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Health effects associated with occupational exposure to hexavalent chrome (chromium VI)

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Chromium (VI) is used and/or released in the occupational setting of a number of major industries, especially chrome ore smelting, electroplating and chromic oxide and tanning salts production. Fig. 1 shows exposure to dust which might contain chromium (VI) at a smelter.

A systematic review of the international literature using Medline, the Internet, published work and personal communication with experts revealed the following information about health effects:

Fig. 1.

Acute effects

Ingestion of high doses of Cr(VI) (>4 mg/kg) can lead to death, although no

Table I. Potential health effects that might result from occupational exposure to Cr(VI)

Potential health effects from the literature review	Strength of evidence
Cancers	There is strong evidence of a small but significant risk of lung cancer from the inhalation of Cr(VI) at levels of >1.2 µg/m^3 (just above the standard initially proposed by OSHA in 2005 (1 µg/m^3) and well below the final 2006 OSHA PEL standard of 5 µg/m^3).[1-5] Although not equally well studied, it is likely that other respiratory cancers (nose, sinus, trachea and bronchus) can also develop at similarly low Cr(VI) exposure
	There is only weak evidence that occupational exposure to Cr(VI) might result in stomach, CNS, brain, kidney, bladder, prostate, liver, and genital cancers, and lymphoma, Hodgkin's disease, and leukaemia[5-6]
Upper respiratory tract effects	The evidence is clear and strong that workers may show early signs of nasal irritation, nasal tissue ulceration, and nasal septum perforation at occupational exposure levels at or below the current OSHA PEL in the electroplating and chrome production industries[5]
Dermal effects	There is evidence of dermal effects due to occupational exposure to Cr(VI) in settings where air levels are below 5 µg/m^3, although the exposure route may be through direct skin contact[5]
Lower respiratory tract effects	There is some evidence from case reports that long-term occupational Cr(VI) exposure at levels just below the current OSHA PEL (2 µg/m^3) may result in occupational asthma in the electroplating, Cr(VI) production and cement industries, but few epidemiological studies have been conducted[5,7,8]
	There is insufficient epidemiological evidence supporting an association between Cr(VI) exposure and bronchitis[5]
Other health effects	There is some evidence that substantially more occupational exposure to Cr(VI) than the current OSHA PEL might result in renal damage or adverse effects on the liver and reproduction or gastrointestinal system, but there is no evidence of effects with exposure below this level[5,9]

PEL – permissible exposure limit.

fatalities caused by its acute inhalation have been recorded.[1] Sub-lethal high doses by inhalation exposure above 0.1 mg/m^3 or ingestion of 0.01- 4.00 mg/kg can lead to a number of effects, including damage to the respiratory and gastrointestinal systems, liver, kidney, lung, CNS and cardiovascular system.

Long-term effects (Table I)

Even at occupational levels of below the 5 µg/m^3 exposure limit set in 2006 by the US Occupational Safety and Health Administration (OSHA), there is strong evidence of a small but significant risk of lung cancer and possibly other respiratory tract cancers, a high risk of upper respiratory tract effects, and a risk of dermal effects from the inhalation of Cr(VI).

The literature shows some evidence that occupational asthma might develop at these Cr(VI) levels.

There is limited evidence for other health effects.

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Occupational health concerns with pesticides in agriculture and beyond

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Introduction to occupational pesticide use in South Africa

The word pesticides generally brings to mind agriculture and occupational exposure with regard to farm workers, pesticide applicators (Fig. 1), tractor drivers and mixers. However, occupational exposure to pesticides is much broader and includes:

- commercial pest control operators spraying in homes, commercial buildings, hotels and recreational areas
- vector control workers and airline staff spraying pesticides for malaria control
- Working for Water staff spraying alien vegetation
- truck drivers transporting pesticides
- manufacturers of commercial boats applying a fungicide to the base of boats
- informal vendors of unlabelled pesticides sold in urban townships for poverty-related pests (Fig. 2)
- pesticide-formulation factory workers
- domestic workers spraying homes and gardens
- pesticide applicators working for municipal or provincial government.

With these wide-ranging occupational uses and ensuing exposure to pesticides, health professionals may be confronted with symptoms of pesticide poisoning but not be sufficiently aware of the correct and relevant questions they need to ask to ascertain if the worker has an occupational exposure that is not related to agriculture. Confusion also exists as to what constitutes a pesticide. For clinical management, a pesticide refers to all substances or mixtures of substances (e.g. herbicides, insecticides, rodenticides, fungicides) for preventing, destroying, repelling or mitigating any pest. These substances are found not only in commercial spray products but also in e.g. chicken feed, lice shampoos and mosquito repellents. This article serves to raise awareness of occupational pesticide poisoning to improve treatment, prevention and reporting of cases of poisoning.

