was carried out with the use of standard chi-square tests; in the case of two-by-two tables with small frequencies in one of the outcome categories Fisher’s exact test was used. Further analyses were carried out by fitting logistic regression models to allow for potential confounders. Comparisons of continuous outcomes were carried out with the use of two-sample t-tests and also by fitting analysis of covariance models to adjust for potential confounders.

Limitations of the retrospective study

There was no randomisation when the study participants were selected at each mine because of the small numbers. For this reason, the possibility of confounding could not be excluded. As this was a pilot study sample size was not calculated and sites were not randomly selected. Therefore, the study was not sufficiently powered and the applicability of the results to the general mining industry could not be inferred. The selection, collection, assimilation, and abstraction of data and sampling did not allow the study team to infer any causal relationships between HIV and the conditions studied, only to calculate measures of association. These measures of association could be used to inform the forward to conducting a longitudinal study.

Retrospective data was compromised, as many of the patient files had data missing and it was difficult to obtain data on heat tolerance from certain mines.
3.3.3 Results and discussion

3.3.3.1 Part 1-Occupational medical record review

Review of audiograms

Table 3.3.3.1: Mean hearing loss for HIV-positive and HIV-unknown groups at the gold and platinum mines

<table>
<thead>
<tr>
<th>4 kHz (dB)</th>
<th>HIV-positive</th>
<th>HIV unknown</th>
<th>P-Value from T-test</th>
<th>P-Value from Mann Whitney test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>Mean</td>
<td>27.82</td>
<td>21.2</td>
<td>0.0105</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>17.20</td>
<td>13.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>23.75</td>
<td>18.0</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Mean</td>
<td>31.14</td>
<td>21.0</td>
<td>0.0002</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>16.93</td>
<td>15.1</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>28.75</td>
<td>17.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6 kHz (dB)</th>
<th>HIV-positive</th>
<th>HIV unknown</th>
<th>P-Value from T-test</th>
<th>P-Value from Mann Whitney test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>Mean</td>
<td>30.86</td>
<td>25.6</td>
<td>0.0246</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>15.73</td>
<td>11.9</td>
<td>0.0345</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>30.00</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Mean</td>
<td>32.18</td>
<td>26.9</td>
<td>0.0283</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>14.93</td>
<td>14.5</td>
<td>0.0061</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>31.25</td>
<td>25.0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8 kHz (dB)</th>
<th>HIV-positive</th>
<th>HIV unknown</th>
<th>P-Value from T-test</th>
<th>P-Value from Mann Whitney test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>Mean</td>
<td>26.36</td>
<td>21.4</td>
<td>0.0409</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>15.69</td>
<td>13.3</td>
<td>0.0274</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>25.00</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Mean</td>
<td>26.36</td>
<td>22.2</td>
<td>0.0811</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>14.20</td>
<td>14.6</td>
<td>0.0286</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>25.00</td>
<td>18.8</td>
<td></td>
</tr>
<tr>
<td>ABHL</td>
<td>Mean</td>
<td>18.17</td>
<td>13.6</td>
<td>0.0039</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>10.63</td>
<td>8.2</td>
<td>0.0057</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>15.42</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>Left DSHL</td>
<td>Mean</td>
<td>18.38</td>
<td>14.6</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>12.25</td>
<td>10.0</td>
<td>0.0534</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>15.43</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td>Right DSHL</td>
<td>Mean</td>
<td>17.48</td>
<td>12.7</td>
<td>0.0022</td>
</tr>
<tr>
<td></td>
<td>Std deviation</td>
<td>10.50</td>
<td>8.0</td>
<td>0.0016</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>15.00</td>
<td>10.0</td>
<td></td>
</tr>
</tbody>
</table>

At the coal mine, there was no significant association found between hearing loss and HIV status. This finding could be the result of the small sample size.

At the gold and platinum mines the mean hearing loss for the HIV-positive group was found to be significantly higher than for the HIV-unknown group (see Table 3.3.3.1a). The hearing loss in the HIV-positive group was classified as mild, especially for the higher frequencies.

When the effect of hearing loss was adjusted for age and length of service, HIV-positive mineworkers had 5.1 dB more hearing loss in the right ear than HIV-unknown mineworkers.
and 8.7 dB more hearing loss in the left ear \((p=0.002)\). Similar significant findings were found for 6000K, ABHL and right DSHL (see Table 3.3.3.1b).

**Table 3.3.3.1b: Mean difference in hearing loss for HIV-positive and HIV-unknown groups at the gold and platinum mines adjusting for age and length of service**

<table>
<thead>
<tr>
<th></th>
<th>Mean difference in hearing loss (dB)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000K (dB) Right</td>
<td>5.1</td>
<td>0.002</td>
</tr>
<tr>
<td>4000K (dB) Left</td>
<td>8.7</td>
<td>0.04</td>
</tr>
<tr>
<td>6000K (dB) Right</td>
<td>3.6</td>
<td>0.09</td>
</tr>
<tr>
<td>6000K (dB) Left</td>
<td>4.0</td>
<td>0.1</td>
</tr>
<tr>
<td>8000K (dB) Right</td>
<td>3.7</td>
<td>0.1</td>
</tr>
<tr>
<td>8000K (dB) Left</td>
<td>2.9</td>
<td>0.2</td>
</tr>
<tr>
<td>ABHL</td>
<td>3.3</td>
<td>0.046</td>
</tr>
<tr>
<td>Left DSHL</td>
<td>2.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Right DSHL</td>
<td>3.6</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Birchall et al. (1992) studied pure-tone audiometry across the clinical spectrum of HIV infection and found that abnormalities in pure tone thresholds were surprisingly common (39 per cent). Within the group with AIDS, there was a weak correlation between pure tone averages and T-cell subset ratio (i.e. CD4:CD8 ratio). Birchall et al. (1992) suggested that any future studies of audiometry deterioration in cases of HIV infection should include pure tone audiometry. Chandrasekhar et al. (2002) showed that more severely HIV-infected patients (i.e. CDC-C3) had significantly higher (worse) pure tone thresholds than HIV patients who were in the early stages of infection (i.e. CDC-A).

Many of the doctors interviewed did not think that HIV/AIDS had an impact on noise-induced hearing loss and felt that any hearing loss recorded in HIV-positive patients was due to otitis infections and/or baro trauma. In the evaluation of sensorineural hearing loss, the use of HAART or medication used to treat opportunistic infections, especially multi-drug-resistant TB, should be considered as an etiological factor.

**Review of heat tolerance screening assessments (HTS)**

Heat tolerance screening (HTS) is required if the working environment is hot, especially in deep mining. For this reason, at the coal mine HTS was not performed. Owing to the small sample size\(^\text{12}\) a formal comparison was not carried out. The doctors interviewed felt that only HIV-positive patients in the late stages of AIDS may fail HTS.

