Summary

Introduction
The health of workers exposed to diesel exhaust emissions in underground coal mines is of growing concern. The chronic effect of long term exposure to diesel exhausts is thought to be tumorgenesis due mainly to the polycyclic aromatic hydrocarbons (PAHs) contained in the emisate. To date, no reliable method exists to measure diesel emissions in the respirable zone of coal miners, nor are there any reliable biological markers to indicate exposure.

A cross sectional study was undertaken on a coal mine to determine if there was any difference in urine PAH levels between workers exposed to diesel exhaust fumes and those not exposed. Ethics clearance was obtained from the Committee for research on Human subjects (Medical) of the University of the Witwatersrand (Ref M00/10/11)

Objectives
- To determine the urine 1-hydroxypyrene level in underground coal miners exposed to diesel exhaust emissions and in plant operators living and working on the same mine but not exposed to diesel emissions; and
- To measure the urinary cotinine of all study participants.

Methods
A coal mine in Mpumalanga, South Africa was selected to participate in the study and negotiations were held with labour and management to conduct the survey in August 2001. Workers were categorised into high and low exposure categories by the safety officer. High risk occupations were LHD drivers, bus drivers, diesel mechanics and technicians. Low risk workers were individuals who lived in the area and worked on services in the plant, services or planning where there was no occupational exposure to diesel emissions. All 40 workers exposed to diesel in two underground sections were asked to participate. From a list of 200 non-exposed workers, a random sample of 40 surface, non-exposed workers were asked to participate.

Workers were briefed one week prior to sample collection on the background and purpose of the survey. Demographic data and urine samples were collected at the end of the 6th shift (end of week). Urine was collected into polyurethane vials, placed on ice and transported to an accredited laboratory where they were frozen at -18°C immediately. The urine samples were defrosted, then subjected to high pressure liquid chromatography to separate out the hydroxyppyrene. The quantity of 1-hydroxypyrene was determined using a fluorescent detector. Urinary cotinine level was determined on the individual urine samples to determine any potentiating effect of smoking on the PAH levels. Reference limits for non-industrial exposure for the laboratory were 0 to 0.45 : mol/mol creatinine while the limits for industrial exposure are 0.45 to 2.34 : mol/mol creatine. Cotinine is also expressed as a ratio to creatinine, with a limit of 0.7mg/g in non-smokers and 8.6 mg/g in smokers.

The data were double punched into a personal computer and analysed with the statistica software program. As data were not normally distributed, the non-parametric, Kolmogorov Smimoff test was used to compare sample means. The Spearman rank test was used for correlation between PAH and cotinine levels.

Results
Of the 40 exposed underground workers, 2 declined to participate and 28 of the 40 selected surface workers agreed to participate as controls. Urine samples from 3 surface workers were insufficient and were discarded. All workers were male except one surface worker and ranged in age from 23 to 57 years.

The results indicate that there was no statistically significant difference in the exposure to PAHs between the two groups. Two workers (diesel bus drivers) had PAH levels greater than 2 : mol/mol creatinine. The exhaust outlets are in close proximity to the drivers who do not wear protective respiratory apparatus. There was no association between smoking (cotinine) and PAH level in the urine.

Recommendations
Further research and interventions should be considered:
- To establish if bus drivers are in a particularly high risk of exposure in underground coal mines
- To introduce measures to reduce emissions from buses
- To extend the study to the non-coal mines and include other factors which may affect PAH levels
• To establish reliable methods to measure diesel particulate matter (and absorbed chemical substances such as PAHs) emissions and personal exposure in the coal and hard rock South African mining industry.