Main occupational health issues with pesticides

Health professionals involved in the prevention and treatment of pesticide poisoning should be aware of some key issues, such as the following:

Exposure

In agriculture the main route of exposure is dermal – systemic absorption of the pesticide usually occurs through unprotected skin or through contact with contaminated clothing. This is even the case if workers are to a large extent exposed to pesticide vapours, because the vapours settle on surfaces and clothes, particularly on areas of the body that are wet from sweat (e.g. the back, face, groin). Even when workers are exposed to pesticide drift, the route of absorption is usually through dermal deposition. Different parts of the body have different rates of absorption (e.g. the genital area absorbs pesticides at a rate 10 times higher than the palm of the hand; www.agf.gov.bc.ca/pesticides/b_2.htm). Unless workers are in an enclosed area where inhalational routes of exposure become important (e.g. a closed room for mixing pesticides, or a sprayed greenhouse), inhalation is usually far less significant than dermal absorption. Wet clothing from pesticides can be a source of exposure while the clothing remains in contact with the skin; therefore removing contaminated clothing is critical in risk reduction. Premature re-entry into sprayed areas may result in high levels of dermal absorption from contact with residues; hence the need to follow re-entry interval periods stated on pesticide labels to reduce exposure. Other routes of exposure may include accidental ingestion and ocular splashes. Pesticide risks are calculated by the toxicity of the pesticide and the level of exposure.[1]

Risk = Toxicity × exposure

Health effects of pesticide exposure

Pesticides are responsible for acute toxic effects as well as causing long-term adverse health impacts.[2-4] The most well-known acute toxicity is associated with

Fig. 1 Child pesticide applicator with high exposure. Photo: Rauri Alcock.

carbamate and organophosphate (OP) insecticides, causing severe cholinesterase inhibition with accompanying cholinergic over-stimulation. However, some workers develop 'tolerance' with regard to OP exposure – they have asymptomatic depressed cholinesterase function, i.e. become 'tolerant' of the biological effect of exposure. This renders them susceptible to severe toxic effects with only little further exposure, disproportionate to the exposure experienced.

Some long-term effects of pesticides resulting from low-dose cumulative exposure include genotoxic effects, cancer, neurotoxicity and endocrine-disrupting effects.[2-3] These effects are difficult to diagnose or attribute to pesticide exposure because there are many possible causes. Moreover, compromised immune systems contribute to an increased risk for pesticide exposure.

Misdiagnosis

Misdiagnosis of pesticide poisoning is common because of nonspecific symptoms and the synergistic effects of pesticides that may result from multiple exposures.[4] While acute poisoning by carbamates and OPs is clinically similar (both mediated by cholinesterase inhibition), the latter is more likely to contribute to long-term neurotoxic effects. Even short-term effects require more than symptomatic treatment with atropine, since there are antagonists that may be used within 48 hours of poisoning to reverse the binding of the OP with the enzyme in the nervous system.[4]

One prevalent myth in South Africa and other countries is that milk is preventive and an antidote, despite the absence of any evidence of its effectiveness. This provides a false sense of security and may aggravate risks from pesticides.

Surveillance

Although pesticide poisoning is a notifiable condition under the Health Act and requires reporting to the local/district health office, it is widely under-reported.[5] Sometimes cases resulting from occupational exposure are mistakenly attributed to accidental or suicidal exposure, or the diagnosis is missed. Another problem is the incorrect belief that only poisoning involving OP pesticides need be reported, whereas any pesticide poisoning must be reported. Health professionals diagnosing a pesticide poisoning must notify the Department of Health on a GW17/5 form and submit it to the local or district health service (notification process and forms: http://www.doh.gov.za/docs/misc/epi_comment/notify.html; ftp://ftp.hst.org.za/pubs/other/dhis/appb.pdf).

In addition, practitioners should report any suspected or confirmed occupational illness, including occupational pesticide poisoning, to the Chief Inspector for Health and Safety in the Department of Labour (DoL). There are no specific forms; instead the report should be faxed to a regional labour office (http://www.labour.gov.za/contacts). Although important for future prevention, the effectiveness of this reporting is often limited by lack of feedback from the DoL.

Health professionals' role in exposure and poisoning prevention and treatment

Health professionals play a vital role in pesticide poisoning prevention and treatment.[6] Firstly, they need to recognise the signs and symptoms of exposure to various pesticides, particularly because these may resemble symptoms associated with common ailments (e.g. flu, fatigue, low energy, rashes, weakness, sleep problems, anxiety, depression).[4] Toxicity of pesticides to humans may imitate the modes of toxicity for pests (e.g. rodenticides are anticoagulants, OPs and carbamates are neurotoxic). Health care professionals should be well versed in the symptoms of poisoning by pesticides commonly used in their work areas (see 'Useful websites' below). The pesticide label and relevant safety data sheets provide active/inert ingredients and treatment information (see 'Useful websites').

Lack of a careful exposure history may also lead to pesticide poisoning being overlooked.[4] Ruling out pesticide exposure as the source of symptoms should become common practice as exposure to pesticides is ubiquitous, not only in rural farming areas. Many urban residents are at risk because of ready marketing of highly hazardous pesticides in the informal sector. Therefore, conducting a detailed environmental history is a critical tool for proper diagnosis (http://www.neefusa.org/pdf/EnvhistoryNEETF.pdf).[4]

To prevent pesticide exposure, safer and less toxic control methods should be used, e.g. spray devices of which the drift is easier to control, integrated pest management (IPM) for pest control that requires less application, or administrative controls (rotating workers so that they spend less time in exposed conditions). Protective clothing should be used as a last resort rather than a first option. Even then, persons who apply pesticides are sometimes given a dust mask rather than the appropriate chemical respirator. Dust masks are completely ineffective in

Fig. 2. Informal street vendor selling unlabelled pesticide.

preventing exposure to organic fumes and mists. Consequently, they may be more hazardous because they create a false sense of security and paradoxically increase exposure by harbouring the chemical vapour.[7]