**Review of function from occupational medical files**

At the coal mine a statistical significant difference was found between the HIV-positive and HIV-unknown groups for weight and the number of days of sick leave taken for this group of coal mineworkers (see Table 3.3.3.1c). There was only one job change for the HIV-positive group,

\(^\text{12}\) Only 1 mineworker at the gold mine failed the heat tolerance screening test
when a worker moved from being an underground aide to being a worker in the lamp room. There were no job changes for the HIV-unknown group.

Table 3.3.3.1c: Mean mass and sick leave taken for HIV-positive and HIV-unknown groups at the coal mine

<table>
<thead>
<tr>
<th></th>
<th>HIV-positive</th>
<th>HIV unknown</th>
<th>P-Value from T-test</th>
<th>P-Value from Mann Whitney test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Mean</td>
<td>64.2</td>
<td>80.5</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Weight Std deviation</td>
<td>6.9</td>
<td>14.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight Median</td>
<td>63.0</td>
<td>78.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sick leave Mean</td>
<td>15.6</td>
<td>4.5</td>
<td>&lt;0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Sick leave Std deviation</td>
<td>8.9</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sick leave Median</td>
<td>12.9</td>
<td>2.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Leigh et al. (1995) found that patients with AIDS reported 38.23 days lost from work and HIV-positive patients without AIDS reported 12 days, which was significantly higher than the 2.5 days reported by the HIV-negative group. In our study, the mean sick leave for the HIV-positive and HIV-unknown group is given in Table 5.3.5. For the HIV-positive group the mean days’ sick leave taken was 33 (std deviation 31.6 days) and for the HIV-unknown group the mean number of days’ sick leave taken was 5.2 (std deviation of 10.2 days).

At the gold and platinum mines there was no significant difference between the HIV-positive and HIV-unknown groups for heart rate, blood pressure, and lung function tests. However, there was a significant difference for BMI (p= 0.0028). The mean BMI for the HIV-positive group was 22.6 compared with a BMI of 24 for the HIV-unknown group.

Twelve per cent of the HIV-positive mineworkers had haematuria (blood in urine) compared with 8 per cent in the HIV-unknown group. Twenty-one per cent of the HIV-positive mineworkers presented with proteinuria (protein in urine) compared with 8 per cent in the HIV-unknown group. The difference was statistically significant only for haematuria (p=0.04). The effect of HIV on BMI was adjusted for age and length of service, and HIV-unknown mineworkers were still found to have significantly higher BMI (p=0.0028). There were no significant differences in blood pressure and heart rate.

At the gold and platinum mines, medical incapacity resulting in change in job (often to a surface position) or termination of employment was recoded. There was a significantly higher number of medical incapacities (p=0.001) for the HIV-positive group than for the HIV-unknown group. The result, however, is biased as many of the HIV-unknown deaths were unnatural and, therefore, an equal opportunity for people from the HIV-unknown group to be medically incapacitated did not exist.

3.3.3.2 Part 2-Recovery from injuries

The mean time lapse from the time of injury to the surgical management of the patient was 2.7 hours for the HIV-positive patients (std deviation of 2), 2.4 hours for the HIV-negative patients (std deviation of 1.7) and 3 hours for the HIV-unknown patients (std deviation of 2.8). The length of hospital stay was 1.7 days for the HIV-positive patients (std deviation of 0.8 days), 2.35 days for the HIV-negative patients (std deviation of 8.6 days), and 3 days for the HIV-unknown patients (std deviation of 5.8 days). Table 5.5 demonstrates the number of patients presenting with sepsis for the different groups. No statistical significance was found due to small sample size.
Table 3.3.3.2: Sepsis rates for the different groups

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV positive</td>
<td>1(14%)</td>
<td>6 (86%)</td>
</tr>
<tr>
<td>HIV negative</td>
<td>1(25%)</td>
<td>4 (75%)</td>
</tr>
<tr>
<td>HIV unknown</td>
<td>31 (27%)</td>
<td>82 (73%)</td>
</tr>
</tbody>
</table>

No evidence of an association between HIV status and hand injury sepsis (p>0.5) and between HIV status and number of days' sick leave as a result of a hand injury (p>0.5) was shown in our study because of the small sample size. Another reason for not finding any significant association may be the small number of study participants whose HIV status was known, i.e. 7. The mechanism of injury, which has a strong influence of the length of stay in hospital and sepsis rate, was not known for any of the study participants. Other confounding variables that could not be controlled for in our study were the management of the patients immediately after the injury and before seeing the hand surgeon and the overall assessment of the patient before the injury, all of which have a direct impact on the outcome of the injury. Therefore, no conclusion regarding the impact of HIV on the recovery of injuries could be drawn.

Ching et al. (1996) assessed hand injuries seen at the Emergency Hand Service in South Africa and found that septic HIV patients spent more time in hospital and required more operations than septic non-HIV patients.

Doctors interviewed in the telephone survey (Section 3.2.1) felt that the recovery from injury and complications from injuries depended on the stage of HIV and that delayed healing and complications were more common in the late stages. Infections were more common in those patients with delayed healing. Some doctors felt that the excellent rehabilitation systems at their mines meant that mineworkers injured at the mines had a better recovery rate from injuries than trauma patients admitted to public clinics. The role of HAART was mentioned as an important determinant in the recovery from injuries. Doctors noted that complications following injuries depended on the injury type and management but that post-operative infections were more common in their HIV-positive patients.

6. Conclusion

The literature search was done using the following databases: Pubmed, Science Direct, Ebsco Host databases, Google search engine, Minelib mining technology reports catalogue, and Dialog. The literature findings suggest that HIV/AIDS may impact on occupational health and safety.

Up to sixty per cent of individuals living with HIV suffer from AIDS-induced dementia during the later stages of the disease. Cognition is also affected. Cognitive impairment commonly found in HIV-infected individuals has been described as: deterioration of concentration and learning capacity; psychomotor slowing; impairment of memory; attention disturbances in processing speed and reaction time; and behavioural changes.

Up to fifty per cent of HIV-infected individuals may present with sensorineural hearing loss. The causes of hearing loss may be HIV itself, opportunistic infections, tumours, or medication, i.e. antiretroviral medication and some of the treatments used to treat opportunistic infections.

Acute intermittent illness, as in non-HIV individuals but frequent in the immuno-compromised, can temporarily lower heat tolerance. Some literature suggests that heat-related illness may accelerate the progression of HIV, and HIV-positive individuals with AIDS may be more prone to heat-related illnesses.

Mortality rates for HIV-positive patients requiring emergency surgery following trauma were initially very high (50-70 per cent). However, since the late 1980s, studies have reported much lower rates (20-25 per cent). Longer hospital/ICU length of stay, more pulmonary,
infectious/septic and renal complications and operative procedures were found when HIV-positive patients admitted to ICU following trauma were compared with an HIV-unknown group. Morbidity was significantly correlated with injury severity score and not necessarily with immune status (i.e. CD4 cell count) in many studies.