Health professionals are also responsible for key aspects of the Hazardous Chemical Substance Regulations (http://www.labourwise.co.za/laws/Safety.ChemicalSubst..htm). This includes medical monitoring of exposed workers for early disease, and overseeing and interpreting biological monitoring to prevent exposure-related disease. Monitoring cholinesterase levels to detect early effects of OP exposure can be done cost effectively using a portable field kit that uses a finger prick sample of capillary blood to identify workers who need to be removed from exposure before further illness results.[8]

Occupational health professionals are often responsible for ensuring accurate and up-to-date risk communication materials on pesticides.[9] It is important to ensure that such materials are appropriate to a broad range of literacy levels, particularly given the high level of illiteracy in South Africa.[10] Further, being up to date with regard to the literature of pesticide-related health effects is vital and can be done through Internet sites and by reading current research. Prevention of exposure to pesticides reduces risks not only for workers, but also for the future children of these workers.

Useful websites

Recognising signs and symptoms of pesticide poisonings:

- Physician's guide to pesticide poisoning (includes pesticide label) – http://www.getipm.com/thebestcontrol/physicians_guide/howto.htm (accessed 16 November 2009).
- Managing pesticide poisoning risk and understanding the signs and symptoms – http://www.ianrpubs.unl.edu/epublic/live/ec2505/build/ec2505.pdf (accessed 16 November 2009).
- Pesticide poisoning symptoms and first aid – http://extension.missouri.edu/xplor/agguides/agengin/g01915.htm (accessed 16 November 2009).
- General pesticide information and symptom indicators – http://www.epa.gov/opp00001/about/types.htm (accessed 16 November 2009).

Current pesticide information on the Internet:

- On-line free continuing medical education course – physician interaction with patients and families about pesticide exposures (available through 30 June 2011) – http://www.pesticideeducation.com/course (accessed 16 November 2009).
- Southern Africa Pesticide List Server – https://lists.uct.ac.za/mailman/listinfo/pesticides-l (accessed 16 November 2009).
- Fact sheets on inert and active ingredients found in pesticides – http://www.npic.orst.edu/npicfact.htm (accessed 16 November 2009).
- Searchable data base of nearly 3 000 acute cases of pesticide exposures – http://www2.cdc.gov/niosh-sensor-pesticides/search.asp (accessed 16 November 2009).
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Tuberculosis in health care workers

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With the growing burden of tuberculosis (TB) infection among populations of developing countries the risk of health care workers (HCWs) occupationally acquiring TB increases. In studies conducted in medium- and low-income countries the median occupational attributable risk of TB in HCWs was estimated at 5.8%.[1] In South Africa the presence of drug-resistant TB, which is dependent on workplace and individual factors, compounds the potential risk posed to HCWs.

Workplace factors include the number of TB patients treated at the facility and infection control practices. In facilities where a high number of TB patients are seen, the risk of developing occupational TB is much greater than in facilities with a small number of cases. Similarly, in the absence of appropriate infection control practices the risk of developing occupational TB increases.[2,3]

Individual factors that increase the risk of developing occupational TB in HCWs include occupational category, depressed immune status and presence of a chronic illness such as diabetes. HCWs who work in TB inpatient facilities, laboratories, medical wards and emergency rooms, and staff required to perform procedures (e.g. intubations, bronchoscopy and chest physiotherapy) likely to cause droplet aerosol, appear to be at greater risk than those working in administration and management.[3] Therefore it is important for a health practitioner responsible for the occupational health of HCWs to have a good understanding of the burden of TB infection managed at the facility and the health profile of those under his/her medical surveillance.

The Hazardous Biological Agents (HBAs) Regulations[4] promulgated in terms of the Occupational Health and Safety Act No. 85 of 1993[5] require that regular risk assessments be conducted to determine

Table I. A suggested cough questionnaire[14]

Date	Hospital				
Name	**Age**	**Sex**	**Date of birth**		
Marital status		**Job description**		**Current workstation**	
1. Do you have a cough that has lasted longer than 3 weeks?				Yes	No
2. Are you coughing at night?				Yes	No
3. Do you have a dry cough?				Yes	No
4. Do you cough up blood?				Yes	No
5. Have you lost your appetite?				Yes	No
6. Have you lost weight (more than 5kg) in the last 2 months without trying to?				Yes	No
7. Do you have night sweats (need to change the sheets or your clothes because they are wet)?				Yes	No

Table II. Required reports for submission to the compensation commissioner in the case of occupational TB

Notification of an Occupational Disease (WCL14)
Employers Report of an Occupational Disease (WCL1)
Exposure History (WCL110)
1st Medical Report (WCL22)
Progress Medical Report (WCL26)
Final Medical Report (WCL26)

whether there is exposure to HBAs in a workplace. *Mycobacterium tuberculosis* is categorised as a Group 3 HBA, i.e. one that 'may cause severe human disease, which presents a serious hazard to exposed persons and which may present a risk of spreading to the community, but for which effective prophylaxis and treatment is available'.

A risk assessment of a health facility should be conducted every 2 years; in the interim, if HCWs with TB are identified, a risk assessment is warranted to review workplace controls. Based on the findings of risk assessments infection and workplace control strategies should be implemented. The three levels of control to be implemented with regard to TB are administrative, engineering/environmental and personal protective controls. Administrative controls are the first line of controls and include aspects of patient triaging, early diagnosis, treatment and management of TB patients as outpatients as opposed to inpatients.[3,6,7]

Engineering controls that have been proposed include negative-pressure local exhaust ventilation (LEV) or dilution ventilation systems, with high-efficiency particulate air filtration (HEPA) and/or UV treatment of vented air.[3] However, in resource-constrained environments the implementation and maintenance of such measures is not always possible.

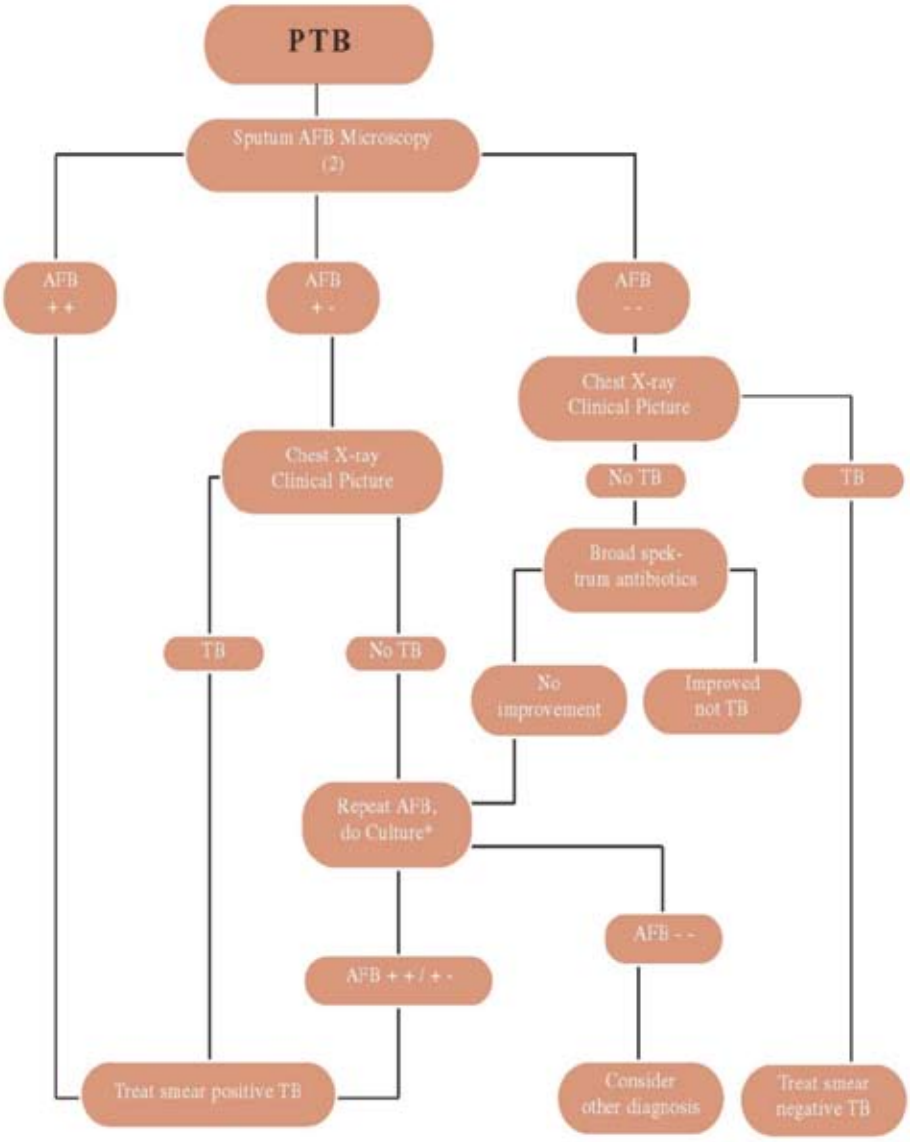

Fig. 1. Diagnosis of a TB case.[11]

Consequently, emphasis on increasing natural ventilation in the presence of administrative controls should be considered. With regard to personal protective equipment (PPE) a respirator with the capacity to filter a 1 micron particle is needed to protect against *M. tuberculosis* transmission.[3] Issuing of respirators must be accompanied by a respirator training programme, which includes elements on fit, use, storage and maintenance.

Workplace controls must be coupled with a medical surveillance programme. Ongoing screening of HCWs is vital to ensure that occupational TB is diagnosed and treated early, preventing complications and spread. Much has been written about the use of tuberculin skin testing (TST) and interferon assays in the immune diagnosis of TB.[8-10] Each method has its own advantages and disadvantages. There are no national guidelines for the screening

and treatment of latent TB infection in HCWs in South Africa.

However, a routine medical surveillance programme of HCWs exposed to HBA is required.[4] Medical surveillance should encompass pre-employment and annual medical examinations together with a self-administered health questionnaire at baseline and a modified questionnaire at subsequent annual examinations. In addition, screening tools such as quarterly cough questionnaires (Table I) and monthly weighing can be implemented in HCWs at high risk as a means of ensuring early diagnosis of TB.

Currently the diagnosis of TB in HCWs follows the routine method of analysis recommended by the South African National Tuberculosis Control Programme,[11] i.e. two sputum samples or the use of chest radiography in cases where there is one positive sputum sample or none of the samples is positive (Fig. 1). In cases of non-pulmonary TB the site of infection will determine the diagnostic method; investigations such as fluid cytology, culture, fine needle aspiration, biopsy and polymerase chain reaction may be required.

Treatment of HCWs diagnosed with TB should follow routine TB treatment guidelines as for any patient diagnosed with TB.