Fatigue is one of the most common complaints of HIV-positive individuals. There is a significant correlation between HIV stages and maximum work rate. HIV-infected individuals have increased resting energy expenditure and loss of lean body mass. Since many mining activities are made up of hard physical work, the increased energy requirements to perform work may contribute to decreasing lean body mass and possibly hasten the progression of HIV.

There was only anecdotal evidence among the South African mine medical doctors interviewed on how HIV/AIDS impacts on occupational health and safety. Effects of HIV in the late stages of disease on physical and functional work capacity were noted, especially in mineworkers working in hot environments and doing hard manual labour. Many of the effects of HIV on physical function and cognition went undetected at annual medical examinations, for reasons that may be attributed to the resources utilised in a medical certificate of fitness. Tuberculosis was the greatest concern among the doctors interviewed.

Labour is very concerned with the perceived early medical incapacitation of mine employees diagnosed with HIV. Labour feels that if the working environment is contributing to the progression of HIV, then changes to environmental conditions should be made so that it is safe for HIV-positive mineworkers to work at most, if not all, job activities and in most workplaces.

The government has a number of key principles in dealing with AIDS in the mining industry. Among them the dismissal of any worker on the basis of HIV status is strictly prohibited in terms of the Labour Relation Act.

Two retrospective studies were conducted at four mines – two gold mines, a coal mine and a platinum mine.

The aim of the first study was to assess the impact HIV/AIDS had on recovery from injuries. One-hundred-and-twenty-five records of mineworkers with hand injuries were obtained from a gold mine’s database for 2001-2004. Owing to the small numbers of HIV-known in the recovery from injury study (n=12), no significant association was found among the HIV-positive and HIV-unknown group with respect to hand sepsis rates, length of stay in hospital, and sick leave.

In the second study, an occupational medical retrospective study was conducted at three mines (gold, platinum and coal mines) to compare hearing loss, heat tolerance and functional capacity among HIV-positive and HIV-unknown groups. There was no randomisation in the selection procedure of study participants at each mine; therefore, the possibility of confounding could not be excluded. Although confounding was adjusted for in the analysis, the study was not designed to allow for representation and was more a convenient sample to describe outcomes at the four mines in the first and second study.0 This was a pilot study. Sample size was not calculated and sites were not randomly selected. Therefore, the study was not sufficiently powered and was not sampled for comparisons. Generalisation to the mining industry as a whole could not be made. The selection, collection, assimilation, and abstraction of data and sampling did not allow the research team to infer any causal relationships between HIV and the conditions studied, only to calculate measures of association. These measures of association can be used as a way forward in conducting a prospective study.

Significant hearing loss was found for HIV-positive mineworkers (n=89) in comparison with HIV-unknown mineworkers (n=67) at the gold and platinum mines. There is a suggestion that HIV/AIDS may have an impact on the assessment of noise-induced hearing loss but this could not be confirmed by our study or in the literature review.

At the coal mine, HIV-positive mineworkers’ (n=16) sick leave was compared with the sick leave taken by HIV-unknown (n=39). There was a significant increase in the number of days of sick leave taken by the HIV-positive (mean 15.5 days) compared to HIV-unknown (mean 4.5 days). At the gold and platinum mine, medical incapacity resulting in change in job (often to a surface position) or termination of employment was recoded. There was a significantly higher number of medical incapacities (p=0.001) for the HIV-positive group (n=26) than for the HIV-
unknown group (n=7). The result, however, may underestimate this difference as many of the HIV-unknown deaths were unnatural and, therefore, the deceased did not have an equal opportunity to be medically incapacitated.

Owing to the small numbers of mineworkers in the study population that required heat tolerance screening (HTS), the effect of HIV/AIDS on heat tolerance could not be studied in detail and no statistical significance would have been shown. However, over 80 per cent of the HIV-positive mineworkers who failed the HTS test did so with the pre-screening evaluation as a result of low weight, high heart rate, and pyrexia (fever). The HIV-positive group weighed significantly less than the HIV-unknown group. BMI were also significantly lower.

In summary, it is well established that silicosis and HIV infection together confer a multiplicative risk for the development of TB, which contributes significantly to the burden of occupational disease in the mining industry. There is also a suggestion that the mining work environment (heavy physical work, heat, noisy etc.) has the potential to hasten the progression of HIV/AIDS, especially if poor nutrition and living conditions are also present. HIV/AIDS and noise-induced hearing loss (NILH) both cause sensorineural hearing loss. This relationship has to be investigated further to determine the risk HIV/AIDS has on NIHL assessments. From the literature it appears that severity of the traumatic insult (reflected by the Injury Severity Score) rather than the severity of the underlying HIV-associated immunodeficiency (measured by CD4+ count) was the major risk factor for the development of post-traumatic infections. Most studies on the surgical outcome of HIV-positive patients have either focused exclusively on asymptomatic HIV infection or full-blown AIDS or have analysed these patients together as one group but have not compared the two groups with respect to outcome. Future research should consider the mechanism of injury, and the immune status must be known in order that the true impact HIV has on recovery from injuries can be determined. The constraints to this research are the challenges and concerns raised by different stakeholders.
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Moazzez, A.H., Alvi, A. 1998. Head and neck manifestations of AIDS in Adults. American Family Physician 57,8; 1813-1822


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1. Health Professions Council of South Africa (HPCSA)
   http://www.hpcsa.co.za
   The health professions council regulates the health profession in South Africa. Established in terms of the Health Professions Act, 56 of 1974, the HPCSA strives to promote the health of the population, to determine standards of professional education and training, and to set and maintain excellent standards of ethical and professional practices.

2. Canadian Psychiatric Association
   http://www.cpa-apc.org
   This is the national voluntary professional association for psychiatrists who are dedicated to ensuring the highest possible standards of professional practice in providing psychiatric services to Canadians.

3. Aids Calgary Awareness Association
   http://www.aidscalgary.org
   Established in 1983, the association has been helping people to learn about, prevent and to live with HIV/AIDS.

4. Jopie van Rooyen and Partners SA(PTY) LTD
   http://www.vanrooyen.co.za
   Sub-Saharan Africa test distributors, publishers and consultants is a dynamic company with entrepreneurial spirit focusing on meeting the current and future challenges in the development of human resources in South Africa.

5. US Department of Health and Human Services: National Institutes of Health (NIH)
   http://www.nimh.nih.gov/publicat/dephiv.cfm
   NIH is the United State's medical research agency that makes important medical discoveries that improve health and save lives. NIH scientists investigate ways to prevent disease as well as causes, treatments and even cures for common and rare diseases.

   http://www.hivguidelines.org
   This site is a collaborative effort between the New York state department of Health Aids Institute and the Johns Hopkins University School of Medicine Division of Infectious Diseases. The website was developed as a central on-line resource that equips health care workers who provide services to people with HIV infection with up-to-date and state of the art tools to ensure that delivery to patients is of the highest quality.