All cases of HCWs diagnosed with occupationally acquired TB must be submitted to the office of the Compensation Commissioner for compensation in terms of the Compensation for Occupational Injuries and Diseases Act No. 55 of 1995 (COIDA).[12] While Circular Instruction No. 178 on Compensation for Pulmonary TB in HCWs[13] outlines the requirements for compensation, even non-pulmonary cases of TB resulting from occupational exposure should be submitted for compensation. The first medical report should be submitted together with notification of the occupational disease, exposure history and employer's report. Progress medical reports must be submitted every 2 months until complete recovery, when a final medical report must be submitted (Table II).

HCWs should have the option of voluntary testing and counselling (VTC) for HIV as part of their medical surveillance programme. Those who test positive for TB should be advised on VTC. In addition to VTC all HCWs who test positive for TB should be advised to ensure that their nearest contacts are tested for the disease. Depending on the progression of TB infection and treatment response, infected HCWs may require leave or re-deployment in the workplace and amendments to working hours.

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Silica, silicosis and tuberculosis – recognising the clinical link

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In any year over 200 000 workers are engaged in mining occupations in South Africa. In the mid-1980s this figure was as high as 500 000 in the gold mining industry alone. The number of South Africans and citizens of neighbouring countries who are former miners is therefore very large indeed. This article proposes the following four guidelines for the recognition and management of silicosis and related pulmonary tuberculosis (PTB):

Take an occupational history in all adults with suspected PTB

The strong association between silicosis – fibrosis of the lung due to the inhalation of silica dust – and an increased risk of PTB is well known. Less well known is that even in the absence of silicosis on the chest radiograph, the risk of PTB is elevated in individuals with retained silica in the lung. HIV infection, currently at prevalence levels of 20 - 30% among gold miners, greatly elevates these risks.

Gold mining is the most important sector involving silica exposure, with a lower risk in coal mining. However, there are a number of smaller industries with a silicosis risk, e.g. sand quarrying, stone crushing, cutting or grinding, ceramics manufacturing, foundry work or sandblasting being the more common ones.

Be aware of the appearances of silicosis and associated PTB on the chest radiograph

Chronic silicosis is a bilateral nodular disease, starting in the upper zones. It may extend to the lower zones but is never only a lower-zone disease. It can potentially be confused with miliary TB, but compared with miliary TB the patient in uncomplicated silicosis is not acutely ill. In silicosis the nodules are rounded and may vary a little in size. They are seldom

calcified, although lymph nodes may be calcified.

Silicosis is frequently found together with old fibrotic PTB, in which case the nodular pattern is typically disturbed by unilateral fibrosis and contraction of one of the upper lobes (Fig. 1).

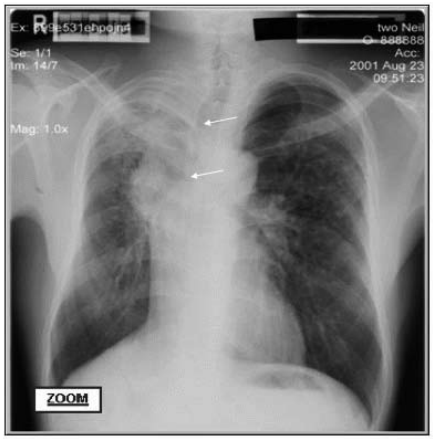

Fig. 1. Chest radiograph showing old pulmonary tuberculosis superimposed on silicosis. (Features: Typical upper- and mid-zone nodulation of silicosis seen in left lung. Contraction fibrosis of right upper lobe attributable to previous tuberculosis, partly obscuring silicotic nodulation.)

Another variant is silicosis with progressive massive fibrosis (PMF). The appearance is one of oval-shaped masses in the upper zones. With progression, the typical nodular pattern becomes less evident as the upper zones contract and the lower zones show compensatory hyperinflation. PMF may be difficult or impossible to distinguish from chronic fibrotic TB or even from active TB.

Take the presence of silicosis into account during treatment for PTB

There is no evidence base for routinely extending short-course antituberculosis therapy in the presence of silicosis. The presence of silicosis will, however, limit the use of radiological clearing as an indicator of response to treatment. Otherwise standard clinical criteria should be used in determining treatment response in patients with silicosis and PTB.

Once treatment is completed, help the patient to apply for statutory compensation

Both TB in silica-exposed workers and silicosis are compensatable diseases in South Africa. However, there are two quite separate systems, depending on the industry.

Mining and quarrying: Occupational Diseases in Mines and Works Act, 1973

This covers active workers who develop PTB while engaged in a dusty occupation or within 12 months of leaving such occupation. The patient need not have silicosis for such a claim to be submitted.

If silicosis is present, the claim for silicosis and PTB can be submitted at any time and, importantly, also in former miners irrespective of when the dusty employment ended.

Other dusty industries: Compensation for Occupational Injuries and Diseases Act, 1993

This covers active and former silica-exposed workers in occupations such as foundry work, sandblasting, and stone grinding or cutting.

In both systems, the patient should be assessed for residual radiological and lung function impairment at the end of PTB treatment before submission of the compensation claim. Whereas chronic silicosis alone may be associated with little impairment at diagnosis, the addition of even fully treated PTB is typically associated with impairment and chronic ill health.

Details of the compensation authorities to whom to report are listed in Table I. Where feasible, such patients can be referred to specialist clinics dealing with occupational disease (see box on p.518 of this issue for details).