7. e-Medicine instant access to the minds of medicine
   http://www.emedicine.com
   Launched in 1996, www.emedicine.com comprises the largest and most up-to-date clinical knowledge base available to physicians and other healthcare professionals. About 10,000 physician authors and editors contribute to the eMedicine clinical knowledge base, which contains articles on 7,000 diseases and disorders. The content of the eMedicine's content undergoes four levels of physician peer review and an additional review by a PharmD prior to publication. The article reviewed was authored by Soma Sahai-Srivastava, MD and Jones M, MD in 2004.
8. Dover Systems and Reha Com
http://www.doversystems.co.za

This is a competency-based evaluation technique that uses state of the art computerised technology. It is culture-free and fair and therefore is applicable for all driving and operating tasks within industry, transport, manufacturing, mining and operators of all mobile equipment.
Appendix A Different areas in the brain that control cognitive functioning

Adapted from
Appendix B  Cognitive impairment related to HIV

HIV/AIDS Dementia Complex (ADC)

ADC is an illness confined to the symptomatic stages of HIV disease progression. The early stage of ADC is called HIV dementia complex and is characterised by a marked slowing of cognitive and functional processing.

Early effects of ADC include memory loss, decreased concentration, psychomotor slowing, poor gait, reading difficulties, depression, mania, poor coordination, poor visual retrieval of information, slowed mental flexibility and the slowing down of complex sequencing of information (Lawrence et al., 2002). In the later stages of dementia, global cognitive impairment, mutism, abulia, reduced insight and denial, hallucinations, spastic weakness and seizures characterise changes to cognitive functioning and information processing (Sacktor, 1988).

Minor Cognitive Motor Disorder (MCMD)

MCMD is a mild change in motor or cognitive functioning with minimal impairment in functioning that forms part of everyday living (McDaniel., et al, 1997). Only the most demanding daily activities are mildly affected. AIDS patients who have MCMD generally report symptoms of poor short-term memory and concentration, behavioural problems or personality changes. Other behavioural dysfunctions include: apathy, lethargy, loss of sexual drive, diminished emotional responsiveness, social withdrawal, irritability and inflexibility. Early changes in motor functioning include unsteady gait, leg weakness, clumsiness, slowing of fine motor movements and tremor (www.emedicine.com).
Appendix C  Psychological factors that increase the rate of cognitive impairment in HIV/AIDS patients

Psychosis

The onset of psychotic disorders enhances motor cognitive impairment (McDaniel et al., 1997) Psychosis refers to a mood deterioration process that is prevalent in 0.5 per cent to 15 per cent of HIV-positive patients (McDaniel et al., 1997). In 1991, Harris and her colleagues showed that HIV/AIDS patients who had developed psychosis had a relatively quick deterioration in cognitive and mental status (McDaniel et al., 1997). The onset of psychosis may be marked by the reduced ability to think, to remember, to respond correctly, to communicate, and to interpret reality (www.aidscalgary.org).

Depression

Evidence shows that 60 per cent of the normal population that contracts HIV/AIDS patients suffer from at least one depressive episode during the course of their illness (Kopnisky et al., 2003). Several findings have also reported that patients with an increased number of depressive symptoms have scored lower on tests of cognitive function, which shows that they will be less effective in applying strategies to coping with stressors in their everyday lives, especially health-related issues (Tozzi et al., 2003).

Depression seems to be a common emotional change in people living with AIDS. Depression may also be a response to a life-threatening illness, and can impact on several other domains of functioning such as cognition, which is marked by poor memory and concentration. Depression may accelerate the progression of HIV to AIDS (NIH, 2002).

Major depression results in attitude changes, slowed thinking, forgetfulness, and the belief that death is approaching rapidly (Sacktor, 1988). Major depression has been detected in about 30 per cent of AIDS patients (NIH, 2002) Depression also results in other complications; for example, it affects a person’s ability to function in everyday life (NIH, 2002).

Delirium

Delirium is a condition characterised by perceptual disturbances, sudden lapses in consciousness and disorientation with regard to time and place. Delirium is a serious condition and also results in perceptual differences to the extent that patients may become disoriented with regard to time and surroundings (McDaniel et al., 1997). Only 37 per cent of AIDS patients who had delirium ever regained complete functioning of their cognitive capacity (McDaniel et al., 1997).

Delirium is common amongst hospitalised AIDS patients but, occasionally, patients may experience delirium during the early stages of infection. When this occurs they must be referred to a hospital immediately. There are many possible causes of delirium; examples include metabolic abnormalities, CNS infections, anemia, and almost all HIV-related drugs and illicit substances (Aid’s Institute’s Clinical Guidelines, 2001).

A large amount of medication is prescribed to people living with AIDS, especially in the later stages, for active treatment of opportunistic infections. Some of the medication, although effective, may produce neuropsychiatric side effects. Therefore, a diagnosis of the neuropsychiatric condition of the patient requires a skilled physician who understands the therapeutic as well as the inherent side effects of the medication on the patient’s psychological state (McDaniel et al., 1997).

Schizophrenia

Psychological disorders such as schizophrenia and schizoaffective disorders exhibit significantly increased rates amongst HIV/AIDS patients (Baillargeon et al., 2003). Schizophrenia causes disturbances in thinking and lapses in reality testing, impairment in accurately reading and predicting environmental cues, and patients are unable to think through problems in a linear and
logical fashion. All of these result in major challenges to understanding and accepting the nature of problems in their lives and the implications of these problems (McDaniel et al., 1997).

**Bi-polar disease**

In a study carried out from 1999 to 2001 at a large correctional services prison in Texas, it was found that inmates with HIV had a significantly higher prevalence of bi-polar disease than seronegative inmates for both male and female prisoners (Baillargeon et al., 2003).

Bi-polar disorder is described as an emotional rollercoaster, as one changes moods from extreme elation to deep depression without any substantive cause for the change (Nevid et al., 2000).

**Mania**

Episodes of mania during HIV/AIDS are characterised by confused speech. The thoughts and speech of sufferers of mania may jump from one topic to another. They are unable to organise and coordinate their efforts constructively and this impairs their ability to work and to have normal relationships (Nevid et al., 2000).

**Emotional stress**

Increased emotional stress can lead to poor quality of life in several life domains, as the ability to engage in basic everyday activities is influenced by the cognitive functioning capacity of the individual (Tozzi et al., 2003)

Emotional deficit has been reported in asymptomatic HIV-seropositive patients by Bungener et al., 1996. The emotional deficit showed decreased expressiveness and has also been described as apathy and lack of motivation.

Emotional stress increases the risk of cognitive impairment in patients who have HIV/AIDS (Bungener et al., 1996).

**Anxiety**

Anxiety is common among patients with HIV/AIDS. Severe anxiety leads to panic and obsessive compulsive behaviour, adjustment problems and post-traumatic stress (NIH, 2001).