Table I. Compensation authorities

Compensation authorities (to whom to report)	
Mining and quarrying	Director, Medical Bureau for Occupational Diseases, PO Box 4584, Johannesburg 2000
Other industries	Compensation Commissioner, PO Box 955, Pretoria 0001
Specialist clinics (for assistance with assessment and submission)	
Cape Town	Occupational Diseases Clinic, Groote Schuur Hospital, tel. (021) 404-4369
Durban	Occupational Medicine Clinic, King Edward VIII Hospital, tel. (031) 260-4471/4676/4387
Johannesburg	Occcupational Medicine Referral Clinic, National Institute for Occupational Health, tel. (011) 712-6415/6531

Further reading

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Medical certification and professional qualifications – who is authorised to do these?

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It is important that medical practitioners understand that adjudicating (or certifying) fitness to work often requires that the medical examiner has certain minimum qualifications.

Using South African law as the primary guide, the following categories of qualification are to be considered:

- Certificate of Fitness signed by any medical practitioner without additional qualification or registration
  - drivers on public roads requiring a PrDP (professional driver's permit) (National Road Traffic Act (93 of 1996), 25 (2) (b), 28 B (1) (c) (instructors), Schedule section 25 (2) (b), chapter IV, 15 (1) (f) - (h), and the National Road Traffic Regulations (2000), Regulation 102 (1) - (2) (vision std), 115 and 116 (who requires PrDP), 117 (b) (who certifies), and 122 (certificate valid for))
  - radiation medicals (Hazardous Substances Act (15 of 1973); Regulations Relating to Group IV Hazardous Substances, 1993, Regulation 14 (2) (b))
  - cold workers (Environmental Regulations 2 (2) (c) of the Occupational Health and Safety Act (OH&SA) 85 of 1993
  - heat workers (Environmental Regulations 2 (4) (b) (i) of the OH&SA).

It is important that medical practitioners understand that adjudicating (or certifying) fitness to work often requires that the medical examiner has certain minimum qualifications.

- Certificate of Fitness signed by an occupational medical practitioner (i.e. a medical doctor with the required postgraduate qualifications in occupational health)
  - construction – workers required to work on suspended platforms (Construction Regulations (15) (12) (a) of the OH&SA)
  - construction – crane operators (Construction Regulations (20) (g) of the OH&SA)
  - construction – operators of all construction vehicles and mobile plants (Construction Regulations (21) (1) (d) (i) of the OH&SA)
  - lead medicals (Lead Regulations 8 (1) - (5) of the OH&SA)
  - asbestos medicals (Asbestos Regulations 9 (1) - (4) of the OH&SA)
  - seafarers (Merchant Shipping (Eyesight and Medical Examination) Regulations, 2004; Regulation 18 (1))
  - employees on mines and quarries (Mines Health and Safety Act, Section 13 (10 - (8[P3])).
- Certificate of Fitness signed by a medical practitioner with other additional postgraduate qualifications
  - divers (Diving Regulations 4 (1) - (8) of the OH&SA)
  - aeroplane pilots (Civil Aviation Regulations Part 61.01.6. The licence to conduct these examinations is issued under the South African Civil Aviation Authority).
- Certificate of Fitness signed by an occupational health practitioner (i.e. a registered nursing sister or a medical doctor with the required postgraduate qualifications in occupational health)
  - hazardous chemical substance medicals (Hazardous Chemical Substances Regulations, Regulation 7, of the OH&SA)
  - hazardous biological agents (Hazardous Biological Agents Regulations, Regulation 8, of the OH&SA).
- Certificates of Fitness that are required by law, but for which the qualifications of the adjudicator are not specified
  - construction – employees required to work at height, with fall protection (Construction Regulations (8) (2) (b) of the OH&SA)
  - on-site driven machinery (i.e. forklift operators) (National code of practice for the evaluation of training providers for lifting machine operators, under the Driven Machinery Regulations of the OH&SA). The code requires the employer to ensure that the employees are physically and psychologically fit to be trained (p.13, point 2 (a)). Note that the code also requires that these employees are certified by an optometrist to have adequate day and night vision and depth perception. Alternatively, should an employee be in possession of a PrDP, this would be deemed sufficient to meet the standard for vision (optometry) and physical fitness (p.14, 2 (b)).

The code also requires that these employees are certified by an optometrist to have adequate day and night vision and depth perception.

- Certificates of Fitness that are not specified by law, but that are part of good risk management
  - work in which there is an obligatory use of respirators
  - confined-space workers
  - food handlers (returning to work after an infectious illness).

Fitness to work - what the general practitioner needs to know

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From time to time medical doctors are called upon to adjudicate whether or not a person is fit to perform a particular job. This may include routine screening (e.g. before employment); return-to-work (post-illness) evaluation; or incapacity or disability assessment (referred by management, union, or insurance company).

The key issue when evaluating a person for fitness to work relates to the concept that every occupation has inherent health requirements (or minimum medical standards of fitness) that the person in that occupation must meet to minimise risk of injury or illness to self or others to an acceptable standard.

Permutations of the outcomes of medical adjudication are given in Table I.

Note that a person may be unfit but not disabled, e.g. someone with a visual impairment who does not meet the minimum visual requirements for the job.