As HIV progresses anxiety may progress and manifest in symptoms such as chest pain, dizziness, gastrointestinal disturbances and headaches. These symptoms affect sleep and rest patterns which, in turn, result in declining concentration levels during the day and while the person is working. An anxiety disorder would also be marked by difficulty in remembering, fear, and compulsive behaviour (NIH, 2001).
Appendix D Psychometric test batteries and their usefulness on South African Mines

Screening batteries

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Description</th>
<th>Tests</th>
</tr>
</thead>
</table>
| National Institute of Mental Health (NIMH)       | Recommended by a group of clinicians and researchers attending a workshop sponsored by NIMH in 1989 (See Butters et al., 1990). | WAIS -R Vocabulary
WMS -R Visual Span
Paced Auditory Serial Addition test
California Verbal Learning Test
Hamilton Depression Scale
Speilberger State – Trait Anxiety test |
| San Diego HIV Neurobehavioral Research Center (HNRC) | The seven tests were part of a seven- hour to nine- hour comprehensive battery that was found to discriminate well between HIV-seronegative and HIV-seropositive participants. (See Heaton et al., 1996). | Paced Auditory Serial Addition Test
Boston Naming Test
Thurstone Written Fluency Test
Story Learning and Memory
Finger Tapping Test
Grooved Pegboard Test |

The core neuropsychological battery used by the NIMH comprehensively tested the domain of cognitive functioning, especially in the early phases of disease progression.

1) The Vocabulary Test (WAIS –R)

This subtest is used to assess premorbid intelligence. The candidates are expected to define 35 words, which range from very common to moderately uncommon. The test usually takes 20 minutes to administer. This vocabulary test would not be suitable for use on South African mines as language ability would be a major hindrance and the cultural exposure of each person is diverse. Items which are common to one person may be strange and unheard of by another (Butters et al., 1995).

2) Visual Span Test

This test is used to assess attention deficits in HIV-positive patients. This is a nonverbal task and forms a part of the Wechsler Memory scales. The test takes 10 to 15 minutes to complete. This test requires the candidates to watch the test administrator as he/she touches a series of coloured blocks. The candidates are then expected to repeat the sequence. The number of blocks used ranges from 2 to 8. The sequence would have to be repeated both forwards and backwards. Since this is a nonverbal test, it could be applied on the mines. However, the Dover suit can test attention and other areas of cognitive functioning simultaneously and therefore a traditional paper and pencil test like the Visual Span Test could be replaced by the Dover tests.

3) The Paced Auditory Serial Addition Test (PASAT)

This test is used to assess attention and speed of information processing. As it is based on the mathematical principle of addition, this test would not be effective on the mines. Most of the workers involved in underground labour do not have a formal education, understanding of the English language is a major challenge, and numerical computations within a short period of time
would also prove difficult and time consuming. A reaction time test to assess the same domain of functioning would be more appropriate for use on the mines.

4) The California Verbal Learning Test

This test measures multiple learning parameters that are associated with memory and learning. It provides an evaluation on how well information is acquired and retained. The candidates are required to recall words which have been presented to them from four different groups such as tools, herbs and spices, fruit, and clothing. The California Verbal Learning test is not suited to conditions on the mines as there may be cultural bias in terms of the categories presented. Not all people are familiar with these groupings, especially those who come from previously disadvantaged backgrounds.

5) Hamilton Depression Scale

This scale provides a simple way of assessing the severity of depression. The test consists of material that checks for cognitive, behavioural and psychological interferences. Candidates with recognisable signs of depression must be referred to a psychiatrist or psychologist. However, mood disorders cannot explain the onset of neurocognitive dysfunction (Butters et al., 1995). Therefore it is not necessary to include a test evaluating mood disorders.

6) The Spielberger State Anxiety Test

This test is available for use in South Africa. It was originally developed to determine the relationship between anxiety and learning and to evaluate the changes in the levels of anxiety. This test makes use of a self-report psychometric scale. This factor could be a major stumbling block for assessment, as literacy levels on South African mines are low and understanding the concept and implementation of self-report questionnaires can be very complicated and frustrating to people and, consequently, lead to invalid and unreliable results. Also, anxiety is a mood disorder and, once again, it is not necessary for it to be included into a test battery which assesses cognitive functioning. Mood disorders affect a person’s overall functioning and not just cognition (Heaton et al., 1995).

THE SAN DIEGO TEST BATTERY

1) The Paced Auditory Addition Test

This test is used to assess attention and the speed of information processing. Based on the mathematical principle of addition, this test would not be effective on the mines. Most of the workers involved in underground labour do not have a formal education and carrying out numerical computations within a short period of time would also prove difficult and time consuming. A reaction time test to assess the same domain of functioning would be more appropriate for use on the mines.

2) The Boston Naming Test

This test requires the user to name 30 outlined drawings or figures. The drawings show easily recognisable objects and become progressively difficult. There are 60 figures in the test and the person would be required to identify all the even- or odd-numbered drawings. The Boston Learning Test is a measure of language ability. Language is a very serious problem in the realm of psychometric assessment. Figures and drawings can also be culturally biased and some populations may not be able to recognise certain drawings.

3) The Grooved Peg Board Test

This test assesses fine motor coordination and speed. The candidates are required to place 25 small metal pegs into 25 holes on a 3 X 3 board. Each peg must be placed into the slot and inserted into the hole. The testing time is 15 – 20 minutes (Butters et al., 1995). (SO? IS IT AN ACCEPTABLE TEST OR NOT?)

4) The Finger Tapping Test

This test samples motor skills of upper limbs. Subjects tap on a key counter using their index finger of both their dominant and non-dominant hands for 10 seconds. Five or 14 trials may be
administered. Thereafter the two highest and two lowest scores are omitted and an average is calculated from the remaining tests, usually five of them (Butters et al., 1995).

The finger tapping test is manual in nature and it is time consuming to administer. For this reason, the Dover tests would be better suited for use on the mines.

5) No direct reference was made in connection to the Thurstone Fluency Test and the Story Learning and Memory Test in the context of this test battery.
Appendix E  Description of the test battery used by Moore, 2002

A description of the test battery used by Moore, 2002

<table>
<thead>
<tr>
<th>Name of test</th>
<th>Description of test</th>
<th>Feasibility for the mining industry</th>
</tr>
</thead>
</table>
| Trail-making Test               | This test consists of five subtests which assess attention, motor functioning, the processing of information and visual perception and cognitive flexibility. These tasks are highly sensitive in detecting any impairment in cognitive functioning. There are two parts to the test:  
**Part A**  
24 numbered circles are randomly distributed on a page. The test taker must connect the circles in numerical order, using lines, as quickly as possible.  
**Part B**  
This part of the test consists of 25 circles. Some of the circles are numbered 1 - 13 while the remaining circles are labelled A – L. The test taker needs to join the circles in the following sequence: circle 1 must be connected to circle A; circle 2 must be connected to circle B; and so on.  
**General information**  
Time is allowed for practising to ensure that all instructions are well understood. Part A has a time limit of 40 seconds while Part B has a limit of 90 seconds. Any time longer than this signifies brain damage (Moore, 2002; www.vanrooyen.co.za). | This test is available in South Africa. It can be obtained from the various distributors of psychometric tests. The test normally takes three minutes to complete. Although the time taken to complete the test is minimal it would not be suited for our purposes on the mine. Numeracy and literacy levels are very low and most workers underground are contract workers who do not understand English. It would therefore be very difficult to carry out such a test on the mine. End results may also be invalid, as the contents and purpose of the test may be misinterpreted and misunderstood. |
| Hamilton Depression Scale       | This test was developed by Max Hamilton in 1960 to measure the intensity of depression experienced by a person. The test is used to rate indicators on current DSM – IV symptoms of depression. The test consists of 21 items and tests for depressed mood and changes in psychological well being. The 21 items are each rated on a 5-point scale from 0 to 4. Questions range from items that deal with depressed mood to insomnia and suicide. To answer the questions the person needs to rate each question according to the scale. A total score of 0-7 indicates no depression, 8-15 shows minor depression, and a score | This is an English medium test, therefore language and communication would be a problem during administration. This test measures mood deficit and the aim of this test battery is to pick out ability and skill deficits which may result from HIV/AIDS. |

52
of 16 means the person is suffering from major depression (Moore, 2002; Williams, 1988).

<p>| Co-ordination Test (SAT 78) | This test is used to evaluate psychomotor speed, finger and hand dexterity and eye-hand coordination. The test consists of circles with narrow spaces between them. The test taker needs to draw a continuous line between the circles without lifting up the pencil and also without touching any of the circles. The duration of the test is limited to 60 seconds; thereafter, the scores are calculated by subtracting the number of times the line touches the circles and the number of times the pencil was raised from the total number of times the candidate managed to successfully draw the line through the circles (Moore, 2002). | Pen and pencil tests can create tension and fear in candidates. They resemble a test situation, one in which people may pass or fail. Such tension would lead to skewed and invalid results. It would therefore be preferable to use tests that are more appealing to the candidates in terms of simulations and game-room set ups. With advancing technology most of the psychometric tests can be adapted for use on a computer, which might make candidates feel more comfortable. |
| Rey–Osterrieth Complex figure test | This is a widely used neuropsychological test to assess visual constructional skills, perceptual organisation and visual memory. It also tests planning- and problem-solving skills and perceptual and motor functions. The test taker is presented with a Rey-Osterrieth complex figure and is asked to draw it. The person must be allowed ample time to complete the drawing to the best of his/her ability. The second phase of the test involves completing the drawing from recall after a three-minute break. Next, the person is given a 30-minute break and asked to reproduce the figure again from memory. The order and accuracy of the manner in which the drawing is completed provides information on the site and extent of damage (Moore, 2002; Canham et al., 2000). | The complex figure test looks at cognitive domains which are not assessed by the test battery that has been suggested for use on the mines. Perceptual and problem-solving skills testing is more suited to those workers who are involved in strategic planning rather than in underground work. |
| Tower of London Procedure | Executive planning, organisation and the integration of behaviour are seen as key in achieving a goal. This procedure is sensitive in picking up impairments with higher-order cognitive functions such as planning processes and other frontal lobe dysfunctions in both adults and children. | This test also looks at those domains that are not assessed by the test battery that has been suggested for use on the mines. Perceptual and problem-solving skills testing are more suited to those workers who |</p>
<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>The test taker needs to move a number of coloured balls from one point to the next by using the lowest number of direct moves. Each person needs to manipulate the model in his/her mind while keeping in mind the restrictions on the number of moves. The problem is solved in memory during the duration of this test (Moore, 2002; <a href="http://www.vanrooyen.co.za">www.vanrooyen.co.za</a>).</td>
<td></td>
<td>are involved in strategic planning rather than in underground work.</td>
</tr>
<tr>
<td>Folstein’s Mini Mental State Test</td>
<td>This is an assessment used to detect the severity of cognitive impairment. The test involves brief tasks or questions assessing orientation to time, place, registration, attention, calculation, recall, naming, repetition, reading, writing and drawing. It is a test that is highly recommended by researchers for inclusion in neuropsychological test batteries as it is possibly the most widely used screening test for dementia (Moore, 2002; <a href="http://www.vanrooyen.co.za">www.vanrooyen.co.za</a>).</td>
<td>Any test that requires reading and writing should be avoided. Again, the literacy levels are low, as is the proficiency in English, since most of the underground workers are contractors from neighbouring countries. Disorientation to time and space normally manifests in the latter stages of the disease when the person is hospitalised or has become delusional. By this time the person would already be at home and not at work.</td>
</tr>
<tr>
<td>Adult Neuropsychological Questionnaire</td>
<td>The questionnaire has been designed to screen for brain dysfunction. The test consists of 54 items and requires individuals to report on subjective neuropsychological functioning. Questions revolve around subtle changes in behaviour and memory.</td>
<td>Generally self-report on cognitive impairment is poor, and could result in individuals being dishonest in their responses for fear of losing their jobs. If the questionnaire were in English this would also pose an understanding problem and the person would have difficulty in completing it.</td>
</tr>
</tbody>
</table>
Appendix F: Telephone survey questionnaire

Effects of HIV on Occupational Health and Safety in Mines
Telephone Survey

Good day Mr/Ms/Dr ________________________

My Name is ________ and I am __________ working for the CSIR Miningtek, Occupational Health and Safety division.

We are currently involved in a study funded by SIMRAC, investigating direct or indirect effects of HIV on occupational health and safety in mines and would appreciate your answers to a few questions.

It would take between 5-10 minutes of your time. Information you provide us will be unlinked and anonymous.

Can we proceed?

1. Do you have a COP (Code of Practice) to determine fitness to perform work at a mine?

   Yes / No

   And if so, what has been done to date to match functional work capacity with work requirements; i.e. do you have functional work capacity tests/procedures required for worker placement?

2. How do you assess fitness of mineworkers?

<table>
<thead>
<tr>
<th>Frequency of periodical examination</th>
<th>How do you assess fitness of mineworkers?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you test:</td>
<td></td>
</tr>
<tr>
<td>Vision</td>
<td></td>
</tr>
<tr>
<td>o Who</td>
<td>Yes / No</td>
</tr>
<tr>
<td>o How often</td>
<td></td>
</tr>
<tr>
<td>o List examinations done and equipment used</td>
<td></td>
</tr>
<tr>
<td>o What is the minimal standard for mineworkers i.e. underground/surface and drivers</td>
<td></td>
</tr>
<tr>
<td>Physical examination</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Medical/surgical history</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Colour blindness</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Hearing</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Epilepsy/neurological state</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Alcohol/drug abuse screen</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Lung function tests</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Heat intolerance screening</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>
3. Are you, or are you looking at, screening mineworkers for physical fitness or/and cognitive ability?