Should an employee or applicant be found to be unfit (or fit with restrictions), the duration of that circumstance should be considered. Employees may be classified as temporarily or permanently unfit. If temporarily unfit, the reason for the unfitness will fall away after a period of time.

The term impairment refers to specific deviations from the functional capabilities expected of an average healthy individual. Therefore loss of hearing or lung function, or a joint that loses a certain degree of its

Table I. Permutations of outcomes of medical adjudication

Outcome	Meaning

Fit	Meets the minimum inherent health requirements for the job assigned, including
	• capability to perform the tasks required:
	  • to the required standard (quality and efficiency).
	  Quality – may require good vision (e.g. quality control worker) or dexterity (e.g. working on PC screens)
	  Efficiency – may require strength and endurance (e.g. heavy manual work) or flexibility (e.g. work in confined spaces)
	  • without undue risk to him/herself or others (e.g. good vision in a professional driver, or absence of certain illnesses, such as uncontrolled epilepsy, in an airline pilot)
	• ability to function in working conditions associated with the job (e.g. potential to be exposed to certain hazards), without undue risk to his/her health (e.g. absence of certain illnesses that increase vulnerability to working conditions, such as poorly controlled asthma in the presence of respiratory irritants, or cardiac failure in a hot working environment)

Not fit, but can do the job with restrictions	Does not meet one or more of the above minimum inherent health requirements for the job, but is able to do the job should certain restrictions be accommodated, e.g.: • task restrictions – exclusion of certain tasks (e.g. no climbing of ladders), reduction in operating performance (i.e. speed or duration of the work) (e.g. only drive short distances, or only work half days, or only drive vehicles of a certain category) • workplace restrictions – working conditions may restrict an employee from working in certain workplaces (e.g. presence of particular hazards posing a threat to the health of the employee, such as chemicals that can irritate the lungs) Sometimes the restriction is simply that there is a requirement for the employee to be under regular medical review (e.g. to monitor blood glucose or blood pressure) Duration of restrictions or unfitness should be stated (i.e. permanent or temporary)
Not fit	Does not meet one or more of the above minimum inherent requirements for the job, not even if any suitable restrictions are applied

range of motion, all refer to impairments. These impairments are not necessarily disabilities or do not automatically render a person unfit. The term disability refers to a long-term or recurring physical or mental impairment that substantially limits the prospects of entry into or advancement in employment. The calculation of disability is complex and is determined by legal, ethical and actuarial factors.

Who is legally mandated to adjudicate fitness to work?

It is important to note that the certification of fitness to work for a large number of occupations is regulated by law. General practitioners are legally authorised to provide Certificates of Fitness with regard to:

- drivers on public roads requiring a PrDP (professional driver's permit) (National Road Traffic Act)
- radiation medicals (Hazardous Substances Act)
- cold workers (Environmental Regulations 2 (2) (c))
- heat workers (Environmental Regulations 2 (4) (b) (i))
- on-site driven machinery (e.g. forklift operators) (National code of practice for the evaluation of training providers for lifting machine operators, under the Driven Machinery Regulations). Note that the code also requires that these employees are certified by an optometrist to have adequate day and night vision and depth perception.

  Alternatively, should an employee be in possession of a PrDP, it would be deemed sufficient to meet the standard for vision (optometry) and physical fitness.

Much more could be written on the subject of fitness to work and its numerous permutations; however, this article focuses on key concepts relevant to the general practitioner.

Conclusion

To adjudicate on fitness to work the examiner should have a clear understanding of the inherent minimum health standards for the applicable occupation.

Should an employee or applicant have a condition that impacts on fitness to work, the potential for accommodating the applicant with regard to certain task or workplace restrictions should be considered.

Adjudicating fitness to work for a large number of occupations or workplace settings requires additional qualifications (e.g. in occupational health, diving medicine, or aviation medicine).

Clinical screening and medical surveillance for adverse health effects of manganese exposure

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Manganese (Mn) is used in the occupational setting of a number of major industries but is principally mined, smelted and mixed with other metals in alloys like ferromanganese or silicomanganese. The commonest form of exposure is to manganese dioxide (MnO2).

The most important health effects involve the nervous system where toxic damage to the basal ganglia can cause manganism or manganese-induced parkinsonism with or without neuropsychiatric manifestations. Other health effects are less clear and include respiratory effects which have

only been reported in miners exposed to very high dust levels, and one report of reproductive effects.

The South African occupational exposure limit for Mn is 5mg/m^3 for inhalable dust. This is 25 times less stringent that the ACGIH TLV of 0.2 mg/m^3. Cases of clinically obvious manganism are very rarely encountered in those exposed below the recommended South African occupational exposure limits.

South African studies of subclinical neuropsychological effects of occupational Mn exposures have been generally negative, while international studies have reported mixed findings both positive. A recent screening at a South African smelter found no cases of definite manganism.

Prevention of manganese-induced parkinsonism

Exposure should be reduced as far as possible below 5 mg/m^3 – preferably to below 0.2 mg/m^3 – guided by high-quality occupational hygiene and prompt engineering interventions.

There is no justification for individual biomonitoring as would be called for with lead exposure, as blood Mn values are very variable and of little use in monitoring exposed individuals.

On the other hand, group mean blood Mn levels for small numbers of representative workers from presumptively high homogeneous exposure zones can be profitably monitored over time as an additional indicator (over and above periodic occupational hygiene surveys) to verify the effectiveness of engineering controls in reducing exposures.