Yes / No

4. Do you think HIV can affect Occupational Health and Safety? Yes / No

And why?

5. Have you done any research to determine the impact of HIV on Occupational Health and safety?

Yes / No

6. In your opinion, are HIV positive mineworkers compared to the general workforce more prone to:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing loss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failing HTS (If applicable)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take longer to recover from injuries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have more complications following an injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unable to perform heavy manual labour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have significant cognitive impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Do you see primary healthcare conditions at the same clinic? Yes / No

8. Are patients presenting with an opportunistic infection at the primary health care clinic encouraged to go for VCT? Yes / No
Appendix G: Occupation of deceased mineworkers at the coal, gold and platinum mine

Table 5.3.1.2b: Occupations of deceased mineworkers at the coal mine

<table>
<thead>
<tr>
<th></th>
<th>HIV-positive</th>
<th>HIV unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aide</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Belt section</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Boiler maker</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Continuous miner operator</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Clerk</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Diesel machine operator</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Maintenance</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Supervisor</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Lampsman</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pump attendance</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Roof bolt driver</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Section operator</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Stonedust barrier</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Shuttle car driver</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Ventilation</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Missing</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>39</strong></td>
<td><strong>55</strong></td>
</tr>
</tbody>
</table>

Table 5.3.1.2c: Occupations of deceased mineworkers at the gold and platinum mines

<table>
<thead>
<tr>
<th></th>
<th>HIV-positive</th>
<th>Percentage (%)</th>
<th>HIV unknown</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>30</td>
<td>33.7</td>
<td>28</td>
<td>41.8</td>
</tr>
<tr>
<td>Driller</td>
<td>18</td>
<td>20.2</td>
<td>6</td>
<td>9.0</td>
</tr>
<tr>
<td>Missing</td>
<td>13</td>
<td>14.6</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>Winch operator</td>
<td>11</td>
<td>12.4</td>
<td>4</td>
<td>6.0</td>
</tr>
<tr>
<td>Loco driver</td>
<td>6</td>
<td>6.7</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>Supervisor</td>
<td>5</td>
<td>5.6</td>
<td>11</td>
<td>16.4</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>2.2</td>
<td>7</td>
<td>10.4</td>
</tr>
<tr>
<td>Team leader</td>
<td>1</td>
<td>1.1</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>Surface worker</td>
<td>1</td>
<td>1.1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Engineer</td>
<td>1</td>
<td>1.1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>89</strong></td>
<td></td>
<td><strong>67</strong></td>
<td></td>
</tr>
</tbody>
</table>
Appendix H: Tripartite Workshop

SIM 030905:
IMPACT OF OCCUPATIONAL HEALTH AND SAFETY
CSIR MININGTEK, CARLOW ROAD
24 AUGUST 2005

Mr. Fourie and Dr Dias welcomed delegates; Mr. Fourie in his capacity as facilitator and Dr. Dias in her capacity as main presenter. The proposed agenda was introduced and, in response, delegates agreed with the proposed structure of the workshop.

By way of introduction, Dr Dias stated that HIV is a major problem in the South African mining industry with the incidence generally believed to be in the range 20 – 30 per cent although some reports have put the figure as high as 50 per cent. The high incidence of HIV posed challenges to those employers who would need to cope with the needs of the infected employees and it also posed challenges to HIV-positive employees, who needed to remain productive in the workplace. More specifically, there were concerns over the effect of a hot environment on a person infected with HIV. Was such a person more susceptible to heat stress and, if so, by what amount? There was also a specific concern over HIV-induced deafness because very little was known about it. For example, was this deafness exacerbated and accelerated by high noise levels, such as rock drilling and, if so, to what extent was it exacerbated and what should employers do about it?

Against this background the MHSC had accepted a CSIR proposal to review published and unpublished data on the effects of HIV/AIDS on health and safety. That CSIR proposal had led to SIMRAC project, 030905, which included the development of a detailed proposal for Phase 2 of the project, in which the impact of HIV/AIDS on the issues identified in Phase 1, would be studied in more detail.

Literature survey feedback

One of the deliverables from Phase 1 of the MHSC project was a literature survey. The CSIR had now completed this literature survey, which examined published and unpublished literature on the effects of HIV/AIDS on work capacity, recovery from injury, and occupational diseases. It was found that:

- Between 30 – 50 per cent of individuals with HIV/AIDS would suffer from AIDS-induced dementia, as well as a deterioration in concentration and impairment of memory.
- About 20 -50 per cent of those individuals would suffer hearing loss, which could be caused, initially, by factors such as infection, medication or AIDS itself.
- Individuals with HIV/AIDS exhibit reduced heat tolerance, especially when suffering from fevers. It was possible that these individuals are inherently more prone to heat-related illnesses.
- HIV-positive patients admitted to an ICU (intensive care unit) remained longer in the ICU and in hospital, in comparison with a comparable HIV-negative group.
- The functional work capacity of HIV-positive persons was shown to be lower than that of HIV-negative individuals. HIV-positive persons were found to complain of fatigue, aches and pains and weight loss, far more often than HIV-negative persons did.

Prof Murray commented that the literature survey should concentrate on up-to-date literature. It was pointless to include references which were not recent, because the field of HIV/AIDS was developing rapidly and out-of-date references were often incorrect; she suggested that the date of all references should be indicated clearly.

Retrospective record review feedback

One output from the current SIMRAC project 030905 was be a retrospective record review of recovery from injuries. The review investigated the recovery from hand injuries of 125 mineworkers on gold mines, during the period 2000 to 2004. A comparison would be made between HIV-positive and HIV-negative patients. Similarly, a comparison was being made between the audiograms and heat tolerance results of a group of miners who died from AIDS and a reference group of mineworkers.

The findings of the record review to date were:
To summarise: there was evidence to indicate that HIV/AIDS can impact negatively on the outcome of non-AIDS patients. Moreover, HIV/AIDS appears to impact negatively on hearing loss, heat tolerance, cognition, and functional work capacity. However, there were still many unanswered questions on how and the extent to which HIV/AIDS produces these impacts and there were many gaps in current knowledge.

Discussion ensued in which it was reported that the mines usually become aware of an employee’s HIV-positive status at an advanced stage of the disease. It was difficult to manage HIV patients at this advanced stage and, ideally, it would be more beneficial to the employer and the patient if both were made aware of the HIV-positive status as early as possible. After all, there was evidence to suggest that HIV-positive people are more susceptible to accidents from a very early stage in the disease and, if this were true, knowledge of HIV status could enable the mine to manage this issue by placing HIV-positive employees in positions where they were less likely to have accidents.

Another issue was: where is the mining industry in the AIDS epidemic? Was the epidemic at its height and, if not, how would it progress? Similarly, it was often difficult to assess what stage of the disease the patient had reached when diagnosed. Later stages of the disease were easy to assess but detection at an earlier stage was important if the employer was to manage the disease. Early detection was important for the purposes of modelling costs as well.

Prof Murray stated that any further work would require a complex methodology. For example, it would be important to know the AIDS status of each person at the outset, and the treatment being given to each AIDS-positive patient. She referred to a study to determine the effect of AIDS on work-related injuries, using 2000 subjects of known HIV status. It was found that the HIV-positive subjects had a higher accident rate than HIV-negative subjects. More surprisingly, this increase in accident rate occurred very early in the disease before symptoms were evident and, typically, a subject would have an accident very soon after being told that he was HIV positive. This finding raised several issues, not least of which was the effect of depression. Typically, soon after being told that he was HIV positive, a patient would become depressed, lose concentration and have an accident, suggesting that it was not HIV as such that caused the accident, but the patient’s emotional response to knowing his positive status. This indicated that there was a need to obtain more insight into how HIV patients behave, especially after being first informed of their status, and later, during counselling. It was evident that the issue was complex and that this complexity would be reflected in the design of any study.

Prof Murray stated that work should, perhaps, concentrate on those issues that could be carefully addressed by a study that was not highly complex. She suggested that a study of the effects of HIV/AIDS on hearing loss might be worthwhile while meeting the requirement of not being impossibly complex. In response, the NUM representatives stated that it was unnecessary to conduct such a study and suggested, instead, that effort should concentrate upon addressing occupational health issues such as noise-induced deafness. According to these representatives, the cause of noise-induced deafness had been known for many years and the mines had continued to do very little about addressing the source of the problem, which was – of course – exposure to loud noises such as rock drilling. The unions would not welcome any studies which diverted attention from the real issue, which was to do something positive about reducing noise levels. It was possible that HIV accelerated the rate at which noise-induced deafness manifested itself but this was not the real issue.

The unions felt, also, that there could be severe implications for the workforce if it were found that HIV accelerates or exacerbates the manifestation of noise-induced deafness. Thus, if an HIV-positive worker claimed compensation for noise-induced deafness it could be argued that only part of his deafness was due to exposure to the noise and the other part was due to AIDS and was, therefore, self-inflicted. Consequently, this would open the door to allow employers to slash compensation payments. A similar implication arose in the issue of HIV and its effect on accident rates; if it were shown that HIV-positive people were more prone to accidents, then compensation could be reduced or the mine could work them out of their jobs. Thus, from the union’s perspective, these studies were not in members’ interests.

Mr. Fourie stated that employees’ interests would probably be better served by having more information available, rather than less. Thus, if the relationship between HIV and noise-induced deafness were well understood, this would probably be better for the employees than if it were not understood. In the ensuing discussion, however, it was felt that any such information could be abused for the purposes of awarding compensation.

- There was a significant association between hearing loss and HIV status.
- Many HIV-positive workers failed the heat tolerance test, mainly because of high temperature, weight loss, and high heart rate. The size of the sample was, however, small.
Prof Murray stated that these fears of abusing information of compensation purposes were perhaps overstated. After all, compensation was basically a function of politics and the available money. Precedents suggested that the information would not be abused. For example, if a mineworker has emphysema, then the only question asked for compensation purposes is whether the person was exposed to silica dust and, if so, what the nature of the exposure was. The mineworker is not asked if he smokes heavily and could have contributed to his disease by doing so. A similar situation existed with TB; a mineworker was not asked if he was HIV positive and, therefore, partly to blame for his problem. Prof Murray felt, therefore, that although the concerns of the union were very well founded, they would probably not materialise, if previous experience was a guide, unless there was a major change in the political landscape.

**Discussion of future work**

Various areas for possible future work in Phase 2 of this project had been identified. For example, as far as the issue of hearing loss was concerned, there was evidence to suggest that HIV/AIDS-positive individuals suffer more hearing loss than HIV/AIDS negative individuals. However, this was not a useful finding in itself because mineworkers are subjected to noise, mining at depth, and poor living conditions, all of which could cause hearing loss, and so it was difficult to gauge the effect of being HIV/AIDS positive. There was also a possibility of malingering.

Likewise, there was a need to learn more about the effect of being HIV positive on the rate and extent of a patient’s recovery from injury and the steps that should be taken by an employer of such an injured person. Also, although the impact of HIV/AIDS on work performance was a negative one, this fact, in itself, did not indicate how large the impact was, how the impact would develop during the course of the disease and what the employer should do about it.

To summarise: there were many gaps in existing knowledge and many questions remaining unanswered. There was a need for follow-up work on functional work capacity, heat tolerance issues, hearing loss and recovery from injuries.

Reference was made to the proposed future work for the follow-on assessment. To summarise: the work would take place at gold, platinum, coal, SSM, and opencast sites. Four groups would be used: HIV negative, HIV positive not on HAART, HIV positive on HAART, and a control group not in mining. The follow-up survey would examine functional work capacity, heat tolerance, audiograms, neuropsychological assessment and a nutritional status assessment.

In the ensuing discussion it was noted that the “HIV positive not on HAART” group was likely to be a very small one and would decrease in size even further in the future. Also, it was noted that the status of the “control group not in mining” was unknown. Thus, the HIV status of each member was unknown, as well as the prevalence of HIV in that group, and this could lead to some complexity in the study. It was noted that members of the control group would be drawn from groups subject to regular medicals in terms of statutes. These groups included workers in petrochemical plants and the like, as well as employees on fishing fleets. The group would not simply be drawn from people at random.

Dr Ross noted that the proposed work would be embedded in the normal clinical management of the HIV-positive patients, which was a good feature of the work. She felt, though, that the issue of whether hearing loss was accelerated by AIDS and, if so, to what extent, needed more prominence. Mr. Guler commented that the CSIR was developing a low-noise rock drill, using funding provided by the MHSC. This drill was expected to reduce noise levels significantly and should be an important factor in reducing the incidence and severity of noise-induced deafness, especially for drill operators but also for other job categories.

It was noted that, in terms of the MHSC mandate, the intention was to reduce compensation levels by 10 per cent by 2008 and by 100 per cent by 2013. The MHSC’s performance would be judged upon whether these targets were reached. In response, the NUM representatives stated that this underlined their concerns mentioned earlier about a move towards reducing compensation levels.

It was then stated that one key issue in the proposed work would be that of confidentiality. Obviously, individuals who were aware of being HIV positive expected confidentiality but there was the issue of individuals who were unaware of their positive HIV status. Any proposal would need to address this issue carefully.

Finally, Dr Dias stated that she would draft a proposal for further work on this project, taking into account all the comments made at this workshop. She asked delegates to this workshop whether they would be willing to give her feedback on that draft, before it was submitted to the MHSC. In response, delegates stated that they would welcome the opportunity, and Dr Dias thanked them.

The workshop ended at 10h50.