The normal range of exposure in the occupationally unexposed population is 0.3 - 12 µg/l of whole blood. Means and ranges of blood manganese exposures for different South African exposure groups showing changes for different exposure groups are shown in Table I.

Table I. Blood manganese (MnB) distributions in recent South African studies

Exposure situation	*N*	MnB µg/l Mean (range)
South African second Mn smelter workers (Myers *et al.*, 2009)	686	15.6 (3 - 118)
South African first Mn smelter workers (Myers *et al.*, 2003b)	509	11.7 (3 - 44)
South African Mn mineworkers (Myers *et al.*, 2003a)	489	8.5 (2 - 24)
South African unexposed controls for the first Mn smelter study (Myers *et al.*, 2003b)	67	6.2 (3 - 11)

Table II. Level 1 manganism screening instrument to be administered by an Occupational Health Nurse

Questionnaire: Do you experience any of the following?

Items	Questions	Answers
Falls	Have you had any falls over the past 6 months?	Yes/No
Voice/speech	Has your voice or speech changed in the last 6 months?	
	If yes, in which way?	Yes/No
Fine motor dexterity	Have you noticed any difficulty with your hands recently?	Yes/No
	Do you have any difficulty doing up buttons or laces, brushing your teeth, or putting keys into locks?	Yes/No
Tremor	Have you noticed a tremor (shaking) of your hands recently?	
	If yes, when does it happen?	
	When your hands are still?	
	When you are working with them?	Yes/No
Gait	Do you feel that the way you walk has changed? If yes, in what way?	Yes/No
Bradykinesia (overall slowing)	Are you taking longer to do things (dressing, eating or at work) than your family members or work colleagues would take?	Yes/No
Facial expression	Have your family or friends noticed any change in the way you look?	
	If yes, what have they noticed?	Yes/No

Examination: Are any abnormalities present on examination?

Items	Signs to look for	Answers
Facies	Lack of expression, reduced blink rate, abnormal contractions	Anormal/Normal/Unsure
Movements, bradykinesia	Observe for lack of energy, lack of spontaneous movement of hands when talking, and for general slowness of movement, e.g. when walking into the room or undressing.	Anormal/Normal/Unsure
Speech	Soft, monotonous, indistinct	Anormal/Normal/Unsure
Gait	Slow shuffle with short strides, lack of armswing, multistep turn (no swivel); particularly unsteady on walking backwards	Anormal/Normal/Unsure
Hand tremor	Uni- or bilateral, at rest or with action/postural maintenance	Anormal/Normal/Unsure
Fine motor dexterity*	Slowing of movements such as repetitive finger tapping, or repetitive fist opening and closing	Anormal/Normal/Unsure

* Quantitative measurements for fine motor dexterity and finger tapping can be obtained by the use of a pegboard or timer.

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Medical surveillance is based on the detection of Mn-induced parkinsonism and can be conducted at 3 levels.

Level 1: An occupational health nurse can conduct first-level screening by asking 7 symptom questions and eliciting 6 signs at periodic annual examinations (Table II). One or more abnormalities should trigger a referral to the occupational medical practitioner at *Level 2* for verification and further examination. Any neurological abnormality should be referred to a movement disorder subspecialist neurologist for a diagnosis of parkinsonism at *Level 3*. A specialist neurologist who has been trained in the examination and diagnosis of manganese-induced parkinsonism is also an option.

An MRI showing hyperintensity in the region of the globus pallidus is a measure of exposure and not necessarily injury.

Further reading

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SAOEL. South African Occupational Exposure Limits – Recommended Limits. Hazardous Chemical Substances Regulations, 1995 of the Occupational Health and Safety Act, 1993.

Single Suture

Smokers can't fool this nose

Most of us who don't smoke reckon that we can smell a smoker a mile off, but some people who smoke tell their doctors they are non-smokers in an effort to get cheaper life insurance. However, a newly developed electronic nose could put an end to this attempted deception.

A team lead by Paul Thomas at the University of New South Wales in Sydney, Australia, tweaked a commercially available e-nose so that it would detect the volatile organic compounds (VOCs) in the breath of a person who had smoked a cigarette. The e-nose used an array of 32 sensors whose electrical resistance changes as different VOCs are detected. The resulting smell-print correctly identified 37 out of 39 volunteers as either smokers or non-smokers. The conclusion was that this e-nose can quickly and reliably detect smokers without the need for a blood or urine test.

Thomas P, *et al. Journal of Breath Research.* DOI:10.1099/1752-7155/3/3/036003.

Single Suture

Smart implants may help Parkinson's

Implants that react to brain signals could help people with Parkinson's disease, as well as depression and obsessive compulsive disorder, according to a team from Medtronic of Minneapolis, Minnesota. The team recently reported their design for a neurostimulator at the Engineering in Medicine and Biology Society meeting in Minneapolis. The device uses electrodes to deliver deep stimulation to specific parts of the brain.

Neurostimulators are already approved to treat conditions such as Parkinson's disease, essential tremor and dystonia, as well as obsessive compulsive disorder. But existing devices deliver stimulation on a set schedule and not in response to abnormal brain activity. The Medtronic researchers think a device that reacts to brain signals could be more effective, and the battery would last longer, which is an important consideration for implantable devices.

The neurostimulator will initially be used to study brain signals as patients go about their daily activities. But eventually the data collected will show whether the sensors would be useful for detecting and preventing attacks.

New Scientist 2009; 12 